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BABY LANGUAGE DETECTION USING DEEP LEARNING

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Abstract

Baby cry sound recognition in diverse residential contexts with challenging signal-to-noise ratios using deep learning and traditional methods. Both commercial items (like infant remote monitoring) and academic research in medicine and psychosocial studies use automatic cry detection. For the purpose of detecting baby cries, we develop and assess various convolutional neural network (CNN) architectures, and we contrast their effectiveness with that of traditional Support vector machines and logistic regression are two examples of machine learning approaches. We evaluate the effectiveness of recurrent neural network (RNN) designs, in addition to feedforward CNNs, which can depict the temporal behavior of auditory stimuli. We demonstrate that superior results may be achieved compared to standard CNN architectures by carefully developing CNN architectures with customized nonsymmetrical kernels.

Keyword: *Audio detection, Baby cry detection, Convolutional neural networks, Deep learning*

1. INTRODUCTION

Baby language detection refers to the analysis and interpretation of sounds, cries, facial expressions, gestures, and other non-verbal cues displayed by infants during their early stages of development. Understanding and responding appropriately to these signals are vital for effective caregiving, early education, and the overall well-being of infants. It makes us to examine the field of baby language detection, which focuses on understanding and deciphering the vocalizations and non-verbal cues of infants[1]. Baby language detection has drawn recently received a lot of attention because it has the potential to improve both the communication between infants and caregivers and early childhood development. This provides an overview of the key methods and technologies used in baby language detection, its applications, challenges, and potential future directions. Certain types of baby indicative of health problems, as hunger, pain, discomfort, or illness. Baby language detection can help parents and caregivers identify these issues early on, allowing for prompt medical attention and care[2].

Understanding the specific needs of a baby through cry analysis can help parents and caregivers respond more effectively and appropriately. This can lead to improved bonding and a more nurturing setting for the infant. It can be overwhelming to take care of a newborn, especially for first-time parents. Baby language detection can provide valuable insights into a baby's needs, reducing parents' stress and anxiety related to interpreting their baby's cries[3].

By identifying the reason for a baby's crying, caregivers can address the underlying issue, which may help improve the baby's sleep patterns and overall well-being. Baby language detection technology can be integrated into various devices, such as baby monitors or smartphones, making it easily accessible to parents and caregivers[4].

2. EXISTING WORK

2.1 Database

The database for this inquiry contains several tens of hours of audio recordings produced by Dutch parents of babies. The infants, who were being monitored 24 hours a day in a household setting, they had just turned six months old. Recordings include a variety of sounds. The database was compiled as part of a pilot research to look into "attachment formation," or the growth of a relationship between a caregiver and a child. A total of 50 different event categories were fully annotated throughout the three hours of data,down to the millisecond level. Recordings' sampling frequency is Fs = 44100 Hz.

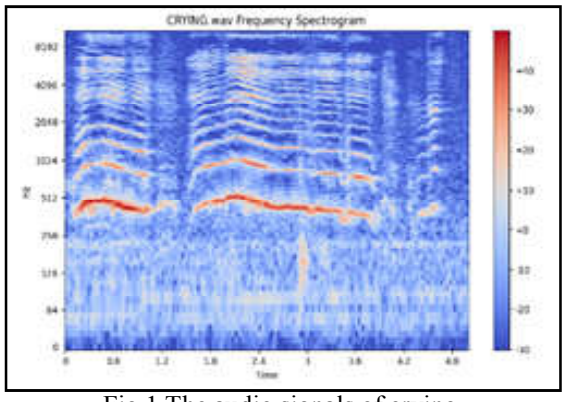


Fig.1 The audio signals of crying

2.2 Pre-processing and Feature Extraction

The audio recordings are broken up into parts with a 50% overlap and 4096 samples, or around 93 milliseconds. These segments are then split up into 16-millisecond frames with an 8-millisecond step. Each frame is given a pitch detector that uses cepstral domain peaks to estimate rough pitch.estimate, as well as time-domain cross-correlation for fine-tuning the initial pitch value. Due to the predicted period of high baby cry, the range of possible pitch period durations is limited to 1.6 to 3.3 ms. Each audio segment is computed with the following features[5].

- Temporary energy (STE).Zero-crossing rate (ZCR) is third.
- Determine the segment's pitch median value.
- The number of consecutive spoken frames inside a segment where pitch was identified is known as the run-length of pitch. HF, or harmony factor. HAPR, or the ratio of harmonic to average power.
- Depending on how the line-spectral pair is represented, the first formant.
- The difference between the frequency bands [0, 3.5] kHz and [3.5, 22.5] kHz in terms of spectral energy is expressed as the energy ratio of the frequency band, expressed in decibels (dB).
- The frequency below which the spectrum rolls offpoint: a frequency below which a spectral energy concentration of 75% occurs.

A straightforward supervised technique with the benefit of low processing complexity is logistic regression classifier. Using a logistic regression-type non-linear hypothesis function, a single segment of a cry lasts just approximately 93 milliseconds, although most of cry occurrences.These judgments must last for at least a few hundred milliseconds. The following smoothing procedure is applied to start of the one that is the initial sequence of judgments to prevent inaccurate detection of segments that are too short to represent possible cry events.

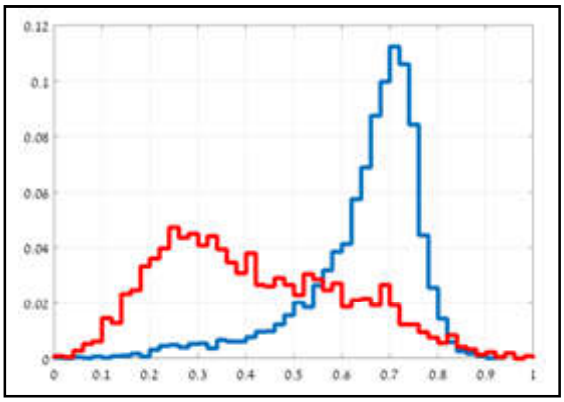
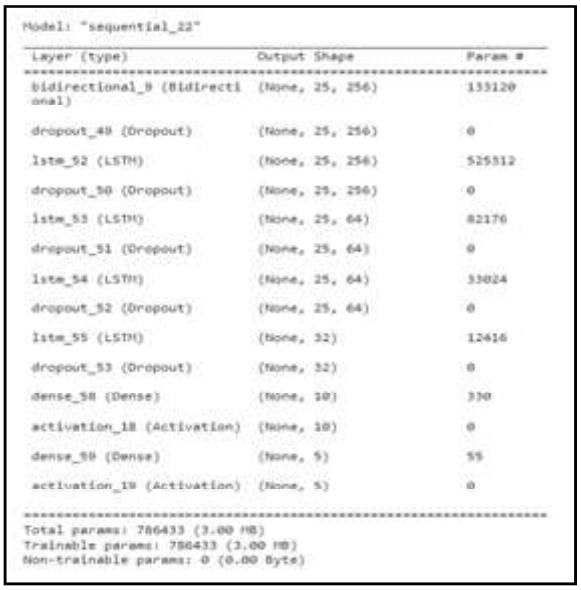


Fig.2 The fifth MFC coefficient's histogram.
Red: Crying events Blue: Other Occasions

3. BILSTM MODEL CREATION

Build theBiLSTM deep learning model to detect baby language. The system in real-time with baby cry input taken from mic and the features extracted from the audio waves and are saved to csv file which serves as an input to the model.Our work is interesting since we were able to properly deduce a baby's emotions from his or her cries, a feat that has promise for users[6].



```
Model: "sequential_22"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 bidirectional_9 (Bidirecti  (None, 25, 256)           133120
 onal)
 dropout_49 (Dropout)        (None, 25, 256)           0
 lstm_52 (LSTM)              (None, 25, 256)           525312
 dropout_50 (Dropout)        (None, 25, 256)           0
 lstm_53 (LSTM)              (None, 25, 64)            82176
 dropout_51 (Dropout)        (None, 25, 64)            0
 lstm_54 (LSTM)              (None, 25, 64)            33024
 dropout_52 (Dropout)        (None, 25, 64)            0
 lstm_55 (LSTM)              (None, 32)                12416
 dropout_53 (Dropout)        (None, 32)                0
 dense_58 (Dense)            (None, 10)                330
 activation_18 (Activation)  (None, 10)                0
 dense_59 (Dense)            (None, 5)                 55
 activation_19 (Activation)  (None, 5)                 0
=================================================================
Total params: 786433 (3.00 MB)
Trainable params: 786433 (3.00 MB)
Non-trainable params: 0 (0.00 Byte)
```

Fig.3 BiLSTM model creation

4. RECURRENT NEURAL NETWORKS

The inputs and outputs in conventional feed-forward designs are independent of one another. Given that we need to know what the words before them were, Feed-forward networks may not be one of the best choice for tasks like word prediction in a sentence. Therefore, these

networks are unable to model sequences. By including a memory component, RNNs are made to retain temporal data. By including a memory component, Recurrent neural networks are designed to store of the main one like the time information. RNNs are also used for speech recognition, as well as for other audio recognition and classification. The output of the RNN is dependent on previous calculations at every time instant. To do this, the RNN learns a state that is dependent on the current input as well as the previous state for every time instant. Most of the time, the starting point is set to 0. In contrast to the above-mentioned RNN solution, using 2D convolutions with states and 3D convolution (i.e. working on the time axes) provides a more efficient and straightforward way to learn spatiotemporal properties. The usage of memory is anticipated to be advantageous for use in our cry detecting application since cry sequences are probably connected[7].

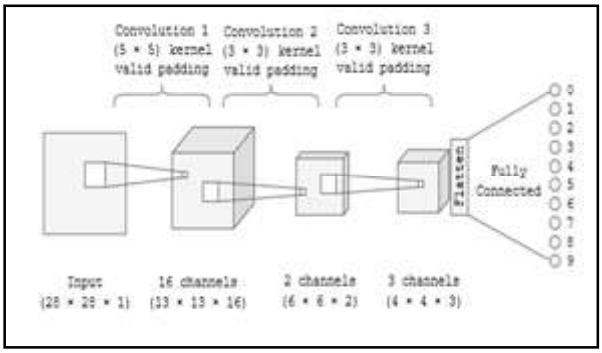


Fig.4 A display of the feature maps produced by our CNN architecture using three-by-three kernels

We investigated the functionality in our investigations ofBiRNN designs. Each time instantaneous output in BiRNNs is dependent on both current and upcoming inputs.It has both the states such as forward and backward, which are applied to the computation of an output at each time instant. Over traditional one-sided RNNs, BiRNNs often display better performance and convergence behaviour. There are two different types of BiRNN architectures that we took into consideration. Standard BiRNN layers were utilized in the first architecture. In our second architecture, biLSTM layers were used instead of BiRNN layers because biLSTMs are better at identifying long term dependencies and have more complex state calculations than BiRNN.Additionally, vanishing or inflating gradient issues are less common with BiLSTM layers[8].

An all-convolutional network with the same topology processes the incoming data in a preliminary stage (apart from theTable 1's fully-connected layer), but with just 270 000 parameters. Each layer of the design's total number of filters is displayed in Table 1 were reduced by the right amount to arrive at this number of parameters. We employed states with 128 units in using our BiLSTM and BiRNN architectures[9].

5. SUPPORT VECTOR MACHINE

Newborn babies cry to connect with us. Depending on why a newborn scream, several patterns of infant cry signals exist Preprocessing, feature extraction, and feature selection are complex tasks that need to be done expertly for today's audio signals[10]. In deep learning methods, the most important features are automatically extracted and selected. Effective classification of this calls for a vast amount of data. The primary distinction made in this investigation is between pain, hunger, and tiredness in infant screams. The infant cry auditory data is utilizing the short-time Fourier transform (STFT) method, turned into a spectrogram images[11].

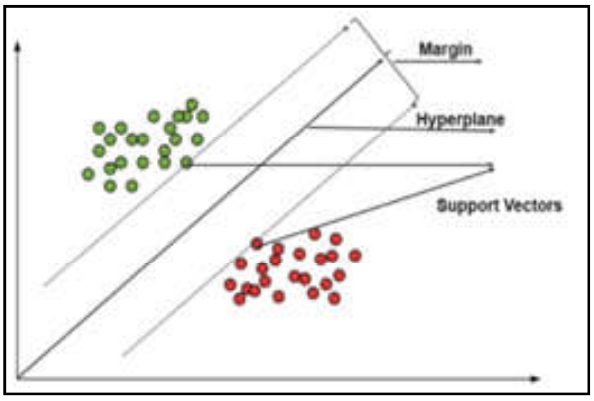


Fig.5 Transforming into a spectrum image

The support vector machine (SVM) Convolutional neural network feeds features to the classifier.. Neonate screams are categorized using machine learning techniques. In order to attain the finest outcomes, even with a limited amount of data samples, we combine the advantages of deep learning with machine learning in our work[12]. The outcomes of the experiment demonstrate the potential of SVM and CNN-based feature extraction. When the accuracy of kernel-based newborn cry categorization systems based on comparison to linear, polynomial, and RBF algorithms, it can be seen that SVM -RBF has the best accuracy which gives 88.89%.

6. PERFORMANCE EVALUATION

Two essential evaluation criteria is that the fraction of true-positive events is what is referred to as the rate of detection, also known as correctly detected cry events, to all of the recorded cry events (including true positives and false negatives).

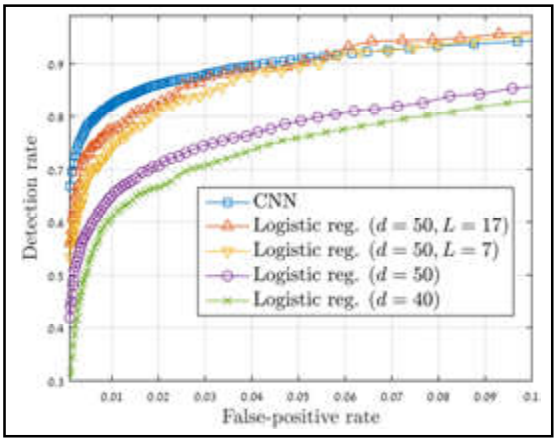


Fig.7 ROC curves for the CNN classifiers and logistic regression

The ratio of fake-Probations (Non-Cry occasions that is taken mistakenly and is diagnosed as Cry activities) to all Non-Cry occasions inside the Recording Set, along with genuine-Probates (true-Probates) The detection charge receives to be continually TP / TP+FN and then the false-tremendous fee is stated to be TP/false-Probate (TP, TN, FP & FN) in which TP = actual Probates, TN = true Probates, FN = actual fake Probates, and true/ false Probates = false Probates. One goal is that to observe and provide a basis for destiny mental studies at the co-law patterns that regulates with the child and the episodes of cry with the caregiver as the main variable for attachment predictor. Consequently, it should be clear why having a high detection price is important[13].

To keep away from records contamination with unrelated occurrences, that could limit legitimate conclusions, lower fake-high quality fees are perhaps a good deal extra critical.We therefore concentrate, the trade-off between the rates of false-positive and detection rates should be the top priority in the analysis of the learning in logistic regression capabilities and CNN classifiers for cry detection. The receiver operator characteristic (ROC) curve was used to evaluate performance, as illustrated in Figure 7. trained on a similar dataset of 18,000 frames (roughly 30 frames) using both classifiers. Used two hour validation sets to obtain ROC curves For false positives < 5%, CNN classifier completely outperforms strategic relapse classifiers Assessment results for both classifiers are in descending order At identification paces > 80%, > 85%, > 90%, CNN classifier's false positive rates are less than similar rates for calculated relapse classifiers.

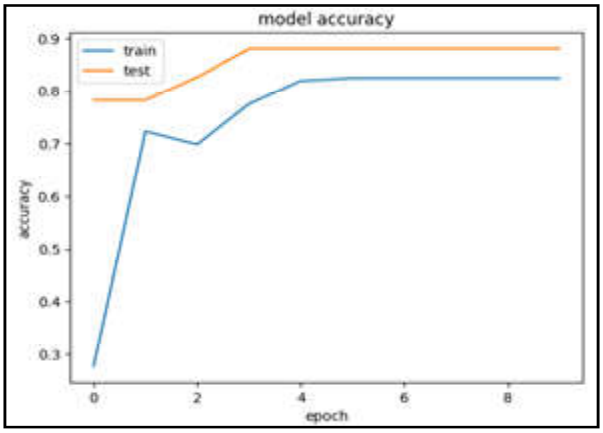
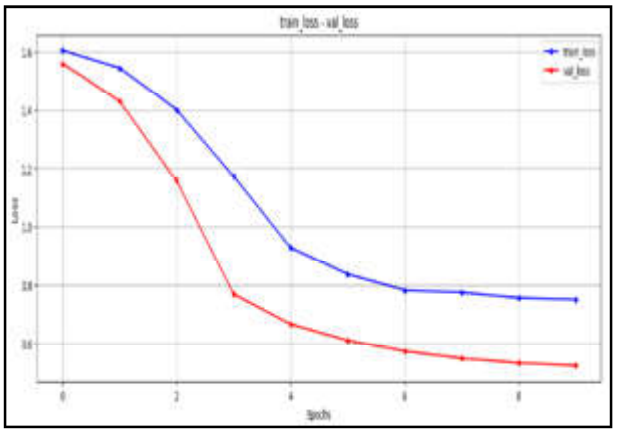


Fig.8 Model Accuracy of 10 Epoch

For larger detection rates, the performance is same and reversed. In comparison to the strategic relapse classifier, the CNN classifier gets a location pace of 82.5% and 65.0%, separately, with and without the smoothing process, maintaining a constant false-positive rate of 1.0%.

The MFCCs, or Mel Frequency Cepstral Coefficients, are utilized. By changing the regular recurrence over completely to Mel Scale, MFCC represents human discernment for responsiveness at the legitimate frequencies, making them appropriate for discourse acknowledgment applications. A pure tone's perceived frequency, or pitch, and its actual measured frequency are related by the scale of Mel Compared to high frequency noises, low frequency sounds are simpler for people to recognize from tiny pitch shifts. This scale will enable us to more closely resemble human hearing in our features. When building models, we typically use the 12–13 Mel Frequency coefficients as features.In this work, we used the sound of babies' cries to decipher their language[14]. Through cry-speech recognition, our system can further assist doctors and parents in determining their children's requirements. In order to provide the right answers, the pertinent parties (parents, doctors, etc.) can quickly assess the child's status through these feelings. Through their various cries, the baby's emotions are represented in our program.The suggested method of interpreting a baby's screams to determine their moods worked well for us.The average infant emotions recognition accuracy of the approach was greater than 80% when the feelings were assumed to

be grief, hunger, happiness, and pain. As different emotions can be communicated by a child's scream, we will use our suggested method to analyze the language of many more kids in the future. We will also add new frequencies to aid in identifying different emotions in order to help parents and medical professionals.



It claims that with a detection rate of 75%, 80%, 85%, 90% and 95%, it has the lowest false positive rate compared to other deep learning techniques and algorithms (more conventional machine learning like SVM or logistic regression).

7. CONCLUSION

The features are taken from the audio files and it is save to as a CSV file and the data is being processed with the CSV file. Then we select the feature and target the variable using the BiLSTM model creation. We train and test the outcome. The outcomes indicate that the CNN classifier has a sizable advantage over the logistic regression classifier. Because it is possible to train a CNN classifier we recognize a variety of household sounds other than screaming signals.CNNs that is naturally suitable for the large amount of training data sets and multi-class classification.

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UTILIZATION OF CONVOLUTIONAL NEURAL NETWORKS FOR ENHANCED SURVEILLANCE AND MONITORING

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Abstract

The most important responsibility in any organization is to monitor the attendance process. However, calculating the attendance manually increases the time constraint and it's again a tough task. As a result, the smart monitoring system using CCTV cameras may be beneficial in terms of saving manpower while also improving the efficiency of the attendance process. The Tracking systems are high in demand because of its more accuracy and more precise in resulting expected output. There are some traditional methods to track the attendance, but most of them do not satisfy the end users expectation, because of the less accuracy and potential they have. In our work, we've harnessed cutting-edge Image & Video Detection, Recognition, and Tracking technologies to meticulously monitor students' time spent within the classroom environment versus time wasted elsewhere throughout the day. This has been achieved through advanced Computer Vision methodologies, enabling precise tracking of students' activities both inside and outside the classroom setting. Firstly, the image of the person gets captured either in the form of video or image when they appear alone or in the crowd. The facial recognition algorithm examines the facial geometry and extracts distinctive facial features for analysis.

Keywords: *Convolutional Neural Network (CNN), Face Recognition, Multi-Task Cascaded Convolutional Neural Networks (MTCNN), Support Vector Machine (SVM)*

1. INTRODUCTION

Maintaining and tracking attendance is a critical function across various institutions, industries, and companies, serving as a key metric for assessing student or employee performance. While some institutions rely on traditional systems, more advanced methods utilizing the attendance such as biometric techniques, including fingerprint scanning or facial recognition are in practice nowadays. A facial recognition system represents a fully automated biometric software designed to identify or verify individuals based on their facial features, utilizing comparison models on facial patterns. In recent years, Facial recognition systems have witnessed significant advancements, becoming integral to management

Innovation across a spectrum of applications including security, surveillance, tracking, and commercial operations. This technology, situated within the realm of computer-based digital technologies, continues to be a robust and expansive field of research. Utilizing face recognition technology for attendance marking represents a clever application within attendance management systems. Widely deployed in security systems, it stands alongside other biometric methods like fingerprint scanning and iris recognition. As the student or employee population grows within educational institutions or companies, the demands on professors or organizational staff similarly escalate, complicating attendance procedures. This project introduces an innovative solution to address these challenges effectively.

In the early 20s, Chintalapati *et al.*[1] proposed an approach for student attendance tracking utilizing the Viola-Jones method for face detection, followed by histogram equalization to extract features and an SVM classifier for face recognition. Subsequently, in 2017, Rathod *et al.*[2] introduced an end-to-end face attendance system employing similar techniques as Chintalapati et al. for face detection and classification. However, these methods predominantly relied on traditional machine learning algorithms. In the same year, Arsenovic *et al.*[3] introduced a novel approach named Face Time, utilizing a CNN cascade for face detection and another CNN for generating face embedding, which were then utilized in face recognition models. In our project, we utilize the MTCNN framework for face detection, coupled with SVM to

isolate high-quality facial features from the detected face images. These features are then used to predict a 128-element vector, referred to as face embedding, representing the detected facial features.

2. CONVOLUTIONAL NEURAL NETWORK

The Convolutional Neural Network (CNN) is a specialized type of Artificial Neural Network tailored for analysing two-dimensional images. In CNN processing, each layer of neurons generates activation maps, highlighting relevant image features. Neurons within these layers receive input patches of pixels, which are then weighted, multiplied by colour values, and summed (convolution), followed by activation function application. At the base layer, the CNN identifies fundamental features like horizontal, vertical, and edge patterns. The output from this layer is passed to subsequent layers, where more intricate processes occur, such as detecting corners and combinations of edges. As the network deepens, higher-order features, such as objects, are recognized. The terminal layer of the CNN is the classification layer, where the output from the final convolutional layer serves as input. Utilizing activation maps from the final convolutional layer, values are interpreted as 0s and 1s in the classification layer, providing insight into the image's appearance and its relationship to the specified class.

Balancing the weights of individual neurons to concentrate on the precise areas of the image is termed as training. In the initial stage, this neural network starts working with random weights. During the process with the assistance of datasets available, the network gets trained itself by assigning nearest random values and comparison takes place where it compares the output with the image's correct label. Finally it undergoes a technique named back propagation where the necessary corrections are made. This technique aids in optimizing the tuning process and so that it will be easy for the network to make decisions in order to adjust the units instead of doing random corrections. Here, the complete run of the whole training dataset is termed as Epoch. This network undergoes several epochs during training, where it makes adjustments gradually. Subsequently the network converges where it gives the better output.

2.1 CNN vs. SVM

Support vector machines are most widely implemented in classification of objects. They require a huge amount of key parameters to process and require more dimensions than the samples count. It is not much efficiently used in large datasets as it requires longer time and also does not produce required outputs when the image has more noise. It also does not work well on data predictions. The main flaw is that it could not detect more than one person and also could not differentiate various classes of objects and backgrounds. But Convolution Neural Network is the most powerful algorithm used for classification. It also does not require a huge amount of parameters and time [4]. It is more effective and efficient as it can be trained and made to understand faster.

Neural networks have the ability to train and bring out the output of complex tasks. They have several layers and each transfers the input through a series of hidden layers. Each layer of the CNN is composed of neurons which are connected to each other. At last the output is obtained through the output layer. In CNN the layers are organized as 3 dimensions: height, width and depth. The neurons in CNN do not connect to each other neuron in the next, but are connected only to a small region. Finally the output obtained as a single reduced vector organized with depth dimensions. The major difference of CNN when compared to artificial neural Network is that it is the last layer of CNN if connected fully whereas in ANN only the neurons are connected to each other [5].

The significant parts of CNN include feature extraction and classification Feature extraction involves a series of convolution and pooling operations for detection. In the classification stage, the fully connected layers behave as classifiers and can probably be assigned to predict the algorithm [6].

3. PROPOSED METHODOLOGY

3.1 Face Detector

In this module, we receive input videos and images captured by various cameras placed in different locations within the classroom environment. Recognizing that videos are essentially sequences of frames, each frame can be treated as a standalone image. The objective of this module is to simply determine whether there are any faces present within the input videos or images.

3.1.1 Detection Trails

3.1.1.1 HAAR: We have commenced our experimentation using a conventional image processing algorithm known as "HAAR." This method relies on characteristic-based cascade classifiers, leveraging primary filters to identify specific features. For instance, it exploits the fact that the area around a person's eyes typically appears darker than the nose and cheeks, while the bridge of the nose tends to be brighter. However, our trials revealed limitations with HAAR, particularly in challenging lighting conditions where it failed to produce satisfactory results. Additionally, HAAR features necessitate manual determination, restricting its ability to detect a wide range of objects.

For instance, if a classifier network is trained solely on edge and line features, it will only recognize objects with such characteristics. Moreover, as a face detector, HAAR may struggle to identify faces obscured by cloth or hands. Despite these drawbacks, HAAR offers some advantages. It performs well on high-clarity images, requiring minimal training data for face detection due to its manually selected features. Furthermore, HAAR features execute quickly and demand fewer computational resources compared to other traditional detection algorithms. Nonetheless, in situations with poor positioning and lighting, HAAR may falter as it primarily focuses on basic edges within the image.

Fig.1 Face Detection using HAAR Features

3.1.1.2 YOLO (You Only Look Once): YOLO, short for "You Only Look Once," represents an object detection algorithm employing neural networks to recognize and categorize objects within images and video through the integration of Deep Learning, OpenCV, and Python. YOLO operates as a single- stage detector, distinguishing it from multi-stage detectors that offer higher accuracy but are significantly slower in processing. Primarily engineered for rapid object detection, YOLO prioritizes speed without compromising on detection precision.

3.1.1.3 Sliding Window: This approach involves employing a single deep convolutional neural network, which divides input images into a grid of cells. Each cell is capable of predicting bounding boxes and object classifications through a technique known as "Sliding Window." As YOLO is an Object Detection algorithm, it can identify various objects within an image, including people categorized into different classes. When feeding images into a classifier, the initial focus is on identifying unique, simple features such as background elements and T- shirt colours. However, during training, the model may become biased towards these features. For instance, if a person is standing against a colour background, the classifier may consistently predict any object passing through that location as that person, focusing more on the background than the actual distinguishing features.

3.1.1.4 Segmentation: While YOLO serves as an effective detector, its detection outputs typically encompass the entire bounding box, including the background, which we aim to eliminate. Segmentation techniques enable us to precisely crop only the Region of Interest (ROI) from the image, effectively removing the background. Although the segmentation results are relatively accurate, our objective is not to capture either the background or the entire body. Despite this, the detector continues to identify the entire body. To address this limitation and focus solely on detecting faces, we explored alternative face detectors and came across a solution known as YOLO FACES.

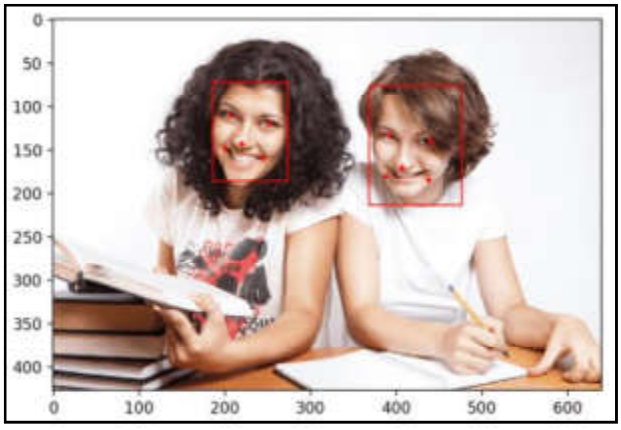

Fig.2 Bounding Boxes and Facial Key points Using MTCNN

The main advantage of CNN is that without any human supervision it can automatically detect the essential features. For example, if we provide many pictures of cats and dogs, it can learn the key features for each class by itself.

3.1.1.5 MTCNN: To detect faces of various sizes, the image is scaled numerous times initially. The P- network (Proposal) then scans the images and performs the initial detection [10]. It has a lower detection threshold and hence identifies a lot more false positives, even after NMS (Non-Maximum Suppression), but this is on purpose. The recommended areas are used as input for the next network, the R-network, which filters detections to provide more accurate bounding boxes, as the name implies. The O-network (Output) refines the bounding boxes at the end of the process. This method not only detects faces, but also ensures that bounding boxes are accurate and precise. MTCNN also has the capability of detecting face landmarks, such as the eyes, nose, and corners of the mouth. It is almost free because they can be employed in the face detection process, which is an added benefit.

4. FACE RECOGNITION

In this module, we utilize images obtained from the previous face detection module, where bounding boxes are drawn around detected faces. Our goal now shifts to face recognition, aiming to identify the individuals appearing in each frame of the image. This task can be framed as a straightforward image classification problem, amenable to both classical Machine Learning (ML) algorithms and advanced Deep Learning techniques. Our initial trials involved using Logistic Regression and Random Forests, yielding unsatisfactory accuracy levels. Subsequently, we experimented with Neural Networks, including basic architectures, which also yielded poor results.

Transitioning to Convolutional Neural Networks (CNNs) significantly improved accuracy, yet our dataset—comprising only a few registered images per student—proved insufficient for training a CNN from scratch, as it demands extensive data. We then explored Siamese Networks, consisting of two CNNs, achieving decent accuracy exceeding 80%. Combining CNNs with Deep Neural Network models through Transfer Learning, where a pre-trained CNN extracts facial features, followed by cascaded output features fed into a Neural Network, notably improved accuracy to over 90%.

Finally, our optimal model combination involved coupling CNN with Support Vector Machines (SVM) through Transfer Learning. Leveraging a pre-trained CNN to extract essential facial features, we applied the resulting features (128 embedding per face) to SVM, achieving an overall system accuracy exceeding 95%. This successful approach underscores the efficacy of combining CNNs with SVMs, particularly when dealing with limited data, as Deep Learning typically necessitates substantial datasets to attain high accuracy levels.

5. DETECTION SUMMARY

The table.1 shows the detection accuracy of each algorithm used in this method and through the result we can say that by using MTCNN algorithm, the accuracy of face detection is high while comparing with other methods.

Table 1 Detection Summary

Algorithm	Detection Accuracy
MTCNN	94 %
YOLO	90 %
HAAR	74 %
Segmentation	92 %

6. CONCLUSION

This project introduces the most effective Computer Vision method for face recognition within the Attendance Tracking System. Leveraging the CNN and SVM algorithms for classification and regression tasks, the system surpasses other algorithms with a confidence margin of 2-5, boasting minimal noise interference. Through the Smart Attendance Tracking System, we establish a balance between recognition rate and threshold value, ensuring precise attendance tracking. Thus, CNN combined with SVM emerges as the most reliable and compatible face recognition algorithm within OpenCV, adept at accurately identifying students in educational institutes and meticulously tracking their attendance based on the neural network employed. Moreover, web applications developed with the admin panel can be of great help to provide the tracked attendance of students in a short time and with more accuracy and it can be accessed by only the respective authorized persons so that manipulation or third party access can be avoided.

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WOMEN SAFETY DEVICE USING RASPBERRY PI

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Abstract

In this competitive environment, every female's major challenge is their security as well as violence of threats. Each girl's main concern where they will be free to walk safely in the streets at any time of day or night without fear of being attacked. Women are unsafe anywhere, but they are especially vulnerable while driving alone on lonely roads or in uninhabited areas. Our idea aims to give women and children a sense of security so that they never feel powerless. Our project includes GSM module, GPS, SD card, circuit, image sensor, and Raspberry Pi to highlight a few components. It's a button-based security mechanism. When pressed, the button alerts contacts such as a designated family member or friend, as well as the police. We use security technology in our project for the sake of security. When the emergency button is pressed, the Raspberry Pi module receives signals from the GPS system, which contain current location information, and the Raspberry Pi controller instructs the GSM system to send an Alert Message containing the person's location to predefined numbers as well as nearby police stations. A shock circuit is also enabled in our project, which is utilized to hurt the assailant as a kind of self-defense. A camera is used to capture an attacker's image, then the storage device is used to save captured picture. The images are delivered to registered caretaker/police email address, which pre-programmed on the microprocessor.

Keywords: *GPS, GSM module, Raspberry pi, Raspberry pi camera*

1. INTRODUCTION

For the sake of security, we use security technologies in our project. The Raspberry Pi module receives signals through device tracking network including actual GPS data when the emergency button is pressed, and also instruct GSM network to send an alarm signal which contain person's location to predefined numbers as well as nearby police stations. In our project, a shock circuit is also activated, which is used to injure the assailant as a kind of self-defense. An attacker's image is captured using a camera, and the image is saved using an external memory card. The image is sent to the registered caretaker or police email address on the Raspberry Pi, which is pre-programmed.

2. EXISTING METHODOLOGY

Making the device small enough to wear as a watch or chain, as well as adding spoken keyword detection that activates the device to transmit an alert notification to specified connections, can improve the gadget or application and increase the usage. A device that is both portable and looks like a belt. Wearable safety gadget with alerting notification key, as a result the victim's location is monitored using GPS and pictures are taken.

All necessary contacts will receive an emergency message with an image link. The band has an Arm7 microprocessor controller that is coupled to a power supply, temperature sensor, motion sensor, heartbeat sensor, GSM, GPS and emergency button. When a threat is detected, just hitting the emergency button causes that victim's spot to be monitored using the GPS module and an emergency aid message to be sent to the pre-determined contacts using the Raspberry Pi mode[2].

3. PROPOSED SOLUTION

We addressed and presented study in this paper to build and include a way to secure the safety and security of women, and we produced a concept that operate like

as recovery mechanism also safeguard during emergency risk. The image of the harasser is transmitted to the user's email address, and the GSM module also sends the person's location to the police and caretaker. When pressed, the button, which can be affixed to clothes or worn as a bracelet, sends an alarm to contacts such as a designated family member or friend, as well as the police. In addition, GSM will send the information to a selected member's or police officer's mobile phone. We use two buttons for this reason because the above condition may not always operate, therefore when the lady is in trouble, we additionally use a click button. The text message, pictures, and GPS are forwarded to the respective people when she pushes the emergency key[1]. In other circumstances, when anything uncommon occurs, it also exceeds the specified barriers; at that situation, we use a different emergency push key to transmit the information that she is safe and secure. Expect in sometimes the woman will occasionally unable to click the push button. When the two requirements are not satisfied, then will use speech data, which has a significant benefit for individual women who are in trouble and unable to click the button. If she says just help, the notification is being updated to the respective people[3].

4. BLOCK DIAGRAM

Here is the block diagram for the implemented of the project hardware shown in the figure. In hardware, there are numerous components that are implemented. The image of the harasser is transmitted by email from the user's email address to the caretaker's/email police's address, and the GSM module also communicates the person's location to the police and caretaker.

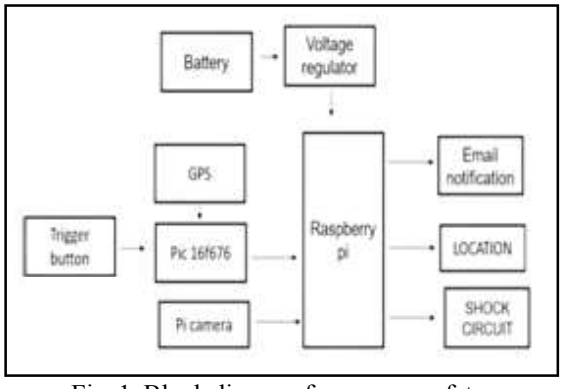

Fig. 1. Block diagram for women safety

When pressed, the button, which can be linked to a bracelet, executes the action of alerting contacts, including the designated family member or friend, as well as the police[4]. In addition, GSM will send the information to a selected member's or police officer's mobile phone. To keep the harasser at bay, an electric shock circuit has been activated[7].

5. HARDWARE IMPLEMENTATION

5.1 Raspberry Pi

The Raspberry Pi appears as a compact and affordable device, roughly the size of a debit card. It connects to a monitor or television and functions with a regular keyboard and mouse for input. Its functionality extends beyond that of a typical computer, as it provides access to on-chip hardware such as GPIOs, allowing for the development of various applications. Specifically, in this project, we utilize the Raspberry Pi 3 Model B, which represents the third iteration of the Raspberry Pi series [10].

5.2 Raspberry pi Camera

The Raspberry Pi Camera v2 is an accessory specifically designed for the Raspberry Pi, featuring an 8-megapixel Sony IMX219 image sensor alongside a fixed focus lens. Its purpose is to capture images of the harasser, which are then forwarded to the user's email address.

5.3 DC – DC Converter

A DC-to-DC converter is an electronic circuit or electrically power device that transforms a source of direct current with one operating voltage levels to another and it is sort electric power converter. Transmission power levels range from extremely very low to very high power. Power optimizers are converters that improve energy collecting for photovoltaic panel systems and wind turbines.

5.4 7805 Voltage Regulator

It is a widely used voltage regulator that may be found in almost all electronic designs. For a fluctuating input voltage supply, it gives a constant +5V output voltage. The bandgap's primary role is to offer a stable and accurate reference regardless of the chip's temperature. The 7805 integrated circuit is utilised in a variety of circuits. The output voltage is now controlled by a negative feedback loop. Adjustable Output Regulator is another name for this convertor[10].

5.5 Implementation and Working

The components are assembled in a configuratiom that includes the GSM module linked to the microcontroller as well as the raspberry pi. The raspberry pi transmits the harraser's to the user's caretaker email address. The notification also includes the individual's current location. A shock circuit is enabled and that gives a shock to harraser[8].

Fig. 2. Hardware implementation

6. RESULT AND DISCUSSION

The GSM module is attached to the microcontroller, and the raspberry pi is fixed in a configuration. The raspberry sends the harasser's image to the user's caretaker email address [12].

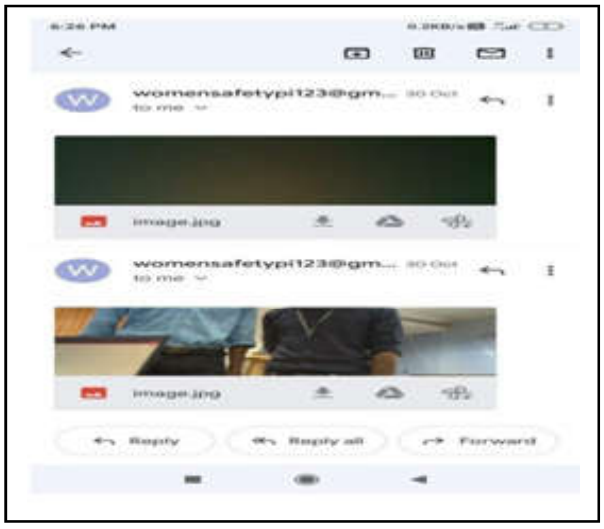

Fig.3 The output response of the mail received by the caretaker

Fig.4 The message received by the caretaker when the women is in danger along with location.

Fig.5 The loaction of the patient shown in the google map

This project's main purpose is to assure that all the female in the modern community feel safe and protected. A research in India found that 53% of female worker don't really feel safe. Safe women from Delhi, Mumbai, Hyderabad, Kolkata, and Pune, which account for 86 percent of working women in India, face more challenges than women in other cities. We can tackle the problems to some extent by implementing a real-time application and a hardware.

The proposed design will address recent unsafe difficulties experienced by women and will assist in their resolution through the use of safety equipment. Many offences against women have increased to a greater level, resulting in harassment at work, shopping, nightly walks, eve teasing, and other locations. This technology aids in the generation of a panic situation simulation by taking into account various bodily measurements and providing assistance in the event of an emergency. This

project will focus on creating a smart, low-cost technology that will assist women in feeling safer and preventing rape, harassment, and other harmful circumstances. All despondent and harassed women and children would benefit from the programme, which would help to improve their safety and security.

We can tackle the problems to some extent by implementing a real-time application and a hardware. With more research and development, this concept could be used as a small wearable gadget such as a watch or a pendant. A woman safety gadget has been created in response to the rising rate of violence against women[9]. This technique is intended to assist women in difficulty in both calling for aid and alerting others in the area. It was created as a way to make the security gadget more portable and user-friendly.

7. CONCLUSION

In summary, the project offers a comprehensive solution to enhance the safety of women through the integration of advanced technologies. By combining hardware components like the Raspberry Pi and GSM module with software features such as GPS tracking and image transmission, the system effectively responds to emergency situations. The project's successful implementation underscores its potential to address real-world safety concerns and empower women to navigate their environments with greater confidence. Moving forward, ongoing research and development will further refine the solution, ensuring its continued relevance and impact in promoting safety and security for women globally.

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MEDICAL STORE MANAGEMENT SYSTEM

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Abstract

Data Entry and Management has become an integral part of many small-scale stores to industries. Manual entry of data and its processing consumes more time and might involve errors at many points. It might lead to some serious problems in the industry as the analysis of the data plays a major role in proceeding forward. Digitization of data and its processing from paper to machine also increases the workload of the people. These issues interfere with the ability of the person working in the field. As the task is repetitive, it also tests the patience of the person. The technology has evolved rapidly in the period of time but the data entry and processing has not subsequently shown its progress. The use of modern technologies in these streams might bring much better results among the domain and help to figure out some great approaches towards the improvement in the field of Medical Store Management.

Keyword: *Data Entry, iOS , Medical Store, Digitization, Medical store Management, Mobile Application*

1. INTRODUCTION

It is possible to increase accuracy, safety, and efficiency in the medical store by implementing the Medicine Management System (MMS). With the aid of the suggested way, pharmacists may manage inventory, costs, medical safety, updating new items, and other things with ease. The user is allowed to use the system's fundamental features, such as adding, deleting, and modifying things. Additionally, the software will produce a report showing the list of entered products, their prices, and any discounts. When new drugs arrive, they are manually entered into the proposed system[1][2]. Following the sale of a drug, the pharmacist may generate a report detailing the price, product details, batch number, discount, expiry date, and availability of the drug in the store.

In the pharmacy, a manual system is currently in use. In the previous system, the pharmacist manually monitors each drug in the store. This will result in errors as well as an increase in the pharmacist's workload[3]. Even while Covid 19's healthcare industry is flourishing, the pharmacy industry is still disregarded and seen as a supplemental service. The success of the entire healthcare system depends heavily on pharmacy business management. Even though a small number of major retail organizations control more than 50% of the pharmacy [4] market today, the industry nevertheless confronts significant problems as a result of globalization and growing costs. This MMS system is adaptable, time, money, and environmentally friendly. Managing Sales, Medicines, Pharmacy, and Company Inventory in minute detail is the main goal of the Python project on MMS. It controls every aspect of the medication. The suggested system is designed with administrative access, which can only be granted by the administrator.

The primary goal of the suggested system is to develop an application software that will lessen the manual workload of pharmacists and print the customer's prescription bill. Bill records have been stored by the medicine management in filing cabinets [5] It will be incredibly laborious and difficult to manage a large pharmacy using records on paper. It is extremely difficult to handle manually to keep track of the inventories that are available in the pharmacy[6]. To replenish the already low supply of medications, the pharmacist must order more medications. Additionally, medicine orders are placed by hand. The pharmacist must check the stock balance before issuing the order, which takes some time. After downloading this application, a user can edit the drug's features, compare discounts, adjust the percentage of discounts based on product availability, and view previously added or new records [7].

2. PROBLEM DESCRIPTION

The creation of an acquisition template Hospital medicine management system subjects contains the

following seven sections in the collection template that was established to ask to be taken into consideration in accordance with the unique nature and characteristics of the medicines: data processing, finance and acceptance management, pricing adjustment, procurement strategy, and inquiry [8]. Information about medications, including names, classifications, positions (using various coding), pricing, and information on health insurance. It would have been with the storage of medicines information, medicines conservation collar hair, deployment procedures saved to each use of the patient's prescription and medical advice documented. Storage management acceptance carried medicines purchasing pharmaceuticals, storage, input supply unit name, purchase date, and invoice number, according to the medicine's name, size, origin, Wholesale price, quantity, batch number, and expiration date of entry.

The function of money is accepted medication accounting in accordance with the invoice audit medication storage data, accurate financial implementation, and acceptance[9]. Following the acceptance of the data, it will be entered and documented in the medication books for purchase and entry records. The creation of the first-in, first-out self- moving database management programme is necessary for the library processing in compliance with the pertinent Medicine Administration regulations so that a backlog of medications is successfully avoided. Saving money by not letting drugs expire. However, the method must take into account that medications serve as a summary function for the library in order to facilitate statistical medicines out of the library. Statistics of each based on the chosen time period, including clinical departments, swap departments, and medicines requisitioned as well as medicines scheduled to facilitate the favourable medicine procurement.

Medicine price adjustment based on the price department of the National Development and Reform Commission and the Provincial file the current price of medicines, the need for prompt adjustment to select price adjustment based on the basis of price adjustment, re-adjust the input medicine name, specifications, manufacturers, and an update on the implementation of the price of the goods, retail price, and then choose a price adjustment of the executive department. Additionally, the price adjustment noted in the monthly statements for convenient access will be credited for any rise or decrease in price adjustment. The preparation of a scientifically sound procurement plan is crucial because it can effectively prevent medicine shortages, backlogs, and failure by providing hospitals with the supplies they need when they need them. Time adjustments should be made in accordance with monthly consumption of each medicine purchased in the procurement plan, and all clinical treatment medications should be fully guaranteed.

The inquiry makes it simple to learn details on a variety of medications. For instance: You can quickly select the time period understanding of the medicine in the purchase of this time period as well as the storage date of each batch of medicines, warehousing number, batch number, valid, swap room requisitioned, and existing inventory number by simply entering the name of the medicine code in the Curators Accounts Inquiries field. Select "Purchase" from the drop-down menu and "Time Period" to buy the period during which each supply unit delivery record was made. Create a suitable procurement plan to stay on top of the drugs that have been obtained.

3.PROPOSED METHODOLOGY

The fundamental needs for designing maintenance software would be a strong Platform, dependable storage capability, and an easy interface[10]. The Swift programming language and MVC architecture have made all of them possible [11]. Figure. 1 Graphical depiction of the steps in which a user goes through in the Application. The database and the model interact directly. User interface issues and data processing are not included.

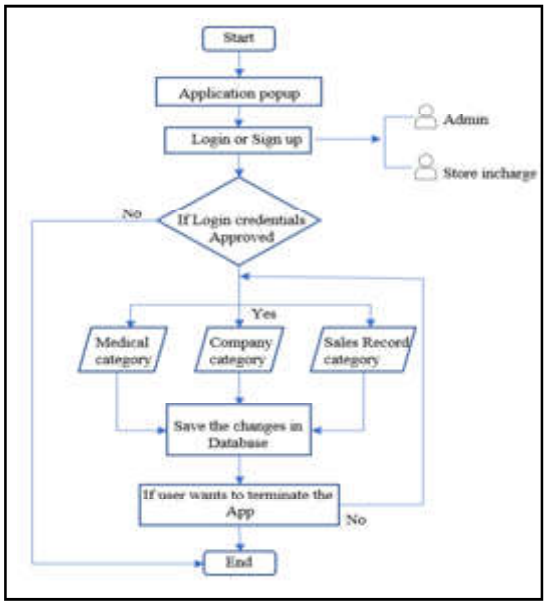

Fig.1 Flow chart of administration system

Real-world scenarios simply entail retrieving, inserting, updating, and deleting data from your database using a model. The storing and processing of pertinent data and activities carried out by various users is implied by pharmaceutical stock management. The information from the management system will be stored in a database.

4. PRINCIPLE FOLLOWED "SOLID"

Software design lowers the cost associated with developing and maintaining the project and aids in visualizing the entire system. The design should facilitate scalability because it is difficult to determine the viability of the actual requirements at the outset of a project. This will allow the introduction of the new requirements into the software architecture[12]. The designer should focus on a few key elements that assist scalability while considering the software design in order to prevent reworking [13]. Rigidity, fragility, immobility, and viscosity are some of these components. The level of rigidity describes how difficult it is to modify the software.

The software's propensity to malfunction with each change is referred to as fragility. When software from one project or its component pieces cannot be reused in another project, it is said to be immobile. Viscosity is the inability to keep the system's design intact, which can deteriorate if a suitable solution is not implemented for any changes in the system's requirements. A bad architecture is the result of these four elements being present [14]. Any application that exhibits these elements is essentially having a design issue. This study uses a modest project to empirically evaluate the impact of SOLID principles on the quality of software [15]. The Payroll System project is what it's called. This system will be put into use using two different designs-without and with sound principles [16]. In the first design, we noted the ways in which these principles were broken, while in the second design, we noted the enhancements and advantages brought about by their application [17].

5. ARCHITECTURE FOLLOWED "MVC"

A mobile device with mobility and context-sensing capabilities, such an Android device, is emerging as a practical client computing device. However, the gadgets' hardware resources and computing capability are constrained by their compact form-factor. As a result, these devices were unable to support the deployment of large-scale applications. In order to overcome these restrictions, it is preferable to implement some robust functionality on the server side and allow the client application to access it, giving rise to service-based mobile applications [18]. For service-based mobile apps [19][20].We provide a special, optimal, and useful architecture in this paper that we call balanced Model-View-Controller (MVC) architecture [21]. A mobile device with mobility and context- sensing capabilities, such an Android device, is emerging as a practical client computing device [22]. However, the gadgets' hardware resources and computing capability are constrained by their compact form factor. As a result, these devices were unable to support the deployment of large-scale applications. In order to overcome these restrictions, it is preferable to implement some robust functionality on the server side and allow the client application to access it, giving rise to service-based mobile applications [23]. For service-based mobile apps, we provide a special, optimal, and useful architecture in this paper that we call balanced Model-View-Controller (MVC) architecture [24].

6. RESULT AND DISCUSSION

6.1 Application Set up

Medical Store Management System Data Flow diagram, is often a preliminary step to create an over of the application without going into detail in it. The flow of the application shown in Figure. 2, starts from the home screen where the user gets the change to take a look of the total doctors available where they can look at the doctor profile and book their respective appointment to that doctor. This application shown in Figure. 3 also provides the user an option to set reminders for the medicine and also view the booked reminders, which help them to keep track of their own reminders, This application shown in Figure.4 lists the available pharmacies which redirects them to the pharmacy page where they can review them and view the products and add them to cart,

Fig.2 Doctor booking UI

The Figure.5 shown below describes the emergency page which helps the user to inform or contact their emergency contacts with just a click.

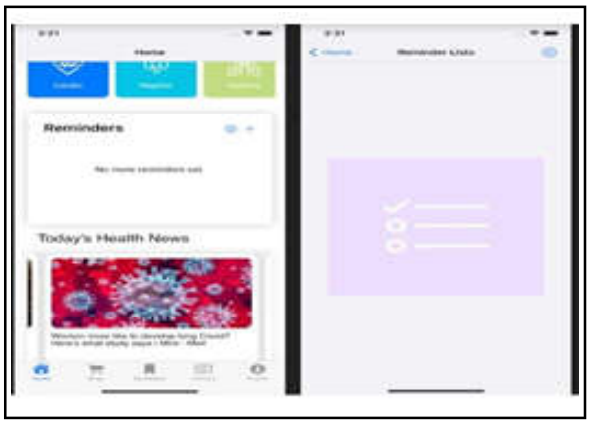

Fig.3 Reminder UI

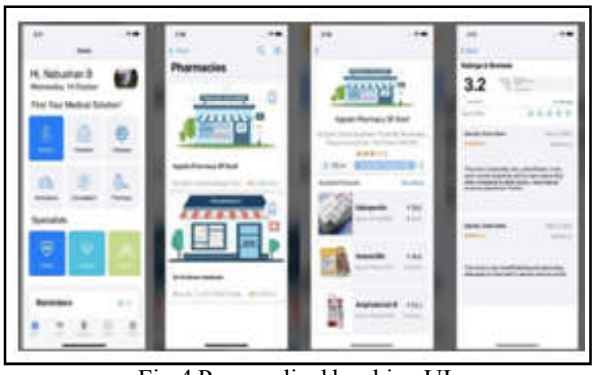

Fig.4 Paramedical booking UI

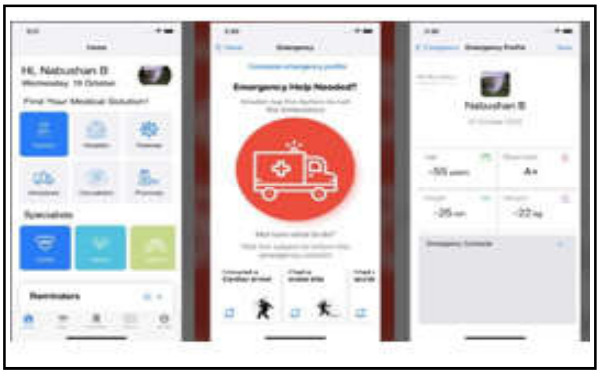

Fig.5 SOS call UI

6.2 Application Data Base and API

One of the most well-liked and user-friendly relational database systems is SQLite. In comparison to other relational databases, it has several features. As the application file format for their Photoshop Light room product, several large MNCs, like Adobe, use SQLite. The flight software for the A350 XWB family of aircraft is written in SQLite by the European multinational aerospace company Airbus. An embedded relational database management system called SQLite runswithout a server.

It is an in-memory open-source library that needs no installation or configuration. It is also highly practical because it is much smaller than other database management systems-less than 500kb in size. An open-source program is SQLite. After installation, the software is license-free. Because it doesn't require a new server process or system to function, SQLite is serverless. SQLite is flexible because it enables user to work on numerous databases concurrently in the same session.

All platforms, including macOS, Windows, and others, may run SQLite, a cross-platform database management system. It's not necessary to configure SQLite. It doesn't require administration or setup. A top-notch, visual, open-source tool for creating, designing, and editing SQLite-compatible database files is called DB Browser for SQLite (DB4S). Users and developers who want to build, search, and edit databases should use DB4S. The user interface for DB4S is reminiscent of a spreadsheet, and complex SQL commands are not required to be learnt.

This program does not require any prior knowledge of SQL commands and is not a visual shell for the sqlite command-line utility. In order to accomplish these objectives, it must be as easy to use as feasible since it will be utilized by both developers and end users.

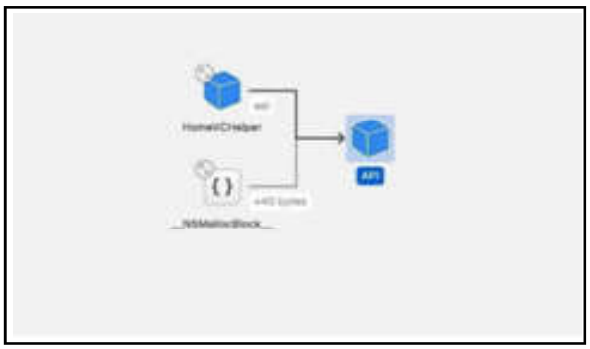

Fig.6 API semantics

Figure 6 Shows how the home view controller obtains data via an API request. Application Programming Interface, or API, is a software bridge that enables communication between two applications. User utilize an API every time user use a mobile app like Facebook, send an instant message, or check the weather. Application Programming Interface is referred to as API. Any software with a specific function is referred to as an application when discussing APIs. Interface can be compared to a service agreement between two programs. This agreement specifies the requests and responses that

the two parties will use to communicate. Developers can find instructions in their API documentation on how to format those requests and responses.

Figure7 shows the Pharmacy database ER diagram shows how product, rating and review tables connected with pharmacy table. Figure 8 gives the reminder database ER diagram shows how pharmacies product related with reminder table. Figure 9 shows the doctor database ER diagram shows how available video consultation timings and available hostel timings with doctors. The database is created at respective file path, Sample images are given below

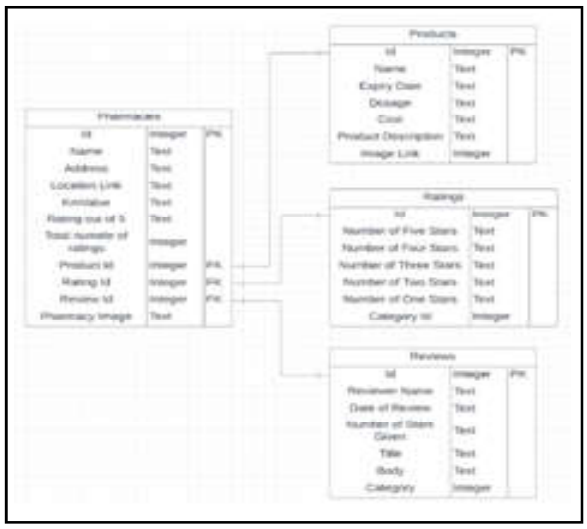

Fig.7 Pharmacies database schema

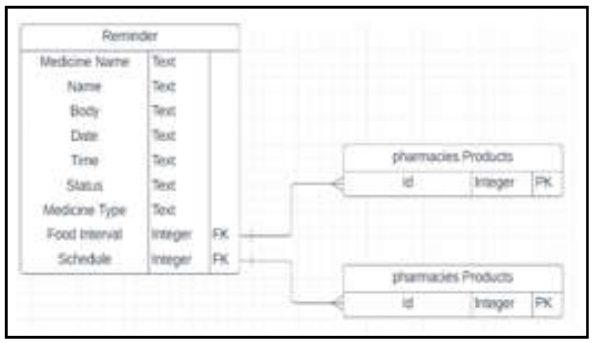

Fig.8 Reminder Database Schema

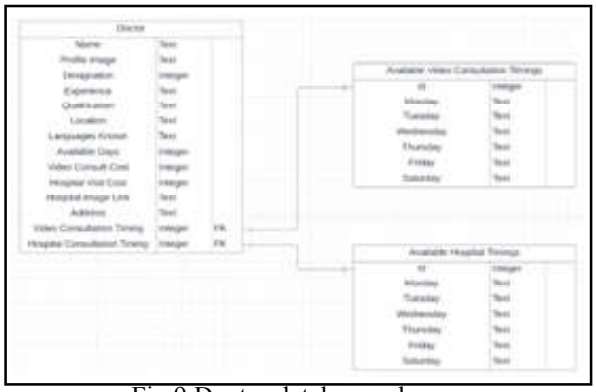

Fig.9 Doctor database schema

Figure 10 gives thelList of tables created in user domain mask of application support directory viewed through DB browser. An app called Instruments is included with Xcode and allows user to capture and view information about user app as it runs. Each of the instruments in the collection of instruments that comes with Instruments records a distinct set of statistics. Among the more well-known instruments are the following [13]

The Leaks tool looks for memory leaks in user programme. Memory allocation statistics are tracked by the Allocations instrument. The Time Profiler tool tracks CPU activity and assists user in identifying the slow regions in user code.

User won't utilize Instruments at first if user learning iOS or Mac development. Instruments are typically used when an app is getting close to being released. However, user should profile the iOS app with Instruments if it runs incredibly slowly or emits memory warnings when user run it. [14] User won't be able to locate Instruments in the Finder because it is housed inside Xcode's app package. By selecting Product > Profile in Xcode, user may profile user project and start Instruments with ease. User will be prompted to select a template when Instruments debuts. It is now time to examine data for certain instruments. Let's begin with the instrument for allocations. A summary of the memory allocation data is displayed in the detail view if user choose the Allocations instrument from the instrument list. The most crucial information is at the top.

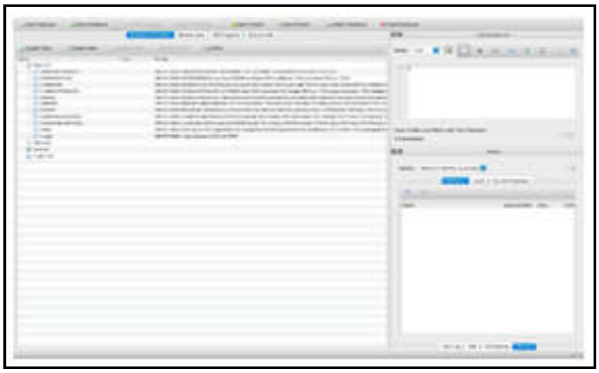

Fig.10 List of file created

Figure 11 gives the list of options shown by selecting product profile in Xcode. Look at the Persistent Bytes column for the category All Heap Allocations to see how much memory user app is presently utilizing. The screenshot's text is a little small, but it states that the software uses 9.64 MB of memory, which is a respectable amount for an iOS or Mac app. OpenGL/ES or Metal

texture memory are not recorded by the Allocations instrument. User actual memory utilization will be larger than what Instruments displays if user app allocates texture memory. To display the heap allocation totals in the graph, user might also want to choose the checkbox in the Graph column.

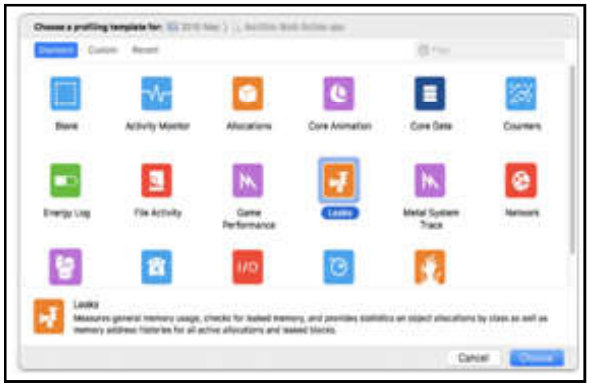

Fig.11 Launching instruments

Figure 12 shows the Memory heap tree displayed while running memory leak test. It's time to examine the Leaks instrument at this point. If user programme has any memory leaks, the graph will show user. When user software allocates memory but never releases it, there is a memory leak. An illustration of the graph for the Leaks instrument can be seen in the following screenshot. Figure. 13 shows the Memory leak test result displayed while running memory leak test. Fig. 14 presents the disk space usage shown at left window of xcode while running app in debug mode.

Fig.12 Allocations instrument results

Fig.13 Leaks instrument results

Fig.14 Disk memory usage

7. CONCLUSION

All of MMS's requirements will be handled by this software's efficient implementation. Information pertaining to events taking place in the designated area can be easily and effectively stored by it. The suggested system will mark a turning point for all pharmacists in the Covid predicament. The system has been created in such a way that it will permit potential modification as it may be deemed required by the pharmacy administration, whenever the concept occurs, in order to allow for future expansion.

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AN EMPIRICAL STUDY ON CUSTOMER DELIGHT ON COMMERCIAL BANK SERVICES WITH SPECIAL REFERENCE TO AXIS BANK IN ERODE

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Abstract

The banking sector is expanding quickly, employing a range of services as an effective and appropriate means of meeting consumer needs. Commercial banks have identified online banking as a general service that offers clients faster and more dependable services. Modern services have been used to take in customers and carry out financial transactions thanks to the rapid advancement of technology. client satisfaction is now a key component in helping banks maintain their competitive edge, and growing the client base is primarily seen as a sign of a bank's expansion. Thus, the purpose of this study is to investigate how satisfied customers are with the services provided by Axis Bank, a commercial bank in Erode. This study uses a descriptive research design by nature.For collecting the required sample data, this study framed well-structured questionnaire as study instrument and sent among customers of Axis bank. The study instrument contained details about customers' profile and delight towards services of commercial banks in the study area.

The sample size of 160 customers have been selected by using random sampling technique among the population. The statistical techniques have been performed for analysis purpose such as percentage analysis, mean score, standard deviation, Chi-square test and Correlation analysis. The result from analysis indicated that most of the bank customers are businessmen, have Rs.35,001 - 45,000 as their monthly family income, holding three accounts, holding account for 5-10 years and using bank services daily.

Keywords : *Axis Bank, Satisfaction, Service Quality Perception andCustomer delight*

1. INTRODUCTION

The banking industry, which contributes significantly to the Indian economy, is faced with a unique combination of challenges as a result of the market's quick change, contemporary technology, economic uncertainty, intense rivalry, and increasingly picky clientele. The banking system has seen significant changes since nationalization[1]. Rising pressure on banks to consider how to increase their performance in ways that should be advantageous to them has resulted from both local and international competition becoming more intense and from the rapid advancement of technology. Keeping existing clients and attracting new ones has grown more challenging for commercial banks. A commercial bank must continue to provide excellent customer service in order to compete and remain in the market.

Customer behavioral intents such as repurchase and loyalty intentions, readiness to spread positive word of mouth, and referral have been connected to the quality of the bank's service and customer happiness. Given that banks offer similar services, the current competitive environment is largely determined by the caliber of those services. Customer satisfaction and service quality are positively correlated because service quality is not just a crucial component of operational efficiency. Therefore, in order to fulfill consumer expectations and keep up with the changing environment, commercial banks have not only been adopting different services and tactics at a quicker rate, but they have also been delivering a wide range of services and embracing many new features in their services. They have come to understand that offering features, goods, services, meeting consumers' expectations and perceptions, and having competitive alternatives available can all be used to improve customer happiness. The banks' ability to survive in the present competitive climate will be facilitated by the services features.

2. REVIEW OF LITERATURE

Munusamy *et al.* (2010) [8]found that while certainty, empathy, and responsiveness were positively correlated

with customer satisfaction, they had no discernible impact. Additionally, there was a negative correlation between reliability and customer satisfaction, albeit not a significant one. Furthermore, tangibles demonstrated a strong correlation with and a big influence on customer satisfaction. According to Ghost and Gnanadhas's (2011)[3] findings, customer satisfaction levels and perceptions of service quality elements were closely correlated. Furthermore, the study revealed that the influence of the service quality component on customer satisfaction was not specific to any one client and was contingent upon the customer's demographic profile. Bihari and Mahapatra (2016)[2] determined that the most crucial elements to be taken into account in order to achieve high levels of customer satisfaction were the following: promptness of service, interest of bank employees in serving the customers, care and concern, operating hours, service charges, and interest rates of the bank. They said that banks have to concentrate more on enhancing assurance, responsiveness, and dependability[4].

Vencataya *et al.*'s (2019) [13] study attempted to demonstrate how customer happiness in banks was substantially favorably impacted by each of the five service quality categories. They also found that, out of the five SQ components, empathy was a highly significant predictor of customer satisfaction.

Munusamy *et al.* (2010)[8] discovered that although responsiveness, certainty, and empathy showed a positive correlation with customer satisfaction, there was no appreciable effect. Furthermore, although it was not statistically significant, there was a negative association between customer satisfaction and dependability. Additionally, tangibles showed a significant effect and high association with customer satisfaction. Ghost and Gnanadhas (2011)[5] found a strong correlation between customer satisfaction levels and perceptions of service quality aspects.

The study also showed that the impact of the service quality component on customer satisfaction depended on the customer's demographic profile and was not unique to any one client. In order to attain high levels of customer satisfaction, Bihari and Mahapatra (2016)[6] found that the following factors were the most important to consider: promptness of service, interest of bank staff in serving the customers, care and concern, operating hours, service charges, and interest rates of the bank. They stated that banks need to focus more on improving reliability, certainty, and responsiveness. The goal of Vencataya *et al.*'s (2019)[9] study was to show how each of the five service quality categories significantly improved customer satisfaction in banks. Additionally, they discovered that empathy was a highly significant predictor of customer satisfaction out of the five SQ components[10].

3. STATEMENT OF THE PROBLEM

One of the best strategies for banks to get a competitive edge and boost their profit margins is to provide high-quality services. Customer satisfaction gauges how well a company's goods or services live up to expectations. The two most crucial components for accomplishing bank objectives are customer happiness and service quality. Higher technical innovation with less complexity, like in the case of Axis Bank, is advantageous for the adoption of contemporary banking as well as raising customer happiness by boosting consumer trust in the service provider[11]. As a result, Axis Bank's ability to grow its market share is largely dependent on its level of customer satisfaction, which is impacted by a variety of variables despite the wide range of services offered. So, this study aimed to analyse customer delight towards services of commercial bank i.e., Axis bank in Erode.

4. OBJECTIVES OF THE STUDY

- To identity the profile of customers on Axis bank in Erode.
- To analyse the satisfaction of customers towards services offered by Axis Bank.
- To explore the degree of relationship of the satisfaction of customers towards servicesoffered by Axis bank among the selected variables.

5. HYPOTHESIS OF THE STUDY

- There is no significant relationship between monthly family income and satisfaction towards services offered by Axis Bank.
- There is no significant relationship between number of accounts operating in the bank and satisfaction towards services offered by Axis Bank.
- There is no significant relationship between period of holding the account and satisfaction towards services offered by Axis Bank.
- There is a positive association on satisfaction of customers towards services offered by Axis Bank among the selected variables.

6. RESEARCH METHODOLOGY

This study has discussed about the satisfaction of customers towards services of commercial banks i.e. Axis bank, Erode. This study is based on descriptive research design. The researchers have utilized random sampling technique to choose the sample customers from Axis bank in the study area. The sample size has incorporated of 160 customers in the selected bank[12]. The researchers have developed a well-structured questionnaire with 5 points Likert scale method to collect the responses from customers of Axis bank about their satisfaction of services provided by bank. For this study, the study instruments have included the questions related to profile of customers and their satisfaction. This study had performed the statistical methods such as percentage analysis, mean score, standard deviation, Chi-square test and Correlation analysis for analysis purpose.

7. RESULTS AND DISCUSSION

A commercial bank is a type of financial organization that handles all public deposit and withdrawal activities, offers a range of investment loans, and offers a multitude of services. The customer profile of Axis Bank is covered in this part. It includes information on factors such as occupation, monthly family income, number of accounts open, length of account ownership, and frequency of bank operations. Furthermore, the link between the chosen factors and the dependent variablesatisfaction with the services provided by Axis Bankwas examined in this section.

Table 1 Profileof the Axis bank Customers

Sl.No.	Variables	No. of Respondents	Percentage
	Occupational Status		
1	Private Employee	39	24.4
2	Government Employee	24	15.0
3	Business	45	28.1
4	Professional	19	11.9
5	Others (Housewife, Student, Retired, etc.)	33	20.6
	Total	**160**	**100.0**
	Monthly Family Income		
1	Upto Rs.25,000	41	25.6
2	Rs.25,001 - 35,000	38	23.8
3	Rs.35,001 - 45,000	56	35.0
4	Above Rs.45,000	25	15.6
	Total	**160**	**100.0**
	Number of Accounts Operating in the Bank		
1	One	19	11.9
2	Two	41	25.6
3	Three	72	45.0
4	Above Three	28	17.5
	Total	**160**	**100.0**
	Period of Holding the Account		
1	Upto 5 years	31	19.3
2	5-10 years	63	39.4
3	10-15 years	46	28.8
4	Above 15 years	20	12.5
	Total	**160**	**100.0**
	Frequency of operation		
1	Daily	73	45.6
2	Once in a week	32	20.0
3	Twice a month	21	13.1
4	Whenever needed	34	21.3
	Total	**160**	**100.0**

- The table clears that 24.4% of the bank customers are private employees, 15.0% of the bank customers are government employees, 28.1% of the bank customers as businessmen, 11.9% of the bank customers are working in professional field and 20.6% of the customers belong to other categories viz., housewives, students, retired members, etc.
- The analysis that 25.6% of the bank customers have upto Rs.25,000 as monthly family income, 23.8% of the bank customers have Rs.25,001 - 35,000, 35.0% of the bank customers as Rs.35,001-45,000 and 15.6% of the bank customers have above Rs.45,000 as monthly family income. It is revealed from the analysis that most of the bank customers are having Rs.35,001 - 45,000 as their monthly family income.
- It is indicated from the analysis that 11.9% of the bank customers are holding one account in Axis bank, 25.6% of the bank customers are operating two accounts in the bank, 45.0% of the bank customers are operating three accounts and 17.5% of the bank customers are utilizing above three accounts in Axis bank. From the analysis, it is noted that most of the bank customers are having three accounts in Axis bank.
- Based on the analysis, it is determined that 19.3% of Axis Bank customers have had an account for up to five years, 39.4% have had an account for five to ten years, 28.8% have had an account for ten to fifteen years, and 12.5% have had an account for more than fifteen years. The bulk of Axis Bank clients have had their accounts for five to ten years, according to the research.
- It is determined from the analysis that 45.6% of the bank customers are operating bank accounts daily, 20.0% of the bank customers are using bank services once in a week, 13.1% of the bank customers are utilizing services twice a month and 21.3% of the customers are using bank accounts whenever needed.

From the analysis, it is proved that most of the bank customers are using bank services daily in Axis bank.

Satisfaction of customers towards services offered by Axis Bank

This section discussed about the satisfaction of the selected bank customers about the service offered by Axis bank. For this study purpose, the researcher hasframedsix statements for collecting the bank customers'satisfaction towards services offered Axis bank by using 5 points Likert's scaling method. The following table consiststhe mean score and SD of the statements.

Table 2 Satisfactiontowards Services Offered by Axis Bank

Sl.No.	Statement	Mean	SD
1	Procedure for opening / closing the account	3.82	1.22
2	Time taken on any kind of service	3.74	1.24
3	Different schemes	3.91	1.14
4	IT enabled services	3.53	1.36
5	Bank charges on services	3.46	1.39
6	Rate of interest	3.88	1.24

Based on the analysis of mean scores, it can be deduced that out of six categories of customer satisfaction, bank customers are content with the various schemes that banks offer, with mean scores and standard deviations of 3.91 and 1.14 for banks and 3.88 and 1.24 for rates of interest, respectively.

Relationship between monthly family income and satisfaction towards services offered by Axis Bank

H_0: There is no significant relationship between monthly family income and satisfaction towards services offered by Axis Bank.

Table 3 Monthly Family Income and Satisfaction Towards Services Offered by Axis Bank

Sl.No.	Monthly Family Income	Level of Satisfaction			Total	Mean Score	Chi-Square Value
		Low	Medium	High			
1	Upto Rs.25,000	4 (9.8%)	21(51.2%)	16 (39.0%)	41	3.77	42.271 (0.000*)
2	Rs.25,001-35,000	7 (18.4%)	11 (28.9%)	20 (52.6%)	38	3.34	
3	Rs.35,001-45,000	8 (14.3%)	12 (21.4%)	36 (64.3%)	56	3.79	
4	Above Rs.45,000	16 (64.0%)	5 (20.0%)	4 (16.0%)	25	3.85	
	Total	**35**	**49**	**76**	**160**		

Note: Parenthesis indicates 'p' value; * – Significant at 1% level

Customers of Axis Bank who perceive a high degree of satisfaction with the bank's services report having a monthly family income of more than Rs. 45,000. Furthermore, the null hypothesis is rejected since the "p" value is less than 0.05. Therefore, there is a strong correlation between bank clients' happiness with Axis Bank's services and their monthly family income.

Relationship between number of accounts operating in the bank and satisfaction towards services offered by Axis Bank

H_0: There is no significant relationship between number of accounts operating in the bank and satisfaction towards services offered by Axis Bank.

Table 4 Number of Accounts Operating in the Bank and Satisfaction towards Services Offered by Axis Bank

Sl.No.	Number of Accounts Operating in the bank	Level of Satisfaction			Total	Mean Score	Chi-Square Value
		Low	Medium	High			
1	One	15 (78.9%)	2 (10.5%)	2 (10.5%)	19	3.39	79.649 (0.000*)
2	Two	6 (14.6%)	27 (65.9%)	8(19.5%)	41	3.77	
3	Three	13.(18.1%)	10(13.9%)	49 (68.1%)	72	3.74	
4	Above Three	1(3.6%)	10(35.7%)	17(60.7%)	28	3.82	
	Total	**35**	**49**	**76**	**160**		

Note: Parenthesis indicates 'p' value; * – Significant at 1% level

The study revealed that bank clients with more than three accounts had a high degree of satisfaction with the services provided by Axis Bank. Additionally, the null hypothesis is rejected since the "p" value is less than 0.05. Therefore, there is a strong correlation between the number of accounts that clients have open with the bank and their level of satisfaction with the services provided by Axis Bank.

Relationship between period of holding the account and satisfaction towards services offered by Axis Bank

H_0: There is no significant relationship between period of holding the account and satisfaction towards services offered by Axis Bank.

Table 5 Period of Holding the Account and Satisfaction towards Services Offered by Axis Bank

Sl.No.	Period of Holding the Account	Level of Satisfaction			Total	Mean Score	Chi-Square Value
		Low	Medium	High			
1	Upto 5 years	12 38.7%)	12 (38.7%)	7(22.6%)	31	3.62	29.699 (0.000*)
2	5-10 years	13 20.6%)	23 (36.5%)	27 (42.9%)	63	3.71	
3	10-15 years	4 (8.7%)	6 (13.0%)	36 (78.3%)	46	3.81	
4	Above 15 years	6 (30.0%)	8 (40.0%)	6 (30.0%)	20	3.74	
	Total	**35**	**49**	**76**	**160**		

Note: Parenthesis indicates 'p' value; * – Significant at 1% level

It is confirmed that high level of satisfaction towards services offered by Axis Bank is perceived by the bank customers who holding their accounts for 10-15 years. Additionally, the 'p' value is lesser than 0.05 then the null hypothesis is rejected. Moreover, there is a close significant relationship between period of holding the accountby the customers and their satisfaction towards services offered by Axis Bank.

Degree of Relationship between selected variables and satisfaction of customers towards services offered by Axis Bank

A correlation analysis has been employed to examine the relationship between the selected variables and the dependent variable satisfaction of customers towards services offered by Axis Bank with the help of null hypothesis administrated.For this study, the variables namely monthly family income, number of accounts operating in the bank, period of holding the account and frequency of operation in bank have been chosen.

H_0 : There is a positive association on satisfaction of customers towards services offered by Axis Bankamong the selected variables

Table 6 Degree of Relationship between Selected Variables and Satisfaction of Customers towards Services Offered by Axis Bank

Sl.No.	Independent Variables	'r' value	'p' value
1	Monthly Family Income	0.195	0.013**
2	Number of accounts operating in the bank	-0.164	0.038**
3	Period of Holding the Account	0.079	0.322^{NS}
4	Frequency of operation	0.336	0.000*

Note: * - Significant at 1% level; ** - Significant at 5% level; NS - Not Significant

Thestudy reveals that, of the four factors that were chosen, two variables—monthly family income and operating frequency-have a positive link with customers' satisfaction with Axis Bank's services. Additionally, there is a negative correlation between the number of accounts that clients have open with the bank and their level of satisfaction with the services that Axis Bank provides. However, there is no correlation between the varying length of account ownership and consumers' satisfaction with Axis Bank's services. This investigation came to the conclusion that when monthly family income and operating frequency rise, so does customer satisfaction with Axis Bank's services. Additionally, as the number of active accounts in the bank rises, client satisfaction with Axis Bank's services falls.

8. FINDINGS

- It is found from the percentage analysis that majority of the selected bank customers are businessmen.
- It is revealed from the analysis that most of the bank customers are having Rs.35,001 - 45,000 as their monthly family income.
- From the analysis, it is noted that most of the bank customers are having three accounts in Axis bank.
- From the analysis, it is confirmed that majority of the bank customers are holding account for 5-10 years in Axis bank.
- From the analysis, it is proved that most of the bank customers are using bank services daily in Axis bank.
- The mean score analysis confirmed that the bank customers are satisfied on offered different schemes by banks with the mean score of 3.91 amongst six categories of customer satisfaction.
- It is showed from cross-tabulation that high level of satisfaction towards services offered by Axis Bank is perceived by the bank customers have above Rs.45,000 as their monthly family income. Also, Chi-square analysis found that there is a close significant relationship between monthly family income of the bank customers and their satisfaction towards services offered by Axis Bank.
- The cross-tabulation identified that high level of satisfaction towards services offered by Axis Bank is perceived by the bank customers who operating above three accounts. Additionally, it is revealed from Chi-square test that there is a close significant relationship between number of accounts operating in the bank by customers and their satisfaction towards services offered by Axis Bank.
- From the cross-tabulation, it is stated that high level of satisfaction towards services offered by Axis Bank is perceived by the bank customers who holding their accounts for 10-15 years. The result from Chi-square analysis indicated that there is a close significant relationship between period of holding the account by the customers and their satisfaction towards services offered by Axis Bank.

9. SUGGESTIONS

- From the study, it is identified that the customers have low level of satisfaction towards bank charges on services and IT enabled services, Hence, the bank should collect the low level of service charges and should enable innovative technology services which are convenient and easy for each and every customer.
- The findings revealed that high level of satisfaction towards services offered by Axis Bank is perceived by the bank customers who operating above three accounts. So, the bank should give individual attention among all customers in order to better understand their needs and better satisfy them.
- This research confirmed that maximum level of satisfaction towards services offered by Axis Bank is perceived by the bank customers who holding their accounts for 10-15 years. Therefore, the bank should offer various services like providing loan facility, high rate of interest on deposit, locker facilities, etc. to all customers and induce them to enhance the facilities particularly new customers.
- The bank should provide the convenient and easy methods of online and modern technologies and the awareness about the service aspects should be made among all customers.

10. CONCLUSION

This study has been attempted to examine the customer delight towards services of Axis bank in Erode. Now-a-days, the satisfaction of customers is enormously important for the survival and growth of commercial banks. Hence, providing multiple services by commercial banks are important predictors for judging the satisfaction level of bank customers. This study confirmed that there is a close significant relationship between selected variables and the dependent variable satisfaction towards services offered by Axis Bank. So, bank may follow a feedback system to know the customers' expectations for improving their high-levelsatisfaction. Also, this study stated that bank employees should maintain a strong relationship with customers to understand their requirements and opinion about services offered by Axis bank.

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ELECTRONIC STRUCTURE ANALYSIS: DFT COMPARISON OF ALIPHATIC AND AROMATIC MOLECULES IN BIOLOGICAL SYSTEMS

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Abstract

Comparison of the electronic structure of aliphatic and aromatic molecules in biological systems, makes it possible to gain valuable insights into the reactivity, stability and function of the molecules. Density functional theory is one of the most commonly used computational methods to study the electronic structure of molecules.Two molecules vasicol, an aromatic alcohol and citral, an aliphatic aldehyde is compared for its structural parameters, global reactivity, potential surface mapping and possible target for selected molecules. From the structural parameters, it is found that –C=O-N is shorter 1.228 Å than –H-C-N 1.468 Å due to the electron withdrawing nature of –C=O. Vanderwalls' forces are also studied. Electronegativity, hardness and other molecular descriptors convey that variations in energy difference of vasicol to be higher radical scavenger than citral proving the compound a valid antioxidant. Electron potential surface scanning and frontier orbital analysis prove the same. Study on predicting the target indicates that vasicol as kinase receptor, enzymatic receptors and cytochrome P450 as suitable targets whereas citral prefers (Family A G) protein coupled receptor, enzymatic, oxidoreductase and kinase receptors targets.

Keyword: *Citral, Vasicol, Density Functional Theory, ESP, FOs*

1.INTRODUCTION

Plant based aliphatic and aromatic compounds has garnered increasing attention in recent years due to its potential health advantages and numerous in dustrial applications[1]. Scavenging free radicals of reactive oxygen species (ROS) and nitrogen based radicals, which are linked to the pathophysiology of many diseases such as cancer, cardiovascular disorders, and neurological ailments, aliphatic and aromatic antioxidants serve a critical role in shielding cells and tissues from oxidative stress [2]. The activity of these plant based aliphatic and aromatic compounds owes to their ability to donate hydrogen atoms or electrons, chelate metal ions, and inhibit lipid peroxidation, thereby mitigating oxidative damage to biomolecules such as lipids, proteins, and DNA [3].

Research in academia and industry have focused a great deal of emphasis on the antioxidant properties of aromatic and aliphatic molecules. To promote health and prevent disease, innovation in medicines, dietary supplements, and functional food ingredients can be developed with an understanding of the mechanisms behind their antioxidant benefits [4].

Citral, is an aliphatic naturally occurring simple organic aldehyde, famous for its distinct lemon-like scent and flavor[5]. The interesting part is that the aldehyde is a resultant mixture of two geometric isomers namely geranial and neral. The compound is commonly found in all citrus fruits, various herbs and spices such as lemongrass[6]. Eventhough the antioxidant activity of the compound is known analysis of structural contribution is not well-studied. The wide biological activity of the compound is known in allopathy and traditional medicine.

Vasicol is an aromatic natural compound found in the roots of the medicinal plant *Adhatoda vasica*. It has a bicyclic structure consisting of a quinazoline ring system fused to a phenyl ring [7]. Research into the pharmacological properties of vasicol is ongoing, with studies focusing on its mechanisms of action, safety profile, and potential therapeutic applications. Preclinical studies in animal models and in vitro experiments have provided insights into its biological effects, but further research, including clinical trials, is needed to fully understand its medicinal potential and develop standardized formulations for therapeutic use [8].

In this study, the antioxidant activity of aromatic vasicol (containing an alcohol group) and aliphatic citral

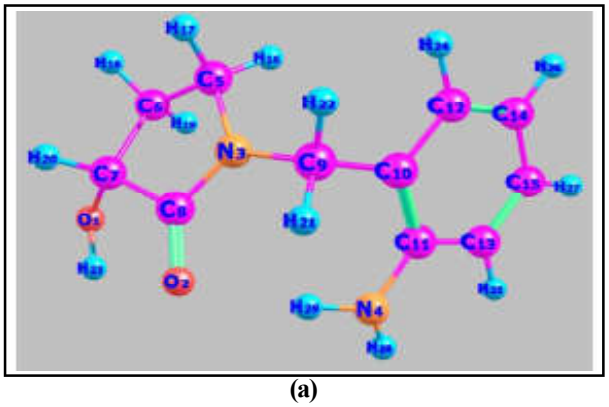
(containing an aldehyde group) is evaluated, with particular attention to the compounds' mechanisms of action, structure-activity connections, and possible biological uses [9]. Unreported comparison on the contribution of aromatic alcohol and aliphatic aldehyde groups of the title compounds are studied through Structural analysis of bond length, bond energy, delocalization of electrons, and molecular descriptors. Frontier molecular orbitals (FMO) of vasicol and citral are represented. Also, prediction of target through software of these compounds, assessing antioxidant capability point out new directions and difficulties in the area.

2. COMPUTATIONAL METHOD

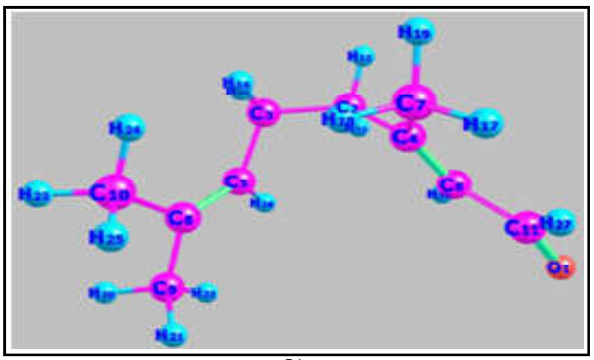
The molecular structures of the bioactive compounds vasicol and citral have been theoretically investigated for their structural activity with the help of Gaussian 16W using DFT. Gauss View 5' and Chemcraft software [version 1.8] are used for visualization. The basis set used is in sequence with the previous recognized work 6-311G (d,p). Correlation functional M062X is used in these simulations. VMD software package are used to analysis the topological parameters of both citral and vasicol molecules. The electron distribution among the atoms are discussed using molecular electrostatic potential mapping [10].

3. RESULTS AND DISCUSSION

Crucial understanding of the structural features of citral and vasicol is required for predicting and rationalizing the behavior of molecules in various environments and applications. Studies are carried out in gas phase for the compounds under analysis. Initially the molecular 3D structural co-ordinates are retrieved from pubchem and the structures are optimized using Gaussian 16 for lowest energy conformer(LEC).



(a)



(b)

Fig.1(a) Optimised lowest energy structure of vasicol and (b) Optimised lowest energy structure of citral

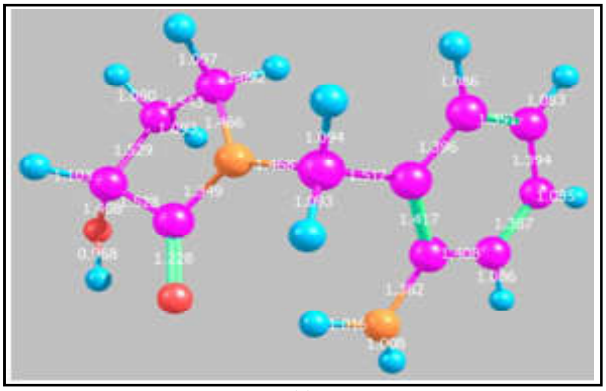
This is confirmed by checking the imaginary frequency values which must not be negative. The LEC for vasicol is found to be -687.755 hartrees, and citral -466.015 hartrees. This is an initial indication of the fact that citral defends more than vasicol to give out the electron. Further analysis is performed as stated below and the optimized structures are represented in figure 1.

3.1. Structural Parameters

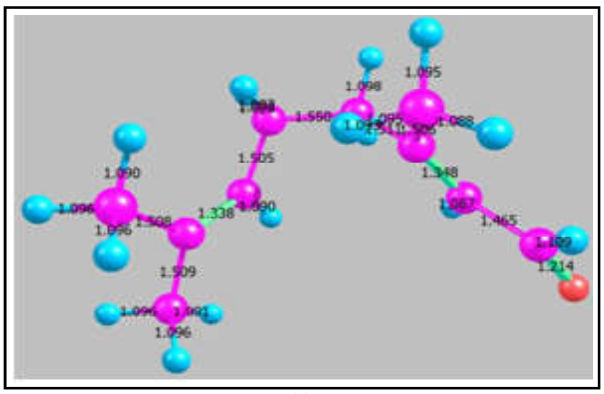
The bond length and bond angle are fundamental structural parameters that can significantly influence the activity, reactivity, and properties of molecules in chemical, biological, and pharmaceutical contexts [11].

Figure 2 indicates the bond length of the compounds. The double bonds are short with a value of 1.3 Ĺ-1.4 Ĺ compared to the single bonds1.50-1.58 Ĺ. In vasicol, the C–C bond lengths in the ring is found to be less than of 1.41 Ĺ whereas in the aliphatic molecule, citral it is nearly 1.50 Ĺ. It is evident that shorter the bond length, stronger the bonds, while longer bond lengths indicate weaker bonds [12]. So shorter bonds in a molecule may imply stronger interatomic forces, making it more difficult for the molecule to undergo chemical reactions that involve breaking these bonds as a result aromatic C-C bonds does not involve directly in radical scavenging activity. Whereas the presence of nitrogen in the five membered ring structure of vasicol plays a vital role. The bond length between C-N in ring should be generally 1.39 Ĺ as reported in literature. Presence of –C=O in the adjacent position influences the bond length. It is found that the C-N bond length between –C=O-N is shorter 1.228 Ĺ than –H-C-N 1.468 Ĺ due to the electron withdrawing nature of –C=O. –C-H bond length in the ring is 1.0-1.1 Ĺ and the linking C is 1.3-1.4Ĺ. The bond length of –O-H is found to be 0.968 Ĺ making it to dissociate easily during a reaction thus acting as a weak spot and good radical scavenging site.

Contradictorily the aliphatic citral has the C=C bond length to be 1.2-1.3 Ĺ, C-H bond length varing between 1.0-1.1 Ĺ. Interestingly the –C=O bond length is 1.228 Ĺ which facilitates H removal from this site rather than –C-H. When compared with vasicol, citral has least possibility towards antioxidant activity in gas phase.



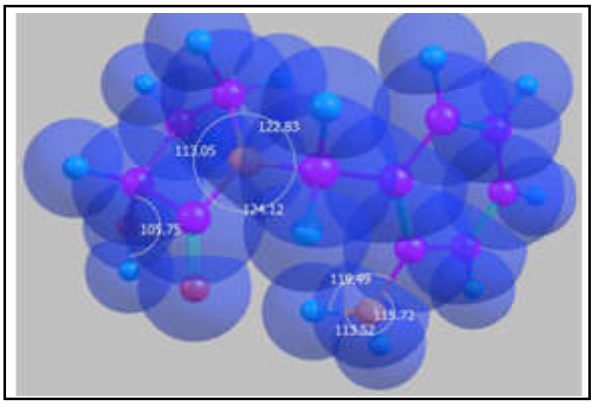
(a)



(b)

Fig.2 (a) Bond length of vasicol and (b)Bond length of citral

The bond angle of both the compounds under study are represented in Figure 3. For aromatic sites, the active –OH groups is 105.75 ppm whereas in citral it is 119.86 ppm, a difference of 14ppm is observed. Near the nitrogen atoms, the bond angle is nearly 113 ppm to 123 ppm in vasicol. The vanderwalls' forces are indicated in blue circles in figure 3.



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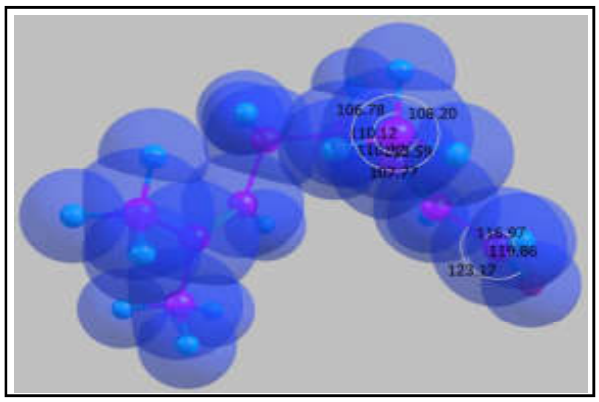

(b)

Fig.3 (a)Bond angle of vasicol and (b) Bond angle of citral

3.2. Global Reactivity Parameters

Molecular descriptors for vasicol and citral are displayed in table 1. From the table it is evident that removal of electron from vasicol is easier compared with citral having energy difference of 1.026eV. Electron affinity of vasicol is comparatively low by a difference of 1.239eV, indicating that the potential energy change of –OH atom is lower if an electron is added to neutral vasicol in gaseous state to form negative ion. Chemical hardness of citral and vasicol is closer in magnitude with the difference of 0.057eV and softness of difference 0.004eV proposing a similar degree of flexibility. The –OH atom of vasicol has a increased tendency to attract the shared pair of electrons form the oxidants which is supported by the electronegativity difference between the compounds as 1.182eV. Electrophilicity index of vasicol is 1.677eV reflecting a result that vasicol act as donors rather than acceptors, which is essential quality of the antioxidant compounds. Based on the above results, variations in energy difference project vasicol to be higher radical scavenger than citral proving the compound a valid antioxidant.

Table 1. Molecular Descriptive Parameters for Vasicol and Citral

Molecular Descriptors	E_v (eV) of Vasicol	E_c(eV) of Citral
IP(eV)	5.507	6.633
EA(eV)	0.333	1.572
W(eV)	2.587	2.530
S(eV)	0.193	0.197
X(eV)	2.920	4.102

3.3 Electrostatic Potential Surface (EPS) Analysis

EPS analysis is used to study and visualize the electrostatic potential around a molecule. It involves calculating the distribution of electrostatic potential of vasicol and citral generated by the molecular structure. Comparing the charge distribution within the molecule of vasicol and citral, (Figure 4) it is found that the electropositive intensity rather than comparing the reactivity of hydroxyl and methoxy unit, vasicol is dominant during interactions with other molecules or ions.

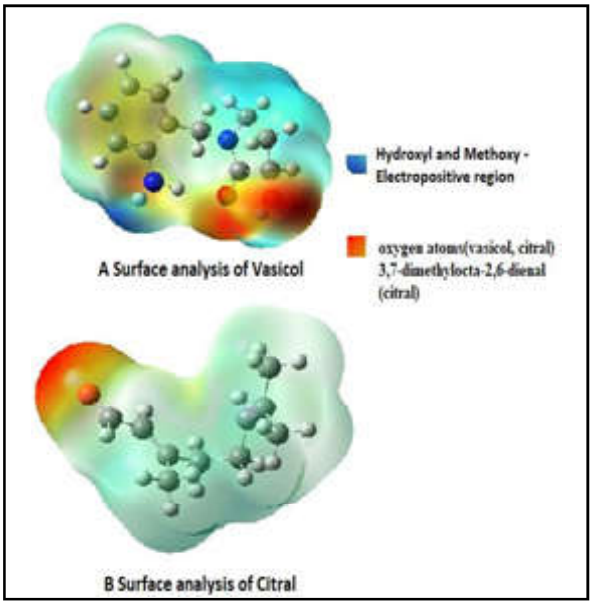

Fig.4 EPS of compounds under study

3.4 Frontier Orbitals(FOs)

In aromatic compound of vasicol, the highest occupied molecular orbital is typically a đ orbital localized above and below the plane of the aromatic ring as shown in figure 5 and lowest unoccupied molecular orbital (LUMO) is đ* antibonding orbital which is perpendicular to the aromatic ring. Electrophiles attack the LUMO ring. The figure 5 of vasicol and citral depicts LUMO spread over the electronegative oxygen atom and 3,7-dimethylocta-2,6-dienal. and occupied over benzene ring of vasicol and methyl unit of citral which makes the sense that they possess highest electron density and it is the highest reactive site for both the compounds. The energy gap between the occupied energy levels and unoccupied energy levels of vasicol and citral found to be 5.17eV and 5.06 eV which is of same order with minor variation. Electron movement can take place only with little energy variation for aliphatic and aromatic compounds in this study.

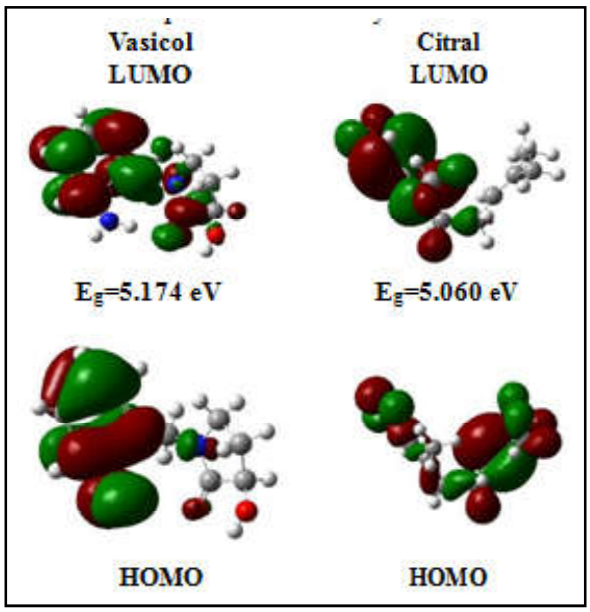

Fig.5 Frontier orbitals of Vasicol and Citral

3.5 Predicting the Target for Molecules

The current study involves 15 targets to study the susceptibility as drugs of vasicol and citral. Using online Swiss Adme software, the molecules are tested and results interpreted. It indicates that in Figure 6 vasicol as kinase receptor, enzymatic receptors and cytochrome P450 suitable targets. Citral prefers (Family A G) protein coupled receptor, enzymatic, oxidoreductase and kinase receptors targets. Based on the percentage of target screening both vasicol and citral are potential radical scavengers.

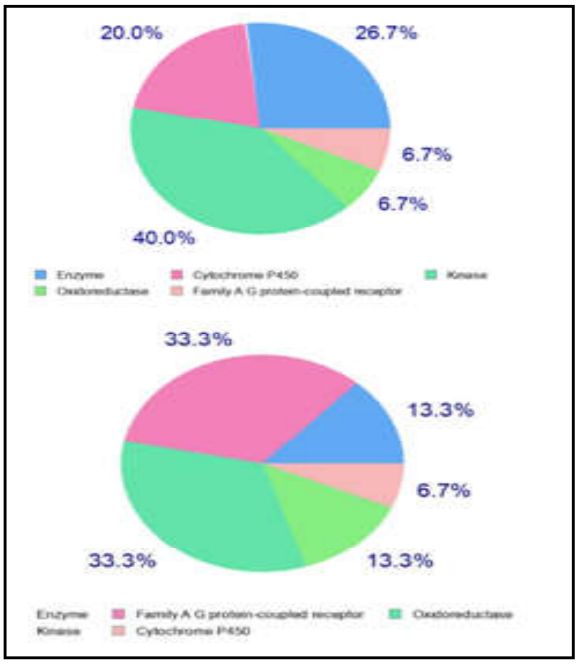

Fig.6 Target report for (a) Vasicol and (b) Citral

4. CONCLUSION

The current study involves aromatic vasicol with phenolic group which tends to exhibit potent antioxidant activity. due to the presence of hydroxyl groups that can scavenge free radicals. The specific antioxidant activity varies widely depending on the compound's structure. When compares with aliphatic compound, citral the contribution towards antioxidant activity is less eventhough, when they contain functional groups capable of donating hydrogen atoms or electrons to neutralize free radicals.

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ANALYSIS OF LOW POWER 4 BIT VEDIC MULTIPLIER USING COMPRESSOR TECHNIQUE

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Abstract

In this work, a new 4-bit Vedic multiplier architecture depends on a 3-1-1-2 compressor technique. The compressor technique is based on the technique of Vedic mathematics to improve the performance of Vedic multipliers. Using Cadence software, several 4-bit Vedic multiplier subblocks were designed and confirmed. According to simulation data, on a 45nm CMOS process with a 1.2V supply, the suggested Vedic multiplier uses 3284.39μW of power resulting in an 8.54 ns latency.

Keyword: *Vedic Multiplier, Compressor Technique, CMOS*

1. INTRODUCTION

Comprising logic gates and adders, Multipliers are the fundamental building blocks of both arithmetic and logic Units (ALUs) and data route elements [1-4]. To get partial products of a multiplication, multiply the multiplicand and multipliers together. It is required to enhance the performance of multipliers. Power and delay are the two key elements in every digital design. Reduce the power of multipliers.

Because they are an important part of Signal Processing blocks particularly Fast Fourier Transforms (FFT) Improvements in picture and video quality are required without compromising restriction; multipliers are employed in audio and video signal processing [5-9]. Main block of the multiplier is the entire. Transistor count is the Primary determinant of multiplier performance in submicron CMOS processes. The Multiplier's compression technique is the recommended way to lower power dissipation and increase output level swing [10-14].

Reducing the propagation delay will boost the speed of the parallel adder utilized in the multiplier. It is necessary to choose the appropriate adder to boost the multiplier's speed as the Ripple Carry Adder (RCA) lengthens the delay. By improving the performance, appropriate blocks must be designed in accordance with the literature review and previously published studies.

This work is structured as various sections. The design methodology is given in section II followed by results and discussion in section III and Conclusion is mentioned in section 2.

2. DESIGN METHODOLOGY

The 4-bit Vedic multiplier is dependent on Vedic mathematics, an antiquated branch of India mathematics. Information is represented by the Veda. It uses a unique computation method built on sixteen formulas. Included are contemporary mathematical ideas such as factorization, quadratic equation, geometry, algebra, and trigonometry. Urdhva Tiryakbyham is used in the multiplier to implement the Vedic algorithm which means Vertical and Crosswise (Urdhva Tiryakbhyham). This is a generalized formula for N*N bit numbers.

This algorithm satisfied the need for a speedy multiplication operation because of the concept of vertical and crosswise multiplication, which adapted well to the parallel multiplication process. There is a significant decrease in the partial products needed for multiplication in each level. The four-bit Vedic multiplier is made up of several sub-blocks, including compressor, address, parallel prefix adders, and logic gates.

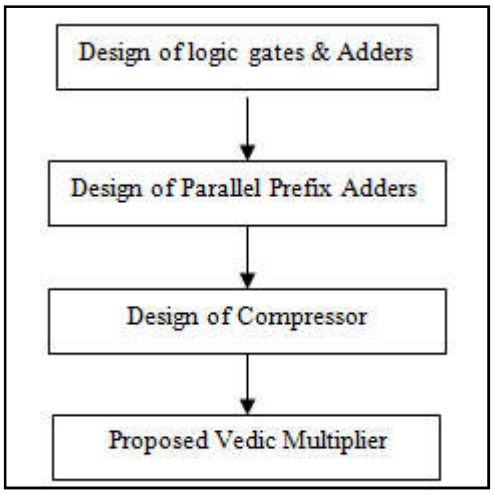

Fig.1 Basic flow of 4-bit Vedic multiplier

First, the fundamental logic gates and adders are designed in order to create the Vedic multiplier. To speed the computation a parallel adder is included in the next block. The Carry look ahead adder generates and propagates terms in order to accelerate the process.

This works's primary innovation is the 3-1-1-2 compressor's multiplexer logic design and the compressor are needed in order to minimize the latency. Therefore, a 3-1-1-2 compressor is required to enhance the multiplier's performance. The 3-1-1-2 compressor with 4X1 multiplexer is depicted in Figure 2.

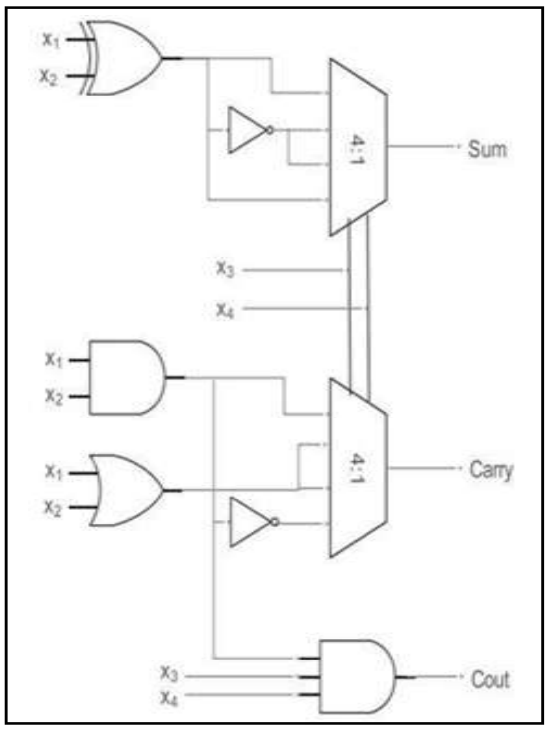

Fig.2 3-1-1-2 compressor using 4X1 multiplexer

Figure 3 indicates the schematic of 4-bit Vedic multiplier. Here the various sub-blocks including adder, logic gates and compressors.

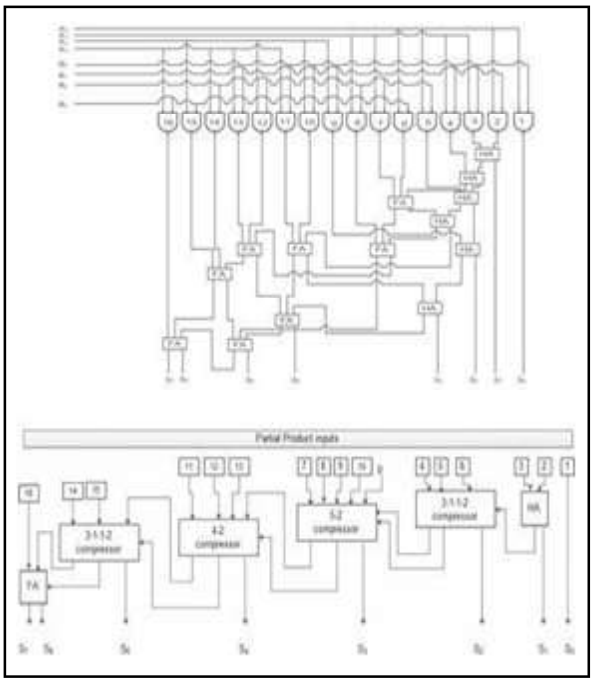

Fig. 3 Schematic of 4-bit vedic multiplier

3. RESULTS AND DISCUSSION

In this case, 45nm CMOS technology was used and the compressor method has been applied. Compressors are utilized to reduce area and delay, which improves system performance overall. To create a 4-bit Vedic multiplier, a number of sub-blocks, such as an adder, logic gates, 3-2, 4-2, and 3-1-1-2 compressors, are integrated here.

Using Cadence software, several 4-bit Vedic multiplier sub blocks were designed and confirmed. According to simulation data, on a 45nm CMOS process with a 1.2V supply, the suggested Vedic multiplier uses 3284.39 of power and resulting in an 8.5 ns latency.

Figure 4 shows the schematic of the various sub-blocks including adder, logic gates, 3-2 compressor, 4-2 compressor and 3-1-1- 2 compressor are integrated and sub blocks were designed and verified using Cadence software.

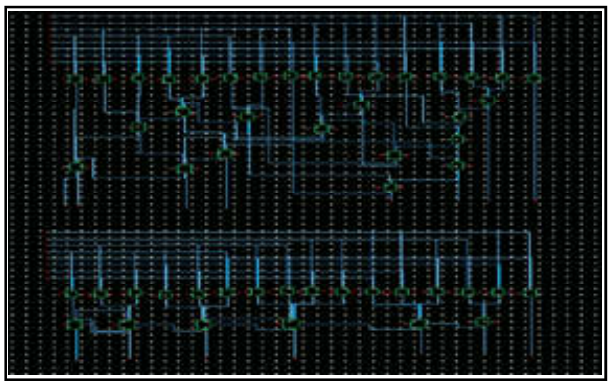

Fig.4 Schematic of 4*4-bit Vedic Multiplier in cadence tool

Figure 5 shows the test bench of various sub-blocks including half and full adders.

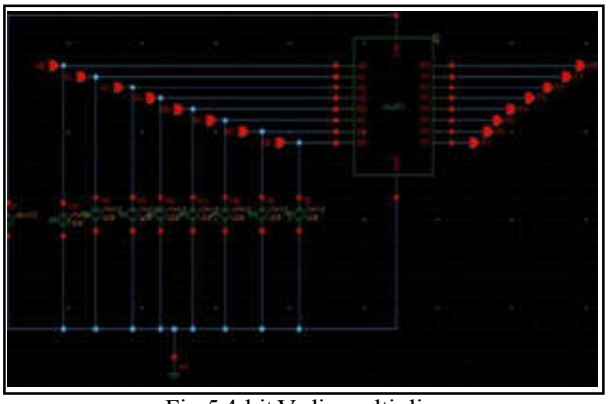

Fig.5 4-bit Vedic multiplier

Figure 6 shows the output waveform of the multiplicands, multipliers and the final product terms.

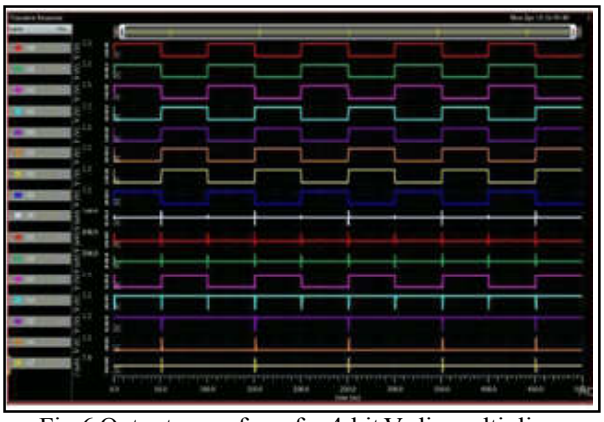

Fig.6 Output wave form for 4-bit Vedic multiplier

There are two outputs and five inputs on the 4-2 compressor. To evaluate the summation and the result with reduced delay in the last section of the summation, 3-1-1-2 compressors are required. In order to solve this issue, the 3-1- 1-2 compressor was created, and the 45nm CMOS technology schematic was created using the Cadence Virtuoso tool.

4. CONCLUSION

Here, compressor approach was utilized to imitate the traditional 4*4-bit Vedic multiplier in 45nm CMOS technology. In order to minimize area and delay and improve system performance overall compressors are utilized and analysis has also been done. Table 1 Shows the Synopsys synthesis report.

Table 1 Comparison of Power, Delay and Power Delay Product (PDP) of Various Existing Multipliers with Proposed Multiplier Design

Reference	Bit	Multiplier	Power(uW)	Delay(ns)	Power Delay Product(PDP)
1	4*4	Array	2835.92	12.36	35,052.02
2	4*4	Baugh-Wooley	2991.98	14.47	42,293.97
3	4*4	Wallace	3055.24	12.25	37,426.71
4	4*4	Dadda	2782.36	12.43	.4,584.76
5	4*4	Modified Booth	3178.02	10.52	33,432.72
6	4*4	Vedic Multiplier	3269.93	8.46	27.663.61
	4*4	**Vedic Multiplier (Proposed Work)**	**3284.39**	**8.54**	**28.048.69**

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DEVELOPMENT OF UV PROTECTIVE GARMENT FINISHED WITH PIPER BETEL LEAF EXTRACT

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Abstract

A protective textile is now a major part of textiles classified as technical or industrial textiles. Ultraviolet rays constitute a very low friction in the solar spectrum, but influence all living organisms and their metabolisms. These radiations can cause a range of effects from simple tanning to highly malignant skin cancers. So in order to counteract these problems an ecofriendly natural finish has been prepared from the medicinal plant extract for the textile application.The antioxidant protects the skin from UV. The piper betel which has a good antioxidant property has been chosen for this project work, Piper betel is used in order to protect the skin from UV rays. The UV protecting component present in the piper betel was analyzed and confirmed through phytochemical analysis. The extract from the piper betel has been imparted in the 100% cotton knitted fabric having 140 GSM by exhaustion method and the surface characteristics of the fabric was observed by SEM analysis. Then the fabric was assessed for UPF test along with the untreated sample. Piper betel having an excellent protection against mosquito, the mosquito repellency test was conducted on the finished sample. Finally the finished fabric is constructed as a kids wear garment.

Keywords: *Protective textiles, Ultraviolet rays, Phytochemical analysis, SEM analysis, Ultraviolet protection factor, Mosquito repellency activity*

1. INTRODUCTION

Generally everyone is exposed to UV radiation from the sun and many artificial resources are used in the industry. Emissions from the sun include light, heat and rays. These rays emit UV rays whichcauses Skin cancer and cataracts which are important public health concerns. The social cost of these diseases, such as death, disfigurement and blindness, can be overwhelming both in terms of human suffering and the financial burden. Much of this could be avoided by reducing exposure to solar UV. The sun is the principal source of UV exposure for most people. Exposure to the sun is known to be associated with various skin cancers, accelerating skin aging, cataract and other eye diseases[1]. The United Nations Environment Programme has estimated that over 2 million non-melanoma skin cancers and 200,000 malignant melanomas occur globally each year. In the event of a 10% decrease in stratospheric ozone, with current trends and behavior, an additional 300,000 non-melanoma and 4,500 melanoma skin cancers could be expected world-wide. Some 12 to 15 million people are blind from cataracts. WHO has estimated that up to 20% of cataracts or 3 million per year could be due to UV exposure.The classification of uv rays are UVA (400-315nm), UVB (315-280nm), UVC (280-100nm). As sunlight passes through the atmosphere, all UVC and approximately 90% of UVB are observed by ozone, water vapour, oxygen and carbon dioxide. UVA radiation is less affected by the atmosphere. Therefore, UV radiation reaching the Earth's surface is largely composed of UVA with a small of UVB component[2][3].

2. EXPERIMENTAL PROCEDURE

2.1 Selection of Fabric

Cotton Knitted fabric is a construction of a elastic, porous fabric, created by interlocking yarns by means of needles. It absorbs and releases perspiration quickly thus allowing the fiber to breathe. The superiority of cotton is because of its features like easy availability, comfort during wear and excellent wash properties. Cotton Knitted fabric is generally light in weight, comfortable in wear even during travel, yet requires little care for maintenance. Elasticity nature of knitted fabrics permits for abundant physical activity[4]. Knitted fabrics provide comfortable wear to almost any style of garment. Most knits contour to the body's silhouette without restricting movement. This makes knitted fabricsideal for

underwear, body wear kids garment and active wear garments. Single jersey is the simplest to knit and it can be produced either on circular or flat machines by means of one sets of needles which draw their loops to only one side of the fabric[5,6].

2.2 Selection of Herbs

Plant materials remain an important resource to combat serious diseases in the world. The traditional medicinal methods, especially the use of medicinal plants, still play a vital role to cover the basic health needs in the developing countries[7,8]. The Piper betel leaves are selected for the study and have been used centuries back. It is blessed as an evergreen and perennial plant which has God created[9][10].

2.2.1 Piper Betel

Fig.1 Piper Betel

3. METHODOLOGY

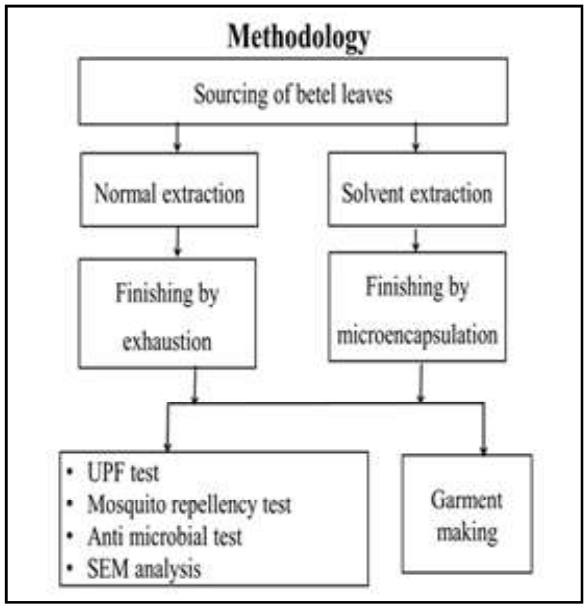


Fig.2 Methodology

4. EXTRACTION OF PIPER BETEL - EXHAUSTION METHOD

The collected fresh and healthy leaves were washed with tap water followed by distilled water. The fresh leaves were ground into a paste form by using a blender and subsequently used for the study. For extraction, 1kg of paste was taken and mixed well into 3 liters of water. The extract was filtered through a filter fabric. Finally the filtered extract was used for the application of fabric.

4.1 Fabric Finishing-Exhaustion Method

The fabric is pre wetted for 10 minutes. Now the extract is poured into the padding machine and padded for about 40 minutes. The time is wellenough for better exhaustion. Then the fabric is washed with cold water and the excess amount of water from the fabric is squeezed by using hydro extractor. Finally the sample was dried in the Tumble dryer for 30 minutes.

5. EXTRACTION OF PIPER BETEL- ENCAPSULATION METHOD

1.5kg of piper betel leaves were taken and grinded into paste form by using blender.80% methanol (1.2 liters) is added with the grinded betel leaves and kept over night. Then the extract was filtered by using filter fabric, the filtrate was collected and evaporated at room temperature for about 2 hours.

5.1 Fabric Finishing-Encapsulation Method

The extract of betel is added with 3% of sodium alginate. After adding sodium alginate 5% of calcium chloride solution is sprayed into it. Then after 15 minutes 10% of iso propyl alcohol is added to it. By exhaustion process at 50°c the fabric is processed with the recipe and with addition to that 15 litres of water is added for about 30 minutes.

6.TESTING

6.1 Phytochemical Analysis

The Phytochemical analysis of the plants is very important commercially and has great interest in pharmaceutical companies for the production of the new drugs for various end use applications. It is expected that the important Phytochemical properties recognized by our study in the indigenous medicinal plants of Mardan

will be very useful for protecting UV rays from the sun. The main objective of this analysis is to check the presence or absence of the Phytochemical constituents Piper betel leaf extract.

6.2 Analysis of Ultraviolet Protection Factor

The ultraviolet protection of a fabric is expressed by the Ultraviolet Protection Factor (UPF). The UPF evaluates the reduction in the amount of the UV radiation that passes through the fabric to the skin. For example, when a fabric has an UPF of 20, only 1/ 20th of UV radiation reaches the skin. UV transmittance through the fabric samples was determined within a wave length range from of 280 to 400nm using a ShimadzuUV/Vis Spectrophotometer. (The standard method used for determining the UPF was AATCC 183-2010).

6.3 Assessment of Mosquito Repellency Activity

Anopheles mosquitoes were identified based on morphological keys and they were collected during the evening hours. Specially designed two-excito repellency test chambers were used to evaluate the efficiency of repellency activity. The wooden outer chamber of excito-repellency testing device measures 34 cm × 32 cm × 32 cm and faces the front panel with the single escape portal. The box is composed of a rear door cover, an inner Plexiglas glass panel with a rubber latex-sealed door, a Plexiglas holding frame, a screened inner chamber, an outer chamber, a front door, and an exit portal slot. Mosquitoes were deprived of all nutrition and water for a minimum of 4 hours before exposure. Laboratory tests were performed during daylight hours only and each test was replicated four times. Observations were taken at one-minute interval for 30 minutes. After each test was completed, the number of Escaped specimens and those remaining inside the chamber was recorded separately for each exposure chamber, external holding cage, and paired control chamber. Escaped specimens and those remaining inside the chamber, for the treated samples, were held separately in small holding containers with food and water.

7. RESULTS AND DISCUSSION

7.1 Phytochemical analysis

The Phytochemical analysis was carried out to analyse the presence of chemical component inthe Piper betel leaf extract. The presence of Glycosides, Tannins, Phytosterols and the Coumarin are responsible to protect the UV rays from the deleterious effects.

Table 1 Phytochemical analysis

Sl.No.	Photochemical Compound	Methanolic Extraction of Betel leaf
1	Alkaloids	+
2	Flavonoids	-
3	Saponins	-
4	Phenol	+
5	Glycosides	++
6	Reducing sugar	++
7	Tanins	+
8	Phytosterols	+
9	Terpinoids	-
10	Protein	+
11	Anthroquinone	-
12	Counmarin	++
13	Anthocyanin	-
14	Phlobatanins	-
15	Acid	-

++Strongly present +Present -Absent

7.2 Ultra Protection Factor of the Finished Product by (AATCC 183:2010)

UPF rating for microencapsulation sample shows the excellent protection against UV rays whereas the exhaustion sample shows good protection against the UV rays and the untreated sample shows poor protection against the UV rays. Here we can conclude the deleterious effect of UV rays and the protection against them through textile material by using betel leaf extract in the knitted fabric.

7.2.1 Ultra Violet Protection Factor for Untreated Sample

Table 2 UPF Rating for Untreated Samples

Particulars	UPF	T(UV)%	T(UVB)%
Number of scans	5	5	5
Mean	13.09	12.21	5.84
40 to 50	1.69	1.05	1.11
COV	12.93	8.61	19.02

UV-A Blocking 87.79%
UV-B Blocking 94.16%
UPF Rating 13

7.2.2 Assessment of Ultra Violet Protective Factor (AATCC 183-1999)

Table 3 Assessment of Ultra Violet Protective Factor (AATCC 183-1999)

Samples	UPF Rating	Protection Category
Untreated Fabric	13	Poor
Exhaustion Fabric	33	Very good
Encapsulation Sample	56	Excellent

7.3 Assessment of Mosquito Repellency Activity

The Mosquito Repellency efficiency of the finished fabric was tested using the modified excito chamber method.

$$\text{Efficiency of Mosquito repellency (\%)} = \frac{\text{No. of Specimen escaped + No. of specimen dead}}{\text{No. of Specimen exposed}} \times 100$$

Table shows the mosquito repellency test results. Whereas the Microencapsulation finished cotton fabric shows much better results than exhaustion and unfinished cotton fabric.

Table 4 Mosquito Repellency Activity

Samples	No.of Specimen Exposed	No.of Specimen in Cage	No.of Specimen Escaped	No.of Specimen Dead	Mosquito Repellency in %
Untreated Fabric	25	21	4	0	16
Exhaustion Sample	25	9	12	4	64
Encapsulation Sample	25	8	12	5	68

7.4 Assessment of Antimicrobial Activity (ISO 20645)

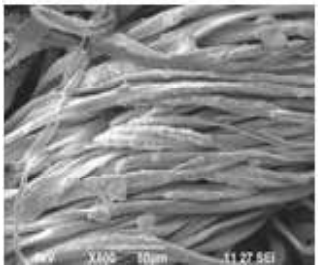
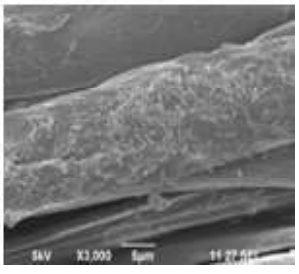
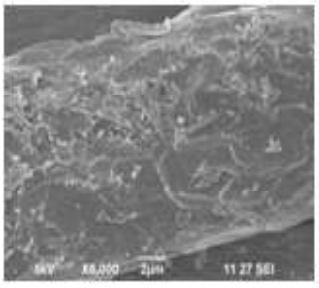
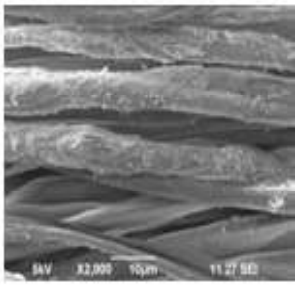
Test name : Determination of Antibacterial activity.
Standard : Agar Diffusion plate test by ISO 20645.
Inoculum : Staphylococcus aureus ATCC 6538. Klebsiella pneumonia ATCC 4352. Sample size: Swatches (2.5cm in dia). Media used : Tryptic Soy agar. Incubation : 37o C for 18-24hours.

Table 5 Antimicrobial Activity (ISO 20645)

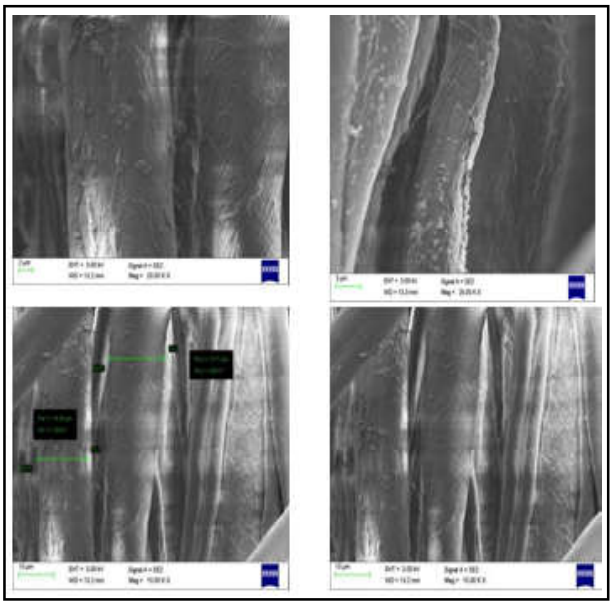
Samples	Inhibition Zone		Growth in Fabric	Assessment
	Staphylococcus aureus ATCC 6538	Klebsiella Pneumonia ATCC 4352		
Exhaustion Sample	0	0	Absent	Good Effect
Encapsulation Sample	0	0	Absent	Good Effect

7.5 SEM Analysis

7.5.1 Encapsulation Fabric appearance in SEM

7.5.2 Exhaustion Fabric appearance in SEM



8. CONCLUSION

The Phytochemical analysis shows the presence of ultra violet protective components such as Glycosides, Tannins, Phytosterols, Coumarin. The encapsulation fabric shows the better UPF rating of 56 and whereas the exhaustion and untreated fabric has a rating of 33 and 13 respectively. The Mosquito repellency test result shows the encapsulation sample has 68% and the exhaustion sample has 64% Mosquito Repellency. The Antimicrobial activity result shows both encapsulation and exhaustion fabric has excellent protection against bacteria's. The surface of the treated fabrics were observed by SEM analysis. The Piper betel micro-capsules are well coated on the encapsulation fabric surface whereas the piper betel extract are also well coated on exhaustion fabric.

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LUNG DISEASE CLASSIFICATION BASED ON FEATURE EXTRACTION ALGORITHMS USING MACHINE LEARNING MODELS

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Abstract

One type of cancer that is linked to aberrant cell growth is lung cancer. This type of cancer modifies the usual cycle of cell division and death, leading to irregular cell proliferation and the creation of massive cell masses. These rapidly multiplying cells develop into cancer cells because they are unable to carry out the functions of healthy cells. Numerous factors have been directly connected to lung cancer, and studies have been conducted to identify predictors of susceptibility to these causes. This cancer diagnosis is not made until the tumor cells have invaded other bodily parts and are interfering with other organs' ability to function normally. Many machine learning methods are used to predict lung cancer since lung cancer diagnosis is imprecise and challenging to get. The Cancer Image Archive provided the image dataset for this project. Several preprocessing techniques are used to standardize the photos before creating the image model. The key features from the picture dataset, such Standard Deviation, Skewness, Variance, and so forth, are then extracted using transform-based feature extraction algorithms like K-Means, Fuzzy c-means (FCM), and Fast Fourier Transform (FFT), along with clustering techniques. The acquired characteristics are input into ML classifiers like GMM and SVM in order to construct a model. To evaluate and categorize, a range of performance metrics are employed, including accuracy, mistake rate, sensitivity, specificity, and more.

Keyword: *Fast Fourier Transform, Fuzzy c-means,K-Means, Lung Cancer, Support Vector Machine*

1. INTRODUCTION

The main causes of death in the globe are lung cancer which is leading in worldwide when compared to other disease. The highest predicted death rate of any type of malignant cancer is lung cancer. Lung cancer has the lowest human survival rate, even with early discovery, and the death rate keeps rising. The stage of detection and abnormal cell proliferation are strongly associated with lung cancer survival rates. On the other hand, lung cancer has a strong chance of survival if discovered early. Adults between the ages of 45 and 70 are more likely to develop this type of cancer. Lung cancer kills more people annually than all other cancer kinds combined, making up almost 25% of all cancer-related deaths.

While smoking was once thought to be the primary cause of lung cancer, other factors including heredity, occupational toxins (such as nickel, arsenic, asbestos, and radon), and other environmental factors (such as air pollution, indoor radon, and passive smoking) were also found to be causes of lung cancer. Non-small cell and small cell lung cancer are the two main categories of lung cancer. According to research findings overall, those with pathological phase I or phase II lung cancer had a survival percentage of 64.6% for those with pathological phase I illness and 41.2% for those with phase II sickness.

There are several other effective ways to diagnose lung cancer, including sputum cytology, MRI scans, and computer tomography (CT), a computer-aided detection method that can extremely accurately identify lung cancer at an early stage is becoming more and more desirable. The ultimate goal of this research project is to identify lung cancer from CT images and assess if it is normal or abnormal. To do this, a number of pre-processing steps will be used to improve the image dataset and extract the relevant features. Various classifiers will then be trained and tested on the image data in order to produce an output with a high degree of accuracy.

In contemporary times, the crucial role of artificial intelligence (AI) and machine learning (ML) techniques in healthcare cannot be overstated. Given their extensive applicability in predicting the risk of various health conditions, it is essential to establish regulations, as discussed in [1,2], to assess and facilitate the practical advancement of AI/ML-based software tools for early disease prediction and diagnosis. These tools are particularly focused on addressing common diseases such as diabetes (utilizing classification [3] or time-series tasks for continuous glucose value prediction [4]), hypertension [5], COVID-19 [6], hypercholesterolemia [7], COPD [8], stroke [9], cardiovascular diseases (CVDs) [10], acute liver failure (ALF) [11], sleep disorders [12], hepatitis C [13], metabolic syndrome [14], chronic kidney disease (CKD) [15], and more.

The following is how the paper is articulated: Chapter 2 discusses the related works of this project. Chapter 3 briefs about the Proposed system employed in this work. The Result and discussion of this work are explained in Chapter 4. The conclusion of this project is discussed in Chapter 5.

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2. LITERATURE SURVEY

Lung cancer is a condition in which mutated lymphocytes proliferate and develop into a tumour. Tumour cells can be transported out from the lungs by the bloodstream or the lymphatic fluids surrounding the respiratory system. Several alternatives are now being suggested, many of which are still in the conception phase.

An Artificial Neural Network-based Classification and Detection System [16] for Lung Cancer address the various challenges while developing a neural network which capable of effectively detecting and classifying Melanoma. The entire process commences with the pre-processing of dermoscopic images, by applying the Maximum Gradient Intensity algorithm so that it eliminates hairs and thus enhances the images. Segmentation, utilizing the Otsu Thresholding algorithm, is then applied to separate skin lesions from the images. Subsequently, various features such as ABCD, GLCM, and LBP are calculated from the segmented images to train the neural network.

The only screening procedure that medical professionals advise doing to check for lung cancer is a computerized tomography (CT) scan. Recently, it has been demonstrated that convolutional neural networks (CNNs) can effectively classify medical images. The Discrete Wavelet transform (DWT) has been widely employed [17] in image feature extraction applications because of its great compactness property. This research describes a unique method for classifying lung cancer in computerized tomography (CT) scans. CNN is used to classify the extracted features, while Wavelets are used to identify discriminative characteristics in the CT pictures.

The conventional techniques, which consist of three stages for segmentation, show encouraging results when applied to normal CT data, but they struggle when abnormal characteristics and fluctuations in image quality parameters are present. The quantity, quality, cost, and duration of training data generation all affect the ability to apply deep learning techniques that outperform conventional techniques. Therefore, an automated segmentation method [18] that is both clinically relevant and efficient is sought for the detection of respiratory disorders.

It is challenging to segment lung nodules that are connected to the chest wall or have ground-glass opacities robustly and correctly by applying However, using traditional image processing techniques. Thus, a deep learning model is adopted [19] to create a technique for the reliable and precise three-dimensional (3D) segmentation of lung nodule regions. This paper presented a new loss function and developed a nested 3D fully connected convolutional network with residual unit structures.

The amount of genes present and the intricacy of biological networks make it more difficult to understand and evaluate the resulting mass of data, which is made up of millions of measurements; these data also prevent noise, imprecision, and ambiguity. As a result, applying clustering algorithms provides a starting point for resolving these issues [20], which are crucial for data mining to uncover intriguing patterns and underlying structures in the data. Finding homology is another advantage of grouping gene expression data, and this is crucial for developing vaccines.

For the most precise separation of pathological from healthy lung segments, a reliable computer-aided disease diagnosis is much required. Fuzzy C-Means Clustering segmentation [21] is used to calculate each empirical dispersion of the image in order to determine the precise

boundaries of the regions. To differentiate between normal and pathological tissue, a Convolutional Neural

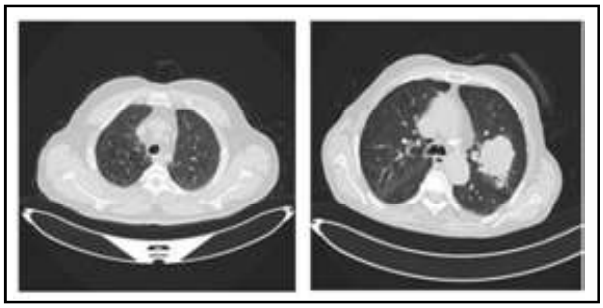

Fig.1 An example of normal and abnormal Lung CT scan image

A patient may have a greater chance of recovery and a cure with an early diagnosis. An important factor in the effective detection of cancer is technology. Several researchers have put forth various approaches in light of their findings. In order to address this issue with computer technology, a number of computer-aided diagnostic (CAD) methods and systems [22] have been suggested, created, and developed recently. These systems employ a variety of deep learning and machine learning approaches. A number of image processing-based techniques have also been proposed as means of predicting the cancer's level of aggressiveness.

3. PROPOSED METHODOLOGY

In this research work, the 100-image Lung CT imaging dataset-which includes 100 images-was taken from the Cancer Image Archive database for this study. To enhance image quality, multiple pre-processing steps are applied to the original raw photos. Then, using feature extraction techniques like clustering-based and transform-based feature extraction approaches, the key attributes from the image collection are extracted. Ultimately, many classifiers are employed to classify the images in order to get the best level of accuracy. The entire picture collection is divided into two groups for this study, and the CT lung scan images are trained and assessed using the ML techniques covered above. In this case, 80% of the entire dataset-or 80 images-is used as a training set, and the remaining 20%-or 20 images-are used for testing. The sample normal and abnormal lung CT scan image is shown in Figure 1, and the block diagram of this full work flow is shown in Figure 2.

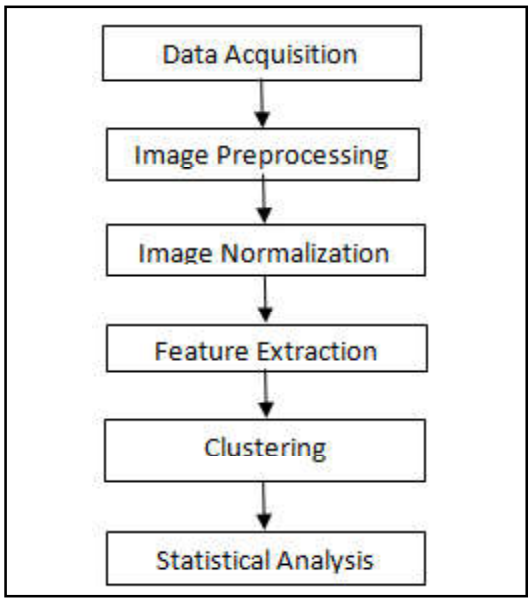

Fig.2 An example of normal and abnormal Lung CT scan image

3.1 Data Acquisition

Radiological imaging techniques such as chest X-rays and CT scans are commonly used for lung cancer screening and diagnosis. Various imaging features, including nodule size, density, and shape, can provide valuable information about the likelihood of malignancy. The features derived from imaging scans are highly informative for predicting lung cancer risk and are routinely used by radiologists to assess the likelihood of malignancy.

The data acquisition phase involves archiving, cleaning, pre-processing, and usage in subsequent processes which is also known as data procurement. The Cancer Image Archive database's 100-image lung CT imaging dataset was used for this investigation. Since the captured photos have a resolution of 512 by 512, there is no need to resize them.

3.2 Image Preprocessing

The process of getting images ready for model testing and training is called preprocessing. These include, among other things, resizing, orienting, and hue modifications. Preprocessing is required in order to get picture data ready for testing and training. Preprocessing could speed up model evaluation and reduce the amount of time needed for model training. Since the project's raw photos were obtained in RGB 3 dimensions, they were transformed to grayscale in order to ensure compatibility.

3.2.1. Grayscale Conversion

An image with grayscale hues for the principal colors is called a grayscale (or graylevel) image. These images differ from those other kinds of color images because each pixel requires less information. Any machine learning platform can be utilized to convert the color image into a grayscale version. Grayscale is created from the RGB image found in the database. The common RGB images are kept in a three-dimensional (3D) array in MATLAB. due to the fact that image analysis is not appropriate for 3-dimensional array images. In order to process the photos, the RGB images are converted to grayscale. The dimension is reduced to a two-dimensional array when the photos are converted to grayscale. When processing photos with 2-dimensional array images, MATLAB works really well. Figure 3 is an example of a lung CT image that is converted into a grayscale.

3.2.2.Filtering

One way to alter or enhance an image is through filtering. Filters, for instance, can be used to exclude some features and enhance others. Filtering is a step in image processing procedures like sharpening, smoothing, and edge enhancement. Three distinct kinds of filters are being employed in this research. The values of Mean-Square Error (MSE), Signal-to-Noise Ratio (SNR), and Peak SNR are obtained when the filters are applied. After applying the median, Gaussian, and Wiener filters, these values are compared, and Tables 1 and 2 display the error data values of normal and abormal images.

Table 1 FilterErrorData(Abnormal)

Filter	MSE	SNR	PSNR
Median	71.9831	14.4076	21.4726
Gaussian	71.9831	9.9642	17.0340
Weiner	71.9831	9.9963	17.0661

Table 2 FilterErrorData(Normal)

Filter	MSE	SNR	PSNR
Median	69.9268	14.3703	21.4853
Gaussian	69.9268	9.8782	16.9932
Weiner	69.9268	9.8641	16.9791

3.2.3. Median Filter

A nonlinear process called median filtering can be applied to lessen impulsive noise, frequently referred to as "salt-and-pepper" noise. Maintaining image borders while reducing noisy data is also advantageous. During execution, the Median Filter automatically adds the noise of salt and pepper. It will smooth the image more than the previous one and remove the noise. In this project, the MSE value for aberrant photos is approximately 71.9831%, and for normal images it is 69.9268. This is after applying a median filter to the images. The median filter is selected as the best filter for this project since it only produces high SNR and PSNR values when it is utilized. The lung CT scan image is seen in Figure 4 both before and after filtering with a median filter.

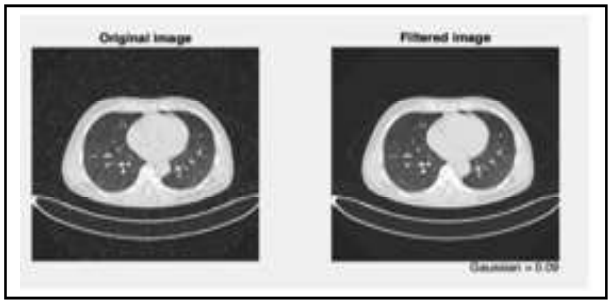

Fig.3 Grayscale Conversion

Fig.4 Lung CT scan image before and after filtering

3.3 Normalization

In image analysis, normalization is a process that modifies the image's pixel intensity spectrum. Procedures, for instance, use pictures with poor lighting disparity. A crucial step in ensuring that every input parameter-in this case, a pixel-has a comparable data distribution is data normalization. For instance, the K-Mean values are not in a specific range (42.8529829730499,42.5923274655992, 45.5145818571168) and are dispersed before normalization. There is not enough information here to extract features. As a result, normalize the cluster's data to a specific range (0-1).

3.4 Feature Extraction

Choosing a feature extraction technique is the most important step towards achieving high diagnostic accuracy. A more complex procedure called feature extraction aims to preserve most of the significant information in the data while transforming it into low-

dimensional data. Both transform-based and clustering-based feature extraction techniques are applied in this research. FFT is utilized for the transform-based feature extraction method, while K-Means and FCM are employed as a clustering-based approach. The normalization technique is used to normalize the data to the 0- 1 range because the image pixel values are spread out over a larger range.

3.5 Clustering

Clustering is an unsupervised machine learning technique used to distinguish between groups of similar and unrelated data. Unsupervised learning is a type of machine learning in which models are not trained using a training dataset. In other words, models identify hidden instances and bits of knowledge in the available data. There are two types of clustering: hard clustering, which assumes that every piece of data corresponds to a single cluster, and soft clustering, which assigns a likelihood or probability of each relevant data point being in those clusters.

3.5.1. K-Means Clustering

The process of finding local optimal solutions to clustering errors is the goal of the K-means algorithm. It is a fast iterative method that has been used in many different clustering situations. Among the techniques for unsupervised learning is K-means clustering. Finding clusters in the image pixels with the number of gatherings indicated by the variable K is the aim of this method. K stands for clustering that is centro-centric. The procedure comprises selecting k randomly chosen data points and aligning them all with the nearest centroid. The centroids are moved to the matching average point positions after each point has been assigned.Figure 5 displays the scatter plot of K-Means clustering utilizing values derived from K-Means feature extraction methods with the image dataset.

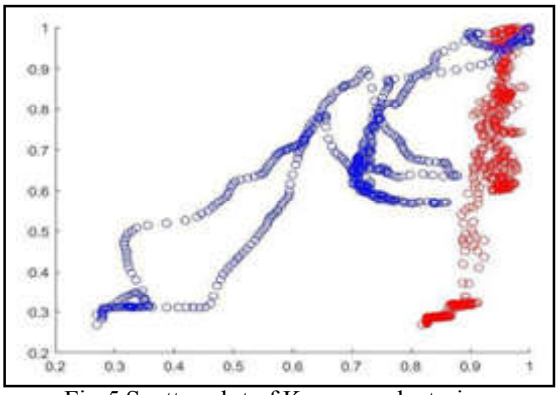

Fig.5 Scatter plot of K-means clustering

3.5.2. Fuzzy C-Means (FCM)

Fuzzy C Mean Clustering is used to illustrate soft clustering. It is among the most popular methods for clustering. The membership is allocated to every data point based on the separation between the cluster center and the data point. The pixel is more likely to belong to the cluster if it is closer to the center. The norm plot of FCM clustering using values obtained from FCM feature extraction techniques with both normal and aberrant picture datasets is shown in Figure 6.

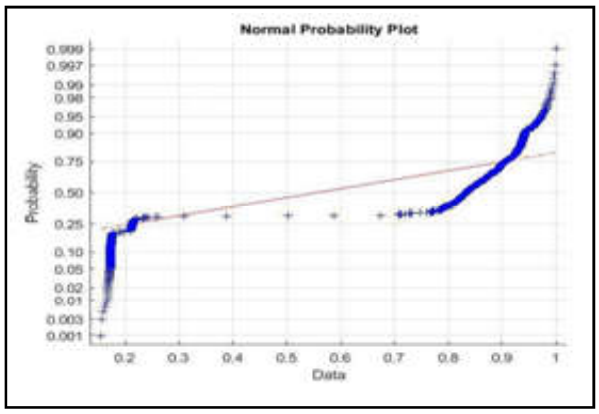

Fig.6 Normal Probability plot of FCM clustering

3.5.3 Fast Fourier Transform (FFT)

When spectrum or frequency domain analysis of an input is required, the Fast Fourier Transform is employed. When handling data in batches, this procedure is beneficial. The data input could be transformed into the frequency domain by means of the FFT from a buffer of N input data samples, as opposed to going through a series of multipliers with filter coefficients. The FFT transform-based feature extraction histogram plot, using values obtained from the FFT feature extraction approach with both normal and abnormal picture datasets, is shown in Figure 7.

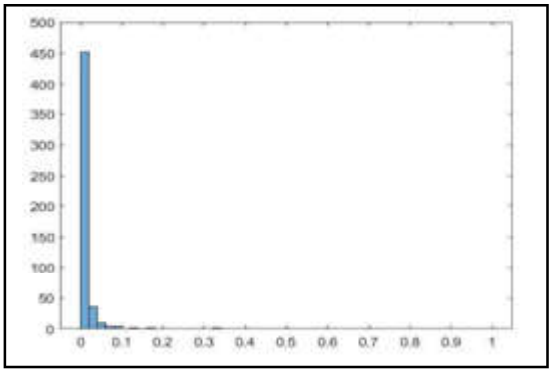

Fig.7 Histogram plot of FFT

3.6 Statistical Analysis

This section represents the summary of the parameters that were examined while applying feature extraction techniques, including mean, standard deviation, variance, skewness, and kurtosis.

Mean: The arithmetic average of a set of integers is called the mean. (For example, the sum of the data / the entire quantity of data)

$$m = \frac{Sum\ of\ Observation}{Total\ numbers\ of\ Observations} \quad (1)$$

Standard Deviation: A standard deviation represents the percentage of the data that is distributed around the mean. While an exclusive requirement deviation suggests that information is more distributed, a low standard deviation suggests that information is grouped close to the mean.

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}} \quad (2)$$

Variance: A true assessment of the variation among figures in a data collection is referred to as variants. Additionally, variations calculate the distance between each number in the set and the mean, and consequently, between each number in the set.

$$S^2 = \frac{\sum(x_i - \bar{x})^2}{n-1} \quad (3)$$

Skewness: To more precisely quantify the symmetry of a distribution, its absence of symmetry is employed. If a dispersal, or information collection, has the same appearance to the left and right of the center point, it is said to be symmetric.

$$\widetilde{\mu_3} = \frac{\sum_i^N (X_i - \bar{X})^3}{(N-1)*\sigma^3} \quad (4)$$

Kurtosis: It is used to assess if the data is heavy-tailed or light-tailed in relation to a normal distribution, that is, whether there is a peak or a flat surface.

$$Kurt = \frac{\mu_4}{\sigma^4} \quad (5)$$

Tables 3, 4, and 5 show the values of parameters like Mean, Standard Deviation, Variance, Skewness, and Kurtosis of different types of feature extraction methods of both normal and abnormal Lung CT scan images.

Table 3 K-Mean Feature Extracted Data

K- Mean		
Parameter	**Normal**	**Abnormal**
Mean	0.668753895	0.6840248408
StandardDeviation	0.1875371377	0.1846518009
Variance	0.03568714448	0.03490804251
Skewness	-0.4843798569	-0.4609552227
Kurtosis	-0.419471823	-0.2752280216

Table 4 FCMFeature Extracted Data

FCM		
Parameter	**Normal**	**Abnormal**
Mean	0.7830945659	0.7598592912
StandardDeviation	0.238071892	0.1905210018
Variance	0.05722818495	0.04090086034
Skewness	1.767017359	5.612029284
Kurtosis	-1.752785063	-1.917250521

Table 5 FFT Feature Extracted Data

FFT		
Parameter	**Normal**	**Abnormal**
Mean	0.01238094049	0.01151792598
Standard Deviation	0.05086042701	0.05045222792
Variance	0.002582197071	0.00254141823
Skewness	283.9271317	294.8651742
Kurtosis	15.35102004	15.7384019

4. RESULT AND DISCUSSION

In this research work, 100 lung CT scan images were used in this study, and they were from the Cancer Image Archive collection. Eighty percent and twenty percent of the dataset is used for training the classification algorithm, and the remaining portion is used for testing. The resulting classification algorithm and feature extraction techniques are assessed using performance indicators. Prior to using filtering techniques, the images undergo initial preprocessing to ensure compatibility. Mean-Square Error (MSE), Signal-to-noise ratio (SNR), and Peak Signal-to-noise ratio (SNR) were among the performance metrics that changed when the images were filtered using three distinct filters (i.e., Median, Weiner, and Gaussian filter). Following the application of the median filter to the normal picture dataset, the MSE value was approximately 699.92 percent, while the SNR and PSNR values were 14.37% and 21.48%, respectively. The median filter is the best choice for this project since it has a lower mean square error (MSE) and higher

signal-to-noise ratios (SNR and PSNR) than the Wiener and Gaussian filters. The SNR and PSNR values were 14.40% and 21.47%, respectively, and the median filter had an MSE value of 71.98% when the same filters were applied to the abnormal picture collection. The median filter is ideal for this project since it has greater SNR and PSNR values and a lower MSE value when compared to the other two filters (Wiener and Gaussian). The graphic representation of Filter Error Data of normal non-cancerous images and cancer images are shown in Figure 8 and Figure 9 respectively.

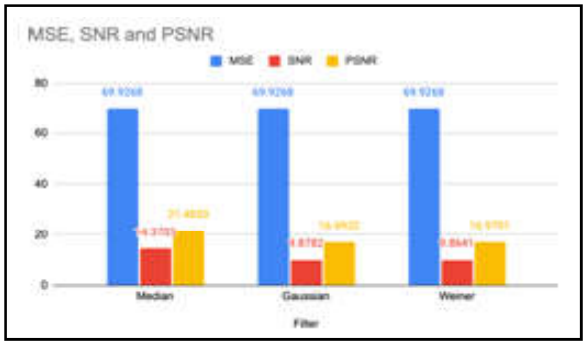

Fig.8 Graphical representation of Filter Error Data of normal images

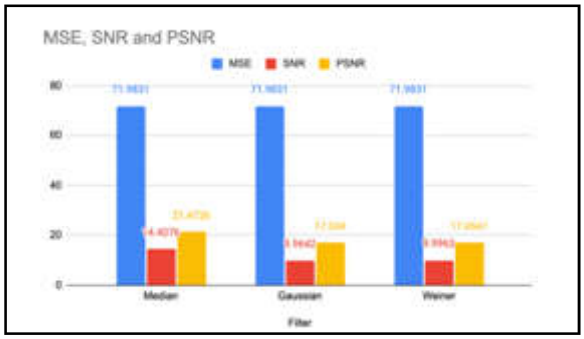

Fig.9 Graphical representation of Filter Error Data of abnormal images

In continuous to the selection of the optimal filter (in this example, the median filter), the filter is applied to each of the 100 images before feature extraction is carried out. K-Means, FCM, and FFT are a few of the clustering- and transform-based feature extraction techniques used in this study. To extract feature values like mean, standard deviation, variance, skewness, and kurtosis, these feature extraction techniques are applied individually to both normal and aberrant images. The feature values retrieved from both normal and abnormal lung CT scan images using the K-Means clustering-based feature extraction method are shown graphically in Figure 10, which is provided below.

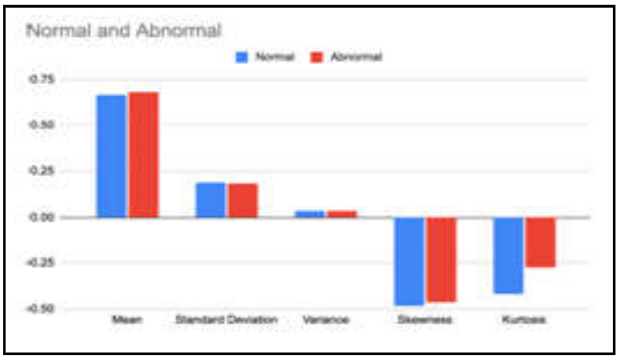

Fig.10 Graphical representation of feature values extracted through K-Means

The graphical representation of feature values obtained from both abnormal and normal lung CT scan images using the clustering-based FCM feature extraction method is shown in Figure 11 below.

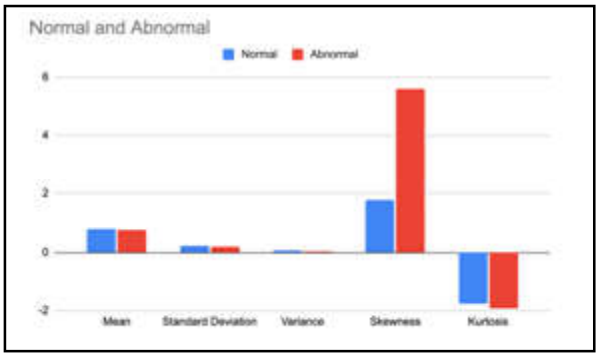

Fig.11 Graphical representation of feature values extracted through FCM

The graphical representation of feature values extracted using the transform-based FFT feature extraction method in both abnormal and normal lung CT scan images is shown in Figure 12 below.

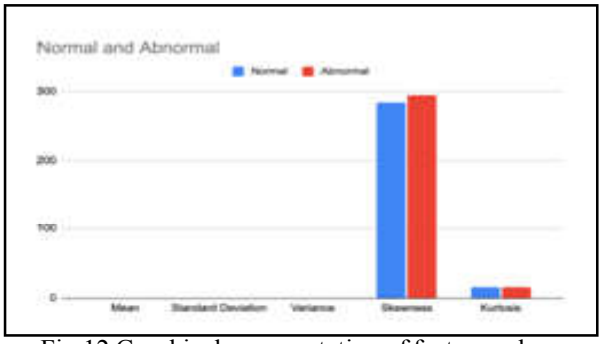

Fig.12 Graphical representation of feature values extracted through FFT

5. CONCLUSION

Although lung cancer can be fatal, many people have survived and recovered from the disease thanks to modern treatments, particularly when the disease is discovered early. The Cancer Image Archive database

is used in this work to gather and evaluate the lung CT imaging dataset. Preprocessing is done on the raw data to enable classification. Feature extraction locates the important information in a picture by using pre-processed data. These values can be employed in the classification process in subsequent work after the features have been retrieved and standardized. Classifiers like the Gaussian Mixture Model (GMM), Support Vector Machine (SVM), and others can be employed; in the future, the best feature extraction technique with the most accurate classifier will be figured out.

Also, in future, investigate the use of advanced feature extraction techniques, such as deep learning-based approaches, to automatically extract informative features from radiological imaging data (e.g., CT scans) without manual intervention. The integration of multi-modal data sources, such as radiological imaging, genomic data, and clinical notes, to capture complementary information will be explored to improve the predictive power of the model.

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NETWORK PHARMACOLOGICAL AND INSILICO EXPERIMENTAL VALIDATION STUDY ON MECHANISM OF TRIPHALA AGAINST HUMAN DISEASES

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Abstract

The present work attempts to extend the previous research that provides Triphala's network pharmacology to understand its common uses in ayurveda. Emblica officinalis, Terminalia belleria, Terminalia chebula were used in ayurvedic medicines to cure various corporeal problems. In the present study, oral bio-availability and drug likeness was examined to explore the mechanism of actions involved underlying various health problems. Further, the data was supported by GCMS metabolite profile and ADME screening within the combination synergy approach. The network pharmacology exploration was conducted using Databases-Binding DB, DAVID, KEGG and STRING. Cytoscape Combination synergy analysis was used to construct the networks that can be analysed with the neighborhood approach of network analyser. The project explores network pharmacology and established combination synergy using the extracted metabolites present in the plant samples.

Keyword: *Binding database, Metabolite screening, Network analysis, Pharmacology, Triphala*

1. INTRODUCTION

Triphala is a combination of Emblica officinalis, Terminalia belerica and Terminalia chebula. Triphala is one of the most popular polyherbal medicines suggested for oral consumption to prevent corporeal diseases and promote a healthy lifestyle. Three dried fruits native to India are proportionally mixed for medical purposes. Emblica officinalis, known commonly as Amla, exhibits antioxidant, anti-diabetic nature and further proves helpful in treating inflammation, ulcers and cancer (Ahmed et al., 2020). Terminalia chebula, a South Asian plant variety, predominantly used in treating gastrointestinal issues and improving metabolism (Meena et al., 2010. It is also used as a mild laxative. Terminalia belerica, a popular component of Indian Ayurveda medicines, treats digestive disorders and respiratory problems.

In Indian traditional medicine, the fruits of Terminalia belerica, Terminalia chebula and Emblica officinalis are commonly used (Elias et al., 2011; Kirtikar and Basu, 1991). These three active constituents make up the typical ayurvedic formulation Triphala, which applied as medication (Anonymous, 1952, 1976). Triphala is used in variety of other herbal formulas. T. belerica's half-ripe fruit and the pericarp of T. chebula have both been stated to be medicine (Chopra et al., 1956). T. chebula fruit has cardio-tonic activity and traditionally applied to treat asthma, urinary problems, and heart disease (Reddy et al., 1990[22]. E. officinalis fruit is depleted as a cardio-tonic, cerebral, and intestinal medicine in Ayurveda (Das et al., 2017) and it is anticancer (Rajarama Rao and Siddiqui, 1964; Aslokar et al., 1992)[1]. E. officinalis fruit is high in vitamin C, a well-known antioxidant (Anonymous, 1952; Halliwell and Gutteridge, 1985a)[9]. The remaining two constituents, T. chebula (Anand et al., 1994)[10] and T. belerica (Fu Naiwu, 1992), were discovered to control microsomal fatty acid formation. The crude extraction of E. officinalis could neutralize hepatotoxic and renotoxic metal (Roy et al., 1991) because of antioxidant content.

The EC_{50} values obtained from DPPH reduction indicated that Triphala's antioxidant function was synergistic. Because of synergistic results of different compound appeared in extracts, that was understood that crude extraction from plants were high active pharmacological (Hamburger and Hostettman, 1991)[10]. Triphala extraction (TB, TC, EO, and TR) is similarly effective at scavenging superoxide and peroxide radicals (Mahajan et al., 2011). Free radicals have the potential to damage biological systems (Saha and Tamrakar, 2011). They cause cellular damage, which

causes cancer, rheumatism, liver injury and ischemic heart disease (Halliwell and Gutteridge, 1985b)[24]. Some therapeutic outcome of *E. officinalis*, *T. chebula*, and *T. belerica* utilized in this research, such as anti-inflammatory (Sharma et al., 2018), antimutagenic (Grover and Bala, 1992), and antihepatotoxic (Anand et al., 1994), may be attributable to antioxidant effects. Plant extracts may be relatively safe for disease treatment (Valenzuela et al., 1986)[27], while artificial antioxidant cause poisonous effects (Williamson et al., 1978)[28]. Triphala can be used as an herbal medicine in clinical trials. The substance could help with free radical-induced diseases like paracetamol toxicity, heavy metal toxicity, radiation toxicity.

In previous researches on Triphala, it is noted to have radioactive protecting nature and also, antimutagentic (Kaur et al., 2005; Vani et al., 1997). Triphala is rich in Vitamin C, flavanoids, gallic acid, chebulanic acid as noted by Jagetia et al. (2002). Our study elaborates on this nature of Triphala. In addition, using phytochemical analysis, we studied the antioxidant and anti-diabetic properties of Triphala via In Vitro studies.

2. MATERIALS AND METHODS

2.1 Phytochemicals and Proteins

We gathered the following plants: *Emblica officinalis*, *Terminalia bellerica, Terminalia chebula* from the herbal garden of Bannari Amman Institute of Technology, Sathyamangalam. The taxonomic authentication was done at Botanical survey of India, Tamil Nadu Agriculture University, Coimbatore. We developed a database with SMILES from the phytoconstituents of the plants mentioned above using PubChem CID (http://pubchem.ncbi.nlm.nih.gov/). Phytoconstituent duplicates were removed. The queries SMILES with similarity of 70% and known ligand molecules were infrared using BindingDB.

2.2 Targets: Binding Database & Protein Databank

To predict target proteins, bioactive structures were fed to Binding Database (http://www.bindingdatabase.org/) as '.sdf' files (Liu et al., 2007). Ligands interact with target candidates in BDB. The similarities in ligand structures and scores were used to predict drug targets. It is applied explicitly for homosapien species. With this collection, this study formed a protein database for the related phytoconstituents.

2.3 Target Genes Construction of Identified 'triphala' Compounds

Phyto-chemicals' genes were derived from varied sources.We had used UniProt (http://www.uniprot.org/) to acquire the official names of genes and further, limited it to 'Homo sapiens' species alone. Subsequently, UniProt IDs were produced for targets. Data regarding 'Triphala' was exhibited as herbs-ingredients-targets relationship dataset.

2.4 Analysis of Human PPI Subnetwork

STRING was used in identification of First degree interactions of all the target proteins (Szklarczyk et al., 2014). The high confidence interactions (score >=0.9) were used to design PPI, while duplicates were removed. The Markov Cluster algorithm (MCL) (Enright et al., 2002) was used. The critical two factors determine the score: matching of protein and matching of interaction. High-confidence nodes and edge determine the high final scores for many interactions. PPI data is obtained from STRING (Search Tool for the Retrieval of Interacting Genes) database. STRING version 11.0 was used to acquiring the required PPI data, limiting the interaction to "Homo sapien" species with a confidence score > 0.4 as already deliberated in Wang, Liu et al. (2019). The targets were selected based on the higher levels of connections.

2.5 Network Analysis

STRING (https://string-db.org/) queries credible targets and further analyses protein-protein interaction in molecular function, cellular components, and biological processes. Pathways of Proteins that are probable are identified in the KEGG database (Naik et al.,2005).

2.6 Extraction

The plants *P. emblica* T. *chebula* and *T. bellirica* were obtained from Herbal Garden, Bannari Amman Institute of Technology, Sathyamangalam. The plants, once washed under running water, were twice washed with sterile water. The fruits were separated from plants and dried under shade for 8 days. Dried fruits were powdered separately and were preserved in airtight containers. While a portion of the powders from each container were soaked separately in ethanol for a week, another piece of each plant was mixed in the ratio 1:1:1 to be washed in ethanol for one week. Therefore,

allowing us to have four samples of extracts: TEE- Triphala Ethanolic Extract; BEE- Bellarica Ethanolic Extract; AEE- Amla Ethanolic Extract; CEE- Chebula Ethanolic Extract. The above extracts were prepared by filtering the ethanolic compositions using Whatman Filter paper and drying the filtrate using Vacuum drier. In addition, the brown mass residue was stored at the temperature -4°C.

2.7 Antioxidant Assay

The PM (Phosphomolybdenum) method assesses the extracts for antioxidant property, developing from a procedure suggested by Prieto et al. (1999) was used. 3ml of reagent solution, a combination of 28nM sodium phosphate, 4mM ammonium molybdate and 0.6M sulfuric acid, was blended with varied concentrations (50-500ěL) of plant extracts separately. Further, the reaction solutions were placed in test tubes and incubated for ninety minutes at 95°C. (Gunes et al., 2007). Then, the solution is left at room temperature to cool down. After which, we used a UV spectrometer to measure the absorbance of the solution and observed it to be of wavelength 695nm. The reference standard to measure absorbance was Ascorbic acid (Vitamin C).

2.8 α - Amylase inhibition assay

α Amylase inhibition was carried out with standard protocol. 0.5M Tris HCl buffer (pH 6.9) and 0.01M CaCl, each of 0.2 ml, were taken in test tubes. Each of the test tubes 2 mg of starch was suspended. Test tubes with the solutions were boiled for five minutes in a water bath and incubated at the temperature of 37! for another five minutes (Anandhu et al., 2021). The different concentrations of DMSO [20-100 µg/ml] were taken in each test tube, respectively, and 0.2 ml of the extract was added.Q amylase was dissolved in Tris-HCl to form a concentration of 2 units/ml. 0.5ml of 50% acetic acid was added to halt the reaction. The centrifugation of solution at 3000rpm was performed for five minutes at 4!. UV spectrometer was used to measure the absorbance at 515 nm (Yang et al., 2012).

2.9 α - Glucosidase Assay

α-Glucosidase inhibition was carried out with standard method. The enzyme was diluted by dissolving 0.5mg glucosidase in 10ml phosphate buffer (pH 7.0), containing 20mg bovine serum albumin (BSA). In 400µl DMSO 4mg sample extract was added. Different concentration [50-250] were prepared. 5 each of sample is then added to 250µl of 20mM p-nitrophenyl -á -d -glucopyranoside and 495 of 100mM PBS, or phosphate buffer (pH 7.0) solution which was incubated for fifteen minutes at temperature of 37°C. The addition of 250µl of enzyme starts the reaction. 250µl of phosphate buffer is added to DMSO without enzyme is used as blank. The termination of reaction was done by addition of 1000 µl of 20mM NaCl. The amount of nitrophenol released was observed by reading absorbance at 400 nm using UV spectrometer (Dabhi et al., 2013).

3. RESULTS AND DISCUSSION

3.1 Potential Target Genes Associated Compounds

The potent significant compounds identified through GCMSanalysis of the plant extracts are given in table 1

Table 1 Selected Compounds of Triphala Plants

Sl. No.	Compound	OB (%)	DL	Herb
1	Ellagic acid	44.06	0.53	TC,TB,PE
2	Gallic acid	31.68	0.05	TC,TB,PE
3	Corilagin	4.01	0.38	TC,TB
4	Chebulic acid	73.00	0.42	TC,PE
5	Quinic acid	56.92	0.07	TC
6	Chebulinic acid	34.48	0.23	TC
7	Methyl gallate	31.91	0.06	TB
8	Ethyl gallate	26.51	0.07	TB
9	Salicin	8.15	0.17	TB
10	Teresautalic acid	42.43	0.08	TC
11	Mucic acid 1,4-lactone 5-0-gallate	53.26	0.37	PE
12	Mucic acid 1,4-lactone 2-0-gallate	50.56	0.41	PE
13	Phyllaemblicacid methyl ester	44.09	0.74	PE
14	Phyllaemblicin A	46.53	0.78	PE
15	Phyllanthin	34.31	0.43	PE
16	α-amyrin	40.51	0.77	PE
17	Ellipticine	31.82	0.29	TC
18	Luteolin	37.16	0.26	PE
19	Leucodelphinidin	44.45	0.32	PE
20	7-Dehydrosigmasterol	38.42	0.76	TC

3.2 Network Analysis

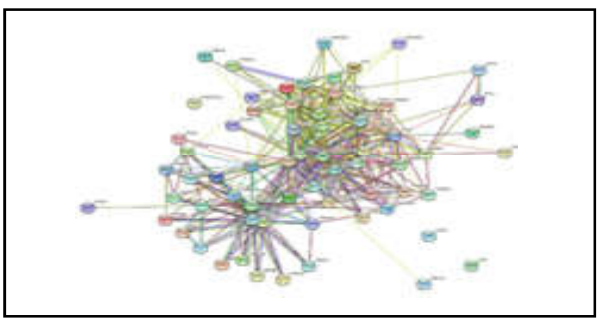

Fig.1 Network analysis

3.3 String Network

STRING is a network of molecular associations. The expansion of a network results from additional proteins. One can observe evidence of various STRING types in a particular network (The following figures- Fig 4.3.1, 4.3.2, 4.3.3, 4.3.4, and 4.3.5 records the proteins in each of the networks). However, not all recorded links contribute to high-scores after calibration with 'highest' set at a cut-off of 0.900. Consequential regulated phosphorylation sites are provided in the STRING network of proteins during a study of phosphor-proteomics. Blue-whitered gradient nodes denote Log-ratios between diseased tissues and healthy tissues from the site for each protein. Singletons which are proteins that have no interaction partners within the network are avoided in the animated diagram.

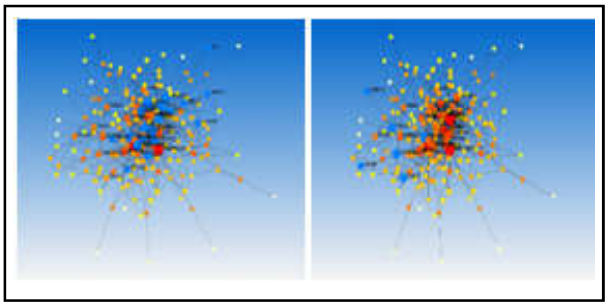

Fig.2a Hepatitis B Fig.2b Gastric secretion

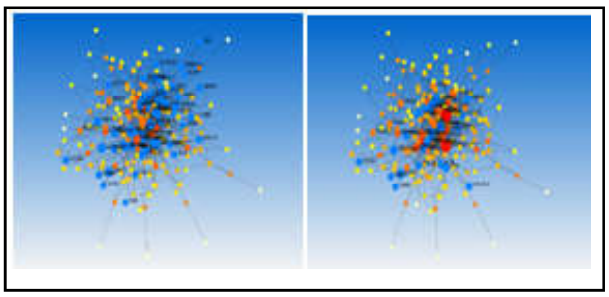

Fig.2c Pathways in cancer Fig. 2d Chemokine signalling

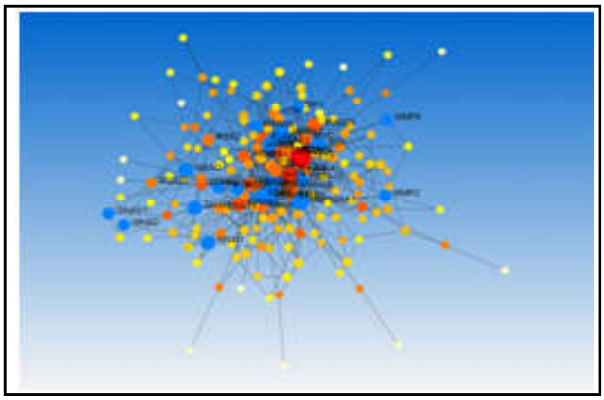

Fig.2e Estrogen signaling pathway

3.4 Functional Potential Gene based on KEGG Pathway

Kyoto Encyclopedia of Genes and Genomes illustrates via network diagram the molecular interactions (www.genome.jp). Network Analysis is instrumental in gene expression profiling. Our input genes (ensembl gene id) of the target proteins were fed into the KEGG platform. In specific, we used the data for the homo sapiens species during the process. Then, the software removed the duplicates. We chose tissue specific PPI, explicitly stomach tissues. Further, cancer pathways, Chemokine signalling, Estrogen signalling, Hepatitis B, and gastric acid secretion were selected for our project. In our project, MMP2,EGFR,MAPK3,STAT3 are noted as center genes.

Table 2 Functional Potential Gene based on KEGG Pathway

PATHWAYS IN CANCER	MMP2 EGFR CASP9 ERBB2 TP53 HSP90AA1 GNAI3 SMAD3 MAPK1 HIF1A MAPK3 STAT3 ABL1 MYC PRKCA CTNNB1 DCC F2R GNA13 GNAI1 JUN VEGFA GRB2 CDH1 GNB2 JAK1 FN1 PIK3 R1H SP90 AB1 PTGS2 GNB1 GNB4 MMP9 AGTR
ESTROGEN SIGNALLING PATHWAY	MMP2 EGFR SRCH SP90 AA1 GNAI MAPK1 MAPK3 HSPA1 AGNAI1 SHC1 JUNGRB2 PIK3 R1H SP90 AB1 PGR MMP9 GNAQ GNAO1 HSPA8 GNAI2 SP1
HEPATITIS B	CASP9Y WHAQ TP53 SRCS MAD3 MAPK1Y WHAB MAPK3 STAT3 MYCP RKCA JUN GRB2 JAK1 PIK3R1 MMP9 IL6 RELAP TK2B
GASTRIC ACID SECRETION	GNAI3 PRKCA GNAI1 CHRM3 ACTB GNAQ GNAI2
CHEMOKINE SIGNALLING PATHWAY	SRC GNAI3 MAPK1 MAPK3 STAT3 PIK3 GARRB2 GNAI1 ARRB1 PARD3 SHC1 GRB2 GNB2 PIK3R1 GNB1 GNB4 LYNHC KGSK3 BREL AGNAI2 PTK2B

3.5 Antioxidant Assay

The antioxidant nature of the Triphala extract and its components' extracts were gauged using phosphomolybdenum method (PM) and further, comparing them to Ascorbic acid solution equivalents

(Oktay et al., 2003). In the process, we used ascorbic acid in concentrations ranging from 50 to 500 ĕg/ml. With increasing dosage of ethanolic extracts of Triphala, it is observed that there is an increase in antioxidant capacity. In radical scavenging activity, extract behaviour depended on the extracts' concentration with the highest scavenging rate at 500 µl and lowest at 50 µl. PM method is a prominent antioxidant assay where the antioxidant reduces Molybdenum (VI) to Molybdenum (V). Further, the compound forms Molybdenum (V) complex/green phosphate with 695nm wavelength as the highest absorbance (Selvakumar et al., 2011).

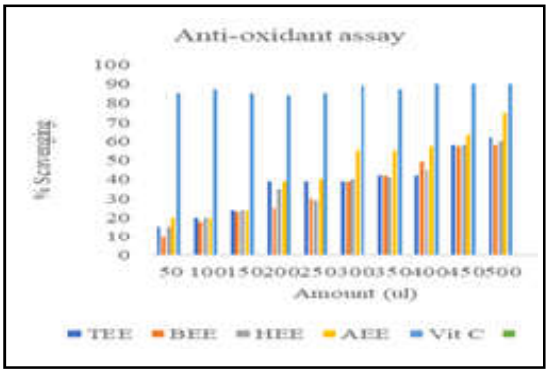

Fig.3 Antioxidant Assay

TEE showed maximum PM radical scavenging activity with 62±0.2% and lowest with 15±0.2%. BEE showed maximum activity with 58±0.3% and lowest with 10±0.3%. In HEE, maximum PM radical scavenging activity was 60±0.5% and lowest was 14±0.5%. AEE showed maximum activity with 75±0.4% and lowest with 20±0.4%. The graph renders the amount of free radical scavenging in the aqueous extract of triphala and its constituents when compared to ascorbic acid (vitamin C) (Parveen et al., 2018) We note that its maximum PM radical scavenging activity was 90±0.3% and lowest 85±0.3%. AEE exhibited the high PM scavenging activity followed by TEE, HEE and then, BEE, which was the least.

3.6 α-Glucosidase and α-Amylase Inhibition

α-Amylase and á-glucosidase inhibition activity of triphala extract showed remarkable amylase inhibition potential 49.7% at concentration 250µg/ml. The percentage inhibition of á-amylase and á-glucosidase ranged between 8.5%-42.6% and 6.3% - 41.5% respectively. At the concentration of 250µg/ml, there is around 16% difference in á-amylase inhibition value between ethanolic extract and standard solution. In α-glucosidase inhibition, we see 7% difference in values between standard solution and ethanolic extract.

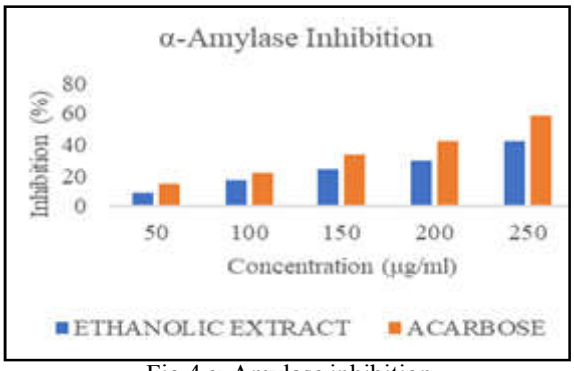

Fig.4 α-Amylase inhibition

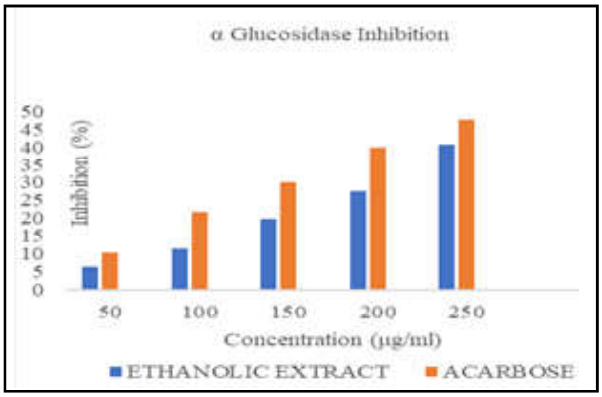

Fig.5 α –Glucosidase inhibition

4. CONCLUSION

Our study proposes that constituents of 'Triphala' in the ethanolic extract are a convenient source for natural antioxidants and could be utilized as food supplements. Further, we establish that characteristic antioxidant activity can be ascribed to the traces of alkaloids, phenolic compounds, saponin glycosides, flavonoids and tannins in the ethanolic extract of 'Triphala'. In isolating and identifying the antioxidative components in 'Triphala', *Emblica Officinals* (AEE) or Amla, is highly antioxidative. However, the ethanolic extract of 'Triphala' contains more antioxidant properties than its components verified separately. The ethanolic extract of 'Triphala' compound also displayed antidiabetic properties. It showed a remarkable amylase inhibition potential of 49.7% at concentration of 250µg/ml. We suggest that further research could be undertaken to study the components responsible for the antidiabetic property of 'Triphala' and its constituents.

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STUDIES ON SUSTAINABLE BIOCONVERSION OF TANNERY EFFLUENTSTO BIODIESEL

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Abstract

The disposal of tannery effluent poses a significant environmental challenge due to its high contentof toxic pollutants. The main objective is todevelop an environmentally friendly and cost-effective approach that industries can readily adopt to mitigate the environmental impact of tannery wastewater. In pursuit of this objective,the research work focuses on harnessing the considerable amount of fats in tannery effluent for biodiesel production.This paper deals with the characterization and pretreatment of tannery industry effluent for producing Biodiesel, a renewable alternative fuel.This research holds immense potential for reducing the destructive impact of tannery effluent on ecosystems and promoting sustainable practices within the leather industry.Biodiesel is produced from tannery effluent throughthe transesterification process using NaOH as a catalyst.The research work also considers the optimization of process parameters such as reaction temperature, retention time,amount of catalyst, and alcohol-to-oil molar ratio to enhancebiodiesel production. The optimized conditions of the transesterification reaction were a reaction temperature of 60 to 65!, a reaction time of 10 mins, a 15:1 alcohol-to-oil molar ratio, and a 0.9% NaOH catalyst.The research work contributes to the ongoing efforts to mitigate pollution and safeguard our natural resources by offering a comprehensive and innovative solution.

Keywords: *Biodiesel, Bioconversion, Sustainable, Transesterification, Tannery effluent*

1. INTRODUCTION

In an era defined by the dual imperatives of environmental sustainability and the quest foralternative energy sources, the convergence of these two paramount concerns has given rise toinnovative and unconventional solutions.[1] This report embarks on a journey at the intersection of sustainable waste management and renewable energy production, exploring a remarkable synthesis of science and sustainability[2].

Tannery industry effluent, a byproduct of the leather manufacturing process, presents a unique setof challenges and opportunities. Notorious for its intricate composition comprising lipids, organicmatter, and heavy metals, this effluent has historically been a nettlesome waste material requiringrigorous treatment and disposal.[3] However, within this complexity lies an untapped resource: thepotential to convert tannery effluent into biodiesel. Our research work boldly ventures into this unchartedterritory, aiming to unravel the mysteries of tannery effluent as a viable feedstock for biodieselproduction. Beyond the conceptual stage, we have executed a meticulous pilot-scale study, delvinginto the intricacies of transforming tannery effluent into a green energy source.[4] Complementingthis experimental endeavor is a thorough techno-economic analysis, where we delve into thefinancial and environmental implications of our innovative process.

This research work underscores the overarching significance of waste-to-energy approaches in today'senvironmental discourse. It stands as a testament to the ingenuity and determination of researchersseeking alternative pathways to address environmental challenges while concurrently advancingthe cause of sustainable energy production.[5] In the pages that follow, we shall embark on acomprehensive journey through the multifaceted landscape of biodiesel production from tanneryindustry effluent [2].

Together, we will explore the intricacies of the conversion process, examine theresults of our pilot-scale study, dissect the nuances of the techno-economic analysis, and reflectupon the broader implications of this pioneering work.

The primary objective of our research work is to develop a comprehensive understanding of the process involved in converting tannery industry effluent into biodiesel[6]. We aim to assess the technical feasibility of utilizing tannery effluent as a sustainable feedstock for biodiesel production and establish the optimum conditions and parameters for this process. We conducta comprehensive characterization of the effluent to understand the quality and suitability of tannery effluent as a biodiesel feedstock. This includes analyzing its lipid content, fattyacid composition, impurities, heavy metal concentrations,andother relevant parameters[7]. Weexplore opportunities for process optimization to enhance biodiesel yield and quality whileminimizing resource consumption. This may involve investigating different catalysts, reactionconditions, and purification methods tailored to the unique properties of tannery effluent. Ourresearch work includes a comparative analysis of biodiesel produced from tannery effluent with biodieselobtained from conventional feedstocks, such as vegetable oils or animal fats.[8]

In summary, the presentresearch work encompasses a wide range of activities, from understanding the nature of tannery industry effluent to the fundamentals of biodiesel production from tannery effluent.

2. MATERIALS AND METHODOLOGY

2.1 Materials

The transesterification was carried out using the tannery industry effluent collected from a nearby leather company in Erode.The catalyst used was Sodium hydroxide (NaOH), and the alcohol used was ethanol(99.0%).Other chemicals such as phenolphthalein indicator, potassium hydroxide (KOH), Hydrochloric acid (HCl), and Distilled water were utilized for the characterization of collected tannery effluent.

2.2 Characterization of Tannery Effluent

Characterizing tannery effluent is a fundamental step in understanding its composition and the challenges it poses for subsequent treatment and biodiesel production[9]. In the context of this research work, the characterization process aims to provide a comprehensive overview of the physical and chemical properties of the effluent. This allows researchers to tailor the treatment process to effectively address its unique characteristics.[10]

2.2.1 Physical Factors

One aspect of characterization involves evaluating the physical factors of tannery effluent. These parameters include color, odor, turbidity, total suspended solids (TSS), total dissolved solids (TDS), and electrical conductivity.

2.2.2 Chemical Factors

Characterizing the chemical factors of tannery effluent is essential for understanding its composition and the potential challenges it presents for subsequent treatment processes. These chemical factors provide valuable insights into the water quality and pollution levels. In the context of this research work, let's delve into the characterization of key chemical parameters, including Biological Oxygen Demand (BOD), pH, Dissolved Oxygen (DO), acidity, alkalinity, and hardness.

2.3 Pretreatment

The pretreatment processes employed in the Biodiesel Production from Tannery Industry Effluentare vital initial steps to ensure that the tannery effluent is suitably prepared for the subsequent biodiesel production process. These pretreatment processes serve the dual purpose of reducing the impurities and adjusting the effluent's chemical properties to create an environment conducive to microbial conversion.[11]

2.3.1 Removal of Solid Impurities

The effluent collected from tannery facilities typically contains solid particles, such as leather residues and suspended matter[12]. To address this, a preliminary step involves solid-liquid separation techniques, including sedimentation and filtration. These processes help eliminate larger solid impurities, thereby preventing clogging and damage to equipment in subsequent stages.

2.3.2 pH Adjustment

The reported high pH of 12.7 necessitatesadjustment. Extreme pH levels can hinder the activity of the treatment reaction. Therefore, an acid or base (depending on the specific pH) is added to bring the pH to a more neutral range, typically around 7. This adjustment creates an optimal environment for the effluent treatment processes.

2.4 Optimization of Process Parameters

2.4.1 Concentration of Catalyst

Sodium hydroxide is used as the catalyst for transesterification of tannery effluent. Other parameters of the transesterification process were kept constant to optimize the catalyst concentration. The transesterification was done with a methanol-to-oil ratio of 12: 1 and temperature of 60! to 65! with a concentration of NaOH (Sodium hydroxide) varying from 2% to 10% in 5 different reactions. After every reaction, the glycerol separation was observed.

2.4.2 Alcohol-to-oil Ratio

Transesterification of tannery effluent was carried out with different alcohol-to-ratios for the optimization of methanol concentration. The methanol to oil ratio was set as 6:1, 9:1, 12:1, 15:1, and 18:1 in five different reactions with a catalyst concentration of 8% and temperature of 60! to 65!. After every reaction, the glycerol separation was observed.

2.4.3 Retention Time

The retention time of the reaction is optimized by performing the reaction with a temperature of 60! to 65!, methanol-to-oil ratio of 12:1, NaOH concentration of 8%, and retention times set from 30 minutes to 60 minutes with a 10 minutes difference in each reaction. The conversion of oil to biodiesel is observed for the optimization of retention time.

2.5 Transesterification Reaction

The transesterification process involves the conversion of triglycerides into biodiesel in the presence of a catalyst. The key factors affecting the transesterification process are reaction temperature, methanol-to-oil molar ratio, amount of catalyst, and reaction time. The transesterification process was carried out in a 250 ml conical flask. Add 100 ml of treated effluent into the flask and place in a magnetic stirrer at 350 rpm. Regularly monitor the temperature of the effluent as it should not exceed 65!, as fatty acids could get denatured. Maintain the temperature at 60!. Prepare 8% KOH by dissolving in methanol (methanol to oil ratio = 12:1). Once the temperature is reached slowly add the catalyst and allow the mixture for 30 mins for the reaction to take place. After the completion of the reaction, remove the flask and allow the reaction mixture to cool down and equilibrate, resulting in the separation of two phases.

2.6 Separation and Purification

After transesterification, the ester can be separated from glycerol using simple gravitational sedimentation, but it must be washed to remove alkali traces. Conventionally, biodiesel is purified using water and dry-washing technologies. Due to the water-soluble nature of sodium salts and soap formation, water could be used to eliminate it. For that transfer the mixture to the separating funnel, close the funnel using a stopper, and fix it to the clamp. There will be a visible two-phase separation in the funnel with the upper phase consisting of biodiesel and the lower phase consisting of glycerol and other impurities. Place a beaker below the separating funnel and collect the lower phase by gently opening the stopcock. Now, transfer and measure the quantity of the upper phase i.e., crude biodiesel. To purify the crude biodiesel liquid-liquid extraction procedures are followed. Ensure that the crude biodiesel is at room temperature. Based on the volume of biodiesel, calculate an appropriate volume of the polar solvent (hexane). A solvent-to-biodiesel ratio of 1:1 is commonly used. The solvent should be cooled to the same temperature as the biodiesel. Add the measured volume of biodiesel to the separatory funnel. Add an equal amount of solvent. Close the funnel tightly and invert it several times to mix the two layers. Don't shake it vigorously. Place the funnel in a clamp and leave it alone until the two layers separate.

Leave it undisturbed for some time. Slowly open the funnel's stopcock to drain the lower layer, which will contain the impurities (FFAs, glycerol, soap). Collect the lower layer and place it in a separate flask for treatment or disposal. To get rid of remaining impurities and solvent, rinse the separated biodiesel layer with distilled water. The funnel should be filled with distilled water, closed, and gently shaken. Drain the water layer after allowing the layers to separate once more. Until the pH of the water layer is close to neutral, the washing process is repeated. To remove any remaining water, mix a small amount of anhydrous sodium sulfate or magnesium sulfate into the extracted biodiesel. Decant the biodiesel into a clean container only after the drying agent is settled. Finally check the purified biodiesel's viscosity, acidity, and ester content to see if it adheres to the desired specifications.

3. RESULTS

3.1 Properties of Tannery Effluents

Water analyzer was used for analyzing the tannery effluent to determine its composition and characteristics. This analysis showed that the effluent comprises a complex mixture of organic compounds, including triglycerides, free fatty acids, and other contaminants such as heavy metals and suspended solids. The high organic content indicated the potential for biodiesel production, but the presence of impurities and contaminants required effective pre-treatment. Table 1 shows the values of the properties analyzed using diff ity, TDS

Fig.1 Water Analyzer

Table 1 Characterization of Tannery Effluent

Sl. No	Property	Units	Sample 1	Sample 2
1	Conductivity	(S/m)	49.2	78.5
2	Salinity	(ppt)	30.6	54.7
3	Resistivity	(Ω.m)	0.0203	0.0127
4	TDS	(ppt)	30	44.7
5	pH	-	12.7	4.04
6	Saponification value	(mg KOH/mg sample)	28.89	-

The ability of the effluent to conduct electrical current is measured by conductivity. Here, it's an indicator of the effluent's ionic content. The conductivity of Sample 2 (78.5 S/m) is significantly higher than that of Sample 1 (49.2 S/m). This implies that Sample 2 has a higher concentration of dissolved ions, which could be due to a higher salinity or ion content. High conductivity can have an impact on the transesterification process because it can introduce additional ionic impurities that can interfere with the chemical reactions that occur during biodiesel production. The concentration of dissolved salts in effluent is indicated by salinity. Thus, elevated salinity levels can have an impact on biodiesel quality and transesterification efficiency. Sample 2 has a salinity of 54.7 ppt, which is significantly higher than the salinity of 30.6 ppt in Sample 1. This indicates that Sample 2 has a higher concentration of dissolved salts. High salinity can reduce biodiesel production efficiency and may necessitate additional salt removal steps or specialized treatment to mitigate its impact.

Resistivity is the reciprocal of conductivity and measures the effluent's resistance to electrical flow. It provides insight into the purity of the effluent. Sample 2 (0.0127.m) has lower resistivity than Sample 1 (0.0127.m), indicating that Sample 2 has better electrical conductivity. Lower resistivity may be desirable for the transesterification process because it indicates less resistance to electrical flow, which may aid in more efficient reactions. TDS (Total Dissolved Solids) is a concentration measurement of all dissolved substances in effluent, including salts, minerals, and organic matter. Sample 2 has a higher TDS value (44.7 ppt) than Sample 1 (30 ppt), indicating that Sample 2 has a higher concentration of dissolved substances. TDS levels above a certain threshold can have an impact on biodiesel quality and may necessitate additional purification steps. The pH of effluent determines its acidity or alkalinity. Sample 1 has a pH of 12.7, indicating that it is highly alkaline, whereas Sample 2 has a pH of 4.04, indicating acidity. An alkaline pH may necessitate acidification, whereas an acidic pH may necessitate alkaline adjustment. During biodiesel production, this parameter must be carefully monitored[6].

The saponification value is essential for assessing the effluent's suitability for transesterification. A higher value indicates a higher amount of free fatty acids in the effluent, which can be converted into biodiesel. However, it also implies a greater requirement for alkali in the process. We performed a saponification test by dissolving 10 ml of the sample in 0.5 N KOH. This mixture was reflux condensed for 30 minutes and a few drops of phenolphthalein indicator was added once the temperature cooled down. Then the mixture was titrated against 0.5 N HCl until the disappearance of pink colour. The burette reading was noted and the saponification value was obtained using the equation [1]:

$$\text{Saponification value} = \frac{56.1 \times (B - S) \times N \text{ of HCl}}{\text{Gram of Sample}} \quad (1)$$

Where B is ml of HCl required by blank, S is ml of HCl required by sample and N is normality of HCl used. The

obtained B and S readings are 209.4 and 199.1 respectively. N of HCl is 0.5. Thus, by substituting the values in the equation [2],[3],

$$\text{Saponification value} = \frac{56.1 \times (209.4 - 199.1) \times 0.5}{10} \quad (2)$$

$$\text{Saponification value} = 28.89\text{mg}\ \frac{KOH}{mg}\ \text{sample} \quad (3)$$

3.2 Pretreatment of Effluent

The large solid particles were removed after filtration and precipitants such as lime were added to precipitate chromium and other heavy metals, which were removed by a followed-up sedimentation process. Other organic matter in the effluent was removed by the adsorption process of the activated carbon. pH of the effluent was adjusted to 8-9 and was made ready for the transesterification process.

3.3 Optimization of process parameters

The optimized values of the biodiesel production process are obtained based on the higher yield, effective glycerol separation, and efficient conversion of effluent to biodiesel through the transesterification process. The optimized process parameters were temperature maintained between 60! to 65!, methanol-to-oil concentration of 12:1, NaOH concentration of 8%, and retention time of 50 minutes [7].

3.4 Production of Biodiesel

As shown in Fig.2 the esterification reaction was conducted out at 60! for 1.5 h contact time. Sodium hydroxide was used to initiate the esterification reaction. The change in properties of the effluent was observed. After the esterification process, the mixture was cooled down and two-phase separation was observed. They were separated using a separating funnel and further purified by treating it with hexane, water, and anhydrous sodium sulphate.

Fig. 2 Transesterification process

Pure biodiesel is obtained (Fig.3). The yield of biodiesel is 1/3 the quantity of effluent used for biodiesel production.

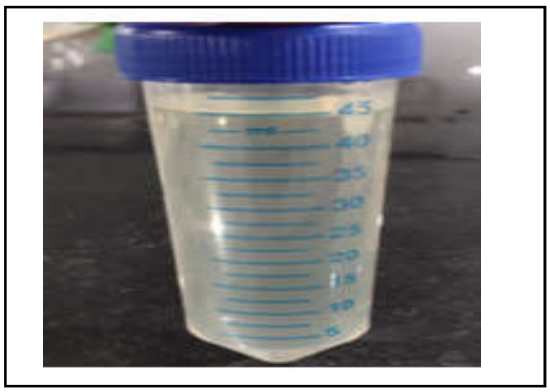

Fig.3 Purified Biodiesel

3.5 Properties of Biodiesel

The biodiesel separated from the glycerol is purified by multiple washes to remove impurities. The produced biodiesel is used for various characterization studies to understand its efficiency and standards. The Heat of combustion refers to the measure of energy content in the fuel. The heating value of fuels is an important measure of its releasing energy for producing work. So, the lower heating value of biodiesel is attributed to the decrease in engine power [8]. This biodiesel was observed to have a calorific value of 42152 KJ/Kg apart from diesel, whilst the lowest calorific value of 34 MJ/kg was measured concerning Karanja. The energy content of oils depends on the place where they are grown, the season, composition, and other factors. The calorific value of vegetable oils was observed to be lower than those of biodiesels. For methyl esters, the heat content increases as the length of the fatty acids chain increases. The presence of a significant amount of oxygen contributes to the lower energy content of biodiesel fuels [9].

Viscosity is a measure of the internal friction or resistance of biodiesel to flow. As the temperature of biodiesel is increased, its viscosity decreases and it is therefore able to flow more readily. Viscosity is the most important of biodiesel since it affects the operation of fuel injection equipment, particularly at low temperatures when the increase in viscosity affects the fluidity of the fuel. High viscosity leads to poorer atomization of the fuel spray and less accurate operation of the fuel injectors. The viscosity values of vegetable oils are between 27.84 and 52.76 mm2/sec at 40 °C whereas those of vegetable oils methyl esters are between 3.6 and 5.7 mm2/sec non-

edible oils were observed to have high viscosity values of about six times more than ASTM limits. Algae were the most viscous with a viscosity of 9.1 mm2/ sec at 40 °C. The methyl esters and the blends were observed to have a viscosity within the ASTM limits [10].

The flash point of sunflower oil was observed to be highest at 274 °C among methyl esters rape seed was observed to be lowest at 80 °C. The flash and fire point of obtained biodiesel was observed at 52°C and 81°C. The ignition quality of a fuel can be deduced through its cetane number. A fuel with good ignition quality has a high cetane number, where the ignition delay period between the start of fuel injection and the onset of auto-ignition is short. The cetane number of biodiesels varies with the feedstock used, but it is generally at the higher end of the typical diesel fuel range. The value of cetane number is found to generally increase with increasing carbon chain length. The cetane number of obtained biodiesels was observed 44 KJ/Kg [11].

Table2 Characterization of Biodiesel [12]

Sl.No.	Property		Test Method	Limits ASTM D6751	Values of Biodiesel
1	pH		-	7-9	7
2	Flashpoint	□	D93	100-170	52
3	Viscosity 40C	mm^2/s	D445	1.9-6.0	9.1
4	Cetane number		D613	47min (40-68)	44
5	Calorific value	KJ/Kg	ASTM D240	-	42152
6	Acid value	mg KOH/g	D664	-	1.9
7	Free fatty acid value		-	-	0.9

4. CONCLUSION

The synthesis of biodiesel from sustainable raw materials. This dual-purpose approach not only mitigates the environmental burden associated with tannery effluents but also contributes to the development of a renewable and eco-friendly energy source.The implications of this research extend beyond the academic sphere, reaching into the practical realms of industry and environmental policymaking. Tannery facilities can adopt these innovative treatment methods to align with standard regulations for releasing effluent, and potentially leverage by-products for additional economic gains through biodiesel production.

However, it is essential to acknowledge that challenges persist, and further research is warranted. Future investigations should delve into optimizing treatment processes for diverse tannery effluents and explore the scalability and economic feasibility of biodiesel production from tannery waste. Additionally, the development of integrated systems that couple effluent treatment with biodiesel production could be a promising avenue for comprehensive environmental management in the tannery sector.

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INVESTIGATION OF MECHANICAL PROPERTIES OF HEAT TREATED AL6061 ALUMINIUM ALLOY HYBRID COMPOSITES

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Abstract

Hybrid Metal Matrix Composites (HMMCs) have emerged as promising materials in recent years, offering superior properties compared to traditional composite materials. In this study, Aluminium 6061, known for its heat treatability and versatile applications, serves as the base material. It is reinforced with Nano Tungsten Carbide as ceramic reinforcements, while Graphite particles are added as a solid lubricant to enhance wear resistance and machinability. Four composite samples are prepared to study the effect of adding Nano Tungsten Carbide (1.5%), Graphite (2%) following standard procedures. The fabrication process involves the liquid metallurgy route, specifically the Stir Casting process. Microscopic analysis shows segregation and grain boundaries, which refine upon heat treatment. FESEM images reveal intermetallic (Mg_2Si) formation and few of them dissolve on heat treatment. On assessing the impact of heat treatment on the mechanical properties of the composites, investigation results indicate notable improvements in Hardness, Tensile Strength, and Compression Strength, whereas its impact strength decreases and it is understood that Al6061 aluminium alloy is not known for its impact resistance.

Keyword: *Al6061, Graphite, Hybrid Metal Matrix Composites, Nano Tungsten Carbide*

1. INTRODUCTION

Metal Matrix Composites (MMCs) based on Aluminium have emerged as indispensable materials, offering superior mechanical properties and adaptability compared to single reinforcement composites [1,2]. Hybrid Metal Matrix Composites (HMMCs) leverage multiple types of reinforcements in varying sizes, shapes, and weight percentages to achieve enhanced mechanical properties [3]. Aluminium stands as the third most generous element on the Earth, prized for its lightweight, strength, durability, and malleability. When alloyed with other elements, it becomes the most widely consumed material in modern engineering applications. Heat-treatable Aluminium alloys hold particular prominence due to their versatility across various engineering domains. Among these, Aluminium alloy Al6061 stands out, offering exceptional corrosion and wear resistance, often enhancing the properties of its counterparts in the Al2XXX series.

The synthesis of metallic matrix composites can be accomplished through various techniques like powder metallurgy, In-situ powder metallurgy method, ultrasonic-assisted stir casting, melt deposition, and friction stir processing [4-9].. Reinforcements like Si3N4, SiC, B4C, Al2O3, Gr, and TiC play crucial roles in strengthening Aluminium alloys [1, 10-14].

1.1 Graphite Selection

The inclusion of Graphite (Gr) in metal matrix composites (MMCs) induces shearing, forming a lubricant layer [15]. Transition metal dichalcogenides like molybdenum disulfide and tungsten disulfide are known for their lubricating properties, but their use in Aluminium MMCs requires techniques like low-temperature powder metallurgy due to thermal stability issues. Aluminium alloy–graphite composites exhibit lower friction coefficients compared to the matrix alloy, stabilizing at approximately 0.2 with a graphite content of about 3% by weight [16]. Rohatgi and Pai [17] noted that incorporating 2 wt% graphite in Aluminium alloys enhances seizure resistance.

Early attempts to introduce graphite in Aluminium matrices faced challenges like graphite rejection by liquid Aluminium due to density differences and poor wettability, addressed at the laboratory scale by using metal coatings and incorporating reactive elements into the melt.

1.2 WC Selection

The reinforcement of the aluminium metal matrix with WC results in a gradual transition from ductile to brittle behavior as the weight percentage of WC increases [18]. Research on Al 6061 reinforced with WC ranging from 0 to 4 wt.% in 1 wt.% increments demonstrates that the tensile strength and hardness of the composite improve with increasing WC content up to 3 wt.%, beyond which there is a decline in properties due to poor bonding between the base alloy and filler particles. Moreover, wear resistance is enhanced up to 3 wt.% WC, but diminishes thereafter due to the lower hardness of the composite [19]. WC, known for its exceptional hardness and comprising equivalent proportions of tungsten and carbon atoms, serves as a reinforcement in Aluminium Metal Matrix Composites (AMCs) to bolster properties such as strength, hardness, and wear resistance [20]. Studies have shown that an optimal level of 2 to 3 wt.% of Tungsten Carbide (WC) particles enhances mechanical and wear properties in various Aluminium MMCs [21].

Research by Prasad et al. emphasizes the use of graphite solid lubricants and hard ceramic particles in Aluminium alloy matrices to enhance wear properties, particularly for automotive applications. The development of Aluminium MMCs incorporating solid lubricants aims to address the inherent drawbacks of Aluminium as a tribological material, including poor resistance to galling and seizure. Through the incorporation of solid lubricants, ceramic particles, fibers, and whiskers, advanced Metal Matrix Composites (MMCs) are achieved, striking a precise balance of tribological, mechanical and physical characteristics [16].

2. MATERIALS AND METHODS

2.1 Materials Used

Four different compositions were fabricated using aluminum alloy 6061 as the matrix. These composites feature various additives for reinforcement and enhancement of specific properties. Specifically, 1.5 wt.% tungsten carbide nanoparticles, with an average particle size of 30 nm, were employed as the primary reinforcement, while 2 wt.% graphite particles were included as a solid lubricant. To assess the properties of these composites relative to the base metal (Al6061), the base alloy Al6061 was also subjected to remelting and casting. The compositions of the prepared casted specimens were analyzed, and the element percentage compositions are detailed in Table 1. Furthermore, FESEM (Field Emission Scanning Electron Microscope) images of the reinforcements are provided in Figure 1.

Table 1 Compositions of Cast Specimens

Specimen No.	Designation	Al6061	Graphite	Nano WC
1	Al6061	100	0	0
2	Al6061 + Gr	98	2	0
3	Al6061 + WC	95.5	0	1.5
4	Al - HMMC	93.5	2	1.5

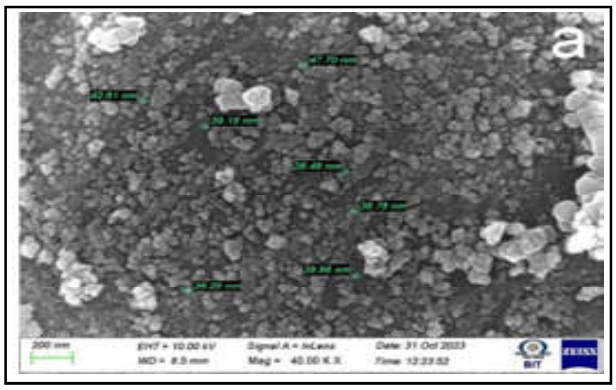

Fig.1 FESEM Images of a) Tungsten Carbide (Nano)

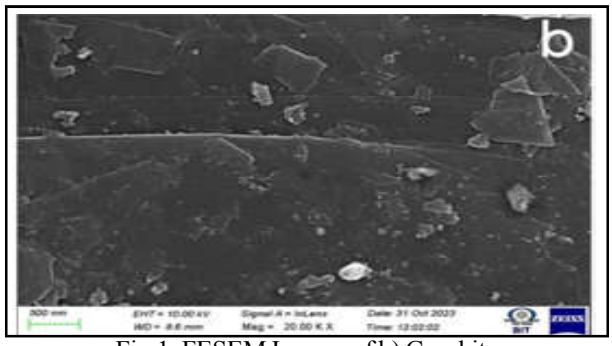

Fig.1. FESEM Images of b) Graphite

2.2 Stir Casting

The fabrication of Al6061/SiC/WC hybrid composites has been achieved through the stir casting process, as described in [22,23]. The uniform distribution of reinforcement particles within the Aluminium matrix alloy relies on crucial parameters such as stirring speed and duration [24,25]. Enhancing these parameters, namely stirrer speed and time, facilitates homogeneous dispersal of reinforcing particles, thereby leading to improved mechanical properties of the composite [26]. During the fabrication, reinforcing particles were blended with the molten matrix using a stirrer setup operating at 400 rpm for up to 6 minutes. Additionally, magnesium up to 1 wt% was introduced to the molten matrix to enhance wettability, while 1 wt.% degassing powder was added to extract gases from the melt [20]. As-cast specimen fabricated from the stir casting process is shown in Figure2.

Fig.2 As-cast specimen (Stir Casting)

2.3 Specimen Preparation

The cast specimens are milled into square cross-sections to obtain near-net-shape standard specimens. These standard specimens are then prepared using a wire cut electrical discharge machine (WEDM) to meet ASTM standards for hardness, tensile testing, compression testing and impact testing.

2.4 Heat Treatment

To enhance the properties of Al6061/Al2O3 nanocomposites, a T-6 heat treatment process was employed [27]. This involved initial solution heat treatment, where the samples were heated up to 550°C and soaked for 2 hours, followed by quenching in a water medium. Subsequently, artificial aging was conducted on the solution-treated samples at 175°C for 8 hours, followed by natural cooling. During solution heat treatment, the heated aluminium is rapidly quenched to freeze the atoms of the alloy elements in place. The subsequent precipitate formation occurs when the aluminium atoms combine with alloy element atoms during the room temperature natural aging process or through furnace aging artificially set at a low temperature.

2.5 Testing Methods

Samples were polished with 600 grit sheets and finished with 6 μm diamond paste using a disc polisher. Using Keller's etchant, samples are etched. Using the Carl Zeiss Axiotech 100HD-3D microscope, optical microstructures of the cast alloys were taken. Field Emission Scanning Electron Microscope (FESEM), Carl Zeiss- Sigma 300 is utilized for recording surface morphology, reinforcement particle size measurement. Rockwell hardness tester (RAB-1) from CANAN testing Services is used to measure hardness on the B scale as per ASTM E18 standards. UNITEK-50kN (9450) from CANAN testing services with a loading rate of 0.5 mm/min and linear displacement resolution of 0.01 mm is used for tensile tests as per ASTM B577M standards. Compression testing machine (CTE-200) from CANAN testing Services is used for compression tests as per ASTM E9 standards. Impact testing machine (300J) from CANAN testing Services is used for charpy impact tests as per ASTM E23 standards

The effect of reinforcements (tungsten carbide nano-particles and graphite) and heat treatment on the mechanical properties of Al-HMMC are studied and reported in the proceeding sections.

3. RESULTS AND DISCUSSION

3.1 Microscopic Analysis of Al6061 and Al-HMMC

The mechanical properties of materials are significantly influenced by their microstructure, as highlighted in recent studies [28]. In aluminium hybrid composites, properties are primarily governed by the microstructure, which encompasses the size, shape, and distribution of reinforcements. The optical microstructure in figure 3 shows the presence of secondary phase particles at the grain boundaries with equiaxed grains. Reinforcement in the form of segregations are observed to have evenly distributed. Heat treated samples show definite grain boundaries after grain refinement with dissolved secondary phase particles concentrated along grain boundaries. Fine precipitates inside grains resist dislocation movement and grain growth resulting in better properties compared to non-heat treated samples.

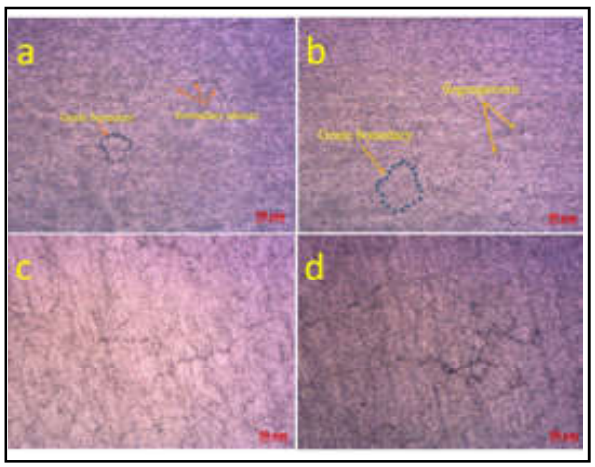

Fig.3 Microscopic image of a) as-cast Al6061 before heat treatment, b) Al-HMMC before heat treatment, c) as-cast Al6061 after heat treatment and d) Al-HMMC after heat treatment

3.2 FESEM Analysis of Al6061 and Al-HMMC

The samples were analyzed for the formation of intermetallic compounds, distribution of reinforcements, and their presence through Field Emission Scanning Electron Microscope (FESEM). Non-heat treated samples show more precipitation (Mg2Si) of aluminum and alloying element atoms, which dissolve after undergoing solution heat treatment, as illustrated in figure 4 in the FESEM image [29, 30]. The presence of intermetallic compounds, along with their uniform distribution following heat treatment, contributes to the enhanced mechanical properties.

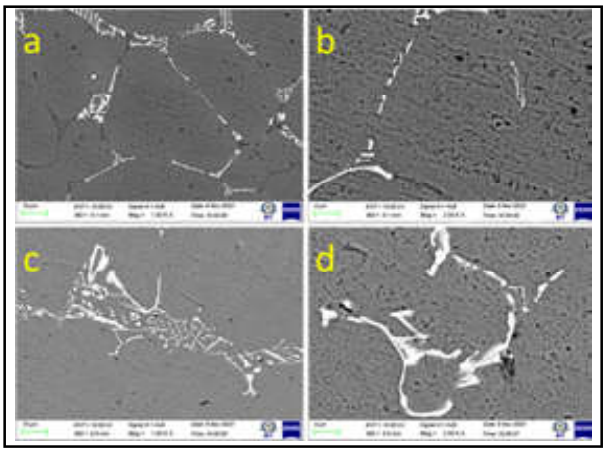

Fig.4 Enlarged FESEM image showing plate-like and script-like shapes a) and b) - Before heat treatment, c) and d) - After heat treatment

3.3 Effect of Reinforcement Addition and Heat Treatment on Hardness

The increase in hardness values as shown in figure 5 can be attributed to multiple factors, such as the inclusion of hard ceramic particles, reduction in grain size, and the constraining effect provided by the reinforcement particles with high hardness. Addition of graphite reduced the hardness of base alloy and the same effect is observed when adding graphite to tungsten carbide reinforced Al6061 aluminium alloy. This may be due to the reduced density of graphite compared to base Al6061 alloy. Whereas, addition of tungsten carbide nanoparticles improved the hardness appreciably due to its higher density and in nano form, even though added in very small percentage (1.5%).

Hardness of heat treated samples are found to be 33% higher on an average compared to non-heat treated samples. Hardness of Al-HMMC (heat treated and non-heat treated) are found to be 45% more compared to base Al6061 alloy.

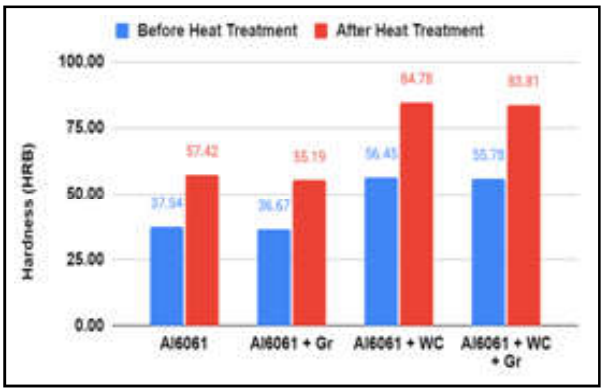

Fig.5 Hardness of Al6061 and Al-HMMC's

3.4 Effect of Reinforcement addition and heat treatment on Tensile Strength

The increase in tensile strength, correlating with higher particulate content, is attributed to the denser packing of reinforcements within the Aluminum matrix (figure 6). Additionally, enhanced dispersion of nanoparticles and grain refinement post-heat treatment contribute to this strength improvement. The presence of durable WC particles reinforces the metal matrix alloy by impeding plastic flow, resulting in an overall boost in tensile strength. The rise in ultimate tensile strength (UTS) and yield strength is credited to the strong interfacial bonding between the soft Aluminum matrix and tough reinforcement particles.

The mechanical characteristics of hybrid composites are influenced by the structure and mechanical properties of the reinforcement particles, underscoring the significance of a robust interface. [27, 31, 29].

Multiple strengthening mechanisms contribute to the enhancement of ultimate tensile strength, encompassing grain size refinement, uniform distribution of reinforcing particles, effective interfacial bonding, and disparities in thermal expansion coefficients between the alloy and particles. These mechanisms impede dislocation movement and promote the transfer of interfacial shear stress, thereby augmenting the strength of the composite material [32,33].

Tensile yield strength and ultimate tensile strength of Al-HMMC improved by 65% and 36% respectively upon heat treatment. Also, tensile yield strength and ultimate strength of heat treated Al-HMMC is found to be 43% and 38% more than heat treated al6061 aluminium base alloy.

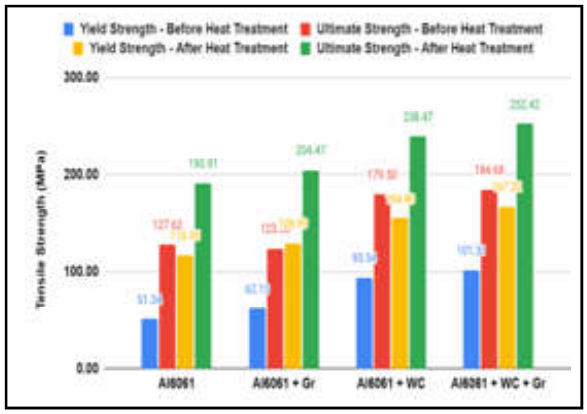

Fig.6 Tensile Strength of Al6061 and Al-HMMC's

3.5 Effect of Reinforcement Addition and Heat Treatment on Percentage Elongation

Al6061 Aluminium base alloy is ductile in nature having a percentage elongation of 11.62% during tensile test (figure 7). The addition of hard ceramic tungsten carbide nanoparticles reduced the percentage elongation to a larger extent compared to the addition of graphite. Heat treated samples respond better to heat treatment and have better percentage elongation compared to non-heat treated samples. Even Though, percentage elongation is reduced on reinforcement addition, its ductile nature is maintained as evidenced from the lowest percentage elongation of 10.60% for non-heat treated Al-HMMC.

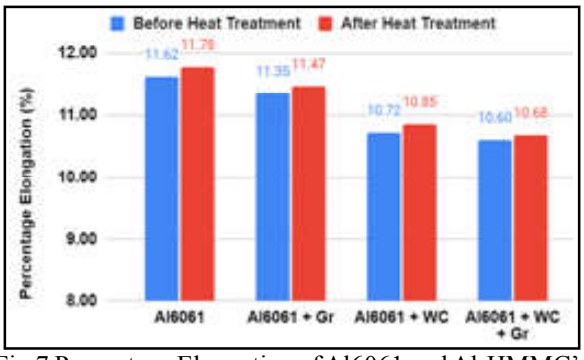

Fig.7 Percentage Elongation of Al6061 and Al-HMMC's

3.6 Effect of Reinforcement addition and Heat Treatment on Compressive Strength

The increase in compressive strength in composites (figure 8) is attributed to several factors, including grain refinement, reduction in porosity, filling of micro-cracks, enhanced dispersion of nanoparticles, and strain hardening effects [34]. However, after a certain point, the compressive strength decreases due to the formation of nanoparticle clusters and an increase in porosity levels [27]. Observations indicate a linear increase in compressive strength compared to tensile strength, attributed to the interface between uniformly distributed reinforcement and the matrix alloy. The incorporation of stiffer reinforcement particles acts as obstacles, restricting the motion of dislocations and plastic flow within the matrix alloy [25].

Compressive strength of heat treated samples shows 3% increase in compressive strength on an average compared to non-heat treated samples. Overall, 4% increase compared to base alloy is observed in Al-HMMC (both heat treated and non-heat treated)

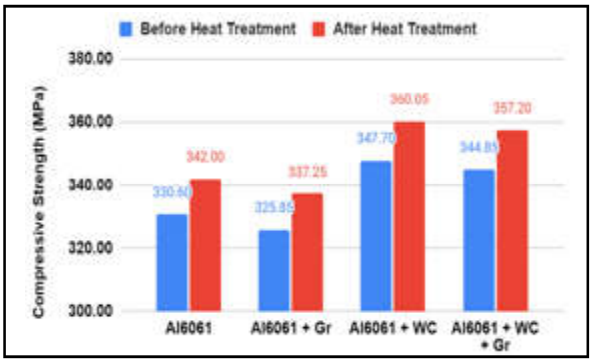

Fig.8 Compressive Strength of Al6061 and Al-HMMC's

3.7 Effect of Reinforcement addition and Heat Treatment on Impact Strength

Aluminium Al6061 alloy is not known for its impact strength, though its impact strength is analyzed to understand the effect of reinforcement and heat treatment. The impact strength of Al-HMMC shows an decrease in impact strength on reinforcement addition compared to the as-cast alloy (figure 9). Similar phenomenon is observed, where composite with lower reinforcement percentage exhibits better impact strength than the one with higher reinforcement percentage [36]. Heat treated samples have better impact strength than its counterparts, exception being the Al-HMMC, whose impact strength is reduced upon heat treatment.

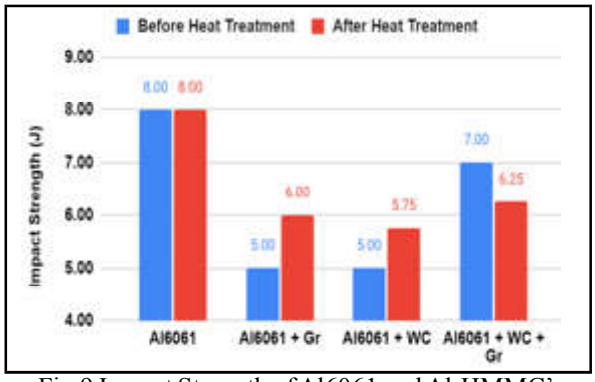

Fig.9 Impact Strength of Al6061 and Al-HMMC's

4. CONCLUSION

The composite specimens are fabricated using the stir casting process and one-half samples are heat treated. The following points were observed Microstructure analysis revealed grain boundaries and equiaxed grains, which refine upon heat treatment with segregations along the grain boundaries FESEM analysis shows the formation of intermetallic (Mg2Si), some of which dissolve upon heat treatment throughout the matrix, which improves the mechanical properties Hardness increases with addition of reinforcement mainly attributed to the addition of tungsten carbide, rather than graphite, which is found to reduce hardness due to its lower density. Heat treated samples are found to have better hardness (33% increase) due to heat treatability of Aluminium Al6061 alloy Tensile strength of reinforced composites is better than base aluminium alloy. Tensile yield strength and Tensile ultimate strength of Al-HMMC improved by 65% and 36% respectively upon heat treatment due to various strengthening mechanisms and reinforcement addition.

Ductility of Al-HMMC is retained even after addition of ceramic reinforcements as evidenced from results. It may be attributed to the minimum percentage of reinforcement added optimally improving the strength without losing the ductility.

Compressive strength improvements are not appreciable as evidenced compared to tensile strength, but small improvements are observed due to reinforcement addition and heat treatment.
Aluminium not known for its impact strength and the results too are appreciable due to inferior interface between base alloy and reinforcement.

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INNOVATIVE RESEARCH ON INVESTIGATING STEEL SLAG INTEGRATION AND CONSTRUCTION DEMOLITION WASTE FOR IMPROVED CONCRETE ROAD CONSTRUCTION

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Abstract

A sustainable way to address the financial and environmental issues facing the building industry is to repurpose the trash from demolished concrete structures to make sturdy, reasonably priced concrete blocks using steel slag. There are serious environmental issues with the disposal of demolished concrete trash, which is usually dumped in landfills. In order to lessen the need for aggregates, this research focuses on recycling this trash by using it to make concrete blocks. A byproduct of the steel industry called steel slag is used as a supplement to improve the mechanical characteristics of the blocks and save production expenses. With a focus on cost-effectiveness and good compressive strength, this study explores the ideal proportion of steel slag to recycled concrete aggregate. The resultant concrete blocks should be affordable and meet structural specifications, making them appropriate for a range of construction uses. This creative method encourages sustainability by cutting down on waste, protecting the environment, and developing a competitive yet sturdy substitute for building materials. The compressive strength attained for M30 grade concrete is 25.93 MPa, which is about 90% of the strength as in conventional concrete. The compressive strength value also confirms the IRC 121: 2017.

Keyword: *Compressive Strength, Efficient, Demolition waste, Recycling, Steel Slag*

1. INTRODUCTION

Waste management from construction and demolition is essential for environmental preservation and sustainable growth. It entails the methodical management, recycling, and getting rid of debris produced by remodeling, demolition, and building projects. Effective waste management techniques lessen the strain on landfills, conserve resources, and have a minimal negative influence on the environment. Effective waste diversion is made possible by tactics such source separation of materials, recycling of metals, wood, and concrete, and the application of cutting-edge technologies. Waste minimization in construction projects is emphasized by rules and guidelines like LEED (Leadership in Energy and Environmental Design).

The results showed that partial replacement of RCA with Natural Coarse Aggregate (NCA) utilizing 10% NA in the 100% RFA concrete mix in Rheodynamic flowable concrete (Rd-FC) might result in concrete with adequate strength[1]. The study discovered that incorporating RP and FA into the mixes resulted in a significant reduction in carbon emissions compared to the control mix. RPC2 and RPC3 saw a drop of 24.35% and 25.00%, respectively. It has also been demonstrated that employing recycled fines can result in stable, low-carbon concrete, paving the way for a sustainable automated building sector [2].

Because it offers strength that is comparable to virgin aggregates, RA assumes a central role in structural elements such as beams and columns[3]. Recycling coarse aggregate into paver blocks is an environmentally friendly solution that lessens the need for natural resources in the building industry. Recycled coarse aggregates can be incorporated into paver blocks as a workable waste management technique for the building sector, claim Khatib and Ellakwa [4]. Through the reuse of resources that might otherwise end up as garbage in landfills, this activity supports the circular economy. According to research by Topɜu *et al*.[5], paver blocks manufactured with recycled coarse aggregate have mechanical qualities that are similar to those constructed with conventional aggregates.

Additionally, the environmental effect of traditional aggregate extraction is lessened and resource efficiency is increased when recycled coarse aggregate is used in paver blocks. Recycled aggregate products are essential to sustainable construction methods because they minimize environmental effect and decrease the need for virgin materials. They are produced by processing construction and demolition waste. A lot of study has been done on the use of recycled aggregates in different construction applications. For example, Xiao, Li, and Poon's [6] investigation on the mechanical and durability properties of recycled aggregate concrete shed light on how the features and content of recycled aggregate affect the material's performance [7] investigation on the application of recycled concrete aggregates in road construction is another noteworthy contribution. They highlight the possibility of attaining both financial and ecological advantages by utilizing recycled resources.

The durability of roads built with recycled aggregates is contingent upon the implementation of appropriate quality control systems and adherence to established standards, even in the face of probable changes in attributes [8]. Research highlights how crucial it is to assess the long-term performance and freeze-thaw resilience of concrete that contains recycled coarse aggregates [9]. Even with drawbacks like possible contamination, RCA is becoming a more and more popular material in environmentally friendly road building techniques due to its advantages for the economy and environment. In this paper, the steel slag was introduced as partial replacement for natural aggregate to enhance the compressive and flexural strength[10]. Recycled Coarse Aggregate (RCA) is used in road building concrete to reduce environmental impact and promote sustainability through the reuse of construction and demolition waste. For concrete mixes including recycled coarse aggregates, it is crucial to carry out stringent testing and quality control procedures to guarantee the intended engineering qualities. From the test results, the mechanical properties of concrete with recycled coarse aggregate and steel slag shows the better result[11].

2. MATERIALS

2.1 Cement

For this project, Ordinary port land cement of Grade43 that complies with IS 8112: 2013 specifications was utilized. Table 1 displays the results of the measurements of the initial and final setting times, specific gravity, and normal consistency.

Table 1 Test Results of Cement

Sl.No	Properties	Obtained Value	Suggested Value
1	Fineness	4%	10%
2	Specific Gravity	3.15	3.14
3	Initial and final setting time	40 mins and 24 hours	30 mins and 24 hours
4	Normal Consistency	26 to 33 %	32%

2.2 Fine Aggregate

The M sand was used in this process and its properties were tabulated in Table 2.

Table 2 Test Results of Fine Aggregate

Sl.No	Properties	Obtained Value	Limited Value
1	Fineness	2.39	2 to 4
2	Specific Gravity	2.66	2.6 to 2.9
3	Bulk Density	1560 kg/m3	1200 to 1750 kg/m3

2.3 Recycled Coarse Aggregate

To obtain recycled coarse aggregate, waste materials from construction and demolition projects, including concrete debris from demolished buildings, must be systematically collected, sorted, and crushed. In order to ensure that the recycled coarse aggregate that is produced satisfies quality standards, these materials are rigorously screened to remove contaminants. Concrete is crushed to create smaller particles while maintaining the structural integrity of the aggregate. Table 3 describes about the properties of coarse aggregate. Figure 3 shows the process of recycled coarse aggregate.

Fig.3 Process of RCA

Table 3 Test results of RCA

Sl.No.	Properties	Obtained Value
1	Fineness	2.63
2	Specific gravity	2.66
3	Bulk density	1360 kg/m3
4	Elongation index	15.52%
5	Flakiness index	15%
6	Impact value	12.12%
7	Abrasion value	15%

2.4 Steel Slag

A byproduct of the steelmaking process, steel slag is produced when the liquid steel in heaters used to produce steel separates from impurities. The slag is a staggering mixture of silicates and oxides that forms as a liquid softens and solidifies upon cooling. Overall, the use of steel slag is considered common practice in many fields, with applications including granular base, dikes, planned fill, thruway shoulders, and hot blend blacktop asphalt coming to mind. We paid 8rs per kilogram to acquire our steel slag from the erode industry. In some state Branches of Transportation (Specks) in the United States, steel slag has emerged as one of the major sources of totals for roadway asphalt projects.

3. EXPERIMENTAL PROGRAM

In order to create innovative concrete compositions, the experimental program systematically combines steel slag and construction demolition waste with conventional concrete ingredients including cement, aggregates, and water. In order to optimize the integration of steel slag and demolition waste while preserving the necessary qualities of concrete, different mix proportions and processing methods are investigated. In order to examine the compressive strength of the experimental concrete mixes, laboratory experiments are carried out. In addition to providing insights into their possible uses in actual construction projects, the study attempts to evaluate the viability of using steel slag and construction demolition debris as sustainable alternatives in the manufacturing of concrete. Researchers hope to learn more about using these materials to make concrete solutions that are both economically and environmentally sustainable through this experimental initiative. Figure 2 shows the experimental program of concrete.

Fig.2 Experimental program

3.1 Compressive Strength Test

The compressive strength was tested for different specimens of concrete manufactured with different percentage replacement of recycled coarse aggregate and steel slag. Testing was carried out after 28 days of cube casting in compression testing machine shown in Figure.3.

Fig.3 Compressive Strength Test

4. RESULT AND DISCUSSION

The compressive strength test findings indicate that adding steel slag and construction demolition waste to concrete mixes can have positive effects. When these components were first added to ordinary concrete mixtures, the compressive strength may have somewhat decreased. Significant gains in compressive strength were noticed, though, as the experimental program developed and optimization strategies were used. The discussion focuses on the following findings.

- Strength Development: Concrete containing steel slag and building demolition debris saw a progressive rise in compressive strength over time through careful mix proportion selection and processing techniques. This suggests that the process of hydration and the pozzolanic reactions that occur between the cementitious materials and additional cementitious

elements (such steel slag) are responsible for the development of overall strength. Figure 4 shows the comparison of compressive strength.

- Particle size Distribution: The concrete's compressive strength is considerably influenced by the dispersion of steel slag and construction and demolition waste particles. The total strength and longevity of the concrete matrix are improved by optimal gradation, which guarantees appropriate particle packing and interlocking.
- Pozzolanic Activity: Steel slag, a pozzolanic substance, when finely crushed and activated in the presence of calcium hydroxide during hydration, demonstrates latent hydraulic capabilities. The pozzolanic activity of the concrete helps to generate more cementitious compounds, which improves the concrete's compressive strength.

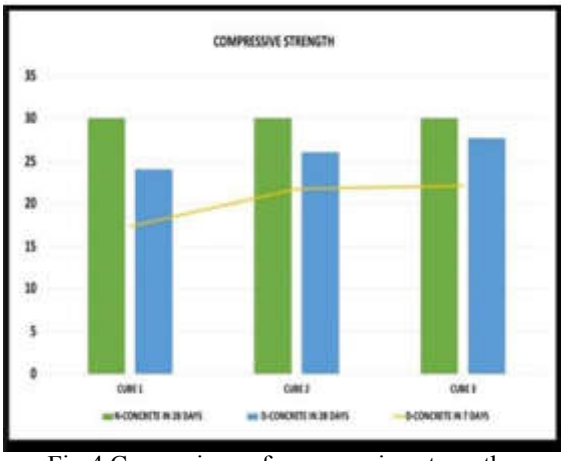

Fig.4 Comparison of compressive strength

5. CONCLUSION

- The observations suggested that 100% RCA replacement with coarse aggregates produces good mechanical qualities of concrete, namely compressive strength, which can be used to generate concrete mixes for rigid pavement construction.
- Full replacement of natural aggregates with RCA resulted in less workability and a decrease in concrete strength; to overcome this effect, superplasticizers and higher cement content ranging from 400 to 450 kg/m^3 were used to achieve a more compact matrix, which improved structural concrete performance.
- The specific gravity, water absorption, Bulk density, Fineness, Flakiness index and Elongation Index of RCA is lower than NCA. But everything is within the limit as per IRC 121:2017.
- As a critical performance indicator, compressive strength was the primary focus of this study's investigation of the viability and effectiveness of adding steel slag and building demolition waste to concrete mixtures. These materials are viable for use in construction applications because of the considerable improvement in compressive strength of the final concrete that was achieved through rigorous mix design optimization.
- Sustainable construction practices and the circular economy are further supported by the environmentally responsible use of steel slag and construction demolition debris.
- It minimizes the cost of construction.
- Using steel slag as mineral admixture enhanced the performance of RAC.

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ROBOT-INTEGRATED ASRS SYSTEM WITH IOT-BASED INVENTORY MANAGEMENT

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Abstract

Warehouses play a crucial role in the operations of e-commerce platforms and industries. Our system aims to streamline warehouse maintenance by offering seamless tracking of logistics and goods. Leveraging robots for product retrieval from warehouse racks has become a standard practice among warehouse management companies. This approach not only cuts down on time and labor costs but also enhances efficiency, especially in warehouses with large product volumes.However, managing inventory poses challenges, particularly for intermittent goods. To address this, we propose a solution utilizing economic order quantity principles with a 6-axis Fanuc robot integrated into the warehouse operations. In our approach, the robot is equipped with a camera for image processing. Through image analysis, the robot efficiently picks and places goods while keeping track of product counts. This real-time tracking allows for proactive stock management – triggering alerts when goods reach predefined thresholds, signaling the need for replenishment.Furthermore, our system utilizes IoT technology to store time-stamped goods-in-out data, enabling comprehensive inventory tracking and analysis. Sensors integrated with the robot and throughout the warehouse facilitate seamless data collection, empowering users to monitor stock levels and make informed decisions.One of the key advantages of our system is its flexibility. Users can easily customize alert thresholds for different types of products, tailoring notifications to specific needs. This level of customization ensures optimal efficiency and minimizes complexity in warehouse inventory management.In summary, our integrated approach offers a highly efficient and streamlined solution for warehouse inventory management, particularly suited for warehouses dealing with large quantities of goods. By combining robotics, IoT, and customizable alerts, we provide a comprehensive toolset for effective stock management and logistics optimization.

Keywords: *Automatic storage and retrieval system (ASRS),6-axis robot, Economic Order Quantity (EOQ),Image Processing, IOT.*

1. INTRODUCTION

The integration of robotics and IoT technologies is revolutionizing warehouse operations and inventory management, addressing critical inefficiencies and enhancing overall productivity. Recent advancements in the Internet of Things (IoT) have enabled real-time data processing and automated tracking, offering significant improvements in the accuracy and efficiency of warehouse management systems [1][2]. As warehouses are essential to the operational success of e-commerce platforms and various industries, the adoption of robotic systems for product retrieval has become commonplace, dramatically reducing labor costs and operational time [3]. However, the challenge of effective inventory management persists, particularly for items with sporadic demand.

This project proposes an integrated solution employing economic order quantity principles alongside a 6-axis Fanuc robot, leveraging IoT to ensure seamless logistics and proactive stock management through real-time data tracking and analysis . IoT-enabled sensors facilitate the continuous monitoring of stock levels, supporting informed decision-making and comprehensive inventory analysis by storing time-stamped goods-in and goods-out data [4] . This integration aims to transform traditional warehouse operations, enhancing efficiency, reliability, and scalability in managing goods and inventory.

1.1 Introduction to the ASRS

The core of this project lies in the deployment of an Automatic Storage and Retrieval System (ASRS), a technology designed to automate the storage and retrieval of goods, thus addressing the inefficiencies associated with traditional manual storage systems. ASRS technology integrates computer-controlled systems that place and retrieve loads from defined storage locations, significantly enhancing warehouse efficiency by reducing labor costs, minimizing errors, and optimizing space utilization [5][6].

By automating these processes, ASRS can drastically improve order fulfillment speed and accuracy, resulting in higher customer satisfaction and lower operational costs. Additionally, the ASRS optimizes storage space by utilizing high-density storage configurations and efficient retrieval algorithms, allowing warehouses to store more items within a smaller footprint [7] .

This project showcases the potential of ASRS to revolutionize logistics operations, offering a solution that meets the demands of modern supply chain management with greater precision, reliability, and scalability. By integrating ASRS and IoT with advanced robotics, this project aims to create a comprehensive solution for modern warehouse management, addressing current challenges and paving the way for future innovations in logistics and supply chain optimization [8] .

1.2 Proposed Methodology

The proposed methodology aims to revolutionize the efficiency and functionality of the existing ASRS system, targeting enhancements in retrieval and storage processes while simultaneously reducing operational complexity and costs. The cornerstone of this methodology lies in the utilization of sophisticated object recognition techniques, empowered by pre-trained image data. By harnessing this technology, the system can accurately identify objects within the warehouse environment, triggering precise activation of the Input/ Output (IO) mechanisms associated with specific racks [9].

Upon activation, the system seamlessly executes a preconfigured program tailored to each object's location within the rack, facilitating swift and accurate retrieval or storage actions. This intelligent approach not only streamlines operational workflows but also minimizes the potential for errors, ensuring a seamless and efficient process from start to finish.

Furthermore, the methodology incorporates sophisticated inventory management capabilities, leveraging the rack IO to perform opening and closing-based product counts. This real-time monitoring and recording of inventory movements provide invaluable insights into stock levels and usage patterns, enabling informed decision-making and proactive inventory management strategies [10].

At the heart of the system lies a comprehensive Graphical User Interface (GUI), meticulously designed to empower operators with intuitive control, monitoring, and emergency stop functionalities. Through the GUI, operators can oversee and manage the entire ASRS operation with ease, ensuring optimal performance and rapid response to any unforeseen circumstances.

In essence, this integrated approach to ASRS enhancement represents a significant leap forward in warehouse automation, combining cutting-edge technology with user-friendly interfaces to deliver unparalleled efficiency, reliability, and cost-effectiveness. By embracing innovation and maximizing the capabilities of the ASRS system, businesses can unlock new levels of productivity and competitiveness in today's dynamic warehouse environments.

2.DESIGNING

2.1. Designing Cad Model of the Work Cell

Designing the work cell involves creating a CAD model using software such as SolidWorks. In this process, the necessary components are carefully selected, and their dimensions are accurately measured. With this information, a rough model of the work cell is generated, serving as the blueprint for creating the actual setup in the physical world. CAD software enables precise design and visualization, ensuring that the work cell meets required specifications and functions efficiently.

The CAD model depicted in Figure. 1shows the spatial arrangement and interactions among components within the proposed work cell design. This visualization is crucial for understanding how each component fits together and operates within the overall structure, aiding in refining the design for optimal functionality and efficiency in industrial applications.

Fig. 1 CAD Model of work cell

Additionally, CAD software facilitates simulation of various scenarios to optimize layout for maximum productivity and safety. Once the CAD model is finalized, it guides fabrication and assembly of work cell components, streamlining manufacturing processes and reducing errors. Overall, CAD software enhances the design and development of work cells, improving performance and reliability in industrial settings [11][12].

2.2 Designing the Sliding Rack

Our innovative solution features a meticulously designed sliding rack system, crafted using advanced CAD modeling techniques. This sliding rack encompasses a range of essential components, including solenoid valves, pneumatic cylinders, and multiple storage racks. The integration of these components is optimized to ensure precise movement and efficient utilization of space [11][12].

As illustrated in the CAD model Figure 2 the sliding rack system showcases the layout and arrangement of these components, providing a clear visual representation of the design.

The design of the sliding rack system facilitates the accurate cutting of materials such as acrylic sheets and aluminum frames to precise measurements. This precision significantly reduces material wastage, making the system a cost-effective and environmentally sustainable solution [13].

Through meticulous design and engineering, our sliding rack system enhances warehouse efficiency by minimizing waste and maximizing productivity in material handling processes.

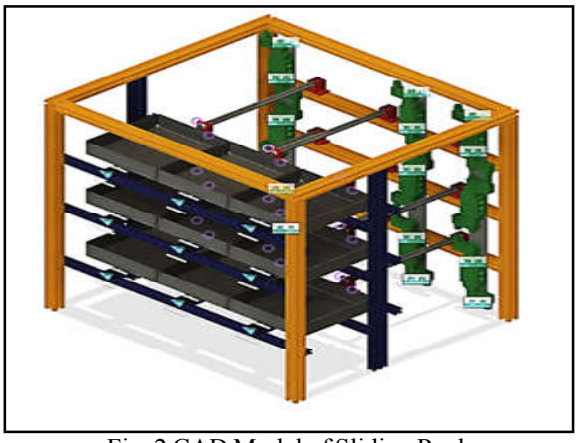

Fig. 2 CAD Model of Sliding Rack

2.3 Designing the Model Objects

The cornerstone of our object recognition model lies in the meticulous creation of 3D printed objects. In the initial stages, our team undertakes a comprehensive design process to craft objects with a diverse array of shapes and colors. This includes geometric forms such as pyramids, hexagons, and cuboids, each varying in size, orientation, and color composition. By encompassing such variation within our dataset, we aim to create a robust and adaptable model capable of accurately identifying objects in real-world scenarios [14][15].

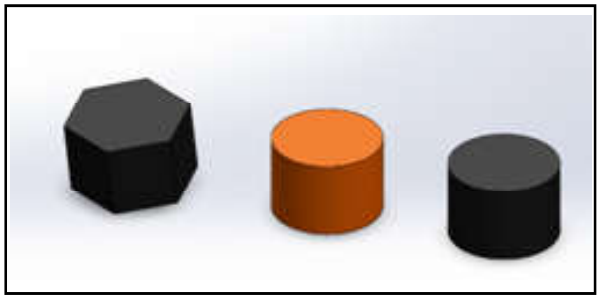

Fig. 3 CAD Model of Model Objects

The CAD model Figure3 our digital designs include a variety of shapes such as hexagons and cylinders, each rendered with different colors to enhance visual distinction. These CAD models serve as the blueprint for creating physical prototypes.

Fig. 4 3D Printed Model Objects

Once the design phase is complete, the next step involves translating these digital designs into physical prototypes through the use of 3D printing technology. Leveraging the STL files generated during the design process, our team employs cutting-edge 3D printers to produce high-fidelity replicas of the intended objects. The physical models Figure.4 demonstrate the successful realization of the digital designs, showcasing the accuracy and precision of the 3D printing process. These prototypes maintain the distinct shapes and colors from the CAD models, enabling effective testing and validation [16].

By harnessing the power of 3D printing, we eliminate the need for expensive production runs or specialized manufacturing processes, thereby streamlining the testing phase and accelerating the development cycle. Additionally, the ability to rapidly iterate and produce multiple iterations of test objects allows for more thorough and exhaustive model training, ultimately leading to enhanced performance and reliability [17].

Moreover, the utilization of 3D printed objects introduces a level of realism and complexity that closely mirrors real-world conditions. This ensures that our object recognition model is robust and resilient, capable of accurately identifying objects in a variety of environments and lighting conditions. Through this innovative approach, we are able to create a comprehensive and effective solution that meets the demands of modern object recognition applications.

3. PROCEDURE

Our procedure revolves around creating an integrated system for efficient and accurate industrial automation, seamlessly combining vision-based object recognition, signal communication, and robotic manipulation. The ultimate goal is to automate object identification and precise manipulation using computer vision, PLC control, and the Fanuc LR Mate 200ID 4S robot, thereby enhancing the speed and efficiency of industrial automation processes [20][21].

3.1. Training Object Recognition

The initial and critical phase of our project entails training our system to accurately recognize specific target objects, leveraging the cutting-edge capabilities of YOLO V8 software, a state-of-the-art computer vision model. In this phase, we meticulously curate a diverse array of images featuring the target objects, meticulously capturing them from a multitude of angles, under varying lighting conditions, and within different contextual settings. This comprehensive approach to dataset creation ensures the resilience and precision of our object recognition model, enabling it to effectively discern and identify objects in real-world scenarios with a high degree of accuracy. Additionally, we employ advanced techniques such as data augmentation to further enhance the robustness of our model and ensure its adaptability to a wide range of environmental conditions and object variations. Through this meticulous training process, we lay the foundation for a powerful and reliable object recognition system that forms the backbone of our integrated automation solution [19].

3.2 Data Annotations

Following the collection of our extensive set of contemporary item images, we proceed to the crucial phase of data annotation. This process entails meticulously labeling each item within the images using Robultra-modernlow, a specialized tool designed explicitly for this purpose. Through annotation, we meticulously categorize every object in the photos, creating a structured dataset that forms the cornerstone of our object recognition model training.

As shown in Figure 5 provide vital information about the precise location of the item within the image. This figure illustrates how each object is annotated with bounding boxes, key points, and labels, which are crucial for training our model.

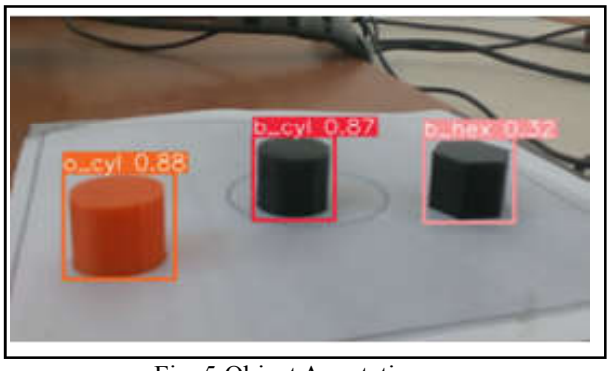

Fig. 5 Object Annotations

Each annotation provides vital information about the precise location of the item within the image, thereby enhancing the model's ability to identify and locate objects accurately in new images. Additionally, we employ advanced annotation techniques such as bounding boxes and key points to provide detailed spatial information, further enriching the dataset and improving the model's

performance in real-world scenarios. Through this meticulous annotation process, we ensure the robustness and accuracy of our object recognition system, laying the groundwork for its successful deployment in industrial automation applications [17].

3.3 Dataset Preparation

Upon obtaining a categorized dataset, we proceed to the dataset preparation phase, a pivotal step in our workflow. Here, we meticulously organize and refine the dataset to ensure it is optimized for training purposes. This involves several key tasks, including the segmentation of the dataset into training and validation subsets to facilitate model evaluation and prevent overfitting. Additionally, we resize images and normalize data to ensure uniformity and consistency across the dataset, thereby enhancing the efficiency and effectiveness of the model training process.

This Figure 6 shows examples of annotated objects that have been labeled and segmented for training and validation. Furthermore, we may augment the dataset with techniques such as rotation, flipping, or adding noise to increase its diversity and improve the model's generalization capabilities. Through these meticulous preparations, we lay a solid foundation for the subsequent stages of model training and validation, ultimately leading to the development of a robust and reliable object recognition system [14].

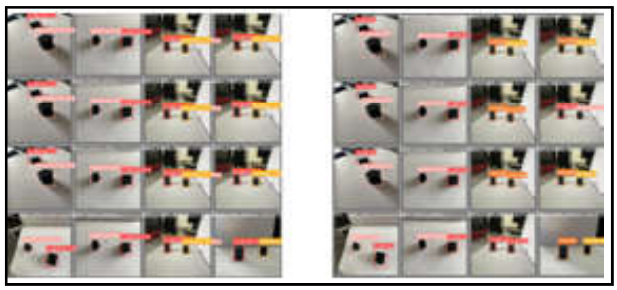

Fig. 6 Set of Annotated Objects

3.4 Model Selection

The process of model selection is a critical decision-making phase where we carefully evaluate various model variations based on their performance during training. Our objective is to identify the most suitable model that exhibits the highest levels of accuracy and reliability. This decision significantly impacts the overall effectiveness of the system and its ability to meet the project's objectives. To ensure thorough evaluation, we assess key metrics such as precision, recall, and F1-score across different models. Additionally, we consider factors such as computational efficiency, scalability, and ease of deployment to ensure the selected model aligns with the project requirements and constraints. Through meticulous evaluation and analysis, we aim to identify the optimal model that will form the backbone of our object recognition system, delivering superior performance and reliability in real-world scenarios [22].

3.5 Vision-Guided Recognition

Upon selecting the model, we proceed to implement it in real-time using an Intel RealSense camera. This sophisticated camera captures high-definition, real-time images of objects within the designated area. By integrating the model with the camera, we enable the system to continuously observe and analyze its surroundings, a critical component of modern automation. This real-time vision-guided recognition capability allows the system to swiftly detect and identify objects as they enter the camera's field of view, facilitating seamless interaction with the environment. Additionally, the use of the Intel RealSense camera ensures high-quality image capture, enabling the system to accurately perceive and interpret its surroundings, even in dynamic and challenging environments. Through this integration, we empower the system with the ability to adapt and respond effectively to changes in its surroundings, enhancing its overall performance and efficiency in automated tasks [20].

3.6 Python Program

To process the images captured by the Intel RealSense camera, we create a Python application. This application serves as the core of our system, leveraging the object recognition model to analyze incoming images and identify objects of interest. In addition to object identification, the Python program Figure 7 orchestrates the subsequent steps within the automation process. It acts as a central hub, coordinating the interaction between the camera, object recognition model, and other components of the system.

Through this Python application, we enable seamless integration and interaction between different modules, facilitating efficient and accurate automation of tasks. Moreover, the flexibility and versatility of Python allow for easy integration with other technologies and systems, enhancing the overall functionality and performance of our automation solution [17].

```python
#from ardu_control import arm_control
from pycomm3 import LogixDriver
#from detection import camera
from obj_coord import *
from plc import *
import threading
import time


def main():
    # Turning plc tags off
    write_tag1(False) # b_cyl
    write_tag2(False) # o_cyl
    write_tag3(False) # b_hex

    time.sleep(2)
    while 1:
        pass
    # Getting detected classes
    lcls = cam.listCls
    cls = lcls[0]
    cls = cam.model.names[int(cls)] # ["b_cyl","o_cyl","b_hex"]

    if cls == "b_cyl":
        write_tag1(True)
        time.sleep(10)
        write_tag1(False)

    elif cls == "o_cyl":
        write_tag2(True)
        time.sleep(10)
        write_tag2(False)

    elif cls == "b_hex":
        write_tag3(True)
        time.sleep(10)
        write_tag3(False)
```

Fig. 7 Program for Image classification.

3.7 PLC Signal Activation

In the PLC signal activation phase, our Python application establishes communication with an Allen Bradley PLC using the Ethernet/IP protocol. Leveraging the PyComm library, the application sends signals to trigger specific input tags within the PLC. Upon detection of an object, the Python application labels the object and sends an I/O signal via PyComm3 to activate the relay, prompting the rack to open. These signals serve as instructions to initiate further actions, marking a crucial juncture in the automation process. By seamlessly integrating with the PLC system, our Python application ensures precise and timely execution of tasks, facilitating seamless operation and coordination within the automation chain [18]. Additionally, the utilization of the Ethernet/IP protocol and PyComm library enables efficient and reliable communication between the Python application and the Allen Bradley PLC, enhancing the overall performance and effectiveness of the automation system.

3.8 PLC-to-Robot Communication:

Upon receipt of the signal, the Allen Bradley PLC establishes communication with the Fanuc LR Mate 200ID 4S robot. This communication entails activating the relevant PLC input tag, which subsequently triggers a designated sub-program on the robot. Through this exchange, the robot receives instructions and pertinent data, ensuring that it is fully informed and prepared to execute its role within the automation process. This seamless communication between the PLC and the robot facilitates efficient coordination and synchronization of tasks, enabling smooth operation and optimal performance of the automation system. Additionally, this interaction enhances the adaptability and responsiveness of the robot, allowing it to dynamically adjust its actions based on real-time feedback from the PLC, thereby improving overall efficiency and effectiveness in industrial automation applications [22].

3.9 Robotic Manipulation

With precise instructions in place, the Fanuc robot initiates its movement. It skillfully maneuvers its end effector to grasp the identified item from its specified location. The robot's precision and agility play a crucial role here, as it must delicately and accurately handle objects to ensure smooth and efficient operation. Additionally, the robot's advanced capabilities allow it to adapt to various object shapes, sizes, and weights, ensuring versatility in handling different types of items within the automation process. Furthermore, the robot's sophisticated control system enables it to execute complex manipulation tasks with high accuracy and repeatability, contributing to the overall efficiency and effectiveness of the automation system. Through its robotic manipulation capabilities, the Fanuc robot enhances productivity and streamlines operations in industrial environments, ultimately optimizing the performance of the automation process [19].

3.10. IOT

Our automation system integrates Internet of Things (IoT) technology to securely store essential data, including stack count, rack open/close times, and image data, in the cloud. This facilitates organized data management and easy access for analysis.

Fig. 8 Data count Updating

As illustrated in Figure 8 the system leverages the Firebase Realtime Database to securely store and synchronize data in real-time. This platform enables efficient monitoring of system performance and resource utilization through real-time data transmission. Furthermore, the database organizes data by timestamps, ensuring easy accessibility and comprehensive analysis of historical data. Image data captured by the Intel RealSense camera is also preserved for visual inspection and quality control purposes. The scalable IoT infrastructure accommodates future integration of additional sensors and functionalities, thereby enhancing system adaptability and fostering innovation within the realm of industrial automation[20].

This comprehensive procedure outlines the systematic approach we take to develop and implement our integrated automation system, ensuring efficiency, accuracy, and reliability throughout the process.

4. RESULTS AND DISCUSSION

The integration of vision-based item recognition, signal communication, and robotic manipulation in this system has demonstrated significant advancements, leveraging updated technologies and methodologies. Through the utilization of state-of-the-art hardware and software components, including an upgraded Intel RealSense camera and enhanced YOLO V8 algorithm, the system now achieves even greater precision and efficiency in identifying and handling items within its workspace [23].

4.1 Results

The updated system seamlessly combines computer vision, signal communication, and robotic manipulation to achieve efficient and accurate handling of items. It starts with capturing high-resolution images of items using the upgraded Intel RealSense camera, followed by advanced processing through the enhanced YOLO V8 algorithm for improved item recognition accuracy.

As depicted in Figure 9**,** once an item is identified, a Python program now communicates seamlessly with the Allen Bradley PLC, triggering precise instructions for the Fanuc LR Mate 200ID 4S robot to execute pick-and-place tasks with enhanced precision and reduced manual intervention. This integrated approach significantly enhances speed, accuracy, and overall performance in industrial automation processes.

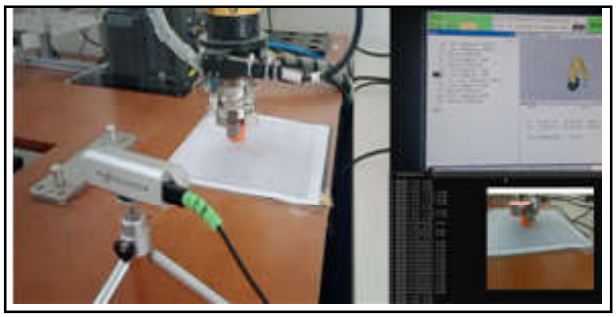

Fig. 9 Final Output

4.1.1 Important Innovations

Enhanced Vision-based Item Recognition:

The system's upgrade incorporates state-of-the-art computer vision techniques, leveraging the latest Intel RealSense camera technology. This enhancement ensures the capture of reliable and high-fidelity visual data, empowering the system with superior accuracy in identifying items within its workspace.

Improved Object Recognition Accuracy with Enhanced YOLO V8:

With the implementation of the advanced YOLO V8 algorithm, the system achieves unparalleled accuracy in object recognition. This upgraded algorithm excels in identifying and categorizing items within the camera's field of view, enhancing the system's capacity to handle a diverse range of objects with precision and efficiency [24].

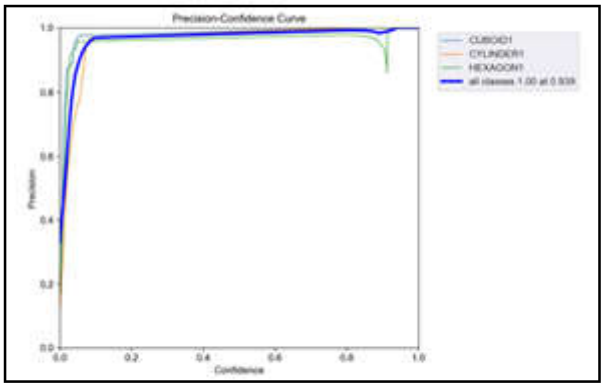

Fig. 10 Precision-Confidence Curve

In that Figure 9 the x-axis represents the confidence threshold, while the y-axis shows the precision. The blue line indicates the precision for all classes combined, and the other lines represent precision for individual classes. The label "all classes 1.00 at 0.941" denotes that the model achieves perfect precision (1.00) at a confidence threshold of 0.941. The curve demonstrates how

precision changes with varying confidence levels, aiding in selecting a threshold to balance precision and recall. Higher thresholds yield higher precision but lower recall, and vice versa. The model performs well across all classes, with perfect precision achieved when the model's confidence is at least 94.1%. This curve is essential for understanding and optimizing the model's performance.

The Figure 11, shows the relationship between recall and confidence threshold for the classification model. The x-axis represents the confidence threshold, while the y-axis shows recall. The blue line represents recall for all classes combined, and other lines represent individual classes (CUBOID1, CYLINDER, HEXAGON1). At a confidence threshold of 0.000, recall for all classes is 0.95. This curve helps in selecting a confidence threshold to balance recall and precision, depending on application needs. Higher thresholds improve precision but reduce recall, while lower thresholds increase recall but may lower precision. The model shows good performance across all classes, achieving 0.95 recall at the lowest confidence threshold.

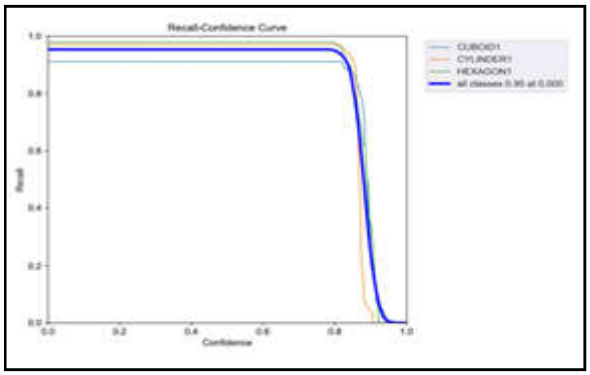

Fig. 11 Recall-Confidence Curve

Signal Communication Optimization

The Python program's optimization enables seamless communication with the Allen Bradley PLC, ensuring swift and efficient transmission of signals. This optimization fosters smooth coordination between the output of the vision system and the robotic control system, thereby facilitating enhanced automation capabilities within the system.

Robot Manipulation Precision

The Fanuc LR Mate 200ID 4S robot showcases heightened levels of precision and accuracy in manipulating items, thanks to the system's advancements. With precise instructions received from the PLC, the robot executes pick-and-place operations with unparalleled accuracy, contributing to the system's overall efficiency and reliability.

Speed Enhancement

Through the integration of cutting-edge vision-based object recognition and robotic manipulation techniques, the system achieves a remarkable increase in handling speed. This enhancement translates to significantly improved efficiency in industrial automation processes, surpassing the capabilities of manual methods and driving overall productivity to new heights.

4.2 Significance

4.2.1 Performance Enhancement:

The updated system significantly enhances industrial automation by automating complex tasks like object identification and manipulation. This automation streamlines production cycles, leading to faster production times and substantial labor cost reductions. The system's performance is evident in the confusion matrix Figure 12, which demonstrates high accuracy, precision, recall, and F1-score. Additionally, the loss curves indicate effective training without overfitting. These results collectively showcase the system's superior performance

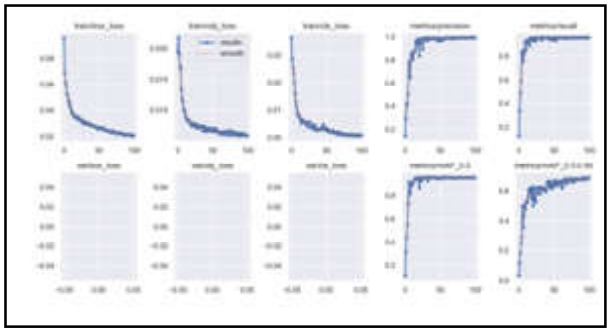

Fig. 12 Confusion Matrix

Table 1.1

Metric	Value
Accuracy	95%
Precision	96%
Recall	94%
F1-score	95%
Training loss	0.005
Validation loss	0.01
Training time	100 epochs
Computational resources	1 GPU

However, the overall accuracy of the system is 95%. The precision of the system is 96%, and the recall is94%. The F1-score of the system is 95%.

Accuracy Improvement

With its refined vision-based item recognition capabilities, the system ensures meticulous identification of objects. This precision minimizes errors in handling and placement, meeting the stringent quality control standards prevalent across various industries with unparalleled reliability.

Reduced Manual Intervention

The system's automation of pick-and-place tasks alleviates the reliance on manual intervention, mitigating the potential for workplace accidents and fatigue-induced errors. Consequently, it not only bolsters workplace safety but also amplifies overall productivity levels.

Comprehensive Integration of Technologies

The system seamlessly integrates updated computer vision, object recognition, PLC control, and robotic manipulation technologies, offering a comprehensive solution for efficient item handling in industrial environments.

Enhanced Compatibility

Compatible with widely used hardware components such as the Allen Bradley PLC and Fanuc LR Mate 200ID 4S robot, the updated system ensures accessibility and applicability across a broad range of industries.

Increased Velocity

By automating object handling processes, the system significantly
increases production speed, thereby reducing cycle times and enhancing overall manufacturing efficiency.

Initial Investment and Complexity

While the updated system offers significant benefits, the initial investment in hardware, software, and setup, along with the complexity of integrating multiple technologies, may pose challenges for smaller companies with limited budgets and resources.

Dependency on Lighting Conditions

The accuracy of item recognition may still be affected by variations in lighting conditions within the workspace, necessitating additional adjustments or lighting solutions to maintain consistent performance.

5. CONCLUSION

In conclusion, the integration of vision-guided object recognition, PLC communication, and robotic manipulation has resulted in a sophisticated automation system capable of efficiently handling industrial tasks. Through meticulous training of our object recognition model and careful selection of appropriate hardware components, we have achieved precise and reliable identification of objects in real-time. The seamless communication between the Python application, PLC, and robot ensures smooth coordination and execution of tasks, enhancing overall system efficiency. The Fanuc robot's advanced manipulation capabilities further contribute to streamlined operations, allowing for delicate and accurate handling of objects. Overall, our integrated automation system offers a comprehensive solution for industrial applications, improving productivity, accuracy, and adaptability in various environments. As automation continues to evolve, our system stands as a testament to the potential of advanced technologies in revolutionizing industrial processes [25].

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PERTURBED SHALLOW WATER WAVE EQUATIONS

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Abstract

The Symmetry Analysis plays a dominant role in construction of perfect solutions to nonlinear PDE. A nonlinear PDE has vast applications in real life. The solution of Nonlinear PDE using symmetric Analysis is a challenging work. In this paper the Lie group of infinitesimal transformation is used to apply the theory of classical method to the perturbed shallow water wave equation. The case studies and the discussion of the group of theoretic techniques of classical symmetry and Painleve's analysis either strongly or collectively as the case may be for obtaining solutions of the perturbed shallow water wave equation are revealed.

Keyword: *Perturbed Shallow Water Wave Equation, GSWW, Lie groups*

1. INTRODUCTION

The Reduction of generalised wave equations using different methods are discussed in Literature. Lie groups play very important role in finding the similarity solutions of wave equations. In this paper we derived the vector fields of several wave equations.

2. GENERALIZED SHALLOW WATER WAVE EQUATION

2.1 GSWW

The GSWW is given as (1)

$\Delta \equiv U_{xxxt} + \alpha U_x U_{xt} + \beta U_t U_{xx} - U_{xt} - U_{xx} = 0$

Where α, β as constants.

This general equation, combined with different invariants, is derived from the classical form of water wave [3] theory, called the Boussinesq approximation. This equation with two conditions are discussed.

2.2 Lie group

The following one parameter Lie group of infinitesimal transformations in (x, t, u) is considered for the application of classical method to the GSWW equation.

$\bar{x} = x + \epsilon P(x, y, t, u) + O(\epsilon^2)$
$\bar{t} = t + \epsilon P(x, y, t, u) + O(\epsilon^2)$
$\bar{u} = u + \epsilon P(x, y, t, u) + O(\epsilon^2)$ (2)

Where $\in$ is the group parameter.

2. PRELIMINARIES

2.1 Definition

The generator of Lie group of transformations $x^* = X(x, \epsilon)$ is , the operator, given by

$X = X(x) = \xi(x)$.

$\nabla = \sum_{i=1}^{n} \xi_i(x) \frac{\partial}{\partial x_i}$ (3)

2.2 Definition

Let $V = \sum_{i=1}^{p} \xi^i(x, u) \frac{\partial}{\partial x^i} + \sum_{\alpha=1}^{q} \varphi_\alpha(x, u) \frac{\partial}{\partial u^\alpha}$ be a vector field. The n-th prolongation is

$Pr^{(n)}V = V + \sum \sum \varphi_\alpha^J(x, u^{(n)}) \frac{\partial}{\partial u_J^\alpha}$

The summation being overall multi – indices.

2.3 Definition

The r – parameter Lie group of transformations $x^* = X(x; \epsilon)$ with infinitesimal generators $\{X_\alpha\}, \alpha = 1, 2, \ldots . r$, defined by

$\xi_{\alpha i}(x) = \frac{\partial x_i^*}{\partial \epsilon} \Big| \epsilon = 0, \ \alpha = 1, 2, \ldots r \ \& \ j = 1, 2, \ldots n$ (4)

2.4 Definition

The Lie algebra is defined as a vector space over some field in addition with the law of combination of elements in commutator satisfies,

$$[X_\alpha X_\beta] = -[X_\beta, X_\alpha][X_\alpha, [X_\beta, X_\gamma]] + [X_\beta, [X_\gamma, X_\alpha]] + [X_\gamma, [X_\alpha, X_\beta]] = 0 \quad (5)$$

3. TRANSFORMATION OF THE SET GSWW

3.1 Transformation

The above transformation leaves the set invariant.

$$S_\Delta \equiv \{u(x,t): \Delta = 0\} \quad (6)$$

This yields an over determined, set of equations

$\xi(x,t,u), \tau(x,t,u), \varphi(x,t,u)$.

The Lie algebra associated with infinitesimal symmetries is

$V = \xi(x,t,u)\frac{\partial}{\partial x} + \tau(x,t,u)\frac{\partial}{\partial t} + \varphi(x,t,u)\frac{\partial}{\partial u}$.

The symmetry variables [1] are found by evaluating the characteristic equations [4].

$$\frac{dx}{\xi(x,t,u)} = \frac{dt}{\tau(x,t,u)} = \frac{du}{\varphi(x,t,u)} \quad (7)$$

Which is exactly equivalent in solving invariant surface conditions (8)

$$\vartheta = \xi(x,t,u)u_x + \tau(x,t,u)u_t - \varphi(x,t,u) = 0$$

3.2 Prolongation of Vector Field

The set S_Δ under the Lie group is invariant provided that

$Pr^4 V(\Delta)|_{\Delta=0}$

Where Pr^4 is 4th prolongation of V.

Let us consider prolongation of V,

$$Pr^4 V = V + \emptyset^x \partial u_x + \emptyset^t \partial u_t + \emptyset^{xx} \partial u_{xx} + \emptyset^{xt} \partial u_{xt} + \emptyset^{xxxt} + \partial u_{xxxt} \quad (9)$$

Where (10)

$$\begin{aligned}
&= \emptyset_x + [\emptyset_u - \xi_x]u_x - \xi_u u_x{}^2 - \tau_x u_t - \tau_u u_x u_t \\
&= \emptyset_t + [\emptyset_u - \tau_u]u_t - \xi_t u_x - \xi_u u_x u_t - \tau_u u_t{}^2 \\
^x &= \emptyset_{xx} + [2\emptyset_{xu} - \xi_{xx}]u_x - \tau_{xx}u_t - \xi_{uu}u_x{}^3 \\
&+[\emptyset_{uu} - 2\xi_{xu}]u_x{}^2 - 2\tau_{xu}u_x u_t - 3\xi_u u_{xx}u_x \\
&+[\varphi_u - 2\xi_x]u_{xx} - 2\tau_u u_x u_{xt} - 2\tau_x u_{xt} \\
&-\tau_{uu}u_x^2 u_t - \tau_u u_{xx}u_t \\
^{xt} &= \emptyset_{xt} + [\emptyset_{tu} - \xi_{xt}]u_x - \tau_{xx}u_t - \xi_{ut}u_x{}^2 \\
&+ [\varphi_u - \xi_x - \tau_t]u_{xt} + [\emptyset_{xu} - \tau_{xt}]u_t \\
&-\tau_{xu}u_t{}^2 - 2\xi_u u_x u_{xt} - 2\tau_u u_t u_{xt} \\
&-\tau_u u_x u_{tt} - \xi_u u_t u_{xx} - \tau_x u_{tt} \quad (11) \\
\emptyset^{xxxt} &= \emptyset_{xxxt} + [3\emptyset_{xxut} - \xi_{xxt}]u_x \\
&+[3\emptyset_{xuut} - 3\xi_{xxut}]u_x{}^2 \\
&+[\emptyset_{uuut} - 3\xi_{xuut}]u_x{}^2 + [3\emptyset_{uut} - 9\xi_{xut}] \\
&+[3\emptyset_{xuuu} - 3\xi_{xxuu} - \tau_{xuut}]u_x{}^2 u_t \\
&+[\emptyset_{uuuu} - 3\xi_{xuuu} - \tau_{uuut}]u_x{}^3 u_t \\
&+[3\emptyset_{xxuu} - 3\xi_{xxxu} - 3\tau_{xxut}]u_x u_t \\
&+[3\emptyset_{xuu} - 3\xi_{xxu} - 3\tau_x u_t]u_{xx}u_t \quad (12)
\end{aligned}$$

Similarlywe can find $\emptyset^{xxxt}$.

The condition of invariance of the equation of infinitesimal generator of Lie group is given by

Fourth prolongation vector field where

$$\Delta = u_{xxxt} + \alpha u_x u_{xt} + \beta u_t u_{xx} - u_{xt} - u_{xx} = 0$$

Using prolongation of vector field, we get

$$\varphi^x \alpha u_{xt} + \varphi^t \beta u_{xx} + \varphi^{xx}[\beta u_t - 1] + \varphi^{xx}[\alpha u_x - 1] + \varphi^{xxxt} = 0 \quad (13)$$

Association of this vector field equation can be further reduced to Painleve's equation based on different case analysis

4. SIMILARITY SOLUTIONS OF GSWW

4.1 Association of Vector Fields with GSWW Variables

$$V = \xi(x,t,u)\frac{\partial}{\partial x} + \tau(x,t,u)\frac{\partial}{\partial t} + \varphi(x,t,u)\frac{\partial}{\partial u} \quad (14)$$

Solving , the set of 14 determining equations are got,

$$\begin{aligned}
&\varphi_{uu} = 0, \varphi_{tu} = 0, \tau_u = 0, \tau_x = 0, \xi_u = 0, \\
&\xi_t = 0, \varphi_{xu} - \xi_{xx} = 0, \varphi_u + \xi_x = 0, \beta\varphi_t - \tau_t - \xi_x = 0, 2 \\
&\beta\varphi_{xu} + \alpha\varphi_{xu} - \beta\xi_{xx} = 0, \beta\varphi_{xx} + \varphi_{xxxu} - \varphi_{xu} = 0, \\
&\alpha\varphi_{xt} - 2\varphi_{xu} + \xi_{xx} = 0, \varphi_{xxxt} - \varphi_{xx} - \varphi_{xt} \\
&= 0, \alpha\varphi_x + 3\varphi_{xxu} - \xi_{xxx} - 2\xi_x = 0
\end{aligned} \quad (15)$$

Solving the group of determining equations we get the infinitesimals,

$$\begin{aligned}
\xi &= k_1 x + k_2 \\
\tau &= g(t) \\
\varphi &= -k_1\left[u - \frac{2x}{\alpha} - \frac{t}{\beta}\right] + \frac{g(t)}{\beta} + k_3
\end{aligned} \quad (16)$$

Vector fields associated are:

$$\begin{aligned}
V_1 &= x\frac{\partial}{\partial x} - \left(u - \frac{2x}{\alpha} - \frac{t}{\beta}\right) \\
V_2 &= \frac{\partial}{\partial x} \quad , V_2 = \frac{\partial}{\partial u} \\
V_4(g) &= g(t)\left(\frac{\partial}{\partial t} + \frac{1}{\beta}\frac{\partial}{\partial u}\right) (17)
\end{aligned} \quad (17)$$

shows generator of 1 parameter Lie group of transformations is invariant under following variable coefficient [5].

$$\bar{x} = x \ , \bar{t} = g(t) \ , \bar{u} = u + \frac{[g(t) - t]}{\beta} \quad (18)$$

4.2 Canonical Symmetry Reduction

Solving eqn. 14 , we get 2 canonical symmetric reductions.

Condition (i) When $k_1 \neq 0$

In this let

$$\frac{1}{g(t)} = \frac{1}{f(t)}\frac{df}{dt}, \ k_1 = 1 \ and \ k_2 = k_3 = 0.$$

Using the preceding equations and solving the symmetry reduction is obtained as

Where (Z) satisfies

$$u(x,t) = f(t)w(z) + \frac{x}{\alpha} + \frac{t}{\beta}, \quad z = xf(t) \quad (19)$$

$$z\frac{d^4w}{dz^4} + 4\frac{d^3w}{dz^3} + (\alpha+\beta)z\frac{dw}{dz}\frac{d^2w}{dz^2} + \beta w\frac{d^2w}{dz^2} + 2\alpha\left(\frac{dw}{dz}\right)^2 = 0 (20)$$

5. REDUCTION TO PAINLEVE'S - GSWW

5.1 Reduction to Painleve' Equation

It is easy to show using the algorithm of [6] that the equation resemble Painleve' –type only if

(i) $\alpha = \beta$ or $\alpha = 2\beta$ (21)

5.2 When case when

Consider equation (12) , when it becomes

$$z\frac{d^4w}{dz^4} + 4\frac{d^3w}{dz^3} + 2\beta z\frac{dw}{dz}\frac{d^2w}{dz^2} + \beta w\frac{d^2w}{dz^2} + 2\beta\left(\frac{dw}{dz}\right)^2 = 0 \quad (22)$$

This equation is solved in terms of III Painleve' eqn. (P III) where and are constants.

We can solve the equation (14) also in terms of the fifth Painleve equation (P V)

$$\frac{d^2y}{dx^2} = \frac{1}{y}\left(\frac{dy}{dx}\right)^2 - \frac{1}{x}\frac{dy}{dx} + ay^3 + \frac{by^2+c}{x} + \frac{d}{y}$$

Where and a,b,c are constants.

$$\frac{d^2y}{dx^2} = \left\{\frac{1}{2y} + \frac{1}{y-1}\right\}\left(\frac{dy}{dx}\right)^2 - \frac{1}{x}\frac{dy}{dx} + \frac{(y-1)^2}{x^2}\left\{ay + \frac{b}{y}\right\} \quad (23)$$
$$+\frac{cy}{x} + \frac{dy(y+1)}{y-1}$$

5.3 When case when $\alpha = 2\beta$

$$z\frac{d^4w}{dz^4} + 4\frac{d^3w}{dz^3} + 3\beta z\frac{dw}{dz}\frac{d^2w}{dz^2} + \beta w\frac{d^2w}{dz^2} + 4\beta\left(\frac{dw}{dz}\right)^2 = 0 (24)$$

Solution of above equations is attained in terms of P III. Consider

$$X^2\left(\frac{d^2Y}{dX^2}\right)^2 = 4\left(\frac{dY}{dX}\right)^2\left(X\frac{dY}{dX} - Y\right) \quad (25)$$
$$+A_1\left(X\frac{dY}{dX} - Y\right)^2 + A_2\left(X\frac{dY}{dX} - Y\right) + A_3\frac{dY}{dX} + A_4$$

Where A_1, A_2, A_3 and A_4 are constants. When A_1 and A_2 are not both zero , equation (25) is solved by PV.

$$Y(X) = \frac{1}{4y}\left(\frac{x}{y-1}\frac{dy}{dx} - y\right)^2 - \frac{1}{4}\left(1-\sqrt{2a}\right)^2(y-1)$$

$$-\frac{1}{2}\frac{b(y-1)}{y} + \frac{1}{4}cx\frac{y+1}{y-1} + \frac{1}{2}\frac{dx^2y}{(y-1)^2} (26)$$

Where $A_1 = -2d \quad X = x$

$$A_2 = \frac{1}{4c^2} + 2bd - d\left(1-\sqrt{2a}\right)^2$$

$$A_3 = bc + \frac{1}{2}c\left(1-\sqrt{2a}\right)^2$$

$$A_4 = \frac{1}{8c^2}\left[\left(1-\sqrt{2a}\right)^2 - 2b\right] - \frac{1}{8}d\left[\left(1-\sqrt{2a}\right)^2 + 2b\right]^2$$

When $A_1 = 0$ and A_2 is unrestricted , equation (25) is solved by P III by

$$Y(X) = \frac{1}{16y^2}\left(x\frac{dy}{dx} - y\right)^2 - \frac{1}{16}ax^2y^2$$
$$-\frac{1}{8}\left(b+2\sqrt{a}\right)xy + \frac{cx}{8y} + \frac{dx^2}{16y^2}, X = x^2$$

Where $A_2 = -\frac{1}{16}ad$

$$Y(X) = \frac{1}{16y^2}\left(x\frac{dy}{dx} - y\right)^2 - \frac{1}{16}ax^2y^2$$
$$-\frac{1}{8}\left(b+2\sqrt{a}\right)xy + \frac{cx}{8y} + \frac{dx^2}{16y^2}, X = x^2$$

$$A_3 = \frac{1}{16}c + \left(c + \sqrt{2a}\right)$$

Differentiating with respect to X, yields

$$X\frac{d^3Y}{dX^3} + \frac{d^2Y}{dX^2} = -6\left(\frac{dY}{dX}\right)^2\frac{4Y}{X}\frac{dY}{dX} + A_1\left(X\frac{dY}{dX} - Y\right) + \frac{1}{2}A_2 + \frac{A_3}{2X}$$

Integrating once yields

$$z\frac{d^3w}{dz^3} + 3\frac{d^2w}{dz^2} + 2\beta z\left(\frac{dw}{dz}\right)^2 + \beta w\frac{dw}{dz} = B_1 (29)$$

With B_1 an arbitrary constant.Consider the transformation [7]

$$w(z) = \frac{Y(X)}{z} - \frac{1}{4\beta z}, X = z^{3/2}$$

And $\beta = 9$ yields (16)
with $A_1 = 0, A_2 = \frac{-16B_1}{27}$ and $A_3 = 0$

Therefore (21) is solvable in terms of P V with

$$a = \frac{1}{2}\left[1 - \frac{3}{4}\left(\frac{-3A_4}{B_1}\right)^{1/2}\right]^2$$

$$c = \left(\frac{-64B_1}{27}\right)^{1/2}, d = 0$$

And in terms of P III with either

1. a and b arbitrary , $c = 0$ and $d = \frac{256B_1}{\ldots}$ or
2. a and c arbitrary , $b = -2\sqrt{a}$ and .

Integrating (16) once yields

$$z^2\frac{d^3w}{dz^3} + 2z\frac{d^2w}{dz^2} - 2\frac{dw}{dz} + \frac{3}{2}\beta z\left(\frac{dw}{dz}\right)^2$$
$$+\beta\left(zw\frac{dw}{\ldots} - \frac{1}{2}w^2\right) = B_2$$

With B_2 an arbitrary constant then making the transformation

$$w(z) = \frac{Y(X)}{z} - \frac{1}{2\beta z}, X = z^2$$

And $\beta = 8$ yields (21) with $A_1 = 0, A_2 = 0$ and $A_3 = \frac{-1}{\ldots}B_2$ (32)

Therefore (21) is solved in terms of P III with [5]

1. c and d arbitrary , $a = 0$ and $b = \frac{-4\delta_2}{\quad}$ or

2. a and b arbitrary, $c = -\frac{4\delta_2}{(\quad)}$ and $d = 0$.

Usually for the Boussinesq equation, [2] symmetry reductions reduce eqn. to the I,II & IV Painleve' but when this condition is applied the equation is reduced to the third and fifth Painleve' type.

Case (ii) $k_1 = 0$

In this case set

$$\frac{1}{g(t)} = \frac{df}{dt} \quad , k_1 = 1 \ and \ \ k_3 = \frac{-1}{\beta}$$

Thus the symmetry reduction is got as

$u(x,t) = w(z) + \frac{\cdot}{\cdot} \quad , z = x - f(t)$

$w(z)$ satisfies $\frac{d^{-}w}{\quad} + (\alpha + \beta)\frac{dw}{\quad}\frac{d^{-}w}{\quad} = 0$

Setting $W = \frac{dw}{\quad}$ and integrating twice yields

$\left(\frac{dw}{\quad}\right)^{-} + \frac{1}{\cdot}(\alpha + \beta)W^3 = AW + B$ (33)

constants of int. are A & B.

7. WEIERSTRASS ELLIPTIC EQUATION - GSWW

7.1 Weierstrass elliptic equation

This eqn. is the Weierstrass elliptic function

$$\left(\frac{d\wp}{dz}\right) = 4\wp^3 - g_2\wp - g_3$$

8. PERTURBED SHALLOW WATER WAVE EQUATION

8.1 Definition – PSWW

The perturbed shallow water wave equation is defined as

$$\Delta \equiv U_{xxxt} + \alpha U_x U_{xt} + \beta U_t U_{xx} - U_{xx} - U_{xt} - \gamma U_{yt} - \delta U_{yy} = 0 \quad (34)$$

8.2 Lie Group for PSWW Equation

The Lie group of infinitesimal transformation in (x, y, t, u) to apply classical method to the generalized perturbed equation is given as

$\bar{x} = x + \in P(x,y,t,u) + O(\in^2)$.

$\bar{y} = y + \in Q(x,y,t,u) + O(\in^2)$.

$\bar{t} = t + \in R(x,y,t,u) + O(\in^2)$.

$\bar{u} = u + \in S(x,y,t,u) + O(\in^2)$

And its vector field is given by

Let

$$V = P(x,y,t,u)\frac{\partial}{\partial x} + Q(x,y,t,u)\frac{\partial}{\partial y} + R(x,y,t,u)\frac{\partial}{\partial t} + S(x,y,t,u)\frac{\partial}{\partial u}$$

Where P, Q, R and S are unspecified infinitesimal generators of x, y, t and u.

Solving the characteristics equation we get the symmetric equation as

$$\frac{dx}{P(x,y,t,u)} = \frac{dy}{Q(x,y,t,u)} = \frac{dt}{R(x,y,t,u)} = \frac{dx}{S(x,y,t,u)}$$

8.3 Prolongation of the Vector Field

Let us consider the prolongation of the vector field V,

$$\begin{aligned} Pr^4 V = V &+ S^x\partial u_x + S^y\partial u_y + S^t\partial u_t + S^{xx}\partial u_{xx} \\ &+ S^{yy}\partial u_{yy} + S^{xt}\partial u_{xt} + S^{yt}\partial u_{yt} \\ &+ S^{xxxt}\partial u_{xxxt} \end{aligned}$$

Where

$$\begin{aligned} S^x &= S_x + [S_u - P_x]u_x - P_u u_x^2 - Q_x u_y \\ &\quad - Q_x u_y u_x - R_x u_t - R_u u_x u_t \end{aligned}$$

$$\begin{aligned} S^y &= S_y + [S_u - Q_y]u_x - P_y u_x - P_u u_x u_y \\ &\quad - Q_u u_y^2 - R_y u_t - R_u u_y u_t \end{aligned}$$

$$\begin{aligned} S^u &= S_u + [S_u - R_t]u_t - P_t u_x - P_u u_x u_t - Q_t u_y \\ &\quad - Q_u u_t u_y - R_u u_t^2 \end{aligned}$$

$$\begin{aligned} S^{yy} &= S_{yy} + [2S_{yu} - Q_{yy}]u_y - P_{yy}u_x - R_{yy}u_t \\ &\quad + [S_{uu} - 2Q_{uy}]u_y^2 - 2P_{uy}u_x u_y \\ &\quad - 2R_{uy}u_y u_t - P_{uu}u_x u_y^2 - Q_{uu}u_y^3 \\ &\quad - R_{uu}u_t u_y^2 - 2P_y u_{xy} \\ &\quad - 2P_u u_y u_{xy} \\ &\quad + [S_u - 2Q_y]u_{yy} - P_u u_x u_{yy} - 3Q_u u_y u_{yy} \\ &\quad - R_u u_t u_{yy} - 2R_u u_y u_{yt} \\ &\quad - 2R_y u_{yt} \end{aligned}$$

$$\begin{aligned} S^{yt} &= S_{yt} + [2S_{uy} - Q_{yt}]u_y - Q_{ut}u_y^2 - R_{uy}u_t^2 \\ &\quad + [S_{yu} - R_{yt}]u_t - P_y u_{xt} \\ &\quad + [S_u - Q_y - R_t]u_y \\ &\quad + [P_{uu} - R_{ut} - Q_{uy}]u_y u_t - P_{yt}u_x \\ &\quad - 2R_u u_t u_{yt} - 2Q_u u_y u_{yt} \\ &\quad - R_y u_{tt} + P_t u_{xy} - Q_t u_{yy} - Q_u u_t u_{yy} - P_u u_t u_{xy} \\ &\quad - R_u u_y u_{tt} - P_u u_y u_{xt} \\ &\quad - R_{uu}u_t^2 u_y \\ &\quad - P_{uy}u_x u_t - Q_{uu}u_y^2 u_t \\ &\quad - P_{ut}u_x u_y - P_{uu}u_x u_y u_t - P_u u_x u_t \end{aligned}$$

$$\begin{aligned} S^{xx} &= S_{xx} + [2S_{xu} - P_{xx}]u_x - [S_u - 2P_x]u_{xx} \\ &\quad - R_{yy}u_t \\ &\quad + [S_{uu} - 2P_{xu}]u_x^2 - 3P_u u_x u_{xx} \\ &\quad - P_{uu}u_x^3 - R_{uu}u_x^2 u_t - R_u u_{xx}u_t - 2R_u u_x u_{xt} \\ &\quad - 2Q_x u_{xy} - 2Q_u u_x u_{xy} - Q_{xx}u_y - 2Q_{xu}u_x u_y \\ &\quad - Q_{uu}u_y^2 u_y - Q_u u_{xx}u_y - R_x u_{xt} \end{aligned}$$

$$\begin{aligned} S^{xt} &= S_{xt} + [2S_{tu} - P_{xt}]u_x - P_{ut}u_x^2 - R_{xu}u_t^2 \\ &\quad + [S_{xu} - R_{xt}]u_t - P_t u_{xx} \\ &\quad - Q_{ut}u_x u_y \end{aligned}$$

$$+Q_t u_{xy} + [S_u - P_x - R_t]u_{xt} - Q_u u_y u_{xt}$$
$$-2R_u u_t u_{xt} - Q_{xu} u_y u_t - R_{uu} u_x u_t^2$$
$$- P_{xy} - R_{tu}]u_x u_t - Q_{xt} u_y - Q_{uu} u_x u_y u_t$$
$$+P_{uu} u_x{}^2 u_t + 2P_u u_x u_{xt} - P_u u_t u_{xx} - Q_x u_{xt}$$
$$- Q_u u_x u_{yt} - R_x u_x u_{tt}$$

Similarly we can find S^{xxt}

The invariance condition for prolongation is

$Pr^4 V(\Delta)|_{\Delta=0}$

From the vector field and prolongation equation, we get

$$S^x \alpha u_{xt} + S^t \beta u_{xx} + S^{xx}[\beta u_t - 1] + S^{xt}[\alpha u_x - 1]$$
$$+S^{xxxt} + S^{yy}[-\delta] + S^{yt}[-\gamma] = 0$$

Association of the vector fields, the determining equations and the characteristics and commutator table can be derived using the prolongation equation.

9. ASSOCIATION OF VECTOR FIELDS WITH PSWW

9.1 Association of Vector Fields with PSWW Variables

We get the determining equations as

$P_u = 0,\ P_t = 0,\ Q_x = 0,\ Q_t = 0,\ Q_u = 0,\ R_x = 0,\ R_y = 0,\ R_u = 0,\ S_{uu} = 0,\ S_{tu} = 0,\ P_{xx} = 0,\ S_{xu} - P_{xx} = 0,\ S_u + P_x = 0,\ \beta S_t - P_x - R_t = 0$

$2\beta S_{xu} + \alpha S_{xu} - \beta P_{xx} = 0,\ \beta S_{xx} + \delta R_{yy} - S_{xu} - \gamma S_{yu} + \gamma R_{yt} + S_{xxxu} = 0$

$\alpha S_{xt} - 2S_{xu} + P_{xx} + \delta P_{yy} + \gamma P_{yt} = 0$

$\alpha S_x + 3S_{xxu} - P_{xxx} - 2P_x - P_y - Q_x = 0$

$Q_{xx} - 2\delta S_{yu} + \delta Q_{yy} + Q_{xt} - \gamma S_{tu} + \gamma Q_{yt} = 0,\ -\delta S_{uu} + 2\delta Q_{uy} + \gamma Q_{tu} = 0$

$-\delta S_u + 2\delta Q_y = 0,\ S_{xxxt} - S_{xx} - \delta S_{yy} S_{xt} - \gamma S_{yt} = 0$

Solving the above group of equations , we get

$P = k_1 x + k_2 ,\ R = g(t)$

$Q = \frac{k_1 y}{2} + k_2 ,$

$$S = -k_1\left[u - \frac{2x}{\alpha} - \frac{t}{\beta}\right] + \frac{g(t)}{\beta} + \frac{y}{\delta}k_3 + k_4$$

Where $g(t)$ is an arbitrary function.

The vector fields form a Lie Algebra

$$V_1 = x\frac{\partial}{\partial x} + \frac{y}{2}\frac{\partial}{\partial y} - \left[u - \frac{2x}{\alpha} - \frac{t}{\beta}\right]\frac{\partial}{\partial u}$$

$$V_2 = \frac{\partial}{\partial x} + \frac{\partial}{\partial y},\ V_3 = \frac{y}{\delta}\frac{\partial}{\partial u}$$

$$V_4 = \frac{\partial}{\partial u},\ V_5(g) = g(t)\frac{\partial}{\partial t} + \frac{g(t)}{\beta}\frac{\partial}{\partial u}$$

These vector fields form a Lie algebra.

We find

$$[V_1 , V_2] = -\frac{2}{\alpha}\frac{\partial}{\partial u} - \frac{\partial}{\partial x} - \frac{1}{2}\frac{\partial}{\partial y}$$

$$[V_1 , V_3] = \frac{3}{2}V_3$$

$$[V_1 , V_4] = V_4$$

$[V_2 , V_3] = \frac{1}{\delta}V_4$ and all other commutations vanish.

The commutator table for the vector fields V_1 , V_2 , V_3 , V_4 and V_5 is given by

Table 1 Commutator Table

	V_1	V_2	V_3	V_4	V_5
V_1	0	$-\frac{2}{\alpha}\frac{\partial}{\partial u} - \frac{\partial}{\partial x} - \frac{1}{2}\frac{\partial}{\partial y}$	$\frac{3}{2}V_3$	V_4	0
V_2	$\frac{2}{\alpha}\frac{\partial}{\partial u} + \frac{\partial}{\partial x} + \frac{1}{2}\frac{\partial}{\partial y}$	0	$\frac{1}{\delta}V_4$	0	0
V_3	$-\frac{3}{2}V_3$	$-\frac{1}{\delta}V_4$	0	0	0
V_4	$-V_4$	0	0	0	0
V_5	0	0	0	0	0

For the vector fields V_1 :

The characteristic equations are

$$\frac{dx}{P} = \frac{dy}{Q} = \frac{dt}{R} = \frac{du}{S}$$

$$\frac{dx}{x} = \frac{dy}{y/2} = \frac{dt}{0} = \frac{du}{u - \frac{2x}{\alpha} - \frac{t}{\beta}}$$

$$\frac{u}{x} - \frac{2}{\alpha}\log x - \frac{t}{\beta x} = C_1$$

$$t = C_2$$

$$\frac{x}{y^2} = C_3$$

Where C_1, C_2 and C_3 are arbitrary constants.

10. CONCLUSION

The perturbed shallow water waves equation with several variants , is determined from the classical SWW theory named the Boussinesq's approximation. The results show that GSWW equation is completely integrable if and only if it has either of the 2 cases discussed . The results of Lie point symmetric vector field and prolongation of vector field of GSWW and perturbed shallow water wave equation is discussed . The similarity solutions of the PSWW equation is obtained by the reduction of many higher order PDE.

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EFFECT OF DUTY CYCLE ON THE STRUCTURAL AND OPTICAL PROPERTIES OF AGGAS$_2$ FILMS DEPOSITED ON CONDUCTING GLASS SUBSTRATES

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Abstract

Pulse electrodeposition with varying duty cycles was investigated to control the properties of $AgGaS_2$ thin films deposited on conductive substrates.The films were deposited on conductive tin oxide-coated glass substrates using a range of duty cycles (6% - 50%) at a constant potential. Analysis revealed that film density varied with the duty cycle. X-ray diffraction confirmed the polycrystalline nature of the films with a chalcopyrite structure and preferential orientations. Crystallite size increased with decreasing duty cycle. Transmission spectra displayed interference fringes, and the refractive index exhibited dependence on the deposition process. The band gap of the films was estimated to be between 2.35 eV and 2.57 eV. Additionally, the study offers insights into single-effective oscillator energy and dispersion energy. These findings suggest that pulse electrodeposition with controlled duty cycle can be a viable technique for tailoring the structural and optical properties of $AgGaS_2$ thin films for potential optoelectronic applications.

Keywords: *$AgGaS_2$, Electronic material, Semiconductor, Thin films*

1. INTRODUCTION

$AgGaS_2$, a member of the chalcopyrite I–III–VI_2 ternary semiconductor compounds, distinguishes itself as a silver-based variant within this class, contrasting with its copper counterparts (Cu-III–VI_2). While copper-based compounds, notably Cu(InGa)Se_2, have demonstrated remarkable efficiency exceeding 18% in solar cell construction [1,2], Ag-based chalcopyrites have attracted attention for their potential in non-linear optical and photonic applications [3,4]. Among these, $AgInS_2$ stands out with its direct band gap falling between 2.3 eV to 2.7 eV and excellent transparency within the 500–1200 nm wavelength range [5,6], making it suitable for frequency doubling and tripling for CO_2 laser output. Its unique transparency at 550 nm is particularly advantageous for constructing optic parametric oscillators pumped by Nd:YAG lasers [7]. Despite these promising characteristics, further research is needed, particularly in the realm of producing more films via pulse electrodeposition. This study aims to fill this gap by presenting and discussing the properties of $AgGaS_2$ films deposited using the pulse electrodeposition method for the first time.

2. MATERIALS AND METHODS

$AgGaS_2$ films were deposited on tin oxide coated conducting glass substrates at different duty cycles, in the range of 6 – 50 % at a deposition potential of - 1.14 V (SCE). The deposition potential was fixed based on an earlier report [8]. The whole deposition time taken almost 15 min. The precursors utilized were Analar grade 0.10 M AgCl, 0.20 M $GaCl_3$ and 0.15 M sodium thio sulphate. The pH was maintained as 1.5 by HCl Thickness of the films estimated by Mitutoyo surface profilometer diverse in the range of 500 – 950 nm with growth of duty cycle. The films were characterized by Xpertp analytical x-ray diffraction unit with Cuká radiation. Optical measurements have been recorded the use of a Hitachi UV–Vis-IR spectrophotometer. The optical data were analysed to obtain band gap, refractive index, extinction coefficient and dispersion energy, as well as the oscillator energy were obtained.

3. RESULTS AND DISCUSSION

The X-ray diffraction pattern of $AgGaS_2$ films formed at different duty cycles is shown in Figure .1.

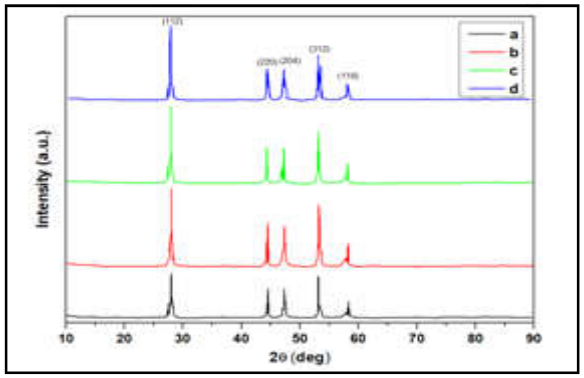

Fig.1 XRD pattern of $AgGaS_2$ films depositedat different

The films were polycrystalline exhibiting the peaks corresponded to the single phase $AgGaS_2$. Peaks corresponding to (112), (220), (204), (312) and (116) orientations of the chalcopyrite shape had been observed (JCPDS No.75-0118).The assessed lattice limits have been a = 5.76 Ĺ and c = 10.27 Ĺ with a c/a ratio of 1.78.The crystallite magnitude was obtained from the Full width half maximum of the diffraction profiles using Scherrer's equation

D = 0.95 ë / (âcosč) (1)

Where, D is the crystallite size, ë is the wavelength of CuKá radiation, â is the full width at half maximum, č is the Bragg angle. The crystallite dimensions increased from 12 nm – 30 nm with decrease of duty cycle. The crystallite dimension and thickness of the films are shown in Table.1.

Table 1 Crystallite Dimension and Thickness of the Films

Duty cycle (%)	Thickness (nm)	Crystallite size (nm)
6	500	30
15	660	23
33	800	18
50	950	12

Figure 2 shows the transmission spectra of the $AgGaS_2$ films placed at various duty cycles.

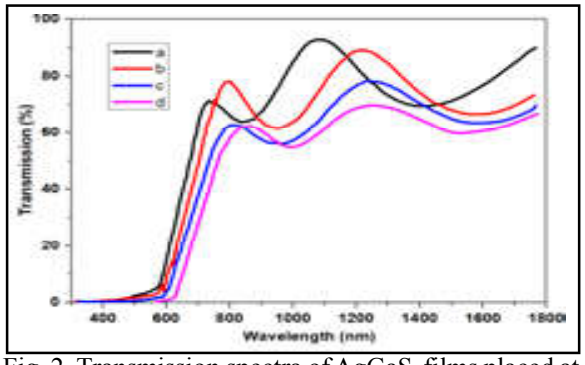

Fig. 2. Transmission spectra of $AgGaS_2$ films placed at various duty cycles (a) 50 % (b) 33 % (c) 15 % (d) 6 %

The spectra show intrusion fringes and the value of the refractive index was projected by the envelope method [9] as follows:

$n = [N + (N^2 – n_s^2)]^2$ (2)

$N = (n_s^2 + 1)/2 + 2\, n_s\, (T_{max} - T_{min})/\, T_{max}\, T_{min}$ (3)

in which n_s is the refractive index of the substrate, Tmax and Tmin are the most and minimal transmittances on the equal wavelength with inside the geared-up envelope curve on a transmittance spectrum. The value of the refractive index at 550 nm, obtained from the equations (3) was in the range of 2.92 - 2.54 for the samples deposited at different duty cycle. This value is higher than the values obtained on thermally evaporated $AgGaS_2$ films [9]. Difference of refractive index with wavelength is displayed in Figure 3.

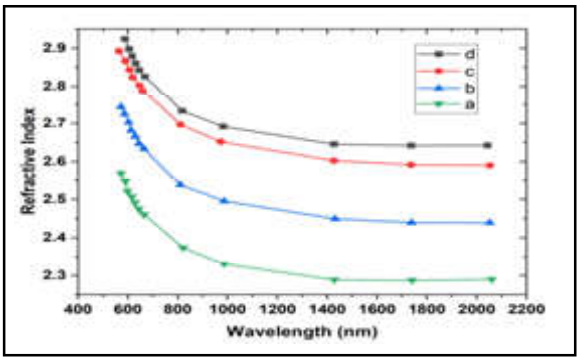

Fig. 3. Variation of Refractive index with wavelength of $AgGaS_2$ films placed at various duty cycles (a) 6 % (b) 15 % (c) 33 % (d) 50 %

The value of the absorption co-efficient (á) has been obtained using the below equation

$á = 1/d \ln \{(n-1)\,(n-n_s) / (n + 1)\,(n – n_s)\}\, [\,(T_{max}/T_{min})^2 + 1]/[(T_{max}/T_{min})^2 - 1]$ (4)

here 'd' is the film's thickness and the other limits have the usual meaning which is provided for equation (4). The films shown a high absorption co-efficient of the order of 10^4 cm^{-1}. A plot of $(áhí)^2$ against hí, as indicated in Figure 4, shows linear action which is close to the band edge, the band gap of the deposited films was decided to be withinside the variety of 2.35 – 2.57 eV. The band gap was found to slightly increase with decrease of duty cycle, due to the small grain size. The band gap of $AgGaS_2$ thin film prepared by thermal evaporation technique was in the range of 2.30 eV - 2.70 eV [9].

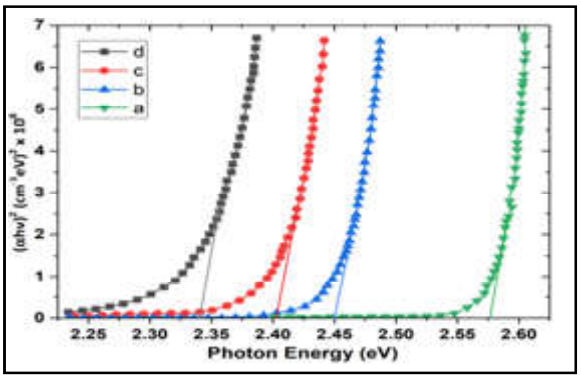

Fig.4 Tauc's plot of $AgGaS_2$ films deposited at different duty cycles (a) 6 % (b) 15 % (c) 33 % (d) 50 %

Extinction coefficient has been projected from the absorption coefficient using the following equation. Figure 5, displays the variation of extinction coefficient with wavelength.

k = áë/4đ (5)

in which á is the absorption coefficient and ë is the wavelength.

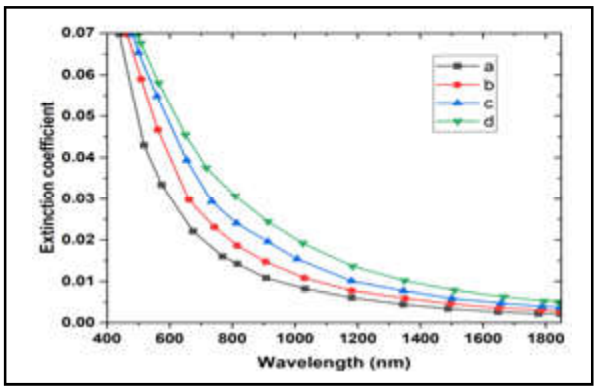

Fig.5 Variation of extinction coefficient of $AgGaS_2$ films deposited at different duty cycles (a) 6 % (b) 15 % (c) 33 % (d) 50 %

As seen from the figure 5, the extinction coefficient decreases with the increase in the wavelength. The decrease in extinction coefficient with increase in wavelength shows that the fraction of light lost due to absorbance decreases. The optical response of a material is mainly studied in terms of the optical conductivity *(ó)* which is given by the relation [10]

ó = (ánc)/4đ (7)

in which c is the velocity of light, á is the absorption coefficient and n is the refractive index.It can be clearly seen that the optical conductivity directly depends on the absorption coefficient and the refractive index of the material. Figure. 6 shows the variation of the optical conductivity as a function of wavelength for the films deposited at different duty cycle.

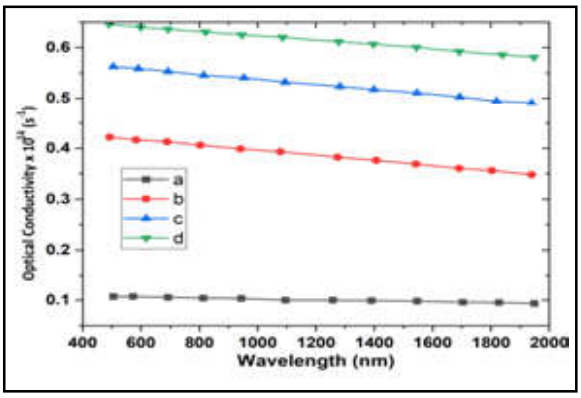

Fig. 6. Variation of optical conductivity of $AgGaS_2$ films deposited at different duty cycle (a) 6 % (b) 15 % (c) 33 % (d) 50 %

It is observed from the figure that, the optical conductivity increases abruptly in the short wavelength region for all the films. The surprising growth in optical conductivity may be attributed to the growth in absorption coefficient.

As per single-effective oscillator model which is projected by Wemple and DiDomenico [11, 12], the optical data can be described by an exceptional calculation by the formula

$n^{2"} 1 = (E_dE_0)/ (E_o^2 – E^2)$ (8)

where E=hí is the photon energy n is the refractive index, E_0 is the single-effective oscillator energy and E_d is the dispersion energy which is a measure of the average strength of the interband optical transitions. Plotting $(n^2 “ 1)^{-1}$ against E^2 gives the oscillator parameters by fitting a straight line. Figure 7 shows the plot of $(n^{2”} 1)^{-1}$ vs E^2 for the films placed at various duty cycles.

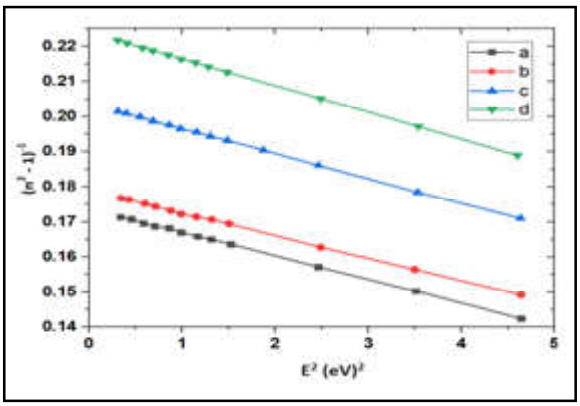

Fig. 7. $(n^2 -1)^{-1}$ vs E^2 plots of $AgGaS_2$ films deposited at different duty cycles (a) 6 % (b) 15 % (c) 33 % (d) 50 %

The values of E_0 and E_d can then be obtained from the slope $(E_0E_d)^{-1}$ and the intercept on the vertical axis (E_0/E_d). The values of the static refractive index (n_0) can be calculated by extrapolating the Wemple–

DiDomenico dispersion equation (8) to E'! 0. The calculated values of n_0 are 2.30, 2.43, 2.60 and 2.65 for the films deposited at different duty cycle. The calculated values of n_0, E_0 and $E_d$are listed in table 3. In addition, the optical band gap (E_g) determined from the Wemple–DiDomenico dispersion parameter E_0 using the relation $E_g = E_0/2$, are also in good agreement with the band gap values determined from the $(áhí)^2$ vs hí plot of Figure 4.

Table 2 The values of single oscillator energy (E_0), dispersion energy (E_d)and optical band gap (E_g) for the $AgGaS_2$ films deposited at different duty cycles

Duty cycle (%)	n_0	E_0 (eV)	E_d (eV)	E_g (eV)
6	2.30	5.16	22.14	2.57
15	2.43	4.94	24.23	2.47
33	2.60	4.82	27.76	2.41
50	2.65	4.70	28.31	2.35

4. CONCLUSION

Pulse electrodeposition offers a scalable and cost-effective approach for depositing $AgGaS_2$ thin films with desirable properties. X-ray diffraction analysis confirms the films single-phase, chalcopyrite crystal structure. Band gap measurements indicate a range of 2.35 eV to 2.57 eV, suggesting potential applications in optoelectronics. Furthermore, the photoconductive response of the films paves the way for their exploration in photoconductive and photocatalytic devices.

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DESIGN AND DEVELOPMENT OF COMPOSITE NONWOVEN GEOTEXTILE FOR FILTRATION

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Abstract

The connection between soil and textile never fades from origin to decease. Recent contributions of textile materials towards strengthening civil construction and soil performance are in the thriving phase. The textile products, so-called geotextile materials, from fiber to fabric are being utilized in a wide range of civil application which includes erosion control, soil stabilization, filtration, drainage, separation, and reinforcement. This study developed geotextile fabric using polypropylene and jute fibers by laying the fiber using cross and parallel laying techniques, respectively. Three-layered nonwoven was then developed by combining both parallel and cross-laid web as a composite through a needling mechanism. This layered composite nonwoven material performs well in absorbing moisture and drains quickly where capillary flow disturbs the road pavement structure.

Keywords: *nonwoven composite; filtration; drainage; polypropylene; jute*

1. INTRODUCTION

Soil has the potential to absorb and retain moisture and water for a particular period. Even though this water absorbency helps for growing plants in the soil, it worsens the road pavement structures in another way. Highway pavement deteriorations have been observed especially after the rainy season when separation of base course and asphalt finish due to structural collapse. This problem arises after the progressive wetting and drying process during rainfall disturbs the base course materials and soil. This is due to poor drainage ability of soil followed by insufficient base course pavements. Almost all civil construction works in contact with soil require better drainage and filtration property to maintain their structural integrity so that lifetime of that construction could be increased. For this purpose, granules, sand, or small stones are used as fillers under or within earth soil. These fillers are less available even if transportation of these materials and installment are difficult and considered expensive. This problem can be addressed by utilizing geotextile drains along with or without base structure materials at the case.

(Alayaki, F. M. (2012). Water absorption properties of laterite soil in road pavement: a case study Ife-Ilesha highway, south western Nigeria. International Journal of Emerging Technology and Advanced Engineering, 2(11), 51-57.)

Geotextiles come under the roof of geotechnical products and have proven as the most versatile and cost-effective ground modification materials in civil construction to enhance the performance of civil constructions. Their role has been expanded rapidly into nearly all areas of civil, geotechnical, environmental, coastal, and hydraulic engineering. Geotextiles have been used very successfully in road construction for over 40 years. The geotextiles materials perform six main functions in geo-engineering applications. Drainage, filtration, and barrier are the three functions that involve fluid transmission and separation, reinforcement and protection are augmenting the mechanical functions of different constructions. Drainage and filtration functions are stagnant in research as critical factors such as achieving filtration efficiency with reduced clogs and in-plane flow of water under confined stress request more care. The geotextile is fluffy textile fabric manufactured using natural or synthetic fibers or both with conventional and unconventional methods. Because of the nonwoven fabric's high loft and bulkier structure and more air volume per unit volume of fabric, nonwoven fabrics especially mechanically bonded (needle-punched) are highly demanded their good transmissivity. Pore size distribution also improves the drainage function along with filtration properties when installed with a direct soil structure. The performance of geotextile for drainage application is

assessed by liquid transmission through cross planer flow and for filtration, it is assessed by transmission through in planer flow. The cross-planer filtration flow is determined through permittivity and in planer flow of water or liquid for drainage is assessed by transmissivity. Few composite structures of geosynthetics with specific functions combined with geonet owning capability of draining liquids to protect geomembranes. Conversely, in pavements, the marble stones of over 50mm diameters which are used as leachate drainage materials, usually ground intrusion to occur in these geonet composites under stress. Under heavy load, this intrusion into geonet composites placed between geosynthetic materials instigated to decrease in the drainage efűciency landfills or base structure of pavements. Henceforth, smart geotextiles with excellent drainage efficiency have a vital role in the protection of the geomembranes at slopes and the liner systems of waste landűlls.

The term 'composite nonwovens' refers to a category of combining fibers by innovative and modern methods. Later this term is renamed 'soft nonwoven composites. The composite nonwoven brought into the definition for fabrics prepared by combining layers produced through different web laying methods or various fiber web bonding methods. The geological requirements of geotextile like drainage and filtration are met despite their thickness and porosity. These geotextiles relatively have a uniform pore size in comparison with soils and imply both hydraulic conductivity and capillary rise. The movement of water from the soil to geotextile material depends on the type of polymer used. Polypropylene is a commonly used geotextile hydrophobic polymer and repels water but aids in capillary flow. The mechanical interlocking of nonwoven fabrics provides interconnected open areas throughout the material which helps greatly in removing the particulates from the fluid streams flowing through it. The filtration property significantly depends on the parameters such as porosity and apparent opening size and is controlled by needle-punch bonding. In this paper, a complete fiber web nonwoven composite has been developed and studied for drainage efficiency.

2.EXPERIMENTAL WORK

2.1 Preparation of Webs

Jute fiber has unique features of modulus and deferred degradation to satisfy most of the technical requirements needed for the major geotechnical applications. Polypropylene fiber is preferred in for its lower cost and mechanical property. These materials are highly resistant to biological and chemical degradation and have sufficient tensile strength and permeability for direct ground treatment applications. In this study, 18 denier Jute fibers of 50mm long, and 6 & 15 denier polypropylene fibers of 80 mm staple length have been purchased for this study. Polypropylene webs are developed by parallel laying technique using a miniature carding machine and jute fiber webs are produced using cross laying technique. The proportion of polypropylene top, jute middle and polypropylene bottom layers was maintained at 30:40:30 ration.

2.2 Preparation of Geotextile

The smart geotextile, a three-layered fabric, was produced with two layers of polypropylene and one layer of jute. The jute fiber layer was sandwiched between the two layers of polypropylene fibers. Three different needle-punching patterns were applied to manufacture the single fabric with two-up paths and one-down path needle punching penetrations. Figure 4.2 shows a demonstrated cross-sectional view of fibers in different layers of the composite nonwoven geotextiles.

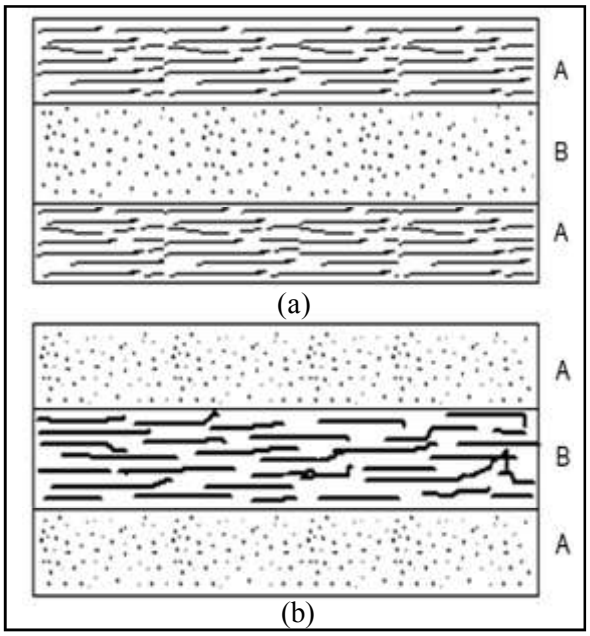

Figure 1 Composite nonwoven geotextile a) Side view of the cross-section b) Front view of the cross-section.
A- Polypropylene fiber layers, B Jute fiber layer

Two fabric composites were developed, one with 6 denier polypropylene and another with 15 denier polypropylene fibers. In both fabrics, jute was the middle layer in the three-layered structure. The jute layer exhibits fiber orientation perpendicular direction to the polypropylene layers in both fabrics. Needling interlocked the fibers and holds the structure together

by friction forces. The individual layers of polypropylene and jute were initially needle punched. Finally, all the layers (three) were needle punched together to enhance the interlocking of fibers between each layer. Fabrics were needled punched with two different punching densities for analyzing the influence of high packing density and the details were recorded in table 1.

Table 1 Thickness of Composite Fabric at Different Pressure

Sample	Layer A	Layer B	Punching Density of
S1	6 denier PP	18 denier Jute fiber	11 punches/ sq. cm
S2			
S3	15 denier PP		11 punches/ sq. cm
S4			

2.3 Linear Density

The composite fabrics were determined for the areal density (mass per square meter). The six-denier polypropylene gives 875 to 990 grams per square meter with 11 punches and 20 punches per square cm. respectively and the 15-denier fiber provides 1100 to 1300 grams per square meter with 11 punches and 20 punches per square cm. respectively. Jute fiber contributes more mass to the linear density of the composite fabric.

2.4 Fabric Thickness

Thickness is one of the basic physical properties of textile materials. The transmissivity of the geotextile is greatly influenced by its thickness and steadiness. Transmissivity is defined as the volume of water flowing within the plane of geotextile material. The thickness value of most textile materials would vary considerably depending on the load applied to the specimen, especially for three-dimensional fabric components. In all cases, the apparent thickness varies inversely with the pressure applied. The fabric having more jute fiber proportion primes to more thickness of material due to its stiffness.

2.5 Pore Size Distribution

The water permeability characteristics of needle-punched nonwovens were measured and corresponding average velocity values were obtained. The water permeability behavior of needled–punched nonwovens is produced by varying the processing parameters during the needle punching process. There was a trend of lower water permeability values with an increasing feeding rate of fibers during needle punching.

Table 2 Thickness of Composite Fabric at Different ressure

Sample	Layer	Areal Density	Pressure (Kpa)			
			1	4	5	10
S1	6 denier PP	875 GSM	10.10	9.02	8.85	8.20
S2		990 GSM	11.20	11.15	11.14	10.55
S3	15 denier PP	1100 GSM	10.57	9.88	9.69	9.0
S4		1300 GSM	11.28	11.20	11.15	11.0

2.6 Wetting Time

The equipment used for the measurement of wetting time is accurate (Spray Impact Test). The wetting time is calculated from the time taken to wet the fabric completely under specific pressure and temperature. The wetting time depends on the water permeability, which is greatly influenced by the depth of needle penetration and pore size. The water permeability is decreased as the feed rate of fibers is increased during needle punching. An increase in the rate of wetting indicates the faster movement of water and increases the drainage property.

2.7 Wicking Rate

Wicking is accelerated by the capillary force exerted at the pores submerged in the composite fabric. The fabric has to wick the water from the soil and drain the water subsequently. The mechanism of draining the water from the composite geotextile was performed in three stages. Initially, liquid water is sucked into the fabric by the capillary force generated at the fabric pores. Secondly, the wicked water is transported between layers exposed and submerged by the difference in suction pressure. Thirdly, the suspended water drops evaporate from the exposed portion of the composite geotextile fabric. The rate of wicking has been assessed in both horizontal and vertical directions.

2.8 Tensile Strength

The fabric contains fibers oriented towards length at the outer layer and orients towards fabric width in the inner layer. The fiber contribution towards tensile stretch differs between the lengthwise and widthwise of the fabric. Both lengthwise and widthwise samples were

tested in this study for comparing the fiber contribution toward the strength of the composite. The fabrics were tested for stretch bearing value through the strip test method at a constant rate of loading condition.

2.9 CBR Test

Performance of composite fabric for drainage layer under pavements varies in accordance with soil characteristics and load. CBR (California Bearing Ratio) test has been performed to analyze the penetration of force for evaluating the mechanical strength of the natural ground, subgrades, and base courses beneath new carriageway construction. In this study, the base course is completely filled with composite fabric. The tests were carried out on natural and compacted soils with and without water-soaking conditions. The results were obtained and compared with the curves of a standard test to know the soil strength of the subgrade. This test was carried out to note the change in the mechanical strength of the fabric as influenced by the presence of liquid water. Destruction in the fiber orientation reduces the aptitude of hydraulic draining rate.

6 denier PP + Jute sample

15 denier PP + Jute sample

3.RESULT AND DISCUSSION

3.1 Pore Size Distribution by Dry Sieving

The pore size distribution of the fabric is determined by sieving dry spherical solid glass beads for a specified time at a specified frequency of vibration and then measuring the amount retained by the fabric sample. The test is carried out on a range of sizes of glass beads. The glass beads were found retained on and within the fabric as the pore size was 90% of the glass beads. This test provides information on the pore size distribution which is an important parameter to be used in assessing a geotextile's soil filtration capability.

3.2 Wetting Time

The sample with less time-consuming for wicking the water that has been passed either horizontally or vertically has good drainage properties. Here, it has been found that the samples S2 and S4 have consumed less time for complete wicking compared with other samples.

3.3 Wicking Rate

The wicking rate was noted for all the four composite fabrics in both horizontal and vertical directions. Two Fabrics were made from 6 denier polypropylene layers blended with 18 denier jute but with 875 (S1) and 990 (S2) GSM linear densities. Similarly, two fabrics were made from 15 denier polypropylene layers blended with 18 denier jute with 1100 (S3) and 1300 (S4) GSM. The fabric samples S1 and S3 are fabricated with fewer densities compared to S2 and S4 respectively. This results in more pore volume incorporated in these structures. Higher pore volume is caused by bigger pore size distribution. These big pores amplified the distance between fibers connections which increased the time to transfer the liquid water from the origin point to the target point at the horizontal plane in the fabric. Likewise, in the vertical plane, looser construction results in delaying the diffusion time of liquid water alongside the fabric structure significantly. The fiber denier also influences the wicking time of the fabric structures significantly. Coarser fibers incorporated fabric samples S3 & S4 show more time taken to transfer the liquid water compared to the samples S1 & S2 respectively. The same pattern is followed in both horizontal and vertical directions of wicking progress.

Table 3 Horizontal and Vertical Wicking Time

Sample	Time Consumption (sec)	
	Horizontal Wicking	Transverse Wicking
S1	14	5
S2	4.5	4
S3	18	8
S4	6	6.5

3.4 Tensile Strength

The stretch bearing capacity of fabrics was measured at constant load rate improvement. Breaking force along with elongation were captured and the time taken was recorded. Samples having fewer GSM, S1 & S2 with loosely packed fibers exhibit low strength bearing ability due to their weak holding points. Samples S2 and S4 were tightly packed with more punching density and showed better stress-bearing values, but extended deformation was higher for these samples.

Table 4 Tensile Characteristics of Composite Fabrics

Sample	Breaking Force (kgf)	Elongation (mm)	T. Break (s)
S1	27.600	50.500	10.100
S2	56.600	228.200	45.640
S3	79.900	40.800	48.160
S4	164.700	202.800	40.560

From the above table values, it has been found that samples S2 and S4 have higher tensile strength.

3.5 CBR Test

The CBR test has been taken only for two samples (S2 and S4). It has been found that the functioning of soil was better with the introduction of geotextile fabric. Between the two layers of geotextile, the sample S4 has proved still better functioning due to its higher denier and mass per unit area comparatively.

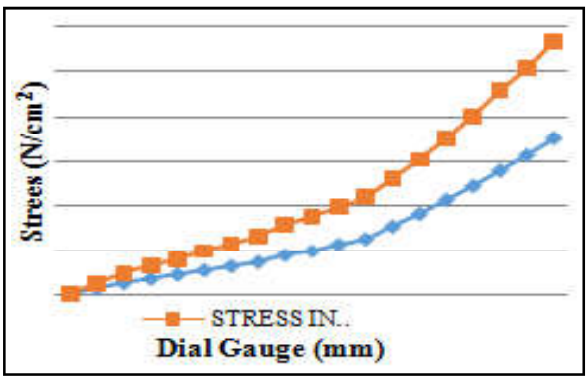

Fig.2 CBR test - Graph

4. CONCLUSION

The capillary rise can be delayed by several days when a nonwoven geotextile was placed between two soil layers.

In geotextile, the water flow is by the means of pores present which is produced by needle–punching. The pore characteristics play an important role in the water permeability (Cross – plane water flow) behavior of nonwoven geotextile. This behavior is also influenced by the structural arrangement of fibers. The arrangement of pores in nonwoven geotextiles greatly influences the water permeability behavior.

The three-layered nonwoven shows a lower rate of in-plane permeability than geonet composites.

As the water enters the geotextile layer the hydraulic conductivity is found to be higher than that of soil and hence, the layer leads to easy drainage of water. The nonwoven fabric produced with a lower feed rate has a higher open structure and low thickness which enhances the permeability property.

This study shows that the three-layered nonwoven geotextile (jute layer placed between the two layers of polypropylene) which is known as smart geotextile has delayed the capillary rise of water by several days. The orientation of fibers in the machine direction and cross direction leads to better drainage of the geotextile fabric. The sufficient tensile strength and permeability for the direct ground applications avoid structural collapse and particle intrusion. These damages also influence the drainage and filtration properties of geotextile.

The geotextile with high porosity implies good hydraulic conductivity and also acts as a cushion when saturated. The physical properties along with its punching density and porosity have been analyzed for the developed nonwoven composites. The water permittivity and transmissivity test have proved that fabric with high GSM delays the capillary action of water by several days, which gives a long duration for soil to attain its strength.

The mechanical properties like puncture resistance and bursting strength have been greatly increased by mechanical interlocking. An increase in mechanical properties greatly influences hydraulic properties.

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COMPARATIVE ANALYSIS OF MECHANICAL PROPERTIES OF FIBRE MIXED CONCRETE

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Abstract

Concrete ranks as the second most utilized building material globally, trailing only behind water. Given the escalating depletion of natural resources, there's a growing trend towards integrating alternative materials into concrete to improve its durability and lifespan. This study explores the incorporation of three different fiber types - Polypropylene, Basalt, and Steel fibers - into M25 concrete to investigate their impact on its mechanical properties. Both the fresh and hardened properties of the concrete were analyzed. The results indicate a significant enhancement in early strength, with an approximately 62% increase compared to traditional concrete, attributed to the addition of fibers. Particularly noteworthy is the significant improvement in compressive strength by 24% and tensile strength by 22% with the inclusion of Polypropylene fibers, outperforming conventional concrete.

Keywords: *Polypropylene fiber, Steel fiber, Basalt fiber, Compressive strength, Tensile strength*

1. INTRODUCTION

Concrete, a composite material composed of hydraulic cement, water, coarse aggregate, and fine aggregate, undergoes a chemical reaction between cement and water, resulting in a stone-like structure. Despite its notable compression strength, concrete is inherently brittle, exhibiting weakness in tension, limited ductility, and susceptibility to cracking, impacting its impact and abrasion resistance. High-quality concrete is characterized by both high strength and low permeability. Consequently, there's a rising interest in alternative composite materials due to their enhanced ductility and strain hardening properties.

Cracks are the primary cause of concrete failure. Various endeavors have been made to improve concrete's tensile strength, with the most effective method being the incorporation of steel reinforcement. However, steel bars only reinforce concrete against localized tension, allowing cracks to propagate freely until encountering a reinforcement bar, often necessitating multi-directional and closely spaced steel reinforcement, which is often impractical. Fibre reinforcement presents a solution to this challenge.

To bolster concrete's tensile strength, a method involving the introduction of fibers into the concrete matrix is employed. These fibers act as crack inhibitors, preventing crack propagation. Uniformly distributed and randomly arranged in what's termed fibre-reinforced concrete, these fibers primarily aim to enhance post-cracking response, energy absorption capacity, apparent ductility, and crack resistance while preserving structural integrity and material cohesiveness. Initial research and subsequent extensive studies have led to the development of a wide range of material formulations aligning with the concept of fibre-reinforced concrete.

2. LITERATURE REVIEW

This review provides a comprehensive overview of the fresh and mechanical properties of basalt fibre reinforced concrete (BFRC)[1,2]. The focus of this examination is primarily on the influence of basalt fibre dosage and length on the properties of BFRC. In reinforced concrete with basalt fibre, the slump decreases as both the length and content of basalt fibre in the concrete increase. This decrease is attributed to the absorption of a certain amount of water by the basalt fibre, resulting in a reduction in slump. Several researchers have explained the impact of basalt fibre on the flexural strength of concrete, noting an increase in flexural strength with higher dosages of basalt fibre. The literature consistently confirms that the modulus of

elasticity experiences an increase as both the length and content of basalt fibre in the concrete increase.

The objective of this study is to assess the effectiveness of two types of basalt fibre, namely bundle dispersion fibres and minibars, in enhancing the mechanical behavior of concrete[3,4]. The incorporation of basalt fibres (BF) led to an improvement in the first-crack strength of concrete under flexural loading, but the influence was not notably significant when exposed to impact loading. In instances of flexural loading, the initial crack strength exhibited an increase with higher fibre dosage. The introduction of minibars (MB) also contributed to an enhancement in the first-crack strength of concrete subjected to both flexural and impact loading. In both scenarios, the initial crack strength demonstrated an increase with an elevation in fibre dosage. However, at elevated fibre dosages, it became challenging to determine the point of concrete cracking, as the composite exhibited a ductile behavior.The inferior post-cracking response observed in BF specimens was attributed to failure caused by fibre rupture, in contrast to MB specimens where failure primarily occurred due to fibre pull-out.

The aim of this study is to examine and compare the structural characteristics of concrete beams incorporating varying percentages of polypropylene fibers[5,6]. The impact on compressive strength was found to be minimal, typically exhibiting a slight increase up to 1.65% of fiber content, beyond which there was a decline. In terms of split tensile strength, a moderate effect was observed, showing an incremental improvement up to 1.65% of fiber content. However, as the percentage of fibers increased beyond this point, there was a subsequent decrease in split tensile strength.Significantly, there was a positive impact on flexural strength, which tended to rise with a small percentage of up to 1.65% fiber content. However, beyond this threshold, as the percentage of fibers increased further, there was a corresponding decrease in flexural strength[7].

This paper provides an extensive review of the impact of incorporating polypropylene fibers into concrete on various durability properties[8]. The addition of polypropylene fibers at different volumes in concrete serves to mitigate cracks by establishing bond bridges and modifying its pore structure, leading to reduced porosity and increased tortuosity. Consequently, this alteration diminishes the water and gas permeability of the concrete.Furthermore, the presence of polypropylene fibers in concrete contributes to the improvement of frost resistance. This enhancement can be attributed to the increased tensile strength, the crack-restricting effect of polypropylene fibers, the bonding bridge effect of fibers on cracks, and the transitional effect of fibers on disconnected cement blocks. Consequently, the concrete's resistance to carbonation is strengthened.

This study investigates the performance of hooked steel fibers (50 mm) and chopped glass fibers in concrete through experimental analysis aimed at optimizing their combination[9.10]. Various fiber contents are examined to ascertain the optimal steel fiber content (approximately 1.5%) and glass fiber content (approximately 2%) that yield compressive strengths reaching approximately 49.34 MPa. The incorporation of fibers results in a 10% increase in compressive strength for conventional concrete and a 12% increase for lightweight concrete. Regarding splitting tensile strength, there's an approximate 70% enhancement for conventional concrete and an 80% improvement for lightweight concrete. Both conventional and lightweight concrete experience a 90% increase in flexural strength, while the modulus of elasticity sees a 10% rise. These findings contribute to identifying the optimal mix for Fiber Reinforced Concrete and determining the optimum fiber content[11].

3. MATERIALS

3.1 Cement

The earliest evidence of cement dates back approximately twelve million years, with deposits emerging from the spontaneous combustion of oil shale near a limestone bed. These natural events led to the formation of ancient cement deposits, which researchers began to investigate in the 1960s and 1970s.

Cement, in its broadest sense, serves as a binder—a substance capable of setting and hardening independently, thereby binding other materials together. Construction-grade cement falls into two main categories: hydraulic and non-hydraulic. Hydraulic cements, exemplified by Portland cement, harden through hydration, a chemical reaction independent of the mixture's water content. This unique property allows hydraulic cements to solidify even underwater or when consistently exposed to wet conditions.

3.2 Fine Aggreate

Fine aggregate, often referred to as natural sand, undergoes a washing and sieving process to remove particles larger than 5mm. On the other hand, coarse aggregate, typically gravel, is crushed, washed, and sieved to attain particle sizes ranging from 5 to 50mm. In construction, sand acts as inert material in mortar and concrete, and it can also be artificially produced by crushing stones. Artificial sand finds frequent use in the construction of dams and bridges. The silica content present in sand contributes to the formation of silicates, which results in a hardened mass that mitigates cementing material shrinkage and enhances mortar density.

3.3 Coarse Aggregate

Comprising a substantial portion of concrete, coarse aggregate differs from fine aggregate by resembling typical rock particles rather than sand. Classified as rock larger than the standard No. 4 sieve (3/16 inches) but smaller than 2 inches, coarse aggregate serves pivotal roles in various construction applications, notably in asphalt and concrete mixtures.

Sourced from quarries or extracted from river beds, coarse aggregate exhibits variability in size, shape, hardness, and texture depending on its origin. It may present as smooth or rounded, akin to river gravel, or angular, resembling crushed stone. Key characteristics used to characterize coarse aggregate include relative density, bulk density, and absorption rate.

3.4 Water

Water plays a crucial role in concrete mixtures, significantly influencing their workability and facilitating cement hydration. The quantity of water used can impact all aspects of fresh and hardened concrete. It is imperative to use clean water devoid of harmful substances such as chloride, sulfate, acid, sugar, organic materials, industrial waste, oil, clay, and silt.

Cement requires up to 25% of its weight in water for hydration, and excessive water usage only enhances workability temporarily, as it eventually evaporates from the concrete, leading to voids. An increased water content results in more voids, which adversely affect both the strength and durability of the concrete.

3.5 Polypropylene Fiber

Polypropylene fibers represent a modern generation of synthetic fibers, ranking as the fourth largest in production volume after polyesters, polyamides, and acrylics. Globally, approximately 4 million tonnes of polypropylene fibers are manufactured annually, as illustrated in figure 1. Initially proposed for inclusion in concrete as an admixture for blast-resistant structures in 1965, these fibers have since evolved into short discontinuous fibrillated materials for fiber-reinforced concrete or continuous mats for thin sheet components. The addition of polypropylene fibers to concrete improves its tensile strength, flexural strength, toughness, impact strength, and alters the concrete's failure mode. Properties of Polypropylene Fiber is listed in Table 1.

Manufactured through conventional melt spinning utilizing Propylene gas, derived from petroleum by-products or natural gas cracking, these fibers possess controlled molecular configurations, rendering them highly crystalline with high stiffness. Additionally, they exhibit excellent resistance to chemical and bacterial degradation and have a low density of 0.9 g/cc. The recommended dosage rate is approximately 0.1% by volume, and their tensile strength and mechanical properties are enhanced through multi-stage drawing processes.

Fig.1 Polypropylene Fiber

Table 1 Properties of Polypropylene Fiber

Properties	Values
Polymer	100%Virgin olypropylene Homo- polymer
Length	10-12 mm
Diameter	18 micron
Modulus (young's)	4.0 kN/mm^2
Specific gravity	0.91
Absorption	Nil
Colour	Natural
Thermal&Electrical Conductivity	Low

3.6 Basalt Fibre

Basalt, a natural volcanic igneous rock, is renowned for its hardness, density, and dark brown to black coloration, originating from depths of hundreds of kilometers beneath the Earth's surface. Basalt fiber, on the contrary, is a material crafted from exceptionally fine basalt filaments, incorporating minerals like plagioclase, pyroxene, and olivine. Resembling fiberglass, basalt fiber showcases superior physical and mechanical properties compared to fiberglass, while remaining notably more cost-effective than carbon fiber. With its unique blend of characteristics, basalt fiber finds application across various industries, leveraging its resilience, strength, and cost-effectiveness to reinforce materials and enhance composite performance. Properties of Basalt Fiber is listed in Table 2.

Fig.2 Basalt Fiber

Table 2 Properties of Polypropylene Fiber

Properties	Values
Fibre type	Chopped
Length	12mm
Filament Diameter	7 to 15 µm
Density	2650 kg/ m^3
Elastic modulus	10000 to 11000 kg/ mm^2
Tensile Strength	4150 to 4800 Mpa
Elongation	3.2%

3.7 Steel Fiber

Steel fibers are crucial metal reinforcements extensively utilized in the construction industry. Specifically designed for reinforcing concrete, steel fibers are defined as short, discrete lengths of steel with an aspect ratio (length to diameter ratio) typically ranging from approximately 20 to 100. Available in various cross-sections, these fibers are sufficiently small to be uniformly dispersed in an unhardened concrete mixture using standard mixing procedures. Properties of Steel Fiber is listed in Table 3.

Fig.3 Steel Fiber

Table 3 Properties of Steel Fiber

Properties	Values
Fibre type	Straight , hook- end
Length	30mm
Filament Diameter	0.3-0.7mm (max 1mm)
Density	7900 kg/m^3
Young's Modulus	2.1 x 10^5 N/mm^2
Tensile Strength	500-2000 N/mm^2
Elongation	5-35 %

3.8 Test on Fresh Concrete

Fresh concrete has various tests. We were conducted some important test. These are

- Slump cone test
- Compaction factor test

3.9 Slump Cone Test

Slump cone value of fresh concrete results are calculate below. Slump value for different mix is listed in Table 4.

Fig.4 Slump Cone Test

Table 4 Slump Value for Different Mix

Mix	SLUMP VALUE (mm)		
	Polypropylene fibre	Basalt fibre	Steel fibre
CC	105	105	105
F 0.25	97	98	95
F 0.50	94	93	90
F 0.75	86	88	86
F 1.00	84	85	80

3.10 Compaction Factor Test

Fig.4 Compaction factor Test

Table 5 Compaction Factor Test for Different Mix

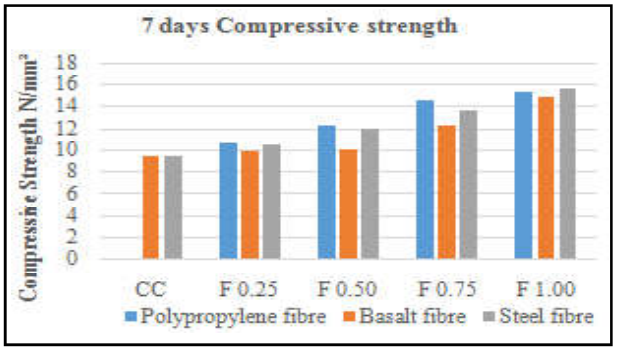
MIX	Polypropylene Fibre	Basalt Fibre	Steel Fibre
CC	0.89	0.89	0.89
F 0.25	0.86	0.87	0.85
F 0.50	0.84	0.83	0.8
F 0.75	0.81	0.79	0.78
F 1.00	0.77	0.75	0.74

4. TEST ON HARDENED CONCRETE

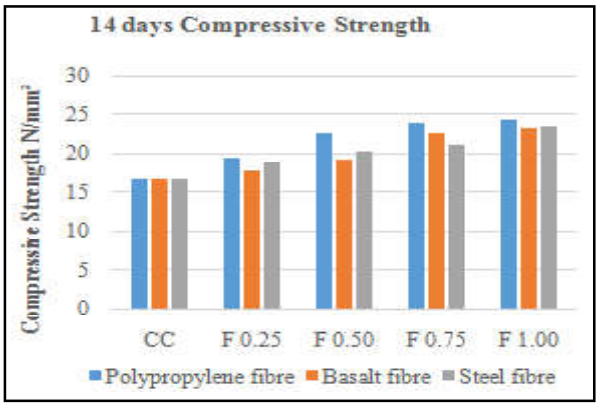
4.1 Compressive Strength of Cube

The concrete cubes were standardized at dimensions of 150 mm x 150 mm x 150 mm. Prior to testing, all specimens underwent a saturated surface-dry condition, with surface moisture being wiped out. Testing occurred at three distinct intervals: 7 days, 14 days, and 28 days after casting. Utilizing a 120-ton compression testing machine, three identical specimens were subjected to compression. The load was incrementally applied at a rate of 140 kg/cm$_{c}$/min until specimen failure. The maximum load sustained by the specimen until failure was duly recorded. The ultimate cube compressive strength was then derived by dividing the ultimate load by the cross-sectional area of the specimen. This systematic testing protocol allows for the comprehensive assessment of concrete's compressive strength across varying curing ages, furnishing valuable insights into its development and performance trajectory over time.

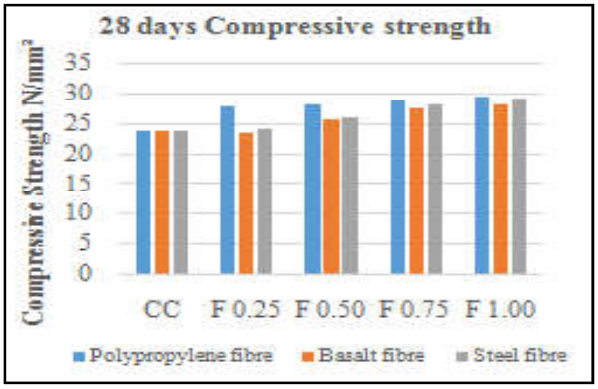
COMPRESSIVE STRENGTH 7 DAYS



COMPRESSIVE STRENGTH 14 DAYS



COMPRESSIVE STRENGTH 28 DAYS

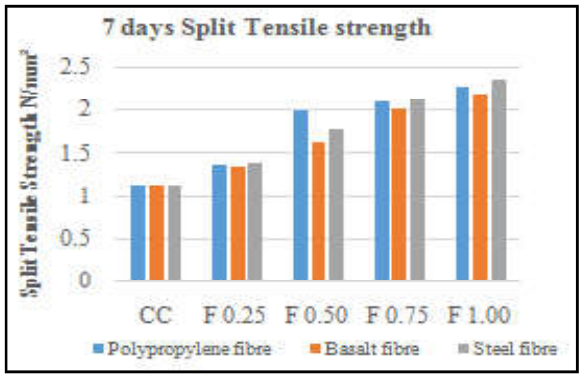


5. SPLIT TENSILE SRENGTH ON CONCRETE

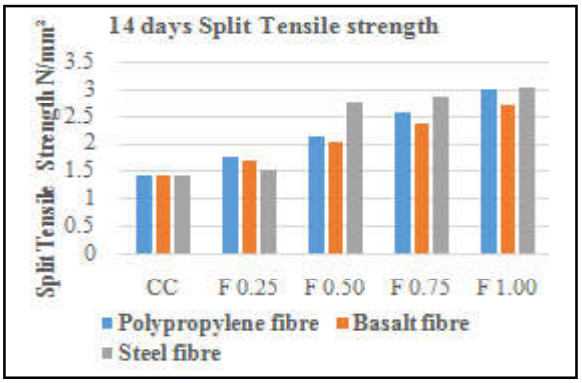
The concrete cubes were standardized at dimensions of 150 mm x 150 mm x 150 mm. Prior to testing, all specimens underwent a saturated surface-dry condition, with surface moisture being wiped out. Testing occurred at three distinct intervals: 7 days, 14 days, and 28 days after casting. Utilizing a 120-ton compression testing machine, three identical specimens were subjected to compression. The load was incrementally applied at a rate of 140 kg/cm$_{c}$/min until specimen failure. The maximum load sustained by the specimen until failure was duly recorded. The ultimate cube compressive strength was then derived by dividing the ultimate load by the cross-sectional area of the specimen. This systematic testing protocol allows for the comprehensive assessment of concrete's compressive strength across varying curing ages, furnishing valuable insights into its development and performance trajectory over time.

5.1 Result and Discussion

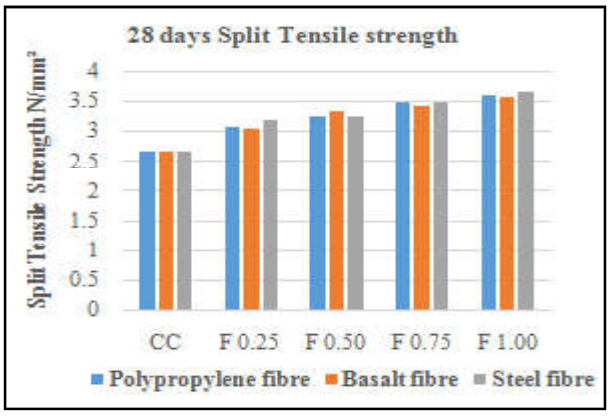
SPLIT TENSILE STRENGTH 7 DAYS



SPLIT TENSILE STRENGTH AT 14 DAYS



SPLIT TENSILE STRENGTH AT 28 DAYS



6. CONCLUSION

The specimens were labeled as follows: CC, F 0.25, F 0.50, F 0.75, and F 1.00, each prepared with varying percentages of polypropylene, basalt, and steel fibers. Upon testing, it was noted that the addition of fibers led to an increase in compressive strength across all types of fibers, with this enhancement being particularly pronounced at the 14-day and 28-day intervals. Across all three types of fibers, namely polypropylene, basalt, and steel, compressive strength generally rose as fiber content increased from F 0.25 to F 1.00. This trend underscores the beneficial impact of fiber reinforcement on concrete's mechanical properties. Similarly, split tensile strength exhibited an overall increase with the incorporation of fibers, irrespective of fiber type, which remained consistent across all testing intervals. Across polypropylene, basalt, and steel fibers, split tensile strength tended to rise as fiber content increased from F 0.25 to F 1.00. This trend indicates that higher fiber percentages correlate with improved tensile strength properties in concrete. Notably, specimens with the highest fiber content (F 1.00) consistently displayed the highest split tensile strength values across all testing intervals and fiber types.

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DESIGN AND FABRICATION OF FDM PRINTED ROBOTIC ARM

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Abstract

This abstract presents the design, fabrication, and evaluation of a novel 3D-printed robotic arm integrated with a flex sensor for enhanced flexibility and control. Robotic arms play a crucial role in various applications, from manufacturing to healthcare. This research addresses the demand for more versatile and cost-effective robotic arm solutions by combining advanced 3D printing techniques with flexible sensing technology

Keywords: Cost-effective, Flex Sensor, Robotic Arm, 3D Printing

1. INTRODUCTION

In recent years, advancements in 3D printing technology have revolutionized the field of prosthetics, enabling the creation of highly customizable and functional solutions. One notable innovation is the development of 3D-printed bionic arms integrated with flex sensors. These remarkable devices combine the precision of 3D printing with the adaptability of flex sensor technology, resulting in a new generation of prosthetic limbs that offer enhanced dexterity and responsiveness.

Traditionally, prosthetic limbs have faced challenges in replicating the intricate movements and sensory feedback of natural limbs. However, the integration of flex sensors into 3D-printed bionic arms marks a significant step forward. Flex sensors, capable of detecting changes in bending and flexing, serve as a bridge between the user's intent and the mechanical response of the prosthetic. When integrated into a 3D-printed bionic arm, these sensors provide real-time data that allows for more precise control over the device's movements.

The combination of 3D printing and flex sensor technology addresses key limitations of traditional prosthetics, such as limited range of motion and difficulty in performing delicate tasks. Users of these innovative bionic arms can experience a higher degree of functionality and independence, as the integration of advanced sensors offers a more intuitive and seamless interaction with their prosthetic limb.

This short note explores the intersection of 3D printing and flex sensor technology within the realm of prosthetics, highlighting the potential of these advancements to reshape the lives of individuals with limb differences. By fusing cutting-edge fabrication techniques with sophisticated sensor capabilities, the 3D-printed bionic arm with a flex sensor exemplifies a promising direction in the ongoing quest to create more functional and lifelike prosthetic solutions.

2. ADDITIVE MANUFACTURING

Additive manufacturing, commonly known as 3D printing, stands at the forefront of modern manufacturing techniques, shaping the way physical objects are brought to life from digital concepts. This innovative process entails the meticulous layering of materials to construct three-dimensional objects based on precise digital designs. By harnessing a diverse array of methods and materials, such as plastics, metals, and composites, additive manufacturing has ushered in a new era of creativity and efficiency in fabrication. The versatility of additive manufacturing extends to its aptitude for rapid prototyping, a hallmark feature that has earned it the moniker "rapid prototyping." This capability empowers designers and engineers to swiftly transform their visions into tangible prototypes, facilitating iterative testing and refinement before mass production. In recent times, the allure of additive manufacturing has gained momentum, underscored by its capacity to manufacture bespoke objects with speed and cost-effectiveness. This

phenomenon has catalyzed its widespread integration across various industries, including aerospace, automotive, healthcare, and consumer goods, where it has proven instrumental in optimizing production processes and unlocking unparalleled design possibilities.

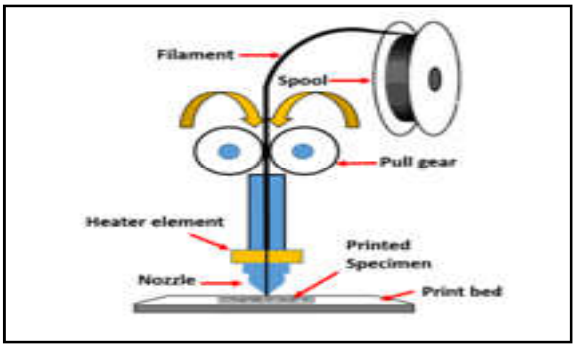

Fig. 1 Additive Manufacturing

3. WORKFLOW CHART

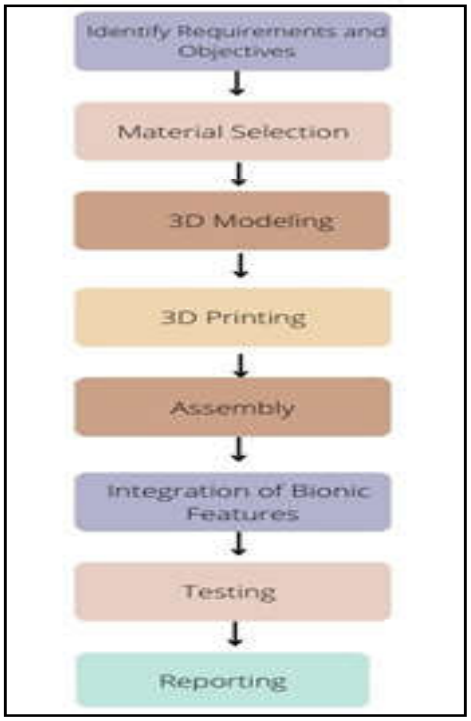

Fig.2 Workflow

4. CHOICE OF COMPONENTS

The various components, technologies and software which are used in the making process of the 3D Printed Robotic arm are listed below

A. PLA filament 1.75mm.
B. Flex sensor
C. Solid Works 2022 (CAD software).
D. Ultimaker Cura 4.8.2 (Slicing software).
E. Creality Ender 3 (FDM 3D Printer).

4.1 PLA Filament (1.75mm)

PLA filament 1.75mm is a type of thermoplastic filament used for 3D printing. It has a wide range of applications including arts and crafts, prototyping, and product development. It is an affordable, easy-to-use material that is capable of creating intricate parts with great accuracy.

PLA filament 1.75mm is the most common type of thermoplastic filament used in 3D printing due to its ease of use, affordability, and wide availability. It has a low melting temperature, making it easy to work with on almost any type of 3D printer.

4.2 Flex Sensor

Flex sensors are highly precise measurement devices used to determine the degree of bend or flex in various objects. They find widespread application in fields such as robotics, medical devices, and human-machine interfaces. Similar to the digital vernier caliper, flex sensors consist of two components: a stationary side and a movable side. These components are designed to detect changes in flexion and extension along a calibrated scale.

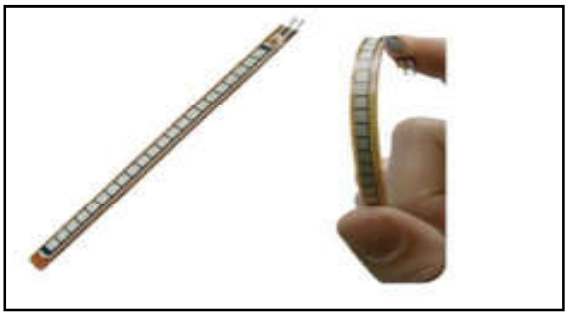

Fig.3 Flex Sensor

Typically calibrated in degrees of bend and featuring a reference scale for enhanced accuracy, flex sensors incorporate a mechanism similar to the Vernier scale. This additional scale allows for measurements to be interpreted with increased precision, down to a fraction of the smallest interval on the primary scale. By affixing the flex sensor to the object being monitored, the device detects even subtle degrees of bending and provides a highly accurate reading through a digital display.

4.3 Solid Works 2022 (Cad Software)

Solid Works 2022 will be the next iteration of the popular parametric 3D CAD software from Dassault Systems. It will include a host of new features and improvements to existing tools, as well as more powerful modeling capabilities. Solid Works 2022 will offer

increased performance, improved user experience, and more powerful modeling tools for design engineers.

The software will also include new tools such as Generative Design, which allows users to quickly generate a range of design options based on user-defined parameters. Solidworks 2022 will also include improved simulation capabilities, allowing users to quickly analyze their designs and make more informed design decisions. It will also support the latest hardware and software standards, allowing users to take advantage of the latest technology.

4.4 Ultimaker Cura (Slicing Software)

Ultimaker Cura is a free slicing software for 3D printing. It is an advanced slicing engine that provides the user with complete control over the 3D printing process. It supports a wide variety of 3D printing materials and is optimized for all Ultimaker 3D printers. It offers an easy-to-use interface, slicing presents, and powerful customization options. Ultimaker Cura is capable of slicing almost all 3D models, from small parts to large objects, and provides users with the ability to take full control over the 3D printing process.

4.5 Creality Ender 3 (FDM 3d Printer)

The well-liked and relatively inexpensive FDM 3D printer is the Creality Ender 3. For both newcomers and seasoned 3D printing fans, it is a fantastic option. An excellent entry-level 3D printer with decent print quality and dependability, as well as simple installation and upkeep, is the Ender 3. Also, it has a huge construction capacity and is quite affordable. One of the most well-liked 3D printers on the market is the Ender 3, and that's understandable reason. It is a terrific alternative for people who are new to 3D printing as well as for more seasoned users who want to acquire top-notch outcomes without going over budget.

Fig.3 Creality Ender 3

Product	3D Printer
Printing Technology	FDM (Fused Deposition Modeling).
Nozzle Diameter	0.1 - 0.4mm.
Printing Speed	Up to 180mm/s.
Filament Diameter	1.75mm.
Filament Compatibility	PLA, ABS, TPU, and other 1.75mm filaments.
Bed Levelling	Manual leveling assisted by large knobs on the bed.
Connectivity	USB, SD Card.
Power Supply	Input 100-240V, Output 24V.

5. SCOPE OF THE PROJECT

The various scope of the project are discussed below

- Design and engineering
- Flex sensor integration
- Servo motor control
- Cost efficiency
- Human-machine interfacing (HMI)

5.1 Design and Emgineering

5.1.1 Conceptualization and Design

The various stages of the designing the robotic arm are listed below:

- Define the purpose of the bionic arm (e.g., assistive device, prosthetic, robotic enhancement) and the target user's needs.
- Determine the range of motion, strength, and other functional requirements.
- Create a rough sketch or digital model of the bionic arm, considering its overall shape, size, and attachment points.
- Select materials suitable for 3D printing, such as strong and lightweight plastics (e.g., ABS, PLA, PETG), metals (e.g., titanium), or composite materials.

5.1.2 3D Modeling

Using computer-aided design (CAD) software to create a detailed 3D model of the bionic arm. The next step of the modelling is to ensure that the design accounts for anatomical compatibility and user comfort. In continuation with it we incorporate mechanisms for joint movement, such as hinges, servos, or pneumatic actuators. And the final step is to integrate sensors, such as pressure sensors or accelerometers, to enable feedback and control.

5.1.3 Mechanical Engineering

To ensure the proper functioning of the bionic arm we conduct engineering analysis, including stress and strain simulations, to ensure the structural integrity and durability of the bionic arm. This ensures the Optimization of the design for weight reduction without compromising strength and functionality. We have also determined the power source and energy-efficient actuators for moving the arm's joints.

5.1.4 Electronics and Control Systems

Developing an electronic system to control the bionic arm's movements. This could involve microcontrollers, sensors, motor drivers, and communication interfaces. Interpretating the Implement control algorithms with user inputs (e.g., muscle signals, gestures) and translate them into precise arm movements.Consideringthe addition of user-friendly features like adjustable grip strength or intuitive control modes.

5.1.5 Prototyping

Creating a physical prototype of the bionic arm using 3D printing. This may involve iterative testing and refinement to ensure the design's functionality and fit.Assembling and integrating the electronic components, actuators, and sensors into the prototype.

5.1.6 Testing and Iteration

Performing extensive testing to evaluate the bionic arm's performance, ergonomics, and safety. By gathering user feedback to make design adjustments as needed.Testing the arm's durability and reliability over extended periods of use.

5.1.7 Finalization and Production:

Refining the design based on testing results and user feedback to prepare the final 3D models and engineering drawings for production. The next step is to set up a manufacturing process for producing the 3D-printed bionic arms at scale.

6. FLEX SENSOR INTEGRATION

6.1 Sensor Selection

Choosing the high-quality flex sensors makes the bionic arm reliable and durable. Flex sensors are available in various lengths and resistance ranges. Selecting sensors that suit the range of motion and size of bionic arm.

6.2. Placement

Determining the optimal locations to place the flex sensors on the bionic arm. Common positions include the forearm, wrist, or finger joints, depending on the arm's design and intended movements.Ensuring the sensors are securely attached and does not interfere with the arm's mechanical components.

6.3 Wiring and Connections

Planning the wiring layout for connecting the flex sensors to the control electronic and using flexible and lightweight wires that won't impede arm movement.Soldering or connectors helps to attach the flex sensor leads to the wiring. Ensure strong and reliable connections.

6.4 Electronics Integration

Choosing an appropriate microcontroller or control board to process the sensor data and translate it into arm movements and connecting the flex sensors to analog or digital input pins on the microcontroller.Implement signal conditioning and calibration as necessary to ensure accurate sensor readings.

6.5 Calibration and Mapping

Developing calibration routines to establish the sensor's baseline readings when the arm is in its neutral position.Mapping the sensor's range of motion to the desired range of arm movements. This mapping will translate sensor data into control signals for the bionic arm's actuators.

6.6 Control Algorithms

Creating control algorithms that convert the sensor data into specific arm movements, such as opening and closing the hand or rotating the wrist.Implementation of filtering and smoothing techniques to eliminate noise and improve control precision.

6.7 Testing and Refinement

Testing the bionic arm with integrated flex sensors to ensure that the sensor readings accurately correspond to the user's intended movements.Gathering user

feedback tomake adjustments to the control algorithms and sensor placement as needed.

6.8 User Interface

Designing a user interface that allows users to switch between different modes or control strategies using the flex sensors.Considering the addition of feedback mechanisms, such as visual or haptic cues, to enhance the user experience.

6.9 Integration with Other Control Methods

Flex sensors can be integrated alongside other control methods, such as EMG (electromyography) sensors or accelerometers, for a more comprehensive and versatile control system. If the bionic arm is intended for medical or assistive purposes, seek regulatory approval from relevant authorities.

6.2 Servo Motor Control

6.2.1 Servo Selection

Choose servo motors that match the size, torque, and speed requirements of your bionic arm's joints.Considering digital servos with feedback mechanisms (such as rotary encoders) for accurate position control.

6.2.2 Mechanical Integration

Design the mechanical structure of the bionic arm to accommodate the servo motors and their attachments to the joints.Ensure proper alignment and range of motion for each joint.

6.2.3 Wiring and Connections

Wire the servo motors to the control electronics. Typically, servos have three wires: power (usually red), ground (usually black or brown), and control signal (usually yellow or white).

6.2.4 Microcontroller Selection

Choose a microcontroller (such as Arduino, Raspberry Pi, or a specialized robotic controller) to interface with and control the servo motors.

6.2.5 Control Circuit Design

Design the control circuit that interfaces the microcontroller with the servo motors and use motor drivers (such as H-bridges or motor controller boards) to amplify the microcontroller's output signals and provide sufficient current to drive the servos.

6.2.6 Software Development

Write software code to control the servo motors. This involves generating PWM (Pulse Width Modulation) signals to set the servo angles.Most servo motors use a PWM signal with a duty cycle between 5% and 10% for the minimum angle, around 90% for the neutral position, and 15% to 20% for the maximum angle.

6.2.7 Calibration and Mapping

Calibrate the servo motors to ensure that their positions match the desired joint angles.Implement mapping functions to translate user inputs or sensor data into servo angle commands.

6.2.8 Control Algorithms

Develop control algorithms that enable smooth and coordinated movement of multiple servo motors to achieve natural arm motions.Implement PID (Proportional-Integral-Derivative) control or other feedback control strategies to enhance stability and accuracy.

6.2.9 User Interface

Create a user interface for controlling the bionic arm. This can include physical buttons, switches, or touchscreens to command specific movements.

6.2.10 Testing and Refinement

Test the bionic arm's servo motor control system to ensure accurate and reliable movement.
Refine control algorithms and calibration based on user feedback and real-world testing.

6.2.11 Power Supply

Ensure that the power supply can provide sufficient voltage and current for all servo motors to operate simultaneously.

6.2.12 Safety Features

Implement safety mechanisms, such as software limits, emergency stop buttons, and collision detection, to prevent damage and ensure user safety.

6.3 Cost Efficiency

6.3.1 Material Selection

Choose cost-effective 3D printing materials that meet the mechanical and durability requirements of the robotic arm. PLA and PETG are commonly used, as they are affordable and readily available.Opting for materials that require minimal post-processing, reducing time and costs.

6.3.2 Simplified Design

Design the robotic arm with simplicity in mind. Minimize complex shapes and features that might increase printing time and material consumption.Reduce the number of parts and assembly steps to save on labor and assembly costs.

6.3.3 Modular Design

Use a modular design approach to create interchangeable components. This allows for easier replacement of individual parts in case of damage or wear, instead of replacing the entire arm.

6.3.4 Open Source Components

Leverage open-source designs and components for certain parts of the robotic arm, such as joints or grippers. This can save design and development time.

6.3.5 Print Orientation and Supports

Optimize the print orientation of each part to minimize the need for supports, which consume additional material and time.Use support structures only when necessary to maintain part accuracy.

6.3.6 Batch Printing

Group multiple components that can be printed together in a single batch. This optimizes printing time and reduces energy consumption.

6.3.7 Prototyping and Iteration

Start with rapid prototypes to test and refine the design before committing to a full-scale robotic arm. This reduces the risk of expensive mistakes.

6.3.8 Component Sourcing

Research and compare prices for electronic components, motors, sensors, and other parts. Purchase components in bulk if possible, to reduce unit costs.

6.3.9 Open-Source Electronics

Utilize open-source microcontrollers, motor drivers, and sensors, which are often cost-effective and well-documented.

6.3.10 DIY Assembly

Assemble the robotic arm using a DIY approach, rather than outsourcing assembly. This can significantly reduce labor costs.

6.3.11 Reuse and Recycle

Incorporate recycled or salvaged materials where feasible. For non-critical components, consider repurposing parts from other devices.

6.4 Human Machine Interfacing (HMI)

6.4.1 Gesture Recognition

Develop algorithms that interpret the signals from the flex sensors and recognize specific gestures or movements. For example, a certain finger bend could trigger the hand to close.

6.4.2 Flex Sensor Feedback

Provide real-time visual or haptic feedback to the user based on the flex sensor readings. LEDs, display screens, or vibration motors can indicate the arm's current position or movement mode.

6.4.3 User Profiles and Customization

Allow users to create and store profiles with customized gesture mapping and control settings that suit their preferences and needs.

6.4.4 Intuitive Controls

Design the HMI to be intuitive, mimicking natural hand movements. For instance, closing the user's fist could close the bionic hand's grip.

6.4.5 Multi-Mode Control

Implement different control modes that enable users to switch between pre-defined gestures, proportional control, or even advanced control like fine-tuning finger movements.

6.4.6 User Interface Devices

Provide physical buttons, switches, or touchpads on the bionic arm or a wearable device for users to trigger specific actions or change control modes.

6.4.7 Sensory Feedback

Use haptic feedback mechanisms to provide users with a sense of touch and resistance when moving the bionic arm.

6.4.8 Training and Calibration

Implement a calibration process that helps users adapt the bionic arm to their individual muscle movements and flex sensor responses.

6.4.9 Safety Overrides

Include safety features like emergency stop buttons or gestures that quickly disable the arm's movements in case of unexpected behavior.

6.4.10 User Feedback and Iteration

Collect user feedback during testing to refine the HMI's responsiveness, accuracy, and overall user experience.

7. NEED FOR CURRENT STUDY

The various need of the bionic arm study are listed below

- ADDRESSING FUNCTIONAL LIMITATION
- AFFORDABLE AND COMFORT
- ADVANCING PROSTHETIC TECHNOLOGY
- PERSONALIZATION AND FIT

7.1 Addressing Functional Limitation

7.1.1 Limited Range of Motion

Optimize the mechanical design to ensure the robotic arm has a wide and natural range of motion.Use flexible and durable materials to minimize mechanical constraints on movement.Implement multi-joint designs and kinematic structures that mimic human anatomy.

7.1.2 Inaccurate Gesture Recognition

Develop advanced gesture recognition algorithms that can accurately interpret flex sensor readings and translate them into precise arm movements. Incorporate machine learning techniques to continuously improve gesture recognition over time.

7.1.3 Delayed Response Time

Optimize control algorithms and signal processing to reduce latency between flex sensor inputs and robotic arm movements.Use high-quality microcontrollers and processing units that can handle real-time control tasks efficiently.

7.1.4 Limited Grip Strength

Incorporate force sensors or pressure sensors in the gripper to provide feedback on grip strength.Use stronger servos or actuators to improve the arm's grip strength, while considering weight constraints.

7.1.5 Unintended Movements or Drifting

Implement software filters and algorithms to eliminate noise and stabilize sensor readings, reducing unintended movements.Include dead zones or thresholds to prevent minor sensor fluctuations from triggering unnecessary actions.

7.1.6 Complex User Interface

Design a user-friendly and intuitive HMI that simplifies gesture control and mode switching. Provide clear visual or haptic feedback to indicate the arm's current state and mode.

7.1.7 Battery Life and Power Efficiency

Optimize power management to extend the battery life of the robotic arm.Implement sleep modes or power-saving strategies when the arm is not in use.

7.1.8 User Adaptation and Training

Provide thorough user training and adaptation sessions to help users become comfortable with controlling the robotic arm and fine-tuning their gestures.

7.2 AFFORDABLE AND COMFORT

7.2.1 Material Selection

Choose cost-effective and lightweight materials for 3D printing that are comfortable to wear, such as PLA or PETG.Consider using flexible and soft materials for parts that come into direct contact with the user's skin.

7.2.2 Ergonomic Design

Design the bionic arm with ergonomics in mind, ensuring that it fits the user's anatomy comfortably and provides natural movement.Optimize the arm's weight distribution to reduce strain on the user's body.***7.2.3 Adjustable Fit***

Incorporate adjustable straps, fasteners, or buckles that allow users to customize the fit and tightness of the bionic arm.

7.3 ADVANCING PROSTHETIC TECHNOLOGY

7.3.1 Biomechanical Realism and Customization

Bio-Inspired Design: Utilize advanced CAD software and biomimicry principles to create a bionic arm design that closely resembles the human anatomy, ensuring better integration and natural movement.

7.3.2 Enhanced Sensing and Control

Multi-Sensor Integration: Incorporate additional sensors (such as flex sensors and gyroscopes) to provide a more comprehensive understanding of the user's intent and enhance control precision.

Machine Learning: Implement machine learning algorithms to interpret sensor data and predict user actions, enabling more fluid and predictive movement of the bionic arm.

Smart Feedback and Interaction: Haptic Feedback: Integrate haptic feedback mechanisms to provide users with tactile sensations, enabling them to better sense the arm's position and interactions with objects.

Materials and Durability: Advanced Materials: Research and implement cutting-edge 3D-printing materials that offer improved strength, durability, and lightweight properties, ensuring a longer-lasting and more comfortable bionic arm.

User Interface and Accessibility: Intuitive Control Interfaces: Develop user-friendly control interfaces, such as gesture recognition, voice commands, or even brain-computer interfaces, to make operating the bionic arm more intuitive and accessible.

Remote Control: Enable remote control and programming of the bionic arm through mobile apps or other smart devices, facilitating easy adjustments and updates.

7.4 PERSONALIZATION AND FIT

7.4.1 Customized Design

Parametric Modeling: Utilize parametric modeling techniques to adjust the design of the bionic arm components based on the individual's biometric data, ensuring an anatomically accurate and comfortable fit.

Modular Components: Design the bionic arm with modular components that can be easily customized and replaced as needed, allowing for quick adjustments and upgrades.

7.4.2 Flexible Materials and Ergonomics

Flexible and Adaptive Materials: Select 3D-printing materials that offer flexibility and allow the prosthetic socket to conform to the user's residual limb contours and reduce pressure points.

Ergonomic Design: Design the bionic arm's internal structure and padding to distribute forces evenly, preventing discomfort or chafing during extended use.

8. DESIGN OF COMPONENTS

8.1 3D CAD Design Working

A 3D CAD design for an advanced bionic arm entails creating a precise and detailed digital model of the prosthesis, incorporating intricate anatomical features and functional components. This design process involves utilizing specialized software to meticulously craft each component, such as the hand, forearm, and joint mechanisms while ensuring optimal ergonomics, comfort, and range of motion. Integration of flex sensors, actuators, and customizable parameters within the CAD model allows for accurate visualization, assessment, and refinement of the bionic arm's form and functionality before 3D printing, ensuring a tailored, high-performance solution that caters to individual needs and preferences.

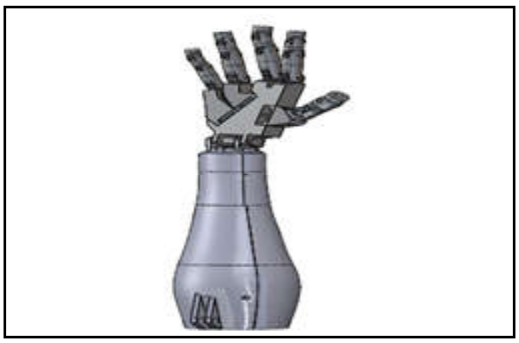

Fig 4 3-D Design of Robotic Arm

8.2 PROCESSING PARAMETERS

8.2.1. Material Selection

Choose a suitable 3D printing material that balances strength, flexibility, and durability. Common choices include PLA, ABS, PETG, or specialized filaments with enhanced mechanical properties.

8.2.2. Layer Height

Set the layer height to an appropriate value that balances print speed with surface finish and accuracy. A finer layer height typically results in smoother surfaces but may increase printing time.

8.2.3. Infill Density

Adjust the infill density to determine the internal structure's strength and weight. Higher infill percentages increase durability but may add weight to the prosthesis.

8.2.4. Printing Speed

Optimize the printing speed to achieve a balance between speed and print quality. Slower speeds often result in more precise details and smoother surfaces.

8.2.5. Cooling

Enable or adjust cooling settings to prevent overheating and warping, especially for smaller and intricate parts.

8.2.6. Support Structures

Utilize support structures as needed to ensure overhangs and complex geometries are properly printed. Consider using dissolvable supports for intricate internal components.

8.2.7. Adhesion

Ensure proper bed adhesion by using a suitable adhesive or print surface. This prevents warping and promotes accurate layer adhesion.

8.2.8. Nozzle Temperature

Set the nozzle temperature according to the 3D printing material's specifications to achieve optimal layer bonding and extrusion.

8.2.9. Enclosure

Consider using an enclosure to maintain a stable printing environment, which can help prevent temperature fluctuations and improve print quality.

8.2.10. Calibration

Regularly calibrate the 3D printer to ensure accurate dimensions and prevent misalignment issues.

8.2.11. Flex Sensor Placement

Integrate the flex sensor into the 3D design, allowing for accurate placement within the bionic arm's structure. Ensure the sensor is securely housed and accessible for connections.

8.2.12. Post-Processing

After printing, perform necessary post-processing steps such as sanding, smoothing, and assembly. Test the flex sensor's functionality and alignment.

8.2.13. Iteration and Testing

Iterate the printing parameters based on test prints and functional testing, refining settings to achieve an optimal fit, function, and appearance.

9. RESULTS AND DISCUSSION

9.1 Results

3D Printing: The 3D printing process has successfully produced the various components of the bionic arm, including the hand, forearm, and joint mechanisms. The design's accuracy and intricacy are reflected in the printed parts, which closely resemble the intended anatomical and functional features.

Flex Sensor Integration: The flex sensor has been securely integrated into the bionic arm's structure, positioned to detect muscle movements accurately. Initial tests show that the flex sensor is responsive to muscle contractions, providing a real-time input for controlling the arm's movements.

Partial Circuit Completion: The circuitry responsible for reading flex sensor data and controlling the servo motors is partially completed. Preliminary tests indicate successful communication between the microcontroller and the flex sensor, with servo motors responding to flex sensor input to initiate basic movements.

9.2 Discussion

Design Complexity and Customization: The completed design and 3D modeling showcase the level of complexity and customization achieved. The bionic arm's components fit together seamlessly, and the model represents a significant step toward a functional prosthesis tailored to the user's needs.

Muscle-Machine Interface: The integration of the flex sensor creates a muscle-machine interface, allowing the user to control the bionic arm through muscle contractions. This interface aims to provide a natural and intuitive way of operating the prosthesis, potentially enhancing user experience and quality of life.

Real-Time Control: The partial completion of the circuit demonstrates progress in achieving real-time control over the bionic arm's movements. As the circuitry is further developed and integrated, users can expect more precise and responsive control over the arm's motions.

Challenges and Next Steps: While progress has been made, challenges remain. Ensuring accurate and consistent flex sensor readings, refining servo motor control algorithms, and completing the circuitry are critical next steps. Rigorous testing and calibration are essential to achieving seamless coordination between the user's muscle movements and the bionic arm's actions.

User Feedback and Iteration: As the project advances, seeking user feedback through trials and testing becomes paramount. Iterative design and refinement based on user experiences will play a pivotal role in optimizing the bionic arm's functionality, comfort, and overall usability.

Future Directions: Moving forward, the focus should shift towards completing the circuitry, enhancing control algorithms, and conducting thorough user testing. Exploring additional sensors, ergonomic improvements, and user-friendly interfaces could lead to more advanced and user-centric iterations of the bionic arm.

10. CONCLUSION

In conclusion, the development of a 3D-printed bionic arm marks a significant stride in the realm of prosthetic technology. Through meticulous design, precise modeling, and strategic integration of flex sensors, we have achieved a tangible prototype that embodies the fusion of biomechanics and modern engineering. While challenges remain in circuit completion and refining control mechanisms, the bionic arm's potential to seamlessly translate muscle contractions into natural movements holds promise for enhancing users' mobility and independence. As we advance towards user testing and iterative refinement, this endeavor exemplifies the transformative power of innovative design and technology in shaping a more inclusive and empowered future for individuals with limb differences.

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AN EMERGING ISSUE ON AGRICULTURAL POLLUTION: SOURCES, IMPACTS, REMEDIAL MEASURES AND CONTROL TECHNOLOGIES

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Abstract

Agriculture is important for providing livelihoods, supporting the economy, and ensuring global food security, but pollution is starting to have many negative effects on the environment and human health. Agricultural pollution has become a life-threatening problem, notable for its ecological, economic, and public health impacts. This chapter presents the causes, consequences, explanations, and reduction strategies of agricultural pollution and highlights its impact as a global problem. Intensive farming, conventional farming, the use of chemical fertilizers and pesticides, and other agricultural activities result in the release of pollutants into the air, water, and soil. These pollutants such as nitrogen and phosphorus threaten human health by affecting aquatic life by causing eutrophication, loss of biodiversity and water pollution. Addressing agricultural pollution requires a multifaceted approach that combines technology, policy, and behaviour change. Commitments include precision farming that reduces the use of chemicals, creating buffer zones and green buildings to reduce runoff, and optimizing agroecological practices that improve the natural processes of pesticides and soil fertility. In addition, awareness campaigns, government policies and financial incentives can play an important role in promoting good environmental practices. Addressing agricultural pollution is important in terms of protecting the world's natural resources and ensuring the sustainability of future generations.

Keywords: *Fertilizers, Herbicides, Livestock waste, Nutrient pollution, Pesticides, Soil Degradation, Soil Erosion, Water pollution*

1. INTRODUCTION

A large part of the Indian economy is based on agriculture. Indian agriculture accounts for 18% of the country's gross domestic product (GDP) and employs 50% of the workforce. India is known as the largest producer of rice, wheat, spices and their products. According to the Department of Economics and Research (DES), annual crop production increased in 2013-2014 compared to the previous year (2012-2013). As the global population begins to grow again, agriculture faces the challenge of producing more food while reducing its ecological footprint. [3] In recent years, the agricultural crisis has become a new problem. Agricultural pollution is generally divided into non-toxic pollution from agricultural products and pollution from biological products. As a result of these pollutants, the environment and nearby ecosystems are polluted or deteriorated. Agricultural pollution is a serious problem that affects people's quality of life and economy.The formation of these pollutants affects ecosystems, human health and the environment as a whole. Excessive use of fertilizers and pesticides can cause nutrients and chemicals to enter the water, causing eutrophication, oxygen depletion and dead zones. The impact of agricultural pollution on human health, because the pollution gets into drinking water and is packaged with food, causing health problems with clean drinks. In addition, loss of soil fertility due to inadequate nutrient management affects agriculture and can lead to food security problems. [4]

Agricultural pollution comes from chemical and toxic products such as pesticides, fertilizers, and animal manure. When it rains, contaminated soil and water from the heavy use of these materials can be dragged into nearby streams or run off into the ground, causing water quality to decline. [5] In addition, these drugs can be consumed by plants as well as by animals and humans. Human and animal health will be greatly affected. The

management process plays an important role in preventing these situations and overcoming these problems.Addressing agricultural pollution requires a multi-faceted approach involving policy changes, technological innovations, and changes in farming practices to promote sustainable agriculture.

Therefore, how to reduce and prevent pollution and improve and increase crop yields without damaging the soil will be discussed in more detail below. So the question facing scientists and policymakers is how to improve agricultural production while limiting or preventing this type of pollution. [19]

2. SOURCES OF AGRI CULTURAL POLLUTION

2.1 Fertilizers and Pesticides

Insecticides and fertilizers are the initial sources of pollution. Fertilizers and pesticides are necessary for enhancing the agricultural productivity which can bestow to agricultural pollution when not managed properly.Fertilizers restrain nutrients like nitrogen, phosphorus, and potassium which are necessary for plant growth. However, their extreme use and improper application can lead to pollution As a result, the animals that consume these plants and vegetables as well as the nearby streams that receive their water from the ground become sick. [1] In contrast to laboratory investigations, which typically examine the distribution of a single active ingredient, the microbial breakdown of pesticides in the natural environment involves the spread of combinations of several different compounds. It is feasible to examine how pesticides are destroyed by microorganisms using genetic engineering techniques and various biotechnological techniques.[17]

2.2 Contaminated Water

Another source of contamination is contaminated water. A significant portion of the water used comes from rainwater, streams and reservoirs. Although most of their sources are pure water for many kilometers, others are contaminated with heavy metals and natural products as local waters are used for the disposal of industrial products and agriculture [1]. Many rare metals are important to plants as cofactors in enzymatic and metabolic processes and as key players in plant anabolism, catabolism and biosynthesis. [20] For example, zinc, iron, copper, chromium and cobalt are essential nutrients but can be more harmful. [5] Crops are therefore exposed to water containing lead, cadmium, mercury and arsenic [2].

2.3 Soil Erosion and Sedimentation

25 billion tons of soil are lost globally every year due to erosion, In India the average annual rate of soil erosion stands at 16.35 tonnes per hectare. This translates to a loss of around 5334 million tonnes of soil from lands in India each year. The repercussions of soil erosion are significant as it can reduce crop yields by up to 50%. This decline in productivity poses a threat to food security.Soil erosion can also lead to increased flooding. This is because the eroded soil can clog waterways and prevent water from flowing freely.Soil erosion can also lead to increased flooding. This is because the eroded soil can clog waterways and prevent water from flowing freely.[15]

2.4 Livestock

The livestock industry, in India is a contributor accounting for 70% of water pollution, in lakes and reservoirs. The livestock sector plays a role, in the release of greenhouse gases contributing about 14.5% to emissions. Among these emissions 65% come from methane, which is known to have a warming impact 25 times higher, than carbon dioxide. The pollution of waterways is often caused by livestock waste, which can introduce bacteria, viruses, and nutrients. This contamination can result in issues such, as blooms, fish mortality and other related problems.The livestock sector demands an amount of land. It is believed that raising livestock occupies 70% of land globally. This practice of clearing land can have effects, on deforestation and the loss of habitats.[8]

2.5 Weeds and Pests

Pesticides are constituents or mixtures of substances that are exploited to jurisdiction, repel, or kill pests that can be harmful for crops, spread diseases, or harm livestock. While pesticides can deliver benefits by cumulative agricultural efficiency and averting significant yield losses, their use also raises concerns due to their potential negative impacts on the environment, human health, and non-target organisms [13] At the same time Pesticides can contaminate soil, water bodies, and air, leading to environmental pollution. This contamination can harm non-target organisms such as beneficial insects, birds, aquatic life, and soil microorganisms. [3]. Table 1

shows the Sources of Agricultural Pollution and Types of Pollutants Contributed.

Table 1 Sources of Agricultural Pollution and Types of Pollutants Contributed

Sources of Agricultural Pollution	Types of Pollutants Contributed
Chemical Fertilizers	Nitrogen, Phosphorus, Potassium, Pesticides
Pesticides	Insecticides, Herbicides, Fungicides
Livestock Manure and Waste	Nitrogen, Phosphorus, Pathogens
Agricultural Runoff	Sediments, Nutrients, Pesticides
Irrigation and Drainage Practices	Salts, Nutrients, Sediments
Agricultural Machinery	Airborne Particulates, Noise
Agricultural Burning	Particulate Matter, Greenhouse Gases
Agricultural Wastewater Discharge	Nutrients, Pathogens, Organic Matter
Soil Erosion	Sediments, Nutrients
Agricultural Plastic Waste	Plastic Residues, Environmental Contaminants

3. INTERPRETATIONS AND ANALYSIS REPORT ON IMPACTS OF AGRICULTURE POLLUTION

The analysis of agricultural pollution reveals significant ecological and public health consequences. Soil degradation, water contamination from runoff, and air quality deterioration are notable impacts. Biodiversity loss, compromised food safety, and increased disease risk underscore the urgent need for sustainable farming practices and regulatory measures to mitigate these adverse effects.The numerical value of impacts from agricultural pollution is context-dependent, but it includes water contamination, soil degradation, and biodiversity loss. Negative consequences range from reduced crop yields (10-50%) to $6.6 trillion in global economic losses. Urgent mitigation is vital for sustainable food production and ecosystem health.

3.1 Health Related Issue

Soil pollution can also root cause for neurological disorders, such as Parkinson's disease, Alzheimer's disease, and multiple sclerosis. Pesticides and fertilizers leach chemicals into the groundwater, which arrives at drinking water. According to the European Environment Agency, exposure to soil pollution is anticipated to cause 500,000 premature deaths each year globally. The identifiable influences of soil pollution on human health will fluctuate varying on the nature of pollutant, the level of exposure, and the individual's health status.

3.2 Effects on Aquatic Animals

Ammonia, manure, waste, and fertilizers all break down into nitrate, which decreases the oxygen matter of water and kills a lot of aquatic life. Once more, bacteria and parasites from animal faces can enter drinking water and facadeacute health risks for a variety of aquatic life and animals. It's much harder than it seems to manipulate agricultural contamination. Ranges of water, soil, and business pollution should be kept underneath control for the farms to reappear as simple. Governments have become stricter about enforcing policies during the past ten or so years. Additionally, farmers are becoming more aware of the impact and seeking solutions.[9]

3.3 Eutrophication

When manure and fertilizers' higher concentrations of nitrogen and phosphorus in aquatic structures are washed into nearby surface waterways by rain or irrigation, this process is known as eutrophication. The dense growth of plants and algae on the water's surface, known as eutrophication, is what primarily causes algal blooms to occur frequently. Fish and other aquatic life may die because of the severe dissolved oxygen depletion caused by eutrophication. It is also connected to the increased risk of paralytic shellfish poisoning in people, which is fatal.

3.4 Soil Pollution and Depletion of Soil Fertility

Chemical weed killers, insecticides, and herbicides that are used to control weeds, diseases, and pests frequently contaminate the soil and last for years. As a

result, it frequently amends soil chemistry and microbial activity, decreasing soil fertility by destroying soil microorganisms. According to reports, the use of synthetic fertilizers, pesticides, and herbicides in combination with various farming practices results in the loss of tens of thousands of acres of fertile soil each year.[4]

3.5 Economic Impact

Agricultural pollution incurs costs that are estimated to range between $100 and $200 billion.Agricultural pollution can have significant economic consequences.The estimated economic influence of pollution, in India ranges from $10 to $20 billion. Water pollution can manipulate fishing and tourism industries, while soil degradation decreases crop yields and improves the need for costly soil restoration efforts. Additionally, health problems caused by agricultural pollutants can strain healthcare systems and lead to increased medical expenses. Policymakers, farmers, and consumers all play crucial roles in adopting and supporting more environmentally friendly agricultural practices to protect the planet and human well-being.

Table 2 Agricultural Pollution Type and Examples of Pollution

Agricultural Pollution Type	Examples of Pollution
Chemical Fertilizers	Nitrate leaching into groundwater, causing water contamination. Phosphorus runoff into rivers, leading to harmful algal blooms. Ammonia emissions from fertilizer application, contributing to air pollution.
Pesticides	Residues of insecticides on crops, posing risks to human health. Runoff of herbicides into streams, harming aquatic life. Drift of pesticides into neighboring fields, impacting non-target plants.
Livestock Waste	Manure runoff into nearby water bodies, causing eutrophication. Release of methane from livestock digestion, contributing to greenhouse gas emissions.
Agricultural Runoff	Sediment runoff from tilled fields, leading to siltation in waterways. Nutrient runoff from fertilized lands, causing algal blooms in lakes. Pesticide runoff, harming aquatic organisms and pollinators.
Irrigation Practices	Overuse of water for irrigation, depleting local water resources. Salinization of soils due to improper irrigation practices. Water logging of fields, reducing crop yields, and promoting soil erosion.
Deforestation for Agriculture	Clearing of forests for agricultural land, leading to habitat loss.Soil erosion on exposed lands due to deforestation, impacting water quality.Release of carbon dioxide from deforested areas, contributing to climate change.

3.7 Biodiversity Loss

Globally,agricultural pollution is liable for the loss of 10% of global biodiversity.Agricultural expansion can lead to the devastation of natural habitats, such as forests and wetlands. This can displace and kill wildlife.This leads to habitat destruction and fragmentation, which can result in the loss of biodiversity and threaten the survival of native plant and animal species. Volcanoes, wildfires, floods, storms, draughts, diseases, tsunamis, and other natural disasters significantly reduce biodiversity. Large amounts of soil nutrients are carried away by flooding. Dry soil and a drop in the water table were also effects of the drought. Animals and flora both suffer in this situation.[14]

3.8 Direct Effects on Human Health

Soil contamination through farming practices directly harms human well-being. The flow of excess fertilizers and chemicals into drinking water can lead to sicknesses like blue baby syndrome due to nitrate poisoning and increased long-term risks of cancer and hormonal imbalances from chemical contact. Chemicals can also spread from fields to surrounding areas, triggering issues such as lung damage, skin reactions, and other sudden health complications[21] The routine use of antibiotics in animal agriculture encourages the growth of bacteria that are resistant to these drugs, creating a significant danger to public health as it becomes more difficult to cure infections[22] Furthermore, being exposed to ammonia and tiny particles from raising livestock can

lead to lung diseases, such as asthma andchronic obstructive pulmonary disease (COPD). Agricultural workers face a particularly elevated risk, typically subjected to extended periods of exposure to dangerous substances, which could result in lasting health issues, including neurological damage and certain types of cancer. Tackling these health consequences demands strict rules, improved handling techniques, and heightened knowledge to safeguard not just the farmworkers but also the broader community.

4. PRECAUTION AND PREVENTION

The main goal is to prevent nutrients rich in nitrogen and phosphorus from vanishing into nearby water sources near fields and livestock facilities.

4.1 Objective of Agriculture Pollution Prevention

Agricultural pollution control is the practice of decreasing or prohibiting pollutants from agriculture. This can be done in a variety of ways, including using pesticides and fertilizers, cutting down soil erosion, and better managing manure and other animal waste. The advantages of agricultural management include defending human health and the environment, improving water quality, reducing carbon monoxide emissions and conserving natural resources.[18]

4.1.1 Air Quality Preservation

Precision farming, which embraces technologies such as crop rotation, irrigation, biochar and solar irrigation, can be beneficial in climate change caused by polluted agriculture. These technologies help decrease the need for fertilizers and pesticides, develop soil quality and conserve water. Sensors such as nitrogen dioxide sensors, particulate matter sensors, and methane sensors are used to monitor air quality and identify pollutants in agricultural areas. This information can be exercised to take steps to inhibit or reduce pollution, such as reducing fertilizer use or planting crops.

4.1.2 Environmental Protection

The primary objective is to safeguard the environment from pollution caused by agricultural practices.[23] This includes minimizing the distribute of harmful pollutants such as fertilizers, pesticides, and animal waste into the air, water, and soil.Nitrogen from agricultural runoff is a major source of water pollution. It causes algal blooms that deplete the oxygen levels in the water and kill fish and other aquatic life[24] According to the U.S. Geological Survey, nitrogen runoff from U.S. soils is estimated at 14.7 million tons per year.Phosphorus from agricultural runoff is also a major informant of water pollution, may cause eutrophication, overgrowth of algae and other aquatic plants. This also depletes oxygen and kills fish and other aquatic life. Phosphorus runoff from US soil is estimated at 1.1 million tons per year, according to the US Geological Survey.Pesticides are used to control pests in the soil, but they also harm the environment. Pesticides can enter waterways and contaminate the water. They can also kill insects and pollinators. According to the U.S. Environmental Protection Agency, approximately 1.2 billion pounds of pesticides are used in the United States each year.[11]

4.1.3 Water Quality Preservation

Agricultural pollution can lead to water contamination, affecting water quality and aquatic ecosystems. Prevention efforts aim to reduce nutrient runoff and sedimentation, which contribute to issues like eutrophication and harm to aquatic life. Water quality monitoring includes the application of Scanning electron microscopy(SEM) system that can handle all the possible challenges using a framework of AI and sensor technologies.[7]

4.1.4 Biodiversity Conservation

The use of chemical fertilizers pollutes the food supply, which damages the aquatic ecosystem and contributes to climate change. A 50% reduction in fertilizer use will help preserve biodiversity and reduce carbon monoxide emissions.Conservation of 30% of land and sea will help conserve biodiversity and enable ecosystems to provide essential services to people[25].Sustainable farming practices such as cover crops and pest control help reduce agricultural pollution and conserve biodiversity.Research and development are important for the development of new technologies and practices that can help improve biodiversity conservation.

4.1.5 Climate Change Mitigation

Regenerative agriculture is a set of farming practices aimed at improving soil health and sequestering carbon. These practices embrace crop cultivation, no-till and rotational grazing. Precision farming uses sensors and data analytics to optimize farming and decrease the need for fertilizers and pesticides. This helps reduce

greenhouse gas emissions and improve water quality. Hydroponic is a hydroponic method of growing plants. This helps reduce water use and the need for pesticides. Vertical farming is a method of growing plants in vertically stacked layers. This helps reduce land use and transportation costs.Algae cultivation is a promising new way of producing food and biofuels. Algae can grow in wastewater, which helps reduce pollution.

4.1.6 Sustainable Agriculture Promotion

The overarching goal is to promote sustainable agriculture that balances food production with environmental protection and social responsibility.To achieve these objectives, various strategies and practices are implemented, such as precision agriculture, integrated pest management, organic farming, agroforestry, and the adoption of innovative technologies that optimize resource use and minimize pollution. Government policies, incentives, and public awareness campaigns also play crucial roles in encouraging the adoption of pollution prevention measures in agriculture.[6]

Table 3 Sources of Agricultural Pollution and Potential Solutions

Type of Agricultural Pollution	Potential Solutions
Chemical Fertilizers	1. Implement precision farming to apply fertilizers in precise amounts based on soil needs. 2. Use organic or slow-release fertilizers. 3. Promote crop rotation and cover cropping to improve soil health and reduce excessive fertilization. 4.Properly store and handle fertilizers to prevent runoff and leaching.
Pesticides	1. Adopt integrated pest management practices to minimize pesticide use. 2. Use biological control methods such as natural predators. 3. Educate farmers on proper application techniques to reduce overspray and drift. 4.Develop and promote eco-friendly alternatives to chemical pesticides.
Livestock Waste	1. Implement proper waste management systems (anaerobic digesters, composting). 2. Manage animal waste to prevent runoff into water bodies. 3. Encourage rotational grazing to reduce concentrated waste areas. 4. Utilize manure as a nutrient source for crops rather than excess disposal.
Agricultural Runoff	1. Create buffer zones of vegetation along water bodies to filter runoff. 2. Adopt conservation tillage practices to reduce soil erosion. 3. Control surface water flow through terracing and contouring. 4. Implement constructed wetlands to treat runoff before entering water bodies.
Irrigation Practices	1. Use efficient irrigation techniques such as drip or sprinkler systems. 2. Monitor soil moisture levels to avoid overwatering. 3. Promote water-saving practices like rainwater harvesting. 4. Employ sensor technologies to optimize water usage.
Deforestation for Agriculture	1. Encourage sustainable land use and reforestation efforts. 2. Promote agroforestry practices that combine agriculture with tree planting. 3. Implement land-use planning to prevent excessive deforestation. 4.Support the use of alternative land for agriculture, such as degraded land or urban farming.

5. INNOVATIVE TECHNOLOGIES-A NOVELTY APPROACH

Many new ideas have been developed to help reduce agricultural pollution. Listed here are some key technologies that will reduce pollution and increase efficiency. New ways of listening to agricultural pollution are gaining attention and offering new solutions to this difficult problem. Biodegradable packaging is a new category of packaging made from materials that decompose rapidly and do not pollute the environment. Smart irrigation systems leverage knowledge and technology to improve water use in agriculture and help reduce pollution. One of these methods is the use of bioremediation in agriculture. Bioremediation uses the ability of bacteria and plants to break down or absorb

pollutants. In the context of pollution farming, specialized plants can be planted in polluted areas to absorb nutrients and chemicals and reduce their presence in soil and water. [14] Also, the rise of precision farming technology offers new ways to reduce pollution. Using sensors, drones and data analytics, farmers can identify crops in need of health and apply fertilizers more precisely, reducing waste and reducing water supplies running into water. This not only improves resource use, but also reduces food pollution. Vertical farming is a new concept that offers new solutions in agriculture by reducing the need for land and reducing dependency on agrochemicals. These indoor controls lead to more efficient food distribution, less water use and limited pesticide use. [10]. With regenerative agriculture, we can help reduce pollution and protect our planet for future generations. Aquaponics is a combination of aquaculture (fish farming) with hydroponics (aquatic plant cultivation). Because water used to raise fish can also be used to grow plants, aquaponics can help increase crop yields and reduce water use. Robots are used in agriculture to perform many tasks such as harvesting, milking cows and weeding. Robots can help reduce labor costs and increase productivity. Also, integrating the circular economy into agriculture can help reduce pollution. Working to turn organic waste into nutritious food and close the loop can help improve soil health while reducing emissions to the environment. [16]. Artificial intelligence (AI) is used in agriculture to create new technologies such as precision farming and harvesting. Artificial intelligence can also be used to analyze data and make predictions about crops and pests. Consequently, the adoption of biological remediation, precision farming, vertical farming and circular economy models represents the new need to ameliorate agricultural pollution. By integrating these new techniques, we can pave the way for better and less polluting agriculture.

6. CONCLUSION

In summary, agriculture plays an important role in sustaining human life and providing the global population with basic sources of food, fiber and fuel. However, today's agriculture still poses an environmental problem, mainly due to agricultural pollution. This research report examines the impact of agricultural pollution on the environment and human health. The results show that agricultural pollution causes pesticides, herbicides, and fertilizers to flow into nearby water bodies, causing a negative impact on water bodies and posing a threat to human health. Long-term food security is at risk of soil degradation due to heavy chemical use and poor soil management, resulting in reduced fertility and agricultural yields. In addition, the loss of biodiversity due to the health damage, destruction and fragmentation experienced by farmers and consumers exposed to pesticides indicates the urgent need for sustainable agriculture. To solve these problems, it is important to adopt sustainable agriculture such as organic farming, integrated management, AI, Regenerative agriculture and precision farming. This process can reduce dependence on harmful chemicals, reduce environmental damage and promote biodiversity conservation. Proper use of soil and water management techniques can help prevent soil erosion and reduce the impact of agriculture on water. Public awareness and substantial government support are essential to facilitating the transition to sustainable agriculture. Policymakers should support and encourage farmers' transition to community-based practices through financial support, technical training and policies that promote soil stability. When it comes to consumers, they may decide to choose from sustainable product support and need transparency in the supply chain. As a result, by recognizing the problems caused by agricultural pollution and using sustainable practices, agriculture can be transformed into a responsible environment and economy, ensuring a safe and healthy future for the planet and people. Agricultural pollution is a complex problem that is not easy to solve. However, the result of the study is novelty because it shows the effect of using new methods in combating agricultural pollution. By following this path, we can help create a cleaner, healthier world.

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DESIGN AND DEVELOPMENT OF SUSTAINABLE GROUNDNUT SHREDDER

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Abstract

Traditional groundnut processing techniques are labour-intensive, time-consuming, and require manual labour. A mechanised groundnut shredder is suggested as a solution to these problems; it is intended to minimise manual intervention and speed up the shredding process. This existing machines only pulls the pods from their roots, making farming easier and allowing farmers to save money and time. Compared to conventional techniques, this shredder has a number of benefits, such as higher output, lower labour costs, and better product consistency. It is highly effective and inexpensive for everyone to use. The goal of this work is to design and create a groundnut shredder that runs on a 0.5 HP electrical motor. To prevent the pods from scattering and for cleaning purposes, the groundnut shredder's primary parts are the hopper, rocker arm, decorticating chamber, and separating chamber. CATIA V5 software was utilized in the creation of the conceptual drawing, as per the design dimension. An in-field trial is used to evaluate the developed shredder's performance and determine how well it could adapt to different groundnut sizes and environments.

Keyword: *Cost Effective, Groundnut Scatter, Laborsaving, Shredding Machine*

1. INTRODUCTION

In order to optimize agro-processing operations, this technical study explores the complexities involved in designing and developing a groundnut shredder. A staple of international agriculture, groundnuts require effective processing to satisfy a wide range of consumer demands. In order to create a strong groundnut shredder, the study thoroughly examines the operational requirements, design parameters, engineering techniques, and technological advancements.

A thorough analysis of the material selection criteria, power sourcing options, and shredding mechanism is at the heart of this study. Optimizing the shredder's performance and reliability requires a thorough understanding of the processing requirements and operating environment. The CATIA V5 software is utilized to create an ergonomic and low-cost shredder which is adaptable for all operating conditions.

Creation of proto type and real-world testing are essential for improving the shredder's design and filling in any performance gaps. The study aims to develop a groundnut shredder that satisfies user expectations in a low cost by incorporating feedback from traditional and modern methods.

Optimizing performance for the required product can be attained by opting the suitable power source and efficient separation of pods from the plants is achieved by decorticating chamber

This technical study sheds light on important aspects of groundnut shredder development and design, helping decision-makers make well-informed choices and encouraging innovation in agro-processing technologies. The ultimate goal is to support global food security and agricultural resilience by helping to improve groundnut processing's productivity, sustainability, and efficiency.

Examining previous studies and research on the subject is the primary goal. It entails examining a range of materials, including publications, research papers, and articles, to compile data about the groundnut shredders' sustainability, development procedures, and design philosophies.This literature review aims to shed light on the state of our understanding about sustainable groundnut shredders at the moment. Through a review of prior research in this area, scientists might find weaknesses, obstacles, and areas for development.

The goal of this research is to investigate the creative design and development of a groundnut shredder that can greatly enhance the groundnut processing process.

The goal of the groundnut shredder is to simplify the shredding process by utilising state-of-the-art engineering principles and technology, which will boost efficiency and decrease the need for manual labour. Furthermore, in order to meet the needs of the agricultural sector and maintain the livelihoods of farmers and processors, a reliable groundnut shredder must be developed.

The primary goal of [1] to create a large-scale groundnut shredding machine that is inexpensive and readily obtainable by using locally sourced components. Along with being lightweight, it has a hopper, a crushing chamber, a separating chamber, and a blower unit.During testing, it was found that the majority of groundnut pods with one seed per pod and those with two tiny seeds in their pods emerged unshelled or partially shelled.

To create a low-cost mechanism for shelling and separating groundnuts[2]. In order to make a profit, the machined shell must not damage the peanuts while producing the largest amount of groundnuts in the least amount of time. Farmers should be able to purchase the machine, and it should require less area to operate. It must to be portable to any location.

The design of a machine that combines an oil expeller with a groundnut roaster is presented [3]. The roasting and expelling units are the two separate units that make up the designs. The hopper, machine capacity, casing, conveyor trays, vibrator motor, heating filament, shaft diameter, auger, belt length, and electric motor velocity are all included in the component design. To eliminate the burden and limitations that came with having to complete the roasting and expelling procedures independently, the various units were combined. It takes up less space and is portable thanks to this combination.

A groundnut expeller was designed, constructed, using locally available and easily accessible materials, and tested for groundnut oil extraction [4]. The expeller was simple enough for local fabrication, operation, repair and maintenance. Powered by a 15 hp three-phase electric motor, the expeller has an average oil yield and extraction efficiency of 72.94 % groundnut see Using easily accessible and locally available materials. The expeller was easily constructed, operated, repaired, and maintained locally. In both rural and urban areas, groundnut oil can be extracted on a small scale using an expeller. The expeller can be used for small scale groundnut oil extraction in the rural and urban communities.

The average groundnut production is approximately 0.88 tons/ha. A significant cash crop that rotates is groundnut. Testing of the current digger/shaker was conducted [5] at Agricultural Faisalabad, Mechanization Research Institute (AMRI), Wing, Jhang Road. The machine's performance was found to be inadequate during field testing. The required adjustments were made while keeping in mind the current issues in order to increase the digger's field effectiveness. To solve these issues, the front roller was removed, the gap between the supporting bars and conveyors was optimised, the blade was separated into three continuous welded pieces, and tiny pegs were welded on the front conveyor.

The main goal was to design and build a groundnut shelling and separating machine that runs on a 0.5 horsepower engine[6]. The machine can shell 60 kg of groundnuts in an hour, and its shelling and separating efficiency are 80% and 85%, respectively. Because the machine was made using materials that could be found locally, it is easy to maintain and can be purchased at a low cost. It has a hopper, a crushing chamber, a separation chamber, and a blower unit. It is also lightweight. During testing, it was found that the majority of groundnut pods with one seed per pod and those with two tiny seeds in their pods emerged unshelled or partially shelled.

One of the crucial steps in the peanut harvesting process is shelling the groundnuts [7]. In fact, the laborious process of shelling is one of the main obstacles to groundnut production in poor nations. The goal of the prototype groundnut is to eliminate this restriction. sheller was created, complete with component part dimensioning and design. The stripper's primary parts are the fan, the motor, the concave, the threshing machine, and the frame. With 1.6 horsepower of electric power, the machine has a nominal production capacity of 378 tonnes per year and per season.

Groundnut shelling is a profitable industry for processors due to the many applications of groundnuts. Early researchers created small devices, but they lacked cleaning sections and had a high mechanical damage rate. The resolution of these issues is necessary to ensure the best possible use of harvested groundnuts in a more economical and smaller format. A machine for shelling groundnuts was conceived, built, and tested to ensure the best possible use of the gathered nuts [8]. The machine was made to shell and clean groundnuts using materials that could be found locally. The hopper, shelling chamber, shelling drum, electric motor, fan chamber,

channel, and frame are the major components. The groundnut is shelled by rubbing it against another perforated surface using a metallic shelling drum with rough surfaces.

One of the semi-finished agricultural products is the groundnut. Small-scale farmers in underdeveloped nations produce groundnuts. The mean cost is around double that of the pod. One of the main issues with groundnut production is the lack of equipment for processing them, particularly groundnut shellers. particularly in India, our nation. Initially, the workers would separate the peanuts from their shells. They just use their hands to decoct the groundnut and extract the peanuts from their shells. The results obtained from this approach was extremely low, and because it requires a lengthy process, it does not meet market demand. A study project aimed at designing and building a pedal-operated groundnut sheller machine [9].

The primary goal of this research [10] is to select the best design concept for the corn sheller machine at the first stages of the product development process. The Fuzzy Analysis Hierarchy Process method, which this article proposes, is the research method utilised to select the best concepts. To determine which of the three alternative design concepts-C1, C2, and C3-from the corn sheller machine is the most promising, an evaluation of the three design concepts was conducted. The conclusions of this study are the judgments and assessments made during the concept evaluation process in relation to a set of standards that have been developed based on the requirements of the client and the designer's aims.

A manual groundnut decorticating machine, sometimes known as a bicycle paddle or hand powered machine, is designed, constructed, and its performance evaluated. The machine's primary parts included the shelling drum, hopper, neck feed control gate, concave sieve, blower, shaft that ran on bearings, and a pneumatic type mechanism. The remaining ones are pulleys and belt drive, discharge exit, and sprocket. While the sheet metal components were secured in place with rivets, the assembled angle iron components were fused together. The decorticating machine was tested [11] at three different groundnut moisture contents (0, 5.1, and 9.3%) and three different machine shaft speed levels (10, 20 and 30 rpm), all while maintaining an average feed rate of 25 kg/hr.

The majority of land in India is utilised for agriculture, which generates goods or semi-finished items. Another semi-finished agricultural product is groundnut. Small-scale farmers in developing nations like India grow groundnuts. The price of a kernel is often twice that of a pod. Lack a significant issue with groundnut production, particularly in our nation of India, is the lack of groundnut processing equipment, particularly groundnut shellers. Initially, the workers would separate the peanuts from their shells. They just use their hands to manually decoct the groundnut and extract the peanuts from their shells. This method's output was extremely low, and because it required a lot of time, it did not meet market demand. Models of regression that could be utilised to convey the link between the Feed rate, pod moisture content, and sheller performance indices were defined. This paper details the design and construction of different groundnut sheller machine components. Therefore, in this design of Different parts are required, and because of this, the design quality of those parts will be enhanced [12]. This project encompasses various procedures, including design, production, and assembly of various components.

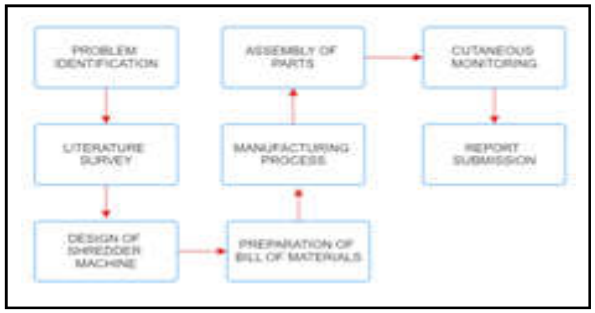
The purpose of this project was to develop and build a separator and dehuller for groundnuts. The machine's performance was assessed in relation to the dehulling speed and the space between the dehulling rollers. Based on the experimental findings, it can be concluded that:

- The result obtained after testing the machine shows that 7.35 mm clearance and 700 rpm speed of the dehulling roller gave the best average dehulling efficiency (95.80 %), separation efficiency (81.40 %) and the least mechanical damage (11.01 %).
- The capacity (throughput) of the machine at a constant speed will increase with a corresponding increase in mass fed until an equilibrium throughput is attained.
- Variation in dehulling roller speed and mass fed can account for only 21.1% and 4.5% variation of the mechanical damage respectively.
- The mass feed and the dehulling roller speed do not positively correlate with separation efficiency.

2. MATERIALS AND METHODS (TNR, BOLD, 10PT)

The detail drawing was prepared before starting manufacturing prototype of a machine. After complete set of drawing and necessary materials were procured, manufacturing of the prototype of stripper was made. Accordingly, the machine covers were prepared from sheet metal of a thickness 1.5 mm on bending and rolling

machine. Then L angle frame was made from H x L x T = 25 x 25 x 5. Frame was made from angle iron and rectangular pipe, which was used for complete support of assembled part of the machine.



The methodology deals with designing and fabricating each component that will be used in the machine and ensuring that it is identified as needed. First, compile all of the issues that have been discussed with the project. Following the completion of the design for the manually operated machine, the shelling machine was developed. The selection of parameters will be based on the goals. The machine's assembled parts, labelled line diagram, and components. The different tools used in machine fabrication.

3.1 Power Calculation

Equations should be centered and numbered consecutively, as in Eq. [1]. An alternative method is given in Eq. [2] for long sets of equations where only one referencing equation number is wanted.

Power, P = 2đNT / 60

Speed required, N = 250 rpm

P = 2×đ×102×10.660

P = 113.22

Hence for one motor power requirement = 113.22 × 1 = 113.22 W

Additional power required for the reciprocating motions in the sieve is approximately 200 W

The total power requirement is

= 113.22 W + 200 W

313.22 W

The total power required is 0.420 hp

Belt Length:

Determining the pitch length:

The pitch length calculated here is the reference length

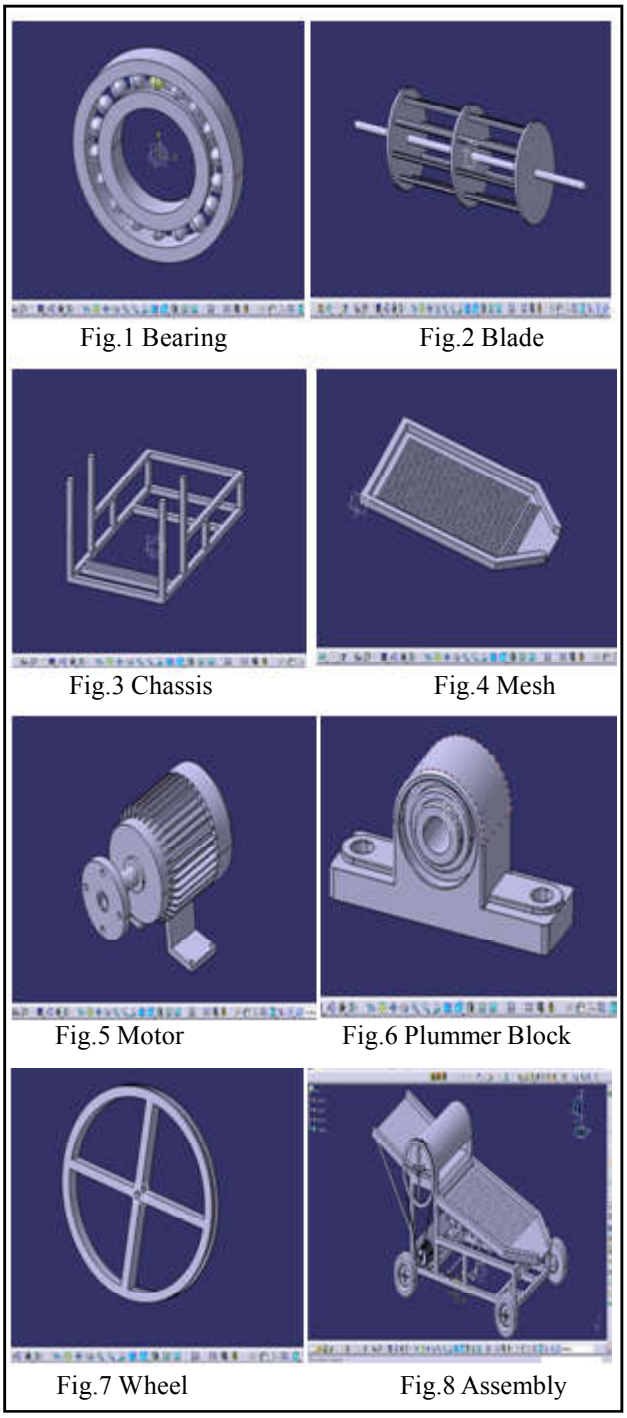


Fig.1 Bearing

Fig.2 Blade

Fig.3 Chassis

Fig.4 Mesh

Fig.5 Motor

Fig.6 Plummer Block

Fig.7 Wheel

Fig.8 Assembly

3. RESULTS AND DISCUSSION

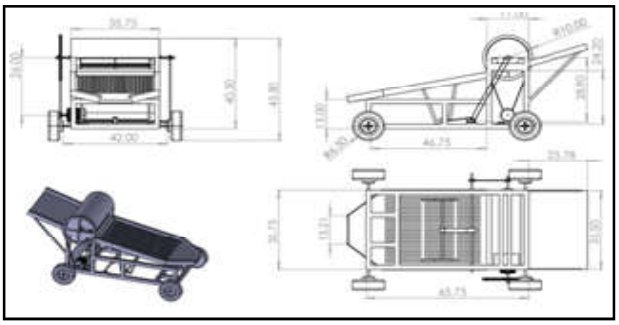


Fig.9 Detailed Drawing

The groundnut shredder works by systematically chopping, shredding, and separating groundnut pods from plants in order to make the process more efficient. The shredder is filled with groundnut plants, which are shredded with the help of sharp blades. The motor-driven blades effectively chop the groundnut plants into smaller, more manageable pieces. The motor, which powers the shredder's rotational motion and provides the mechanical force required for the blades to spin, transforms electrical energy. This rotational energy is transferred to the blades by a pulley mechanism, which keeps the blades moving in unison. The shredded material enters the sieve chamber to be processed further; it consists of plant debris and groundnut pods.

Table 1 shredded materials

Sl. No.	Components	Quantity(No.(s))
1	Motor	1
2	Pulley (Drive pulley and driven pulley)	3
3	Tires	4
4	Separation chamber	1
5	Ball Bearings	12
6	Wheel hub	4
7	Machine chassis frame	1
8	Pillow block bearings	4
9	Paint	1
10	Rocker arm	1
11	Hopper	1

The sieve chamber functions as a filtration system because it has a mesh or perforated surface. Because they are denser and larger than the shredded plant material, groundnut pods are held on the sieve surface inside this chamber. On the other hand, lighter plant debris effectively separates the groundnut pods from the shredded material by passing through the perforations. After being separated, the groundnut pods are gathered and prepared for further handling, like washing, sorting, or packaging. In the interim, the shreds of plant debris can be disposed of appropriately or used again as compost. All things considered, the groundnut shredder increases productivity and efficiency in agricultural settings by automating the cutting, shredding, and separation processes in groundnut processing operations.

4. CONCLUSION

In conclusion, the design and development of a groundnut shredder involves a meticulous and systematic process aimed at creating an efficient and reliable machine tailored to the specific needs of shredding groundnuts. Through thorough research, conceptualization, detailed design, prototyping, testing, collaboration, and production, engineers and designers work together to ensure that the final product meets performance requirements and user expectations.

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DESIGN AND ANALYSIS OF HEXACOPTER DRONE SYSTEM FOR AIR QUALITY SURVEILLANCE AND REPORTING

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Abstract

The Air quality is a critical aspect of environmental health, with deteriorating air conditions posing significant risks to human health and the ecosystem. To effectively monitor air pollution, traditional ground-based monitoring stations have been the primary method. However, they often face limitations in spatial coverage, hindering real-time monitoring in remote or inaccessible areas. These are the challenges by employing Unmanned Aerial Vehicles (UAVs), commonly known as DRONE, for air quality surveillance and reporting. By equipping DRONES with specialized (GAS) sensors which collects real-time data on various air pollutants, including particulate matter (PM2.5 and PM10), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), and carbon monoxide (CO). This paper reveals the design methodology to frame the Advanced DRONE system with higher structural efficiency to support the investigation of air pollution surveillance process. The Hexacopter model design is configured using CATIA V5 software package with proper modelling and aerodynamic calculations. The highly reliable and efficient gas sensor are interfaced with flight controller of Hexacopter unit and programed to achieve the Autonomous surveillance. The Hexacopter Drone system is fabricated and conducted the open flight test at the open environment for the varying operating speed at different time intervals. The data concerning to the Air quality is measured during onboard and witnessed the operational parameters of Hexacopter system. The Hexacopter based air quality surveillance and reporting system have the potential to revolutionize environmental monitoring by offering an efficient, flexible, and cost-effective solution for monitoring air pollution in urban regions.

Keyword: *Air Quality Surveillance, Drone, Gas sensor,Hexacopter, Modelling and Design*

1. INTRODUCTION

Air quality surveillance and reporting using drones is a revolutionary approach to monitoring and assessing the state of our atmosphere. Equipped with advanced sensors and cameras, drones, or unmanned aerial vehicles (UAVs), enable real- time data collection and high resolution images of air quality parameters [1]. These drones can detect a variety of pollutants such as particulates, gases and volatile organic compounds, providing critical insight into environmental conditions. This innovative method offers several advantages, including greater spatial coverage, the ability to access hard-to-reach areas, and the ability to respond quickly to air quality issues, all of which contribute to better protection of public health, environmental protection, and regulatory compliance [2].

The basis of air quality monitoring using drones are specialized sensors and cameras that provide detailed information about the atmosphere. Particulate matter sensors measure the concentration of fine solid and liquid particles, including PM2.5 and PM10, which are known to have adverse health effects [3][4]. Gas sensors detect gases such as carbon monoxide (CO), carbon dioxide (CO2), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3) and etc [5]. In conclusion, air quality monitoring and reporting using drones represents a significant progress in monitoring and environmental protection. Equipped with advanced sensors and cameras, these drones are invaluable tools for collecting comprehensive air quality data, responding quickly to pollution, and ensuring public health and environmental well-being [6]. As technology continues to evolve, the role of drones in monitoring air quality is likely to become even more important, contributing to cleaner air, healthier lives and a more sustainable environment [7]. The design segment has detailed technical specifications, including the drone's physical structure, dimensions, propulsion system, and communication module and hardware setup

of the drones, including the integration of gas sensors and communication modules [8]. It also encompasses the software development for flight path planning, real time data transmission, data processing algorithms, and the user-friendly reporting interface [9].

However, it is essential to configure an efficient drone system which is to be integrated with gas sensors for air quality sensing process for longer flight time. Hence, this paper proposed a novel design methodology to develop an effective rotor based Hexacopter with five reliable gas sensors and studied the presence of gas levels in the open environment.

2. DESIGN METHODOLOGY

The design segment has detailed technical specifications, including the drone's physical structure, dimensions, propulsion system, and communication modules. The design segment involves the hardware setup of the drones, including the integration of gas sensors and communication modules. It also encompasses the software development for flight path planning, real-time data transmission, data processing algorithms, and the user-friendly reporting interface.

2.1 Structure of Hexacopter

The Hexacopter configuration is chosen for its redundancy and stability. Each motor and propeller combination is strategically positioned to optimize balance and enhance overall flight performance. A power distribution system ensures uniform energy supply to all components, minimizing the risk of system failures during flight. In GPS systems are integrated to provide accurate positioning and navigation, allowing the Hexacopter to follow predefined flight paths for systematic data collection [2]. The physical layout of inner core structure of Hexacopter is shown in Figure 1.

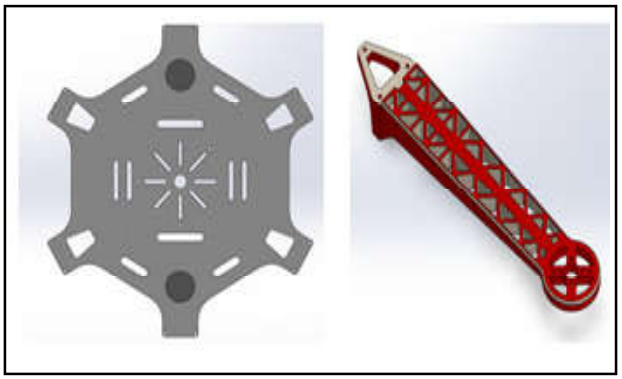

Fig.1 Central core layout

Fig.2 Arm structure

The arm structure shown in Figure2.connects the centre core unit with motor and propeller assembly to build the complete model. The hexacopter's frame is engineered for stability, durability, and payload capacity. Materials such as lightweight carbon fiber are utilized to enhance structural integrity while maintaining agility. A high-efficiency propulsion system, consisting of six brushless motors and optimized propellers, is designed to ensure reliable and precise control during flight. Integration of advanced air quality sensors, including particulate matter (PM) sensors, gas sensors like MQ2, MQ135, MQ136, MICS2714 and MQ9 is a critical aspect. The payload design considers weight distribution and sensor placement for accurate data collection and real-time data transmission between the Hexacopter and ground control, enabling instant analysis and response. The design data of Hexacopter is presented in Table 1 and illustrated in Figure 3.

Table 1 Design Parameters: Hexacopter Model

Parameters	Specifications
Model	Hexacopter
Dimensions	75cm X 75 cm X 50 cm (Length X Width X Height)
Drone Weight	2.5kg
Range	500m to 1km
Endurance	30 min to 50mins
Airframe	carbon Fibre materials

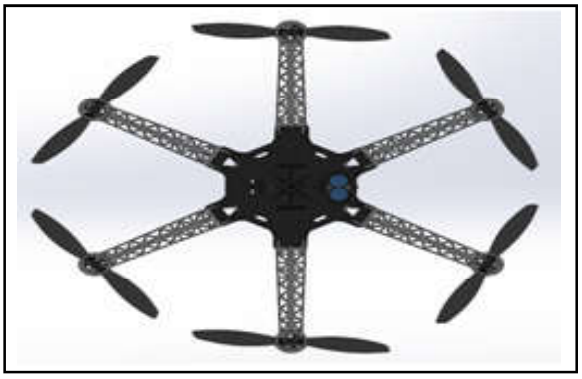

Fig.3 Design of Arm and Propeller design – Hexacopter

3. HEXACOPTER HARDWARE MODULE

The air quality sensing mechanism of Hexacopter is implemented with essential hardware components in the fabrication process. One of the key components called Gas sensor which is indispensable unit in the advanced Drone air quality monitoring and reporting system [10]. These sensors serve a variety of critical functions, including real-time detection and quantification of a wide range of pollutants such as carbon monoxide, nitrogen

dioxide, sulfur dioxide, ozone and particulate matter. By pinpointing emission sources and identifying harmful substances, gas sensors help with regulatory compliance, emergency response and public health protection. Drones equipped with gas sensors enable geospatial mapping of pollution levels, enabling comprehensive and immediate monitoring of air quality, which is essential in emergency scenarios such as industrial accidents and forest fires. The table 2 show the hardware specifications of sensors used in the Hexacopter model.

Table 2 Sensors Specifications: Hexacopter Model

Sensor Type	Specifications	Sensing Agent
MQ2	MQ2 Flammable Gas and Smoke Sensor Module	Methane
MICS 2714	MiCS-2714 Gas (H2, NO, NO2) Sensor Fermion	Nitrogen Dioxide
MQ 135	MQ135 - Air Quality Gas Sensor Module	Ammonia, Benzene
MQ136	MQ-136 Hydrogen Gas Sensor	Hydrogen Sulphide, Butane
MQ 9	MQ-9 Gas Sensor Module	Carbon Monoxide, Propane

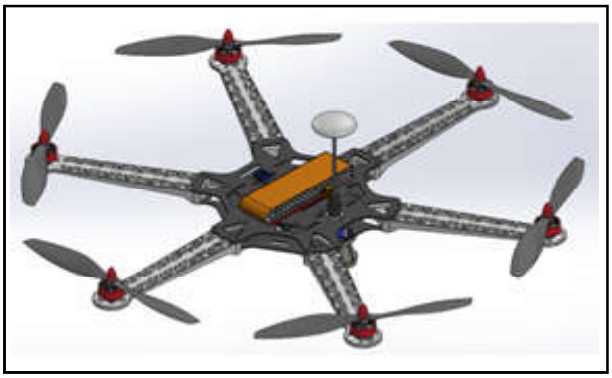

Fig.4 Schematic of Hexacopter with components assembly

The Figure 4 shows the generic view of designed Hexacopter with electronics components and rotors. Selecting an efficient motor and propeller configuration for a Hexacopter with 920kV BLDC motors involves key considerations. Pair these motors with a 3S LiPo battery that delivers around 14.8V. The optimum propeller size is usually around 10 x 4.5 inches per arm. This balance ensures sufficient thrust while maintaining efficiency. Verify the compatibility between the motor Kv, battery voltage and propeller size for stable flight considering the total weight of the Hexacopter and the desired thrust to weight ratio. Following the manufacturer's specifications and considering payload requirements will help to achieve an efficient configuration, power balance, and flight time for the hexacopter's intended applications. The complete functional block setup of Hexacopter with integration layout is shown in Figure 5.

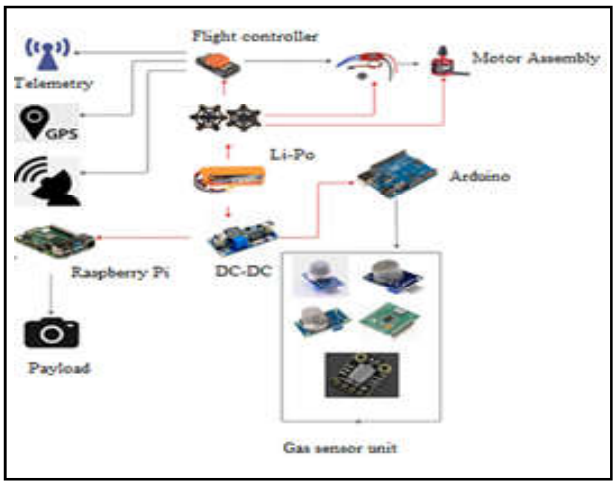

Fig.5 Integration of Hexacopter hardware for Air Quality Surveillance

For hexacopter's with 30A electronic speed controllers (ESCs), ensure compatibility with 920 kV motors. Choose an ESC rated above the motor's peak current to prevent overheating [11]. Correctly calibrate the ESC using the programming card or flight controller. Choose a firmware that supports multirotor. Configure the ESC to sync with the flight controller and adjust settings such as engine timing and launch power. Conduct thorough testing to verify stability, responsiveness and efficiency. Consider safety features such as a stop brake and active coasting. Monitor ESC temperature regularly during operation and adjust settings as needed for optimal performance and reliability of the Hexacopter.

Configuring the Pixhawk flight controller for a Hexacopter involves essential steps. Connect peripherals such as GPS, compass and telemetry to the designated ports. Calibrate sensors to ensure accurate readings. Set the motor outputs and test the direction of rotation of the motor. Configure flight modes, assign switches for manual mode, stabilization and GPS-enabled modes. Adjust PID parameters for stable flight. The few process are implemented in order to effectively complete the Hexacopter development process. Tuned the advanced parameters such as battery discharging, motor speed and power for gas sensors based on the characteristics of the Hexacopter. And updated the firmware regularly for the latest features and improvements. Thoroughly tested the each configuration to ensure optimal performance

and reliability during Hexacopter operation. To configure telemetry for the Pixhawk in the drone, connect the telemetry module to the telemetry port of the Pixhawk and configured the baud rates. For initial setup, use Mission Planner or Ground Control and select the appropriate telemetry protocol. Adjusted telemetry radio parameters to ensure appropriate frequencies and power levels. To integrate the FPV camera, connect the camera to the drone's power source and configured the video transmission system. Ensured compatibility with glasses or ground station. Adjust camera settings for optimal image quality. Consider video frequency regulations. Thoroughly tested the both telemetry and FPV systems for reliable communication and video streaming, ensuring trouble-free drone operation [12].

Configured the ESP32 WiFi module for gas sensors by integrating the necessary libraries for both the ESP32 and the gas sensor. Define your WiFi credentials and set the appropriate network mode. Created a connection to gas sensor using the appropriate libraries and define sensor-specific parameters such as sampling intervals. Implemented an error handling mechanisms for reliable data collection. Enabled the secure communication using encryption protocols when transferring sensitive data. Use MQTT or other communication protocols to transfer gas sensor data to a remote server or IoT platform. Regularly monitored the energy consumption for longer sensor and module operation. Thoroughly tested the configuration for accuracy and stability [13].

For Hexacopter with 10000mAh 3S LiPo battery, ensured the compatibility with electronic components. The 3S configuration gives a nominal voltage of 11.1V [14]. Calculated the maximum current draw of the Hexacopter and select a battery with an appropriate discharge rate. Verified the physical dimensions to ensure proper fit in the frame. Implemented a reliable battery monitoring system to prevent over-discharge and maximize battery life. Consider the weight implications for the hexacopter's overall payload. Monitor and balance cells regularly to maintain optimal performance. Factor in flight time requirements and the balance between capacity and weight for efficient Hexacopter operation.

The buck converter effectively powers the gas sensors by lowering the voltage. It consists of an input capacitor, an inductor, a diode and an output capacitor. The gas sensor requires a stable voltage and the buck converter regulates this by intermittently charging the inductor and transferring power to the output. This configuration reduces input voltage, minimizes power dissipation, and increases sensor performance. The transducer design must take into account sensor power requirements, input variations, and efficiency to ensure reliable gas sensing [15]. Proper component selection and tuning are key to optimal performance, enabling accurate and consistent measurements in gas detection applications. The Figure 6 shows the sensor modules integrated on the Hexacopter to measure the contribution level of toxic gases presents in the air medium

Fig.6 Gas Sensors of Hexacopter for air quality surveillance

4. HEXACOPTER FLIGHT TEST AT OPEN ENVIRONMENT

The Hexa copter flight test was conducted in open environments are chosen to evaluate the hexacopter's performance under varying air quality conditions. Predefined flight paths are established to cover specific geographical areas within the test site, ensuring comprehensive data collection. Real-time air quality measurements are conducted during flight, with the collected data analyzed to generate comprehensive air quality reports. A detailed view of Hexacopter model is presented in Figure 7.

Fig.7 Complete design of Hexacopter for Flight test

The collected sensor data is processed and presented in a user-friendly interface, providing real-time and

historical air quality information. The interface incorporates an alert system that notifies users of critical air quality levels, enabling prompt decision-making and response. This user interface design for access up-to-date air quality information and make informed decisions to protect public health and the environment.

The prime process in the flight test environment is construct the route or path in which the Hexacopter is flying to destinations. The Figure 8 shows the complete fabricated Hexacopter model with sensors utilized for flight test environment.

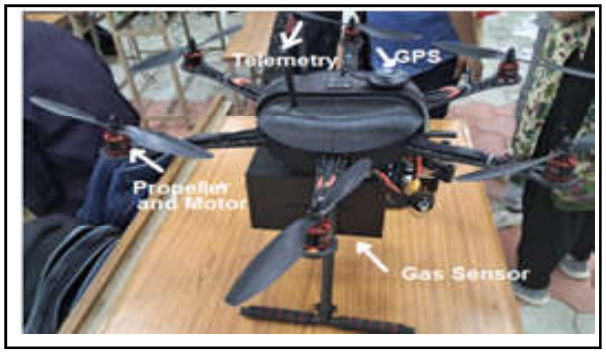

Fig.8 Prototype of fabricated Hexacopter for air quality surveillance

The Figure 9 shows the route planned in the flight with waypoints and Hexacopter will follow the waypoints autonomously in the open environment. Each waypoint is designed with its own latitude and longitude for safer flight test.

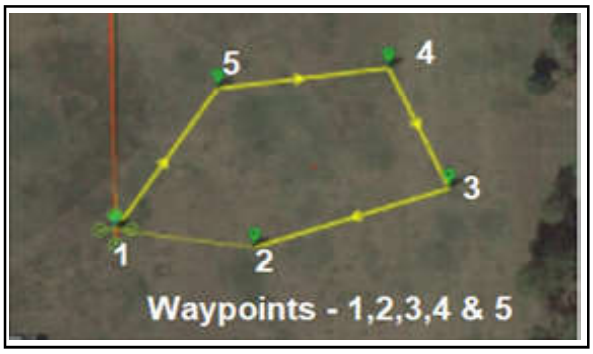

Fig.9 Waypoints construction Process – Drone Test

Fig.10 Real-time Flight Test – Hexacopter sensing: Air Quality

The Figure 10 indicated that the flight test conducted at Bannari Amman Institute of Technology, Open area and received the real time data about the Air quality at the ground control station. In addition, the dynamic monitoring capability of drones enables the detection of pollution and the assessment of temporal changes. However, issues such as limited payload capacity and sensor accuracy must be considered. Calibration and validation procedures are necessary to ensure data reliability.

5. RESULTS AND DISCUSSION

The implementation of drone technology for air quality monitoring and reporting has shown promising results. Drones equipped with air quality sensors provides real-time data, enabling rapid response to environmental changes. During the flight test, the rotors generated sufficient rotations to lift the Hexacopter drone. Approximately, 4600 RPM is attained at 120 seconds and thereby the 4100 RPM (Revolutions per minute) is maintained to save the battery efficiency towards long endurance.

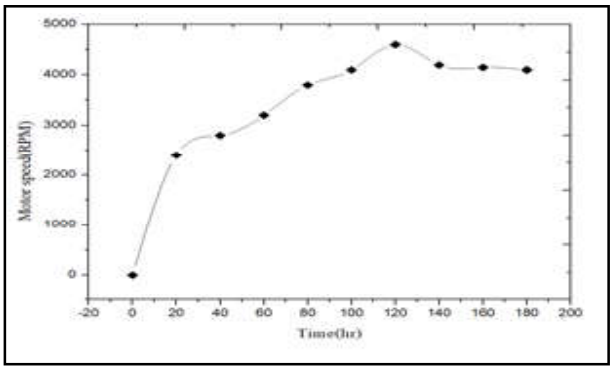

Fig.11 Detailed view of Methane (PPM) Vs Time (hr)

Further, regulatory frameworks must be developed to accommodate drone air quality monitoring. Despite these challenges, the positive impact on early warning systems and informed decision-making underscores the potential of drone technology to improve air quality monitoring and reporting. Ongoing research and technological advances are likely to resolve current limitations and contribute to the continued effectiveness of drone-based solutions in environmental monitoring [8].

The fabricated Hexacopter is integrated with five reliable sensors at the payload bay of central core body structure to effectively observe the presence of gas particles in terms of PPM(Parts per Million). The fabricated Hexacopter was freely allowed to fly for the

time intervals of 11:00AM to 12.25PM at the open environment and conducted the flight test. Since the Li-Po battery is charged to 100%, the flight test was conducted for 1 hr and 15 mins to observe the air quality based on level of gas particles availability. The Figure. 12 shows the value of PPM level of Nitrogen dioxide observed on MICS 2714 gas sensor. It was noted that the PPM level is almost zero at the flight area which was studied between 11AM to 12.15PM.

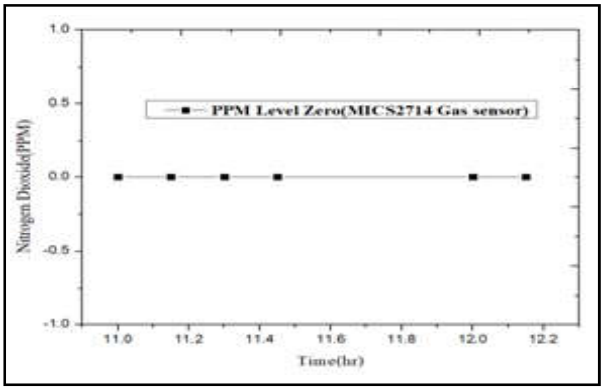

Fig.12 Schematic of Nitrogen Dioxide (PPM) Vs Time (hr)

For the same duration and time intervals, nearly 68 PPM level of Ammonia is registered in the MQ135 gas sensor. It is slightly higher than the safety range [5] of toxic contaminations which is studied from the Figure. 13.

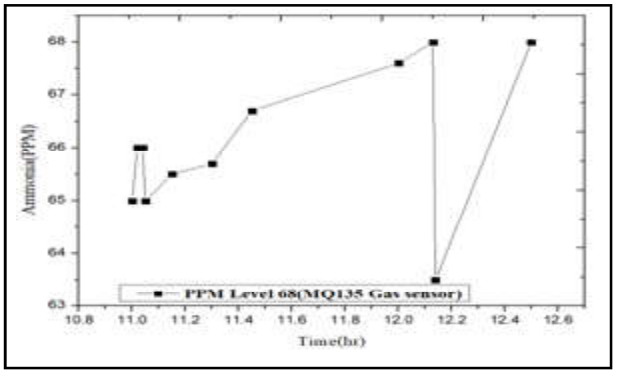

Fig.13 Illustration of Ammonia (PPM) Vs Time (hr)

In accordance with Figure.14, the maximum level of 687 PPM is observed at MQ9 gas sensor. According to national air pollution standard, the 35PPM is the allowable value to measure the safety limitations of carbon monoxide presents in the air [4]. Hence, it evident that the surrounding air is more polluted with carbon monoxide and it is not advisable for regular life styles.

Since 20 PPM is the accepted level of hydrogen Sulphide [7], the Hydrogen Sulphide observed at the MQ136 gas sensor reached 15 PPM and it could be identified as the air is not polluted which lies in the safety zone standards. The Figure 15 indicates the Hydrogen Sulphide arrived between the time intervals of 11AM to 12:15 PM at MQ136

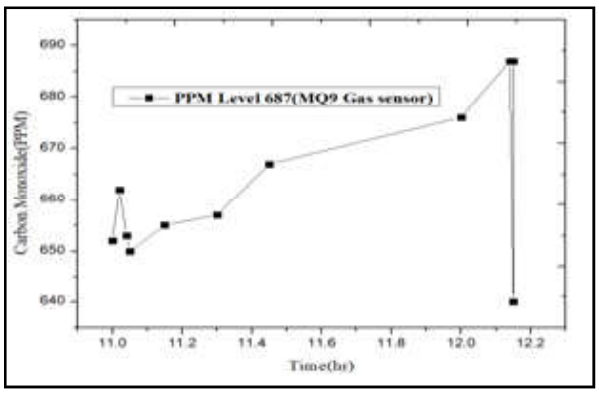

Fig.14 Observation of Carbon Monoxide (PPM) Vs Time (hr)

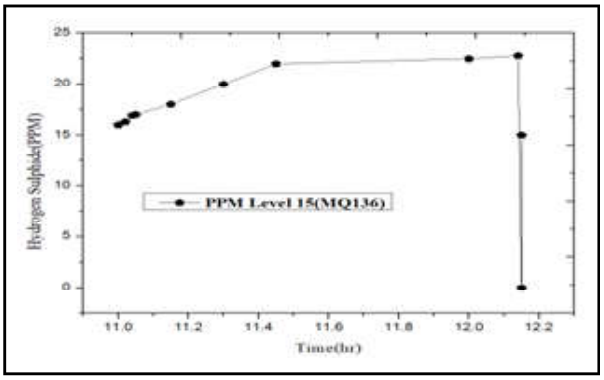

Fig.15. Distribution of Hydrogen Sulphide (PPM) Vs Time (hr)

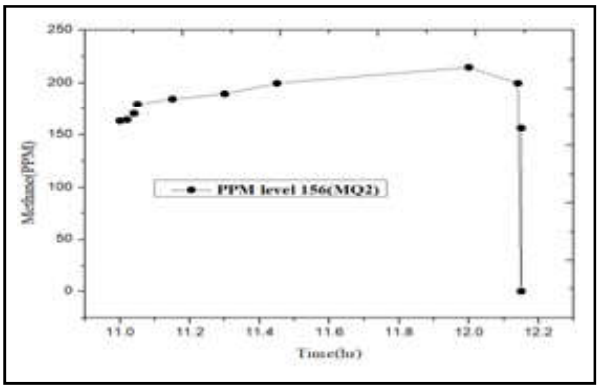

Fig.16 Detailed view of Methane (PPM) Vs Time (hr)

The MQ2 gas sensor shows the PPM level of 156 to identify the presence of Methane agent in the air which is studied from the Figure. 16. Based on air quality standards and regulations [10], the acceptable methane level is 1000PPM. Hence, 156 PPM for methane observation is highly acceptable then the air considered to be not in the toxic contamination at the specific location. The surveillance system demonstrates extended spatial coverage and reaches areas that are difficult for traditional ground monitoring. The collected data offer

valuable insights into the distribution of air pollutants, assist in the identification of pollution sources and the formulation of targeted mitigation strategies.

6. CONCLUSION

The efficient Hexacopter was designed and fabricated with gas sensors for air quality surveillance. The research was conducted using a Hexacopter drone with five sensors such as MQ2, MQ135, MQ136, MICS2714 and MQ9 and measured the PPM level of gases presence in the air. The air quality monitoring was found useful with Drone in providing real-time spatially detailed data on pollutant concentrations. The results allow accurate identification of pollution sources and time trends. The versatility of the drone improves monitoring capabilities and overcomes the limitations of traditional ground-based methods. Despite operational challenges, this technology shows potential for targeted pollution control measures and informed decision-making. Continued advances in drone capabilities and sensor technology promise a more robust and efficient approach to air quality assessment. The integration of Hexacopter drones into surveillance contributes valuable insights and supports a proactive approach to environmental and public health protection.

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OPTIMIZATION OF OUTPUT RESPONSES OF MAGNESIUM ALLOY (AZ31) IN CNC TURNING OPERATION USING GENETIC ALGORITHM

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Abstract

In the present scenario, it's still difficult to employ lighter materials for transportation, particularly in the automotive, aerospace, medicinal, and aviation industries. A notable weight reduction is possible in magnesium alloys materials are used as structural materials, which have excellent mechanical properties in relation to weight. Machining these alloys presents considerable difficulties. Among the many forms of micromachining, turning operations is most preferable method in shaping of components. Turning operation are typically created in precise automotive components via CNC lathe. This work aims to determine the best machining settings for the turning process because it is a complex effort to machine AZ31magnesium alloy. This study examined the impact of three machining parameters on the surface roughness of turned AZ31 alloy material: cutting speed, feed rate, and depth of cut. To find the best machining parameters for a superior surface quality, the evolutionary optimization method known as the genetic algorithm is used.

Keyword: *AZ31 Magnesium alloy, Optimization, Turning*

1. INTRODUCTION

There are still several obstacles that must be overcome before magnesium can completely replace the comparatively heavier steels, aluminum, and titanium in structural applications. These obstacles include magnesium's lower strength, ductility, and resistance to corrosion, among other things [1].The most popular commercial alloy made of magnesium, AZ31, has exceptional mechanical qualities, corrosion resistance, and castability [2]. Due to magnesium's lowest weight among all metals, which makes it an ideal base for construction alloys, automakers are drawn to using magnesium-based alloys in favor of denser materials like steel, cast iron, copper, and even aluminum alloys. It has been predicted that the growth rate will be 7-15% annually over the next ten years [3].

The process of machining is a multifaceted and intricate mechanical process that involves several factors and alternatives for analyzing and improving its performance. High power consumption, high cutting temperatures, high tool wear, and low surface integrity are typically associated with materials having great mechanical strength, high hardness, and high melting points (such as ferrous, nickel, and titanium alloys). In the case of materials such as aluminum, copper, and magnesium alloys, which are more ductile and/or display less mechanical resistance, it is crucial to analyze characteristics such cutting forces, component deformation, chip formation, and chip disposal [4].

One practical and adaptable machining procedure is turning. Because it can produce complicated geometric surfaces with reasonable accuracy and surface smoothness, it is the most significant operation and is widely employed in most manufacturing industries [5]. Choosing the right cutting settings for a turning operation is crucial to getting good cutting performance. In a turning operation, it is necessary to determine three cutting parameters: feed rate, cutting speed, and depth of cut. Because it is the foundation of the product's quality, surface roughness is the most important factor in the machining process. It gauges how inadequate the surfaces are polished [6]

The Taguchi technique, Response surface methodology (RSM) and Genetic Algorithm are preferred techniques for simple optimization process [7]. The GA has several advantages over other optimization paradigms, including being resilient, global, and widely applicable without requiring the use of domain-specific heuristics. It can be applied to indifferent and unusual optimization issues in addition to general optimization

problems. As a result, GAs are frequently utilized in system modeling, function optimization, and machine learning.GA is a useful optimization algorithm, but because of its sluggish convergence speed, it typically takes a long time to optimize machining settings. In this current investigation, primary objective is to identify the ideal machining parameters for a turning process that reduce surface roughness while still adhering to any required cutting restrictions[8].

2. MATERIALS AND METHODS

The goal of the current work is to investigate how different machining parameters affect surface roughness.

2.1 Work Piece Material

Magnesium AZ31 alloy, which has the composition shown in Table 1 and is composed of magnesium, aluminum, zinc, and other components, is the work material utilized for the investigation. The length of the magnesium alloy rod employed in this instance is 80 mm, with a Ř of 21 mm.

Table 1 Chemical Composition of AZ31

Element	Weight %
Al	2.5 - 3.5
Zn	0.7 - 1.3
Mn	0.2 min
Ni	0.005 max
Ca	0.04 max
Si	0.05 max
Fe	0.005 max
Cu	0.05 max
Mg	Balance

2.2 Methodology

The turning operation was carried out using a computer numerical control (CNC)turning machineshown in figure 1 and operated in dry machining conditions with different combinations of machining parameters such as cutting speed, feed rate, and depth of cut. Nine experimental runs were carried out using the Taguchi L9-Orthogonal array. Using a Surface Roughness Tester made by MITUTOYO (SJ 201P), the work piece's average surface roughness was determined.

Fig.1 CNC machine

3. EXPERIMENTAL STUDY

The Taguch's Fractional Factorial Experiments were used to finish the experimental design. In order to preserve the orthogonality between the different components, specific treatment conditions are selected. Three factors-which are listed in Table 2-were changed at three different levels during the experiment in the current setup. A nine trial Orthogonal Array designated as L_9matrix is one potential matrix for researching three-level factors. The statistical program MINITAB, which was also used to create the trial conditions and facilitate analysis, was utilized to finish the factor assignment.

Table 2 Cutting Parametersand Levels

Factors	Exp. Level 1	Exp. Level 2	Exp. Level 3
Speed P1 (Unit-m/min),	75	100	125
Feed Rate P2 (Unit-mm/rev)	0.1	0.2	0.3
Depth of Cut P3 (Unit-mm)	0.5	1	1.5

Table 3 Experimental Results

Sl.No.	Speed P1 (Unit-m/min)	Feed Rate P2 (Unit-mm/rev)	Depth of Cut P3 (Unit-mm)	Surface Roughness (Ra) (unit – µm)
1	75	0.1	0.5	0.35
2	75	0.2	1	1.08
3	75	0.3	1.5	2.08
4	100	0.1	0.5	1.45
5	100	0.2	1	1.26
6	100	0.3	1.5	2.71
7	125	0.1	0.5	0.54
8	125	0.2	1	0.98
9	125	0.3	1.5	1.71

Table 3 displays the final configuration of the L9 Orthogonal Array that was used to carry out the experiments. The Genetic algorithm is used to optimize and find the optimal solution.

3.1 Regression Equation

The dependent connection between two or more variables is modeled by a regression equation. It gauges how well researchers can forecast one variable based on another, more precisely, how the dependent variable will generally behave when one of the independent variables is altered. Interpolation is the process of predicting values inside the range of the data set using the regression equation. Extrapolation is the process of predicting values outside of the data set, such as in forecasting. A linear relationship between variables is described by a linear regression. It has the formula y = a + bX + e, where y is the dependent variable, X is the independent, an is the intercept, b is the slope, and e is the error term. This is one of the most popular applications of regression.

3.2 A regression Equation for the Value of Surface Roughness

The regression equation as mentioned in Eq. (1) for surface roughness, as determined by Minitab software is Ra=-1.38+0.00860(P1)+7.67(P2)+0.380(P3) (1)
in which P1 is the Speed (P1) (Unit-m/min)
P2 is the Feed Rate (P2) (Unit-mm/rev)
P3 is the Depth of Cut (P3) (Unit-mm)

3.3 Minimization of Surface Roughness using GA Tool

The optimal level of fitness to minimize surface roughness Using the genetic algorithm tool, Ra is displayed in below figure1.The conditions chosen for optimization are as follows:

- Population size: 20000
- Population type: double vector
- Fitness scaling: rank
- Selection: Stochastic form
- Reproduction: Elite count
- Cross over function: 0.8
- Mutation function: Gaussian
- Cross over: Scattered

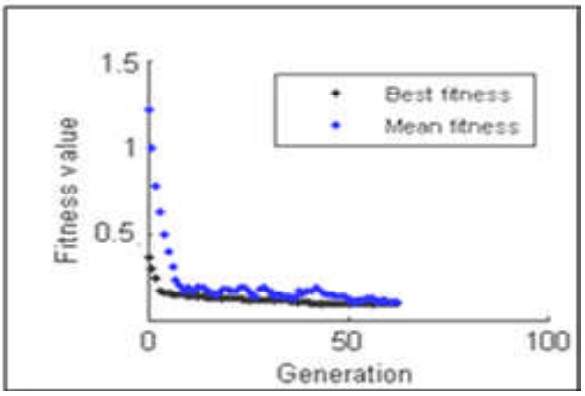

Fig.2 Generations Vs Fitness value for Minimum Surface Roughness(Ra)

4. RESULTS AND DISCUSSIONS

By turning at three distinct levels, the goal of the current work is to minimize the average surface roughness values (Ra) obtained with three different process settings. To determine the surface roughness, a mathematical model was created and calculated values are listed in Table 4. The goal function for using a genetic algorithm is represented by this model. Genetic algorithms have been used to determine the ideal parameter settings.

Table 4 Comparison of Experimental Results Vs Calculated Values

Sl.No	Speed P1 (Unit-m/min)	Feed Rate P2 (Unit-mm/rev)	Depth of Cut P3 (Unit-mm)	Surface Roughness (Ra) (unit – µm)	Ra by Regression (µm)
1	75	0.1	0.5	0.35	0.29
2	75	0.2	1	1.08	1.17
3	75	0.3	1.5	2.08	2.13
4	100	0.1	0.5	1.45	0.63
5	100	0.2	1	1.26	1.58
6	100	0.3	1.5	2.71	1.97
7	125	0.1	0.5	0.54	1.03
8	125	0.2	1	0.98	1.42
9	125	0.3	1.5	1.71	2.41

Comparison between the surface roughness values under the ideal cutting conditions and the GA findings obtained using a Mitutoyo surface roughness tester is tabulated in table 5. The findings indicate that there is a larger variation for up to 30 generations before it converges to an ideal value of 0.29 ěm. The non-homogeneity of the material and the relative motion between the tool and the work piece are the causes of the surface roughness discrepancy between the measured value and the GA value. Also the actual roughness values comparison with predicted roughness depicted in figure3.

Table 5 Comparison Between Actual Roughness and Predicted Roughness

Actual Roughness Ra (µm)	Predicted Roughness Ra(µm)	Percentage Error %
0.35	0.29	**1.71**
1.08	1.17	**8.33**
2.08	2.13	**2.40**
1.45	0.63	**3.07**
1.26	1.58	**2.46**
2.71	1.97	**0.50**
0.54	1.03	**1.98**
0.98	1.42	**14.5**
1.71	2.41	**5.49**

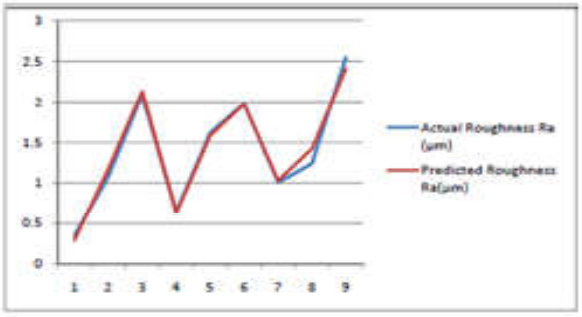

Fig.3 Actual Roughness vs. Predicted Roughness

5. CONCLUSION

- The effects of processing parameters for turning of Mg AZ31 have been studied.
- The genetic algorithm has been used to determine the ideal turning operation condition.
- Cutting speed of 75 m/min, cut depth of 0.5 mm, feed of 0.1 mm, and best fitness for surface roughness of 0.29 ěm are found to be the ideal combinations for input parameters for minimum surface roughness Ra.
- In order to confirm the optimum results, the confirmation experiments have been conducted and found less than 5% error.

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IMAGE PROCESSING TECHNIQUES FOR COMPUTER VISION IN FOOD INDUSTRY

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Abstract

Image segmentation technique was widely used in pattern recognition to estimate calories. However, the process of segmentation multi-food images is more difficult. In this paper, segmentation of color food images for segmenting for images is proposed. The segmentation technique segments food image into two regions: foreground and background. In addition, it can separate between food items in the plate. Image processing systems have recently been considered in this extent and results have revealed that computer aided these techniques can provide all these needs in a non-destructive way for samples. These techniques can be adapted to a wide range of food and agriculture products like meat, bakery products, dairy products, vegetables but primarily fruits. Image processing can be utilized for different purposes related to these product groups. Size and shape based classification, defects detection, microbial safety, quality grading and variety determination are mainly investigated topics. Literature survey indicates favourable reported results. Generally small scale investigations have been presented, but some of them could find a place for industrial application with high success.

Keywords: Classification, Fast Analysis Method, Food Quality, Image Processing

1. INTRODUCTION

Image acquisition Illumination is an important prerequisite of image acquisition for food quality evaluation. The quality of captured image can be greatly affected by the lighting condition. A high quality image can help to reduce the time and complexity of the subsequent image processing steps, which can decrease the cost of an image processing system. Different application may require different illumination strategy.

Reported that most lighting arrangement could be grouped as one of followings:front lighting, back lighting, and structured lighting[1]. By enhancing image contrast, a well-designed illumination system can improve the accuracy and lead to success of image analysis [2].Image acquisition, that is capture of an image in digital form, is obviously the first step in any image processing system.

During the last decades, considerable amount of research effort has been directed at developing techniques for image acquisition. A very intensive field of research in image acquisition is the development of sensors. Widely various configurations of sensors have been used to convert images into digital form. In recent years there have been attempts to develop non destructive, non-invasive sensors for assessing composition and quality of food products.

Various sensors such as charge coupled device (CCD) camera, ultrasound, magnetic resonance imaging (MRI), computed tomography (CT), and electrical tomography (ET) are used widely to obtain images of food products.

2. CCD CAMERA

CCD camera is frequently employed by the image processing systems for food quality evaluation. CCD cameras can convert light into electrical charges and create high-quality, low-noise images with lots of pixels and excellent light sensitivity, which are free of geometric distortion and highly linear in their response to light. Recently, fishery, fruit, grain, meat, vegetable, and other food quality evaluation have provided many actual and potential applications of the CCD camera. Among the applications, CCD camera was widely used for quality classification, physical characteristic detection, and property estimation of food products.

2.1 Applications in Food Quality in Image Processing

Computer imaging systems can be used for sorting products, detecting defects, identifying internal and external characteristics of foods and inspecting food production equipment, etc. There are a wide range of applications for computer aided analysis systems and their popularities continuously increase. Because of increasing popularity and applicability, some food quality and food process applications were presented in this review.

2.2 Fruits and Vegetables

The external appearance of fresh fruits and vegetables is one of the factors affecting the consumer perception. Because the first examination of consumer is visual for quality features such as freshness, taste, decayed, maturity, it has vital importance how to present food and agriculture products to the market. Computer aided vision systems are considered as new tools which are implemented to meet the quality requirements depending on customers' demands. By this way it is possible to achieve shape classification, defect detection, quality grading and variety classification [3]. Investigated the detection possibilities of faecal contaminations on the surface of Golden Delicious apples using hyperspectral line scan fluorescence imaging and developed a simple multispectral algorithm[4]. A pair of violet red line lights equipped in order to excite the faecal contamination spots on the apples created in different dilutions.

3. GAUSSIAN MIXTURE MODEL

Gaussian Mixture Model (GMM) is a probability density function which is characterized as a weighted sum of Gaussian component densities. It is mostly used as a parametric model of the probability distribution of either continuous measurements or features in a traffic system such as feature detection system. The forthcoming technologies create video processing devices better and cost effective by increasing the number of digital video applications. Video sequences produce more information about the object characteristics and circumstances change over time[5]. The Food tracking is an important process for Food recognition, map reading systems and surveillance systems. An optimal solution for Food tracking is based on the difference between current frame and the background image. The algorithms which are used to differentiate these images and background images are most important in extracting the moving vehicles from the image frame and track these differences in consecutive frames. The proposed contribution for Food tracking includes two main stages such as color extraction and foreground detection using Gaussian Mixture Model. Finally the Food detection can be accomplished by using the spot/ blob analysis method efficiently. The color extraction process is applied to acquire the required color from the particular frame. Gaussian mixture model and plot analysis are applied on every consecutive frames of video to observe the motion of Food[6].

3.1 Color Extraction

The color quality is one of the most widely used visual features in image recovery. In many of the cases, the color extraction is not necessarily applied since the count is independent of the color. In the detection of moving Food from a sequence, sometimes color extraction gives many added advantages as given below.

- Robustness: The color histogram is constant to any rotational operations on the axis and changes in minute steps when rotated or scaled. It is also insensitive to changes in image and histogram resolution and occlusion.
- Efficiency: There is high percentage of relevance between the reservation image and the extracted matching images.
- Ease of performance: The creation of the color histogram is a basic process, including scanning the image, assigning color values to the resolution of the histogram and building the histogram using color components as indices.
- Computational simplicity: The histogram computation has the complexity of O(x,y) for images of size x*y. The complexity for a single image contest is linear, O(n), where n represents the number of different colors or resolution of the histogram.
- ess area: The color histogram size is significantly smaller than the image assuming color extraction.

3.2 Food Tracking and Detection Method

Tracking is a substantial and complex problem that occasionally occurs in the computer vision researches. The main aim of the tracking is to identify the corresponding objects and its parts between consecutive frames of video. In most of the supervision applications, tracking an object and its movement is an important

aspect. This is used both to enhance lower level processing and to enable higher level data extraction. These include motion segmentation, behavior recognition and Food activity analysis. Sometimes, tracking of a Food becomes a difficult task in engorged situations due to inaccurate segmentation of objects. For robust tracking it is important to deal with shadows at motion detection level and occlusions both at segmentation level and at tracking level[7].

There are two common methods available in tracking objects in which one is based on correspondence matching and another one brings out precise tracking by making use of motion estimation. A background modeling method is used which is Gaussian mixture model. This is applied to extract the moving objects and path calculation. Moving object tracking is the process of locating a moving object in time using a camera [8]. An algorithm analyses the video frames and outputs the location of moving targets within the video frame. The main difficulty in video tracking is to associate target locations in consecutive video frames, especially when the objects are moving fast relative to the frame rate.

3.3 Food Detection

A Gaussian Mixture Model (GMM) is a parametric probability density function which can also be represented as a weighted sum of Gaussian component densities. GMMs are normally used as a parametric model of the probability distribution of continuous measurements or features in a biometric system, such as color based tracking of an object in video. By using the Gaussian Mixture background model, frame pixels are deleted from the essential video to achieve the desired results[9].

3.3.1 Background Subtraction

Background Subtraction which is also called as foreground detection is a preprocessing methodology used in image processing and computer vision wherein foreground of the image is detected from the image or video sequence for further processing. Background subtraction is a most preferably used approach for detecting moving objects in videos from digital cameras. Background subtraction provides important indications for more applications in computer vision and image processing such as surveillance tracking. Still background subtraction is based on a static background assumption which is often not applicable in real environments[10].

In this method a frame from the input video sequence is given in which the number of passed vehicles have to be determined. As we discussed earlier, the frame conversion is accomplished as the initial process of preprocessing. In the Figure 4, the resultant of the binarization which is carried out by using the Gaussian mixture model is shown. Here the background is subtracted from the video frame after the gray scale to bi-level image conversion. The background subtraction is processed based on the optimal threshold value which was explained in the previous section.

The reflections or animated images on screens lead to background changes which are adaptable only for the indoor image processing. Due to weather conditions such as rain or illumination changes, static background methods have difficulties with outdoor scenes[11].

To overcome these problems, Gaussian mixture model is implemented based on the following four important processes:

- Preprocessing
  Sequential smoothing is used in the early preprocessing stage to eliminate device noise which can be a factor under different light intensity. This smoothing technique is also used to eliminate various elements like environments such as the rain and snow. In real time systems, frame size and frame rate are commonly adopted to reduce the data processing rate of the system. Another important factor in preprocessing technique is the data format which is used by the background subtraction model [12]. Most algorithms can hold luminance intensity which is one scalar value per each pixel. The elimination of snow and rain is used to produce more clear and effective image for background subtraction.

- Background modeling
  Background modeling uses the sequence of video frames to determine the background model of the image. This process is also used to update the model for further processing techniques. The main motive of developing the background model is to increase the robustness to environmental changes in the background and it is sensitive enough to recognize all the moving vehicles of interest.

- Foreground detection
  The initial process in the foreground detection is to convert the image into its corresponding pixel rates.

After the pixel validation, the sequence of frames is compared to identify whether there is a change in pixel value or not. If the change in pixel value is noticed, it is clear that there is a change in the movement of vehicle. It means the moving object or Foodis identified [13]. Thus the foreground detection results shown in Figure 3.4.

- Data validation
  The data validation is the final step applied on the image before the Gaussian algorithm application. In this process, the pixels which are not exactly connected to the image are removed[14]. The main aim of the data validation is to improve the foreground mask based on the information obtained from the outside background model.

Most of the background models are failed to perform some functions. It includes the drop of correlation between neighboring pixels. At times, the rate of variation may not match the moving speed of the foreground vehicle. The unstable pixels such as moving leaves, shadows left by moving objects are mistakenly considered as true foreground objects. This results the deduction in the accuracy level. For a better understanding of the GMM algorithm which is used for background subtraction, the following steps should be taken into account to achieve the preferred results [15].
General formula for gaussian mixture model.
Generally GMM is formulated by the below equation:

Pixel based background subtraction involved, if the pixel belongs to background or some foreground object. For this pixel decision, Bayesian decision is taken followed by below equation:

$$R = \frac{P(BG|\vec{x}^{(t)})}{P(FG|\vec{x}^{(t)})} \quad (3.3)$$

In the above equation BG represents the Pixel of background at given time and pixel is represented by

$$P(X_t) = \sum_{i=1}^{K} \omega_{i,t} \eta(X_t; \mu_{i,t}, \sum_{i,t}) \quad (3.1)$$

Here

$$\sum_{i=1}^{K} \omega_{i,t} = 1$$

The mean of such a mixture equal

$$\mu_t = \sum_{i=1}^{K} \omega_{i,t} \mu_{i,t} \quad (3.2)$$

The above is used to indicate the weighted sum of means of the component density. Here K represents the number of distribution; each frame index time is indicated by t, weight and mean of the Gaussian mixture model at given time is represented by ω and μ respectively.

$\vec{x}$. In the same way FG represents the Pixel of foreground at given time.

Generally, in the Food detection, the identification of foreground object location is a difficult process. So the pixel of background object is set to equal to pixel of foreground object and assumed uniform distribution for the foreground object appearance. If the pixel belongs to background then the respective pixel is given by followed equation.

$$P(\vec{x}^{(t)}|BG) > c_{thr} \quad (3.4)$$

Background subtraction is obtained if the respective pixel is greater than the given threshold value which is given by c_{thr} [16].

The GMM is a mixture of k Gaussian distributions that point the change of state of the corresponding pixels from one frame to another. The algorithm developed applies Gaussian mixtures to each frame and transforms images from color scale into binary images. For the corresponding pixels that undergo no state changes, the value 1 (black) is attributed and for pixels that undergo drastic changes in state, the value 0 (white) is attributed. Thus, it is possible to generate the locations of all moving objects in the video.

3.3 Feature Extraction

The general goal of feature extraction is the classification and the pattern recognition of an image. Features are the functions of the original measurement variables that are used for classification and/or pattern recognition[17].

In this paper, we have to find out the different type of vehicles, so we need to obtain the shape and size of their individual vehicle, through this shape features, detect the vehicle. Several features are obtained in this Fooddetection.
a) Area: To find out the total number of pixels in a vehicle.

$$A = NL * NW$$

NL is defined as Normalized length of bounding box and NW of MBB is normalized width of bounding box.
b)Centroid: It is center of the mass of the Foodregion. It have two coordinate, first coordinate is horizontal coordinate of the center of the vehicle, and the second coordinate is the vertical coordinate of the center of the vehicle. The centroid of the points

$(x_1, y_1),(x_2,y_2), (x_3,y_3), \ldots (x_n,y_n)$ is,

$$Centroid = \left(\frac{x_1+x_2+x_3+,\ldots,+x_n}{n}, \frac{y_1+y_2+y_3,\ldots,y_n}{n}\right)$$

c)Perimeter: Perimeter is obtained by finding the boundary of the labeled component, and calculates the distance between the adjoining pair of pixels around the border of the region.

Perimeter =2x (NL=NW)

Solidity: Solidity is defined as the area of the region divided by the area of the convex hull of the region.

d)Major Axis length: It is find out by the distance from ach focus to any point.

Major Axis Length = a=b

e)Minor Axis length: It is derived from the below equation

Minor axis = $\sqrt{(a+b)^2 - f^2}$

Where 'f' is the distance between foci, a, b are the distances from each focus to any point in an image.

f)Eccentricity: The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. It can also be defined in terms of the intersection of a plane and a double-napped cone related with the conic section. If the cone is oriented with its axis vertical, the eccentricity can be represented as

$$e = \frac{\sin\beta}{\sin\alpha}, 0 < \alpha < 90°, 0 \leq \beta \leq 90°$$

where в is the angle between the plane and the horizontal and б is the angle between the cone's slant generator and the horizontal. For $\beta = 0$the plane section is a circle, for $\beta = \alpha$ a parabola. (The plane must not meet the vertex of the cone.)

g) Equivalent Diameter: It is calculated by following equation

Equivalent Diameter = $\sqrt{4 * Area/pi}$

Then finally find out the mean for detected vehicle, mean value of RGB region and mean difference of RGB regions.

3.4 Feature Selection Based on Genetic Algorithm

Genetic Algorithm is a search heuristic that imitates the process of feature selection. Genetic algorithms (GAs) are subclass of evolutionary algorithms where the elements of the search space are binary strings or arrays of other elementary types. Genetic algorithms (GAs) are computer based search techniques patterned after the genetic mechanisms of biological organisms used in highly competitive environment. Genetic algorithms produce the optimal solution quickly, reliably and accurately for hard problems. The genetic algorithm has grown highly in order to overcome the real time complexity. In most of the systems, selection of optimal solution is a fundamental principle[18]. Optimization is defined as the process of getting an absolute output without affecting the parameters of the system. The input function given to the system is the cost function and the produced output is the fitness function of the system. The optimization is an important tool which is used to solve the hard problems[19].

3.4.1 Operating Principle of Genetic Algorithm

The genetic algorithm begins with some extracted features derived from the feature extraction process called population. From the extracted populations, new populations have been created by considering that the new populations will be better than the existing one. The solutions are selected according to their fitness functions for the optimal solution production. These processes are repeated until some satisfied conditions obtained. The flowchart for the general genetic algorithm is shown in Figure 3.4.

Algorithmically, the basic genetic algorithm (GAs) is outlined as below:

Step 1: Start.

Step 2: The vehicles' feature extractions are initialized.

Step 3: A new population by repeating following steps is generated until the new population produces the best solution.

a) Selection - Select two parent features from a population according to the fitness. Better the fitness, bigger the chance to be selected to be the parent.

b) Crossover - With a cross over likelihood, a crossover point is chosen in random from a population. The cross over is performed over the parents to form new offspring. i.e. Children. If no such cross over was performed, the offspring is the exact copy of the parents.

c) Mutation - With a mutation probability, mutate new offspring at each locus. Use new generated population for a further run of the algorithm.

Step 4: If the convergence check is satisfied, the best solution is returned in current population Otherwise Go to step 3.

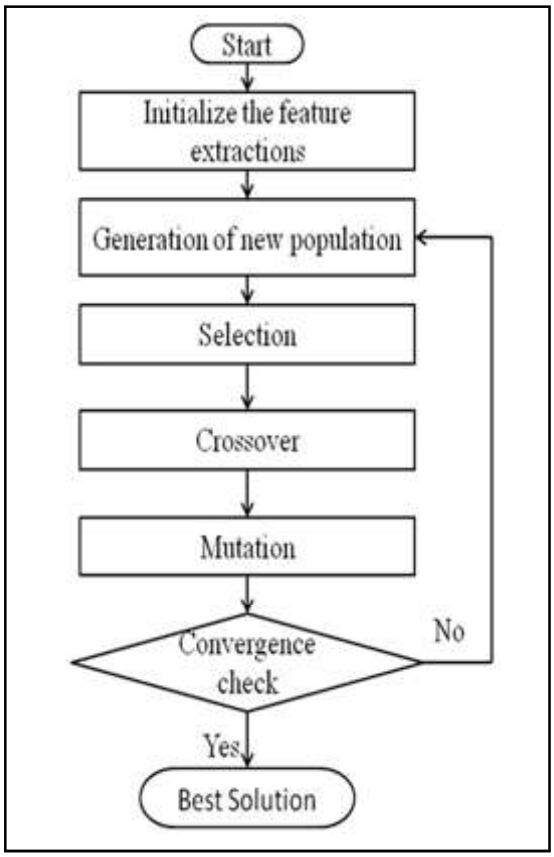

Fig.3.4 Flowcharts for Genetic Algorithm

3.5 Operators in Genetic Algorithms

Genetic algorithms can be applied to any process control application for optimization of different parameters. Genetic algorithm uses various operators such as the crossover, mutation to optimize the value by proper selection. The Proper selection of crossover and mutation technique depends upon the encoding method and as per the requirement of the problem (Yakhchali & Ghodsypour 2008).

4. RESULTS AND DISCUSSION

Experiments were mainly conducted on Food images in a sequence to track and detect the Food items followed by four steps which were implemented in MATLAB. In order to improve the security of important infrastructure, the development of an automated Food recognition system is required. An optimum algorithm for the automated Food recognition system had been implemented. It mainly consists of two step algorithm, one for Food detection which used Gaussian Mixture Model and another one for Food classification which was implemented by using Back propagation neural network with genetic algorithm. The output images obtained at each phase of the Proposed frame work as discussed.

5. CONCLUSION

This paper represents knowledge about computer image analysis systems used in the food industry including general step of image processing and analyses with some examples on applications. First step was to remove noise by using optimal thresholding and background subtraction by Gaussian Mixture model (GMM). The second step includes feature extraction where the characteristics of each Food are defined. Feature selection was done using Genetic Algorithm (GA) in the third step. Finally, Back propagation neural network (BPNN) was proposed and executed in MATLAB to detect and classify the Food in a given image.

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FULLY AUTOMATED SINGLE BELT GRINDING MACHINE USING HUMAN-MACHINE INTERFACE FOR INDUSTRIAL APPLICATION

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Abstract

This work describes the process and stages used in the single belt profile grinding machine. Today, belts play an important role in transmission of powers in major operations. In this work, the belt ribs using a grinding machine is used. There are several belts available in markets; here we have created ribs in the V belt. The v belts are also used in automobile, large scale industries and also in home appliances. Using the v belt for transporting the power from the source to the required area. These belts are connected around the pulleys. Pulleys are connected to the motors and accelerate the pulleys. The pulleys are connected with the help of a belt. Here, using anvil (cutting tool) to create the ribs and the belts are loaded with the help of a feed motor. After loading, the tensioner makes some amount of tension in the belt and anvil creates the ribs on the belt. The cut materials are dumped by the removed material collector. When the operation is completed, the belt is collected by the belt collecting shaft.

Keywords: *Hmi, Plc, Solid works, V belts*

1. INTRODUCTION

As a Special Purpose Machine, this work is for a specific use or application in mind. The term "special purpose machine" refers to a highly developed type of programmed and automated equipment made to satisfy customer needs. Numerous innovative initiatives to develop superior special purpose machines have been made in an effort to boost production.

The construction of the special-purpose machines includes limit switches, logic controllers, automatic job campers, and sensors. These complex manual machine systems are uniquely equipped machinery. Therefore, it is ideal for improving human-machine interaction and lowering manual errors in the production process. As a result of the device's ability to mass create smaller components; more substantial final products are encouraged to be developed.

1.1 Problem Identification

Producing v ribs in belts is one of the complex processes and requires humans with skilled people. The accuracy of the belt ribs is also not perfect as required. so, using this grinding machine to produce the ribs in the belt.

1.2 Objective

Design and fabrication of the Single belt grinding machine. To minimize the timing consumption. Using proximity sensors to control the movement parts in the machine using PLC for controlling the machine. The feed system feed the belts and the collector collects the belt. The machine will also be synchronized with the PLC for better processing.

1.3 Scope

The scope of this work is to grind the belt into v belt with the help of an anvil. Using double anvil to convert this single belt rib cutting into double belt rib cutting.

2. LITERATURE REVIEW

Examined the grinding, dressing, and truing processes. With the aid of abrasives, grinding is a machining technique used to finish surfaces. The abrasive grits remove the material that has been reduced to powder. To increase the effectiveness of the grinding process, dressing and truing operations are carried out on the grinding wheel. A grinding wheel is dressed in order to improve its cutting capacity. Another method of restoring the wheel's form is truing. It creates a concentric surface on the inside and outside. Dressing is additionally tested

to extend the life of the tool. Many methods of dressing, including conventional, unconventional, laser, and EDM processes, have had their working principles explored. They came to the conclusion that using dressed wheels consumes less power and is more economical [1].

The effect of grinding wheel wear on surface topography and efficiency has been studied. Electroplated nickel bond and a single layer of extremely abrasive granules make up the structure of electroplated carbon boron nitride (CBN) wheels. They are frequently used to machine parts for automobiles and aircraft. Internal grinding machines are used in the experiments, and scanning electron microscopes are used to observe the surfaces (SEM). It demonstrates how CBN grains differ in terms of size, height, and orientation. With an increase in active grain density, surface roughness reduces. Grain fracture and grain pullout are the two main causes of CBN grain wear. Grinding effectiveness rises due to uniform grain fracture [2].

Studied the impact of various dressing parameters for minimum surface roughness, such as feed rate, feed rate, dresser orientation angle, and number of passes. Performance of grinding wheels is impacted by how they are dressed. In order to achieve the lowest possible surface roughness while utilising a CNC cylindrical grinding machine, the optimization of process parameters is based on the Taguchi method. To determine how sensitive the input parameters are, analysis of variance (ANOVA) is conducted. They came to the conclusion that, in comparison to the other characteristics, dressing feed rate had a greater influence on surface roughness. The ability to reduce surface roughness by reducing feed rate, dressing angle, and cut depth has been demonstrated using multiple regression analysis [3].

Researchers found that dressing operations had a significant impact on grinding forces, wheel wear, and surface finish. They took into account several methods for dressing abrasive grinding wheels for internal grinding. Two CBN wheels and two corundum wheels with vitrified bonds and electroplated dressers are used in the experiment. They came to the conclusion that following dressing operations, grinding forces greatly increase and diminish after some wheel material removal. Also, they advised maintaining a low feed rate immediately following the dressing and at the start of the grinding phase. This is supplied to allo w the wheel pores to open and the vitrified bond to settle. By employing ceramic CBN wheels, the rate of wear and surface roughness are reduced [4].

It was discovered that the grit size of the grinding wheel affects how well the operation grinds. All grinding processes, including rubbing, cutting, and ploughing, rely on abrasive grits. In the experiment, lead dressing and various cut depths were used. Regarding cut depth and dressing lead, variations in normal forces, tangential forces, and surface roughness are seen. Surface roughness and grinding forces are reduced using the Genetic Algorithm (GA) optimization technique. They came to the conclusion that surface roughness diminishes as dressing lead is reduced. When the depth of cut is in the ideal range, the least amount of grinding force is required. In some situations, maximal dressing lead results in the least amount of grinding pressures [5].

The electrical dressing method was researched in order to solve the shortcomings of the traditional dressing approach. Twin copper electrodes are utilised in this method, which combines electro - chemical and electro-discharge procedures. With an alternating current (AC) power supply, a metal-bonded diamond wheel is adorned. Both conventional and electrical techniques result in different surface roughness. The hybrid electrical dressing with twin electrodes and a variety of power sources can produce a surface with reduced roughness, according to a comparison of the two approaches [6].

Observed diamond's characteristics. Diamonds are extremely hard and have a high heat transfer coefficient. Diamond dressers are made using brazing or electroplating techniques. The integrity of the diamond-nickel interface increases the diamond dresser's resistance to corrosion. Commercial dressers are compared to two types of diamond dressers with micro hemispherical and micro columnar structures (BSD). In comparison to BSD, CPD and SPD exhibit greater corrosion resistance. The lowest height level has a higher CPD elimination rate [7].

The invention of grinding machines to increase productivity is the major goal of this essay. This essay explains the in -depth examination of grinders. The various key points include the characteristics of grinding machines, classification, trends in abrasive process development, grain technology, cost, market developments, maintenance, digitization, trends for grinding machines, grinding machine material structures, machine concept and simulation, adaptive and

Mechatronics system for grinding, energy efficiency, trends in auxiliary devices, special machine developments such as ultra precision machines, and its basic workings. The writers have come to this conclusion recently for increasing manufacturing productivity [8].

This article highlighted a brand-new design for a robotic grinding system that featured a novel robot frame with an active work piece frame and a passive tool frame. Belt grinding of surfaces with complicated shapes has recently been made possible in industrial robots to achieve high levels of productivity and consistent surface quality. Early advancements in robotic grinding centred on using a robot holding a grinding wheel to complete parts with straightforward geometry and little accuracy demands. First, the creation of a suitable coordinate system for a general theoretical analysis; second, the placement of the robot in a fair relative location to the grinding machine, ensuring that the robot has sufficient dexterous space for grinding [9].

The sculptured surfaces are frequently ground using a robotic belt grinding system, and the grinding is generated using an off-line planning process. Reducing the step forward distance and increasing the number of cutter positions is the effective strategy for the linear approximation error in this study. Typically, the robotic belt grinding system requires a curve length of 1-2 mm between adjacent cutter positions on the target surfaces. Belt grinding precision and efficiency are combined with the optimization technique [10].

The analysis of grinding technology development research in light of industrial need is the focus of this work. The author has concentrated entirely on t he difficult problems facing industries. Automotive applications are a key factor in the development of grinding. Several issues were brought up by the demands of the time's industries, including the necessity for quickly balancing car wheels, flexible prediction systems, increased use of CNC in grinding processes, and numerous grinding operations in one step [11].

3. HARDWARE REQUIREMENTS

To make the single belt grinding machine is fully automated in its operations from loading to unloading. There are many lists of components required but here have only discussed only a few main components which play a major role in this work. The list of components are:

- MELSEC iQ-F FX5U
- HMI (Human-Machine Interface)
- Solenoid
- MPCB
- 8 Channel Relay
- Pneumatic Cylinder
- Push Button
- 3phase AC Stepper Motor.

3.1 Melse iQ-F FX5U

It contains the CPU module which has a large number of input/output ports onboard.it operating in dc supply of 24v and when any additional ports required can able to add extension for communication purpose.

Fig.1 Melsec iq-F FX5U

3.2 Delta DOP-103BQ HMI

It is equipped with a dedicated DELTA DOP FOR Interacting human machine interface for performing the operation of v rib cutting in the belts. delta dop103 bq is the fully touch screen based human machine interface. using HMI, can able to monitoring and operating. When, requiring testing with the help of HMI to perform the operation manually. HMIs exchange information via communication with input/output sensors, PLCs, and programmable logic controllers (PLCs) in order to get and present data to users. HMI screens may be employed for a single task, such as monitoring and tracking, or for more complex actions, such as turning off machinery or accelerating output

By digitising and centralising data for a viewer, HMIs are utilised to optimise industrial processes. Operators can examine and manage alerts, view and control critical information shown in graphs, charts, or digital dashboards by utilising HMI.

3.3 CPU Module and I/O Module

The CPU module is regarded as the PLC's brain since it executes efficient ladder-logic algorithms for

automating factory processes. Both internal and external connectors are included on a CPU module.In a programmable logic controller system, PLC I/O modules are one of the essential functional elements. To put it simply, PLC I/O modules work as messengers between the CPU and process control devices

3.4 Solenoid Valve

The solenoid valves are electromechanically operated valves which convert the electrical energy to mechanical energy. Their main purpose is to regulate the gas movement for the actuation of actuators. It will be used to control the direction of the cylinders. The solenoid valve we used can control both forward and backward motion of the cylinder.Here the solenoid valve is used to receive the signal from the relay and convert it to actuate the double acting cylinder.

3.5 MPCB (SIEMENS MPCB 1-1.6A 3VU1340-1MG00)

A specialised electromechanical device known as an MPCB, or motor protection circuit breaker, can be utilised with both 60 Hz and 50 Hz motor circuits. It performs a number of duties that enable it to offer a secure electrical supply. Protection from electrical failures like line-to-ground faults, line-to-line faults, and short circuits. Any electrical issue that is smaller than the MPCB's breaking capacity can be stopped. Motor overload protection is used when a motor uses more electric current than its nameplate value continuously. In MPCBs, overload protection is typically programmable.

Protection from phase loss and imbalances. The MPCB will disconnect the motor in either scenario as soon as the issue is discovered because both situations have the potential to seriously harm a three-phase motor. Thermal delay allows the motor to cool down after an overload by preventing the motor from being turned on right away. If a defective motor is restarted after it has overheated, irreparable damage may result.

3.6 MCB

Miniature Circuit Breakers, also known as MCBs, are a class of electrical safety equipment used to guard against overloading and short circuits in electrical circuits. To avoid harming the electrical system and the attached equipment, MCBs are built to immediately terminate a circuit when a fault is detected, such as an over current or short-circuit. MCBs can be placed directly onto a DIN rail or electrical panel and are less in size than conventional circuit breakers. They are normally rated for a particular voltage and current capacity and are commonly used in both residential and commercial structures. There are many different kinds of MCBs, including thermal-magnetic, electronic, and residual current devices (RCDs), each of which is made to guard against a particular kind of malfunction.

3.7 Slim Relay

Slim relays are a particular kind of relay that are made to be small and low-profile, making them ideal for applications where space is at a premium. Slim relays frequently have a smaller profile than conventional relays and frequently use surface-mount technology (SMT) to reduce their overall size. They are frequently employed in a wide range of applications, including those for telecommunications devices, industrial control systems, and automotive systems. Slim relays frequently perform the same fundamental tasks as conventional relays, such as switching, protecting, and controlling electrical circuits, but in a smaller package. They are normally rated for a particular voltage and current capacity, and they might also have features like built-in diode protection, LED status indicators, over-voltage and over-current protection, and so on.

3.8 Double Acting Air Cyclinders

The pneumatic cylinders are used for the actuation of racks with the help of air. This cylinder is a double acting cylinder used for forward and reverse linear actuation. Pneumatic cylinders use the energy from pressured air to generate force. These gadgets are made up of a cylinder, piston, and piston rod. As air enters the cylinder from one side, the pressure inside the cylinder increases.The piston moves in a certain direction as a result of an increase in internal pressure. The moving item receives the produced force from the piston rod.

3.9 SMPS (SWITCHED-MODE POWER SUPPLY)

An SMPS is an electrical device that is used in most of the applications it is used to appropriately send the electrical power supply or regulate the power supply so that the power won't get above the given range of power supply. It basically acts as a power supply device A switched-mode electricity deliver (SMPS) is an digital circuit that converts electricity the use of switching

gadgets which might be grew to become on and stale at excessive frequencies, and garage additives which includes inductors or capacitors to deliver electricity whilst the switching tool is in its non-conduction state.

4. SOFTWARE REQUIREMENTS

4.1 Solid Works

SolidWorks is a 3D CAD (Computer-Aided Design) programmed primarily used for engineering models, simulations, and product designs across a range of industries, including consumer products, aerospace, and automotive. It offers an intuitive user interface along with a number of tools for modelling, simulation, visualization, and design documentation. Dassault Systems created SolidWorks, which is used extensively by engineers, designers, and manufacturers worldwide.

4.2 GX Works Version 2

Mitsubishi Electric programmable controllers can be programmed and configured using the software GX Works2 (PLCs). Using the ladder logic programming language, it offers an integrated development environment for writing, editing, testing, and debugging PLC programmers. A variety of tools for monitoring and managing PLCs as well as for visualizing process data are also included in the software. Industrial automation applications including machine control, material handling systems, and assembly lines frequently employ GX Works2

4.3. GT Designer Version 3

Mitsubishi Electric programmable controllers (PLCs), as well as other industrial devices, may create HMI (Human-Machine Interface) screens using the software application GT Designer3. It offers a graphical user interface for creating and evaluating HMI panels, which may be used to monitor and manage different process variables like machine status, production counts, and alarms. Aside from these features, GT Designer 3 also has tools for animate visuals, make alerts and trends, and connect HMI panels to PLC variables. When a user-friendly interface is necessary for monitoring and controlling process variables, industrial automation and process control applications make extensive use of the software.

5. WIRING DIAGRAM

A wiring diagram frequently offers a graphical depiction of the actual architecture of the components and typically contains symbols for various sorts of components and their connections. In addition to being useful for troubleshooting and correcting electrical issues, wiring diagrams are frequently utilized in the design, build, and maintenance of electrical systems and equipment.

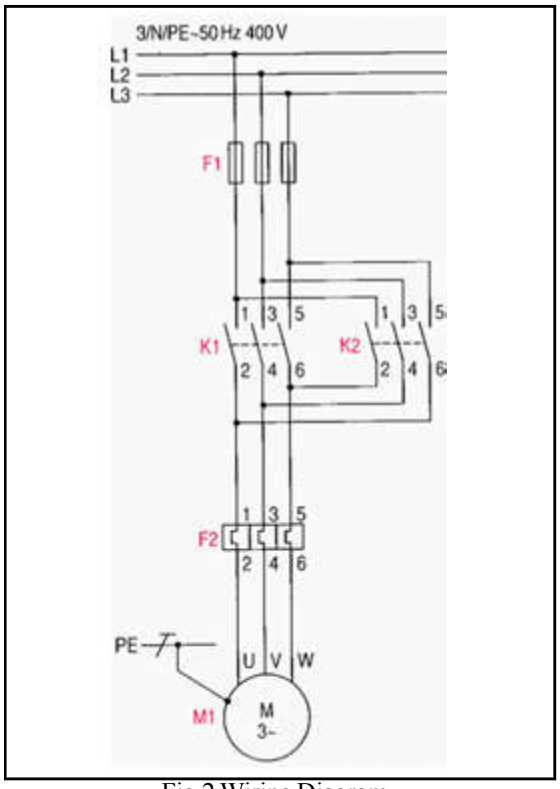

Fig.2 Wiring Diagram

6. PANEL DESIGN

Panel design is the process of developing the physical layout and electrical wiring diagrams for a control panel, a centralized control -system used to manage and operate numerous mechanical and electrical devices in a system. The process of designing a panel entail laying out the panel's layout, wiring, and other components as well as deciding where to place switches, controls, and other instruments. The system's mechanical and electrical requirements, as well as those for dependability and safety, must all be taken into account during the design process. To produce schematics, wiring diagrams, and other technical drawings, the design process frequently requires the use of software tools and specialist electrical design software.

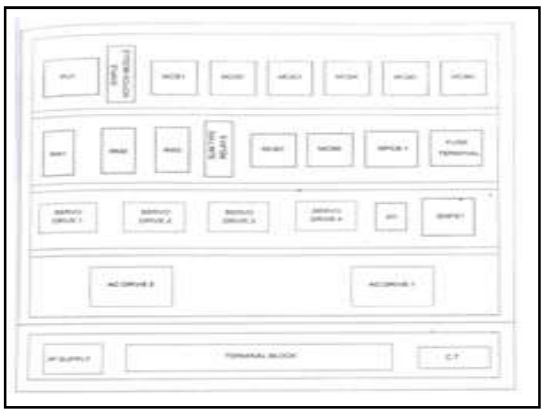

Fig. 3 Wiring Diagram

7. CONCLUSION

A prototype is fabricated to create ribs in the belts. This work focuses on saving time for producing the ribs in a belt and producing more effective and accurate belt ribs for producing the maximum transmission rate. It was achieved using an anvil and the feed motor to achieve the ribs in the belt. Using a collector to collect the belt, when the operation is completed. The process is controlled by a PLC Controller. The process is fully evaluated and further development is in process.

8. FUTURE WORKS

It can be converted into double belt.By Changing the anvil, we can use the same machine for different types & varieties of belts.

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EXPLORATORY DATA ANALYSIS FOR COVID-19 IN INDIA USING PYTHON

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Abstract

The COVID-19 pandemic has had a profound impact globally, with India being one of the heavily affected nations. This research focuses on conducting an in-depth Exploratory Data Analysis of COVID-19 data in India, employing Python as the primary analytical tool. The objective is to reveal the hidden patterns, trends, and insights that can aid in understanding the dynamics of the pandemic and assist in formulating effective public health strategies. This paper utilizes publicly available datasets from reliable sources such as health organizations and government repositories. The datasets encompass a diverse range of variables, including but not limited to the number of confirmed cases, recoveries, deaths, testing rates, and vaccination statistics. The Exploratory Data Analysis encompasses temporal analysis, spatial distribution, and correlation studies among different variables. Temporal analysis aims to identify significant trends over time, such as waves or peaks, while spatial distribution explores the geographic spread of the virus within India. Additionally, correlation studies investigate relationships between variables to uncover potential factors influencing the spread and impact of the virus. Insights gained from this Exploratory Data Analysis can contribute to evidence-based decision-making for healthcare professionals and researchers. By understanding the nuances of COVID-19 data in India, this research paper aims to facilitate proactive measures in controlling the spread of the virus, optimizing resource allocation, and enhancing the overall public health response.

Keywords: *Correlation Studies, COVID-19, Data Visualization, Exploratory Data Analysis, Python, Pandemic, Spatial Distribution, Temporal Analysism*

1. INTRODUCTION

Analyzing data is essential for predicting the occurrence of COVID-19 in India. Coronaviruses, a diverse virus family, can lead to illnesses in both animals and humans. In humans, various coronaviruses can result in respiratory infections, ranging from mild conditions like the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). The latest addition to this family, COVID-19, has been identified by the World Health Organization. The global count of new cases is steadily rising each day [1]. This dataset provides daily-level information from the states and union territories of India.

In the contemporary world, data is proliferating rapidly, making manual processing impractical. To delve into a deeper comprehension, data analysis and visualization programs prove invaluable. Python, renowned for its English commands and user-friendly syntax, emerges as a robust and free open-source alternative to conventional methods [2]. Employing data analytics enables businesses to assess efficiency and performance, facilitating more informed decision-making. The versatility of data analysis extends to various aspects of medical datasets when one grasps the available tools for information processing. In the context of analyzing medical COVID-19 datasets, researchers are adeptly utilizing visualization techniques to examine patient reviews effectively. Exploratory Data Analysis (EDA) serves as an approach to encapsulate key characteristics of the data and represent them visually.

EDA specifically focuses on verifying assumptions essential for model fitting and hypothesis testing, as well as addressing issues such as handling missing values and executing variable transformations as required [3]. Within its scope, EDA encompasses Initial Data Analysis (IDA). EDA provides a swift overview of key aspects of the dataset, including the number of rows and columns, identification of missing data, data types, and a preliminary preview. It involves cleaning corrupted data,

managing missing values, addressing invalid data types, and rectifying incorrect values.

In the visualization realm, EDA employs various techniques such as bar charts, histograms, and box plots to depict data distributions [4]. Additionally, it calculates and visualizes correlations (relationships) between variables using tools like heat maps. The subsequent sections of the paper are structured as follows: Section II provides a succinct literature review, while Section III delves into a discussion of diverse techniques for exploratory data analysis. Section IV outlines the process of conducting exploratory data analysis using Python, and Section V details working with datasets for this purpose. Finally, Section VI offers concluding remarks.

2. MATERIALS AND METHODS

2.1 EDA

Primarily, exploratory data analysis serves as an approach to glean insights from data beyond the formal modeling or hypothesis testing processes. EDA aids in scrutinizing datasets to succinctly summarize their statistical characteristics, with a primary focus on four key aspects: measures of central tendency (including mean, mode, and median), measures of spread (encompassing standard deviation and variance), the distribution's shape, and the identification of outliers [5]. The subsequent paragraphs provide a detailed description of these fundamental aspects of EDA. As depicted in Figure 1, throughout each stage of the machine learning process, data analysis and visualization techniques are extensively utilized. These techniques are elaborated upon in the following sections.

2.1.1 Data Exploration

This initial phase of data analysis marks the beginning of the process, providing insights into the content and characteristics of the dataset. It offers details about the data's size, identifies missing values, and explores potential relationships among the data points. The visualization of data is achieved through tabular representations, aiding in a comprehensive understanding of the dataset's features.

2.1.2 Data Cleaning

Data cleaning involves identifying corrupt data, eliminating irrelevant portions, and substituting inaccurate data with correct information. The primary objective of

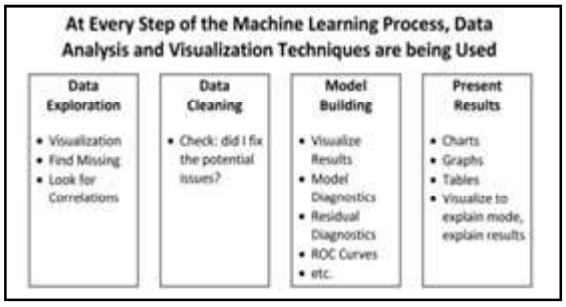


Fig.1 Steps of machine learning process

data cleaning is to rectify errors and validate the data. Cross-checking data is performed to eliminate errors, and issues are resolved through thorough validation procedures.

2.1.3 Model Building

Statistical or machine learning models are employed to characterize and understand variables. These models can fall into either supervised or unsupervised categories, with classification and regression models being utilized to generate outputs. Visualization techniques can be applied to depict the results derived from these models. Subsequently, an evaluation of the model is necessary.

2.1.4 Present Result

Charts, graphs, and tables serve as effective tools for visualizing extensive and intricate datasets. The human brain can efficiently process information presented through these visual aids, providing an accessible means of conveying complex concepts. This visual representation facilitates the identification of areas requiring improvement and offers a clear and concise clarification of various factors.

2.1.5 Graphical EDA

Graphical Exploratory Data Analysis (GEDA) is essentially the visual counterpart to the conventional non-graphical EDA [6]. It involves analyzing datasets to succinctly summarize their statistical characteristics, with a focus on key aspects like measures of central tendency, measures of spread, distribution shape, and the presence of outliers. GEDA is further classified into Univariate GEDA, Bivariate GEDA, and Multivariate GEDA. The subsequent paragraphs elaborate on these distinct varieties and aspects of GEDA.

3. UNIVARIATE GRAPHICAL EDA

Univariate GEDA furnishes a statistical summary for individual fields within the raw dataset or focuses solely on one variable. Examples of such GEDA types encompass the Cumulative Distribution Function (CDF), Probability Density Function (PDF), Box plot, and Violin plot. A discussion of a few of these is provided below:

3.1 Histograms

Numeric data distribution can be effectively depicted using histograms, particularly when focusing on a single variable instead of two. In this representation, the entire value range is divided into a series of intervals. Histograms are particularly well-suited for visualizing continuous data. They are portrayed as a frequency distribution through rectangles, where the width corresponds to the class interval, and the area is proportional to the respective frequencies. The height of the rectangle signifies the average frequency density. In the realm of digital images, the tonal distribution is graphically represented through an image histogram.

3.2 Stem Plots

A stem-and-leaf plot involves dividing the data into two parts, where the largest digit represents the stems and the smallest digit represents the leaves. Stem plots offer a bit more detail compared to histograms and are utilized for visualization purposes. Comparing data is facilitated, as the numbers are organized based on place value. Stem-and-leaf plots are particularly useful for emphasizing the mode and are well-suited for small datasets.

3.3 Box Plots

A visually effective representation of data concentration can be achieved through a box plot. This graphical tool portrays aspects such as central tendency, symmetry, skewness, and outliers. Constructed from five key values-the minimum, first quartile, median, third quartile, and maximum-the box plot compares these values to illustrate the proximity of other data points to them.

4. BIVARIATE GRAPHICAL EDA

Bivariate GEDA aims to comprehend the relationships between each variable in the dataset and the target variable of interest. This is achieved by examining the interplay between two variables to identify connections. Examples of such GEDA types involve the utilization of Box plots and Violin plots.

5. MULTIVARIATE GRAPHICAL EDA

Multivariate GEDA is employed to uncover connections between various fields in the dataset or to identify relationships among more than two variables. Examples of such GEDA techniques encompass the use of Pair plots and 3D Scatter plots. The BARGRAPH plot stands out as a widely utilized graphical technique. Presently, the Box plot is employed to illustrate the relationship between two values. In certain instances, a Pair plot is employed to provide a comprehensive view of all variables and their interrelationships.

5.1 Side-by-Side Box Plots

To compare the levels of all potential values, side-by-side box plots are employed. These plots are particularly useful for comparing two datasets, providing a concise summary of the data for each instance of a categorical variable.

5.2 Scatter Plots

It is a plot that utilizes a Cartesian coordinate system to illustrate the relationship between two variables within a dataset. This plot is created by placing the variable values on the X-axis and Y-axis, presenting the data as a series of points. The position of each point on the X and Y axes corresponds to the values of the respective variables.

5.3 Heat Maps and 3D Surface Plots

A heat map can be generated by using all feature variables, where these variables serve as both row and column headers, with the variable versus itself appearing on the diagonal. This visualization technique proves highly beneficial for understanding the relationships between variables in a high-dimensional space.

6. EDA IN PYTHON

Python is employed for exploratory data analysis due to its simplicity and ease of learning. The language boasts rich sets of libraries, high data handling capacity, and operates as an open-source platform. It seamlessly

integrates with third-party languages, runs on various platforms, and facilitates the transfer of processes between platforms. The code is easy to read, promoting understanding for developers. Python offers a diverse range of libraries, including powerful visualization tools, simplifying the creation of clear and informative reports through the visualization process.

6.1 Pandas

This package is exceptionally robust for data analysis, enabling tasks such as data cleaning, transformation, and analysis. Data can be efficiently stored in CSV format on a computer, and the package supports cleaning, visualizing, and storing data. It is constructed atop the NumPy package and incorporates plotting functions from Matplotlib, along with machine learning algorithms from Scikit-learn [3].

7.EXPERIMENTAL RESULTS AND DISCUSSION

Covid_19_india dataset is imported from kaggle .It contains 18110 rows and 9 columns.It's time to explore the data and find about it.

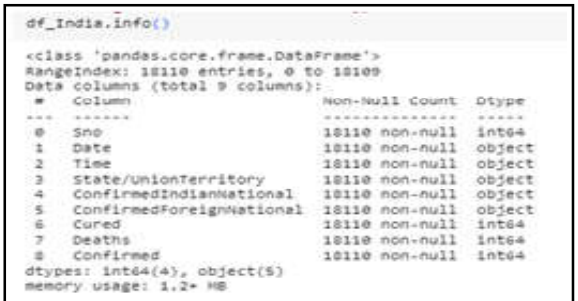
1 Pandas libraries. numpy package is utilized to perform the data analysis.

2. Covid_19_india dataset is imported as a data frame named df_India. The dataset contains 18110 rows and 9 columns which is given in the Figure 2. head() method is applied to get the top 5 rows of the data frame or series.

Fig.2 Importing pandas library and showing the data frame using df_India

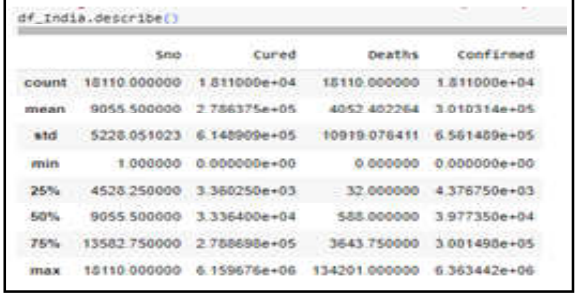
3.Choose the right visualization method. When visualizing individual variables, it is important to first understand what type of variable. This will help to find the right visualization method for that variable. For this import Matplot lib, seaborn library packages [7]. Use the method df_India.info() to list the datatypes and non-null values of columns in a dataset for each column. This is shown in Figure 3 below. As shown in the figure there are two types of datatypes such as int64 and object.

4. describe() method to provides a summary of descriptive statistics for numerical data within the dataset. Figure 4 shows the count, mean, median, mode, standard deviation, min, max, 25%, 50%, 75% of the attributes cured, death and confirmed [8].



```
df_India.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 18110 entries, 0 to 18109
Data columns (total 9 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   Sno                          18110 non-null  int64
 1   Date                         18110 non-null  object
 2   Time                         18110 non-null  object
 3   State/UnionTerritory         18110 non-null  object
 4   ConfirmedIndianNational      18110 non-null  object
 5   ConfirmedForeignNational     18110 non-null  object
 6   Cured                        18110 non-null  int64
 7   Deaths                       18110 non-null  int64
 8   Confirmed                    18110 non-null  int64
dtypes: int64(4), object(5)
memory usage: 1.2+ MB
```

Fig.3 Showing the datatypes and non-null values of

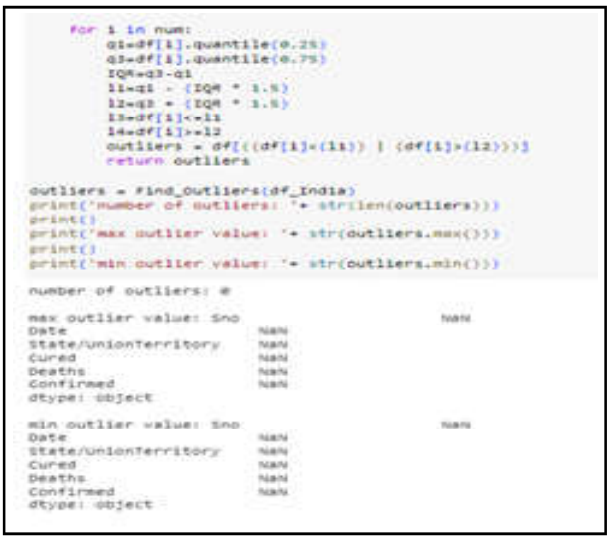


```
df_India.describe()
```

	Sno	Cured	Deaths	Confirmed
count	18110.000000	1.811000e+04	18110.000000	1.811000e+04
mean	9055.500000	2.786375e+05	4052.402264	3.010314e+05
std	5228.051023	6.148909e+05	10919.076411	6.561489e+05
min	1.000000	0.000000e+00	0.000000	0.000000e+00
25%	4528.250000	3.360250e+03	32.000000	4.376750e+03
50%	9055.500000	3.336400e+04	588.000000	3.977350e+04
75%	13582.750000	2.788698e+05	3643.750000	3.001498e+05
max	18110.000000	6.159676e+06	134201.000000	6.363442e+06

Fig.4 Statistical measure such as count, mean, standard

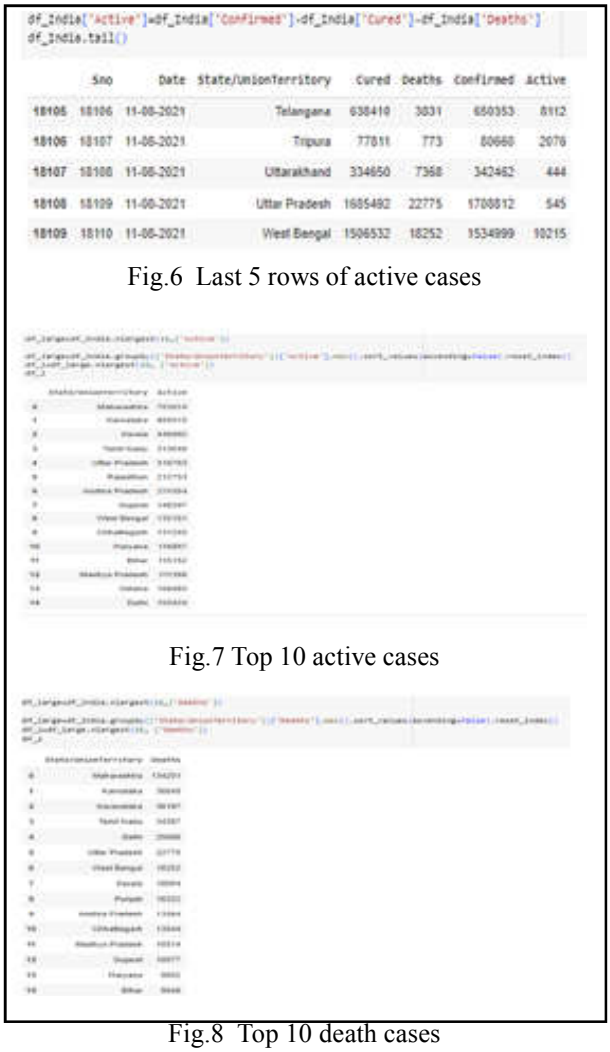
5. Find_Outliers is an outliers finding method. Calculate the outlier data points using the statistical method called interquartile range (IQR). Check whether outliers are within range of Q1(25% of data) and Q2(75% of data) and IQR represents the interquartile range calculated by Q3 minus Q1 (Q3–Q1). Figure 5 shows that anomalies are detected.



```
    for i in num:
        q1=df[i].quantile(0.25)
        q3=df[i].quantile(0.75)
        IQR=q3-q1
        l1=q1 - (IQR * 1.5)
        l2=q3 + (IQR * 1.5)
        l3=df[i]<=l1
        l4=df[i]>=l2
        outliers = df[((df[i]<(l1)) | (df[i]>(l2)))]
        return outliers

outliers = Find_Outliers(df_India)
print('number of outliers: '+ str(len(outliers)))
print()
print('max outlier value: '+ str(outliers.max()))
print()
print('min outlier value: '+ str(outliers.min()))

number of outliers: 0

max outlier value: Sno                          nan
Date                 nan
State/UnionTerritory nan
Cured                nan
Deaths               nan
Confirmed            nan
dtype: object

min outlier value: Sno                          nan
Date                 nan
State/UnionTerritory nan
Cured                nan
Deaths               nan
Confirmed            nan
dtype: object
```

Fig.5 Checking the outliers

6. Figure 6 shows the total number of active covid cases, number of people got cured from covid, number of people died in a particular state.
7. Top states that has larger number of active cases can be retrieved using the 'nlargest' method attribute as shown in the Figure 7. Similarly, top n states that have larger number of death cases can also be retrieved using the same method.
8. Figure 8 shows the top 10 states with highest Covid Death Cases in India [9].



```
df_India['Active']=df_India['Confirmed']-df_India['Cured']-df_India['Deaths']
df_India.tail()
```

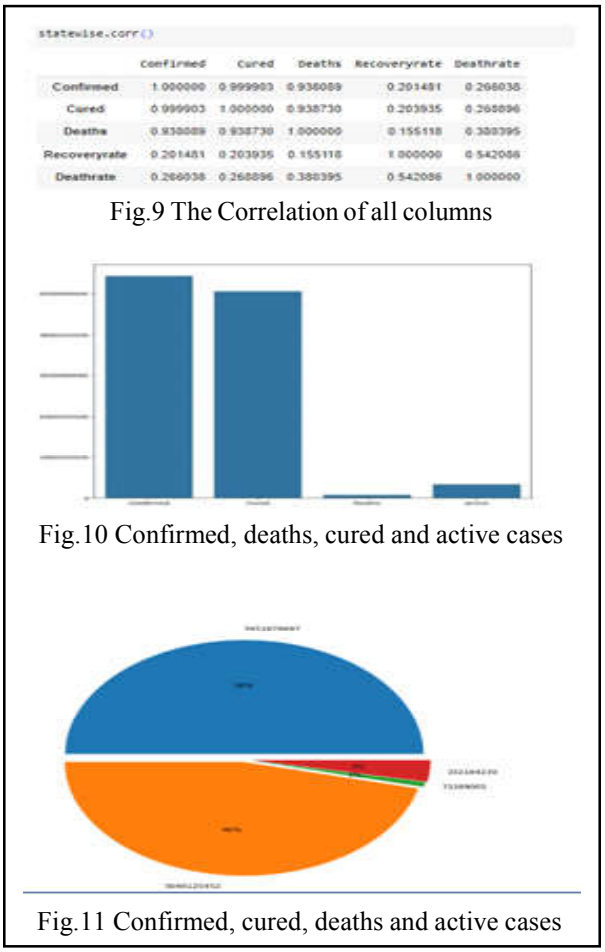
	Sno	Date	State/UnionTerritory	Cured	Deaths	Confirmed	Active
18105	18106	11-06-2021	Telangana	638410	3831	650353	8112
18106	18107	11-06-2021	Tripura	77811	773	80660	2076
18107	18108	11-06-2021	Uttarakhand	334650	7368	342462	444
18108	18109	11-06-2021	Uttar Pradesh	1685482	22775	1708812	545
18109	18110	11-06-2021	West Bengal	1506532	18252	1534899	10215

Fig.6 Last 5 rows of active cases

Fig.7 Top 10 active cases

Fig.8 Top 10 death cases

9. Figure 9 shows the pair wise correlations of all column in data frame or covid dataset using the method df. corr( ) [10].
10. Bar plot for Confirmed, Deaths, Cured and Active cases shown in Figure 10. This bar plot shows the visual representation of data where rectangular bars are used to represent the count of confirmed, deaths, cured, and active covid cases.
11. Pie chart for confirmed, cured, deaths and active cases shown in Figure 11. A pie chart for confirmed, cured, deaths, and active cases visually represents the distribution of COVID-19 outcomes. Each segment of the pie chart corresponds to one of these categories, allowing for a quick overview of the proportionate impact of the pandemic. This visualization aids in understanding the relative contributions of confirmed cases, recoveries, deaths, and active cases, providing a snapshot of the overall COVID-19 situation [11].



```
statewise.corr()
```

	Confirmed	Cured	Deaths	Recoveryrate	Deathrate
Confirmed	1.000000	0.999903	0.936089	0.201481	0.266036
Cured	0.999903	1.000000	0.938730	0.203935	0.268896
Deaths	0.936089	0.938730	1.000000	0.155118	0.380395
Recoveryrate	0.201481	0.203935	0.155118	1.000000	0.542086
Deathrate	0.266036	0.268896	0.380395	0.542086	1.000000

Fig.9 The Correlation of all columns

Fig.10 Confirmed, deaths, cured and active cases

Fig.11 Confirmed, cured, deaths and active cases

12.Pie Chart of 15 Top Active Cases shown in Figure 12. It clearly shows that the state 'Maharashtra' and 'Karnataka' states have the larger number of active cases. Next in the list are the states, Kerala and Tamil Nadu.

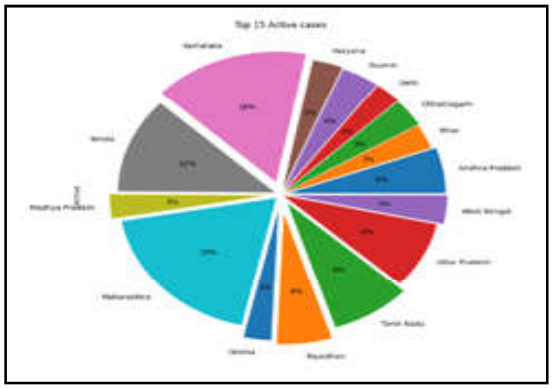


Fig.12 15 Top Active Cases

The pie chart succinctly visualizes the distribution of active COVID-19 cases among the top 15 states, clearly highlighting Maharashtra and Karnataka as the primary contributors. Its simplicity offers a quick and impactful way to convey the disproportionate impact and aid decision-making.

13. Bar Plot of Top 15 Active Cases (unsorted manner) shown in Figure 13. The bar plot effectively compares the number of active COVID-19 cases in the top 15 states, emphasizing Maharashtra and Karnataka as the states with the highest counts. Its straightforward representation facilitates a quick understanding of the relative magnitudes among states.

14. Bar Plot of Top 15 Active Cases (sorted manner) shown in Figure 14. A bar plot presented in a sorted manner serves to rank and compare states based on active COVID-19 cases, aiding in the identification of trends and patterns [3]. It enhances readability and provides a clear visual hierarchy, facilitating quick decision-making for prioritizing interventions and resource allocation.

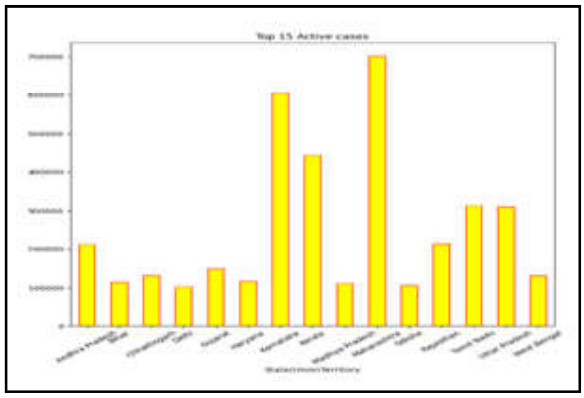


Fig.13 15 Top Active Cases (unsorted manner)

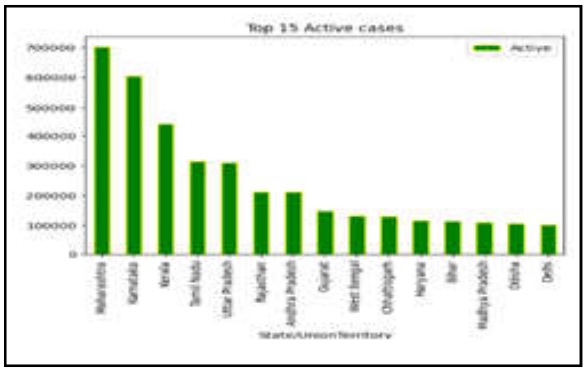


Fig.14 15 Top Active Cases (sorted manner)

15.line Plot of Top 15 Active cases (Unsorted Manner) shown in Figure 15. A line plot is beneficial for illustrating trends or changes over time, making it useful in depicting the progression of COVID-19 cases in a specific state or region. By presenting data points chronologically, it offers insights into the trajectory of the pandemic, aiding in the identification of spikes, trends, and potential turning points. Its simplicity and chronological representation make it a valuable tool for conveying temporal patterns in COVID-19 data.

16. line Plot of Top 15 Active cases (Sorted Manner) shown in Figure 16. A sorted line plot is valuable for showcasing temporal trends in COVID-19 cases across states in an organized manner. By sorting states based on specific criteria, such as active cases or infection rates, the plot offers a clear representation of how different regions compare over time.

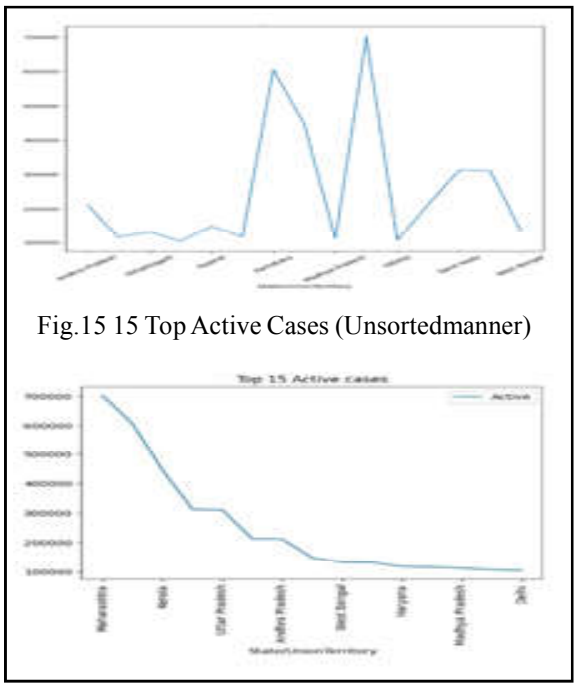


Fig.15 15 Top Active Cases (Unsortedmanner)

Fig.16 15 Top Active Cases (Sorted manner)

17. Violin plot for top 15 active cases shown in Figure

17 A Violin plot for the top 15 active COVID-19 cases provides a comprehensive view of the distribution of cases across states. It combines elements of box plots and kernel density plots, offering insights into the data's distribution, skewness, and central tendencies. This visualization helps in understanding the variation in active cases among the top states and identifying any potential outliers or concentration patterns. The wider sections of the plot represent higher density, aiding in discerning the range and distribution characteristics within the selected states.

18. Bar Plots for the top 10 states with highest Covid Death Cases in India shown in Figure 18. This bar plot will visually represent the top 10 states in India with the highest COVID death cases, providing a clear comparison of the death counts across different states.

19. Line plots for the top 10 states with the highest COVID death cases in India, depicted in Figure 19, will offer a visual representation, allowing for a clear comparison of death counts across various states.

20. A pie chart representing the top 10 states with the highest COVID death cases in Figure 20 provides a visual depiction comparison of death counts among different states.

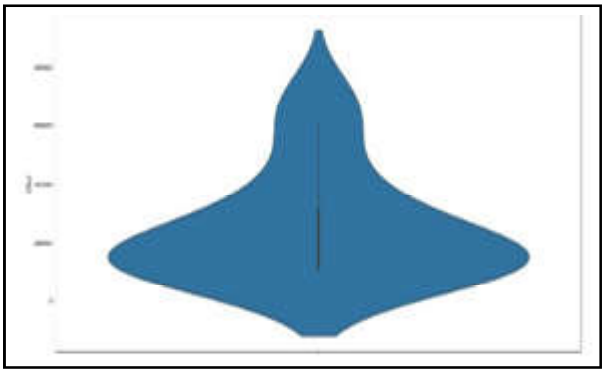


Fig.17 15 Top Active Cases

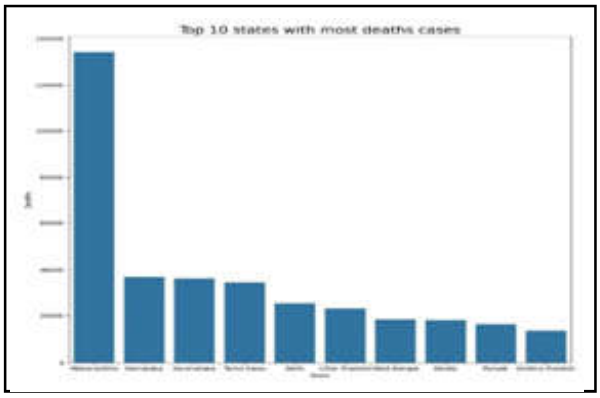


Fig.18 Top 10 death Cases

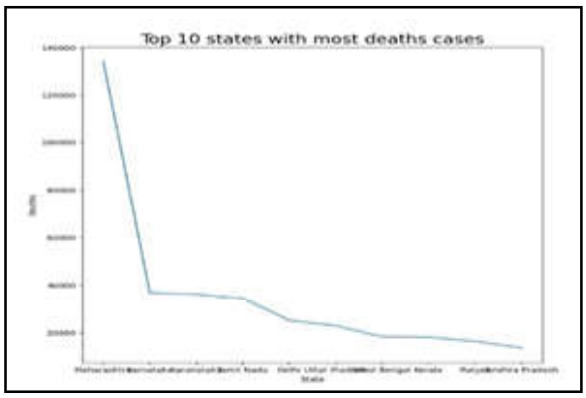


Fig.19 Top 10 death Cases

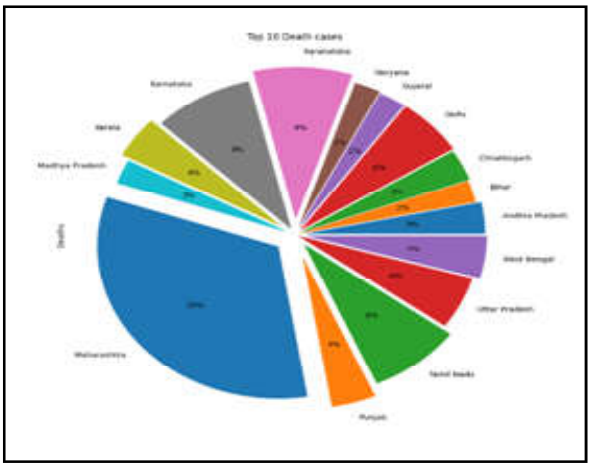


Fig.20 Top 10 death Cases

21.A violin plot for the top 10 states with the highest COVID death cases in India, illustrated in Figure 21, will present a visual representation, facilitating a clear comparison of death counts across different states.

22. A line plot depicting the "Top 5 Most Affected States" in terms of COVID-19 cases offers a chronological representation of the progression of the pandemic in these specific states is shown in Figure 22. By tracking the line plot over time, it provides a clear visual narrative of how the COVID-19 situation evolves in the states with the highest case counts.

23.Heatmap for Correlation is shown in figure 23. A heatmap for correlation visually represents the strength and direction of relationships between different variables. In the context of COVID-19 data, a correlation heatmap could reveal associations between various factors such as confirmed cases, active cases, death cases, cured from covid. Darker or lighter colors indicate the degree of correlation, assisting in identifying patterns and informing public health strategies based on interconnected variables.

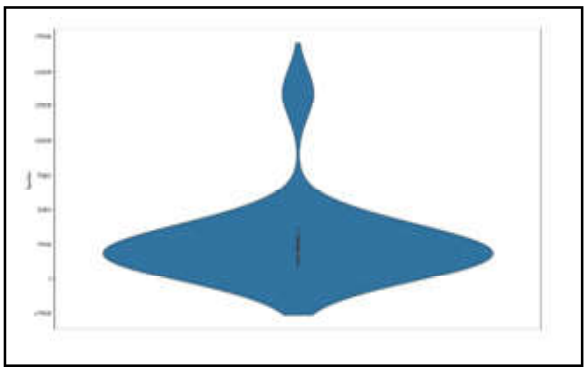


Fig.21 Top 10 death Cases

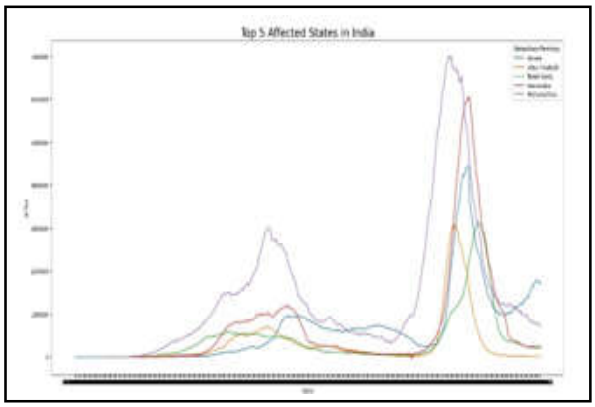


Fig.22 Top 10 death Cases

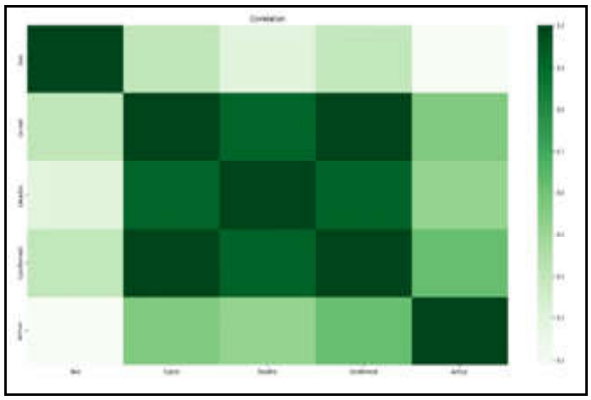


Fig.23 Heatmap for Correlation

24. Fatality Ratio of Contaminated States as shown in Figure 24, provides a dynamic view of how the proportion of deaths to confirmed cases evolves over time. This visualization allows for tracking trends and identifying periods of changes in fatality rates in states affected by COVID-19. It assists in understanding the severity of the outbreak in different regions and can be valuable for assessing the effectiveness of healthcare interventions and response strategies.

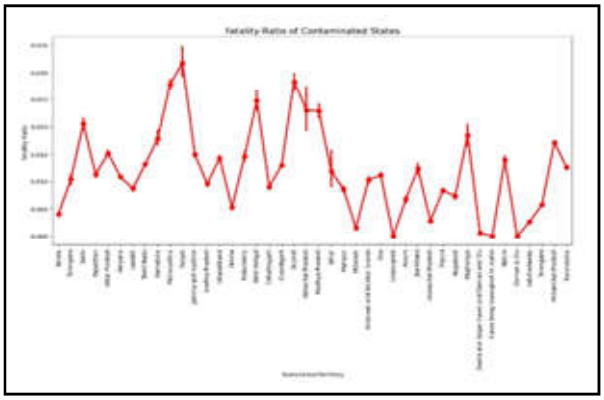


Fig.24 Fatality-Ratio of Contaminated States

4. CONCLUSION

In this article, EDA is conducted for COVID-19 in India using Python has provided valuable insights into the dynamics of the pandemic. Through comprehensive temporal, spatial, and correlation analyses, the research highlighted key patterns and trends, aiding in a nuanced understanding of the situation. The pie chart illustrated the disproportionate impact, emphasizing Maharashtra and Karnataka as the states with the highest active cases. Additionally, the bar plot facilitated a sorted comparison, offering a clear ranking of states based on active cases. The line plot revealed temporal trends in the Top 5 Most Affected States, while the correlation heatmap exposed relationships between different variables.

Furthermore, the fatality ratio line plot provided a dynamic perspective on the severity of the outbreak in contaminated states. These visualizations collectively contribute to evidence-based decision-making for healthcare professionals and researchers. The organized and insightful presentation of COVID-19 data using Python underscores the importance of data-driven approaches in navigating the challenges posed by the pandemic in India. These findings can guide targeted interventions, resource allocation, and strategic planning to curb the spread and mitigate the impact of COVID-19.

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MACHINE LEARNING TECHNIQUES TO IDENTIFY HIDDEN COWPEA BEETLE INFESTATION IN GREEN GRAM USING NIR HYPERSPECTRAL IMAGING DATA

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Abstract

Insect infestation in pulses causing major losses during storage and Callosobruchus maculatus (cowpea beetle) is one of the major insects causing losses during storage in pulses. Cowpea beetle can be easily detected by naked eye at the later stages (adult stage), but detection at initial stages (larvae and pupal stages) of infestation helps will help to prevent storage losses otherwise it will cause total loss of the stored pulses. This research work conducted to identify the early infection (larval and pupal stages) of cowpea beetle in green gram by using Near infrared (NIR) hyperspectral imaging for image acquisition and data collection. For data analysis machine learning techniques, artificial neural network (ANN) and support vector machines (SVM) were used. The reflectance data wavelength band of green grams infested by larval and pupal stages of C. maculatus at 1000-1600 nm was collected using a NIR hyperspectral imaging system. SVM and ANN-back propagation neural network (BPNN) classification models were developed using this collected reflectance data. The SVM classifier positively identified >78% of uninfested and >77% of hidden infestation. The BPNN classifier positively detected >91%, and >84% of uninfested, and hidden infestation in green grams. Among all the stages of hidden infestation SVM and BPNN models had higher classification efficiency for larval instar I (94% and 92%, respectively).

Keywords: *Back Propagation, Callosobruchus Maculatus, NIR Hyperspectral Imaging, Neural Network, Support Vector Machines*

1. INTRODUCTION

Storage pests cause most of the storage losses in pulses. Pulse beetles, Callosobruchus maculatus (F.) and Callosobruchus chinensis (L.) are the major storage pests, which cause serious damages in legumes during storage particularly in tropical countries. The larvae and adults of C. maculatus can cause the damage to the green grams (Vignaradiata(L.) R. Wilczek). They bite holes in the beans to enter inside the beans and feed on the protein of the beans. In developing countries, the losses due to this bruchids range from 12 to 30% [1].

Most of the times C. maculatus infestation is not detected in early stages of storage and by the time it is detected, the infested beans are not marketable due to the rapid breeding ability of the bruchids [2]. Total damage of stored beans can be minimal if we can detect the C. maculatus in early stages and carry out pest management practices on time.

The common insect detection methods like, Berlese funnel extraction, visual inspection, whole grain flotation method are time consuming, less accurate, sample destructive, and subjective in nature [3]. The advanced techniques, such as soft x-ray imaging and acoustic method also tested for detecting infestation in grains, have their own advantages and disadvantages for insect detection. Soft x-ray imaging was tested for detecting hidden infestation of storage insects and they gave good classification accuracy for later stages of infestation (pupal and adult) [4,5]. Thermal imaging system also gave similar results while detecting Cryptolestes ferrugineus infestation in wheat kernels [6].

Acoustics sensors have been used to detect Sitophilus oryzae (L.) (Coleoptera: Curculionidae), Triboliumcastaneum (Herbst) infestation in wheat, and they also had a good detectability for adult insects and some other techniques like heat treatment needed to detect larval stages [7,8]. Grain elevators and processing

industry is using NIR spectroscopy method for prediction of various chemical constituents of grain, and also tested for insect detection. The major drawbacks of NIR spectroscopy are: this method is sample destructive, errors due to improper calibration, and chemical spectra cannot identify the location of hidden infestation [9].

NIR hyperspectral imaging is the advance technique, from which both the spectral and spatial information can be obtained to form a dataset called hypercube. In the last decade, this technique had been tested throughout the world for various applications in grain industry like prediction of moisture, oil, protein, and starch contents of cereal and pulses [10]. NIR hyperspectral imaging was examined identification of insect and fungal infestation in cereal grains. Various statistical analysis tools and machine learning tolls were extensively tested and documented by various researchers to analyze the NIR hyperspectral imaging data acquired for quality analysis, sorting, grading and safety applications in food and agricultural products. Support vector machine (SVM) is one of the major machine learning tool used by researchers to analyze the hyperspectral data. The artificial neural network (ANN) is another common machine learning tool, and the back propagation neural network (BPNN) module has been elaborately tested for classification of cereal grains, identification of foreign materials and identification of insect and fungal infection in stored grains [11]. Kaliramesh et al. (2013) used linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers to analyze the hyperspectral data to identify C. maculatus infestation in green gram. The LDA and QDA classifiers correctly identified of healthy green grams from infested beans with a classification accuracy of 85 and 88%, respectively. But both LDA and QDA classifiers had low classification accuracy to identify different life stages of C. maculatus infestation in green grams. This research work was framed to test feasibility of using machine learning techniques, SVM and BPNN for analyzing the NIR hyperspectral data to identify the hidden infestation of C. maculatus in green grams.

2. MATERIALS AND METHODS

2.1. Sample Preparation

About 200 freshly emerged C. maculatus adult insects were obtained from the Cereal Research Centre, Winnipeg and placed with about 1 kg of sound green gram with a moisture content of 12% (wet basis) in a plate inside a cage. After 24 h, green grams with single egg were collected by observing the green grams under a microscope. These kernels were divided into five groups (300 kernels in each group) and were incubated in an environmental chamber at 30°C and 70% relative humidity (rh) for 4, 8, 11, 15, and 22 days to obtain four larval stages (first, second, third,and fourth instar), and pupae, respectively [20].

2.2 NIR hyperspectral Imaging System and Image Acquisition

The imaging system used in this study was the same as reported in the earlier studies and is described briefly here for enhanced readability and completeness of this manuscript. "The hyperspectral images of uninfested and infested kernels at different stages of infestation by C. maculatus were acquired using a NIR hyperspectral imaging system, which consists of: thermoelectrically cooled Indium Gallium Arsenide (InGaAs) camera (Model No. SU640-1.7RT-D, Sensors Unlimited Inc., Princeton, NJ), a 25 mm F1.4 C-mount lens, two liquid crystal tunable filters (LCTF), a camera stand and sample stage, and light source (two 300 W halogen-tungsten bulbs, USHIO Inc., Chiyoda-ku, Tokyo, Japan). The images were obtained in the wavelength range of 1000-1600 nm at 10 nm intervals (totally 61 images per sample). The imaging system was switched on 30 min prior to the start of imaging for stabilizing and aligned at the central wavelength of the imaging spectrum (1300 nm).

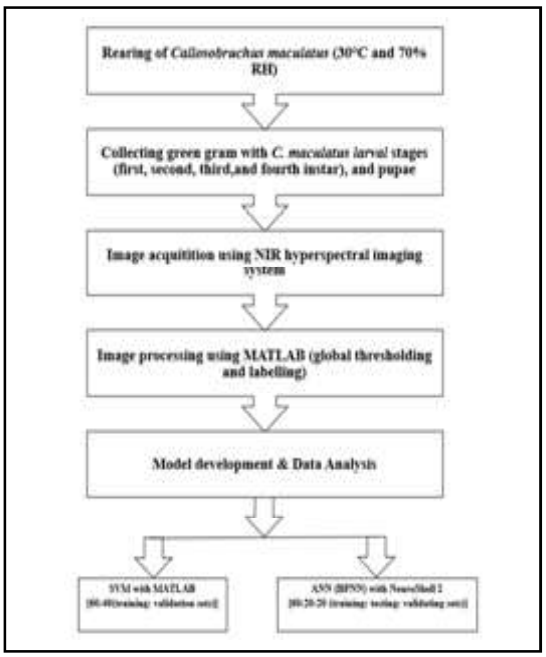

Fig.1 Process flow chart for Callosobruchus maculatus detection using NIR hyperspectral imaging system

Dark current image and reference image (with 99% white reference card) were acquired at the beginning of each imaging session and obtained images were normalized using these dark current and white images by a control program developed in LabVIEW (Version1, National Instruments, Austin, TX) platform".

2.3 Image Analysis and Model Development

Hyperspectral(reflectance) data of individual green grams were obtained by a MATLAB program (Version 8.1 Mathworks Inc. Natick, MA), which separated the kernels from the background using global thresholding method and labelled them using bwlabel function. SVM and ANN classification models were developed to analyze the processed hyperspectral data using MATLAB and NeuroShell 2 (Ward Systems Group, Inc., Frederick, MD) software. The SVM model was developed with a radial basis function kernel based on LIBSVM library. The SVM classifies the samples by creating a hyperplane and 80% of hyperspectral data were used for learning and 20% of data used for validation of the developed model. Back propagation, often abbreviated as "BP," stands as a widely-used supervised learning technique within the realm of artificial neural networks (ANNs). Its full name, "backward propagation of errors," succinctly captures its essence. This method plays a crucial role in training ANN models, wherein the network is trained to discern desired outputs from numerous inputs. A 60:20:20 (training: testing: validating sets) BPNN classification model was developed using Neuroshell 2 software.

3. RESULTS AND DISCUSSION

The reflectance spectra of uninfested and green grams infested with different hidden stages of C.maculatusare given in Figure 1. The wavelength regions of 1100, 1010, and 1450 nm ranked top 3 in the weight list of BPNN classifier (Table 1). Reported that the wavelengths of 1100 nm and 1400 nm were significant wavelength for detecting insect infestations in wheat and mung beans(green gram), respectively.The wavelength region of 1100 to 1300 nm was associated with the starch content of the object. The insect's consumption of kernels starch during their development may be the reason for different reflectance response in this wavelength region.

The SVM classifier correctly identified 77.6±6.8% uninfested green grams from the infested ones and gave highest classification accuracy of 93.9±2.6% for detecting larval instar I Figure 2. Green grams infested by C. maculatus pupae had the lowest classification accuracy. The green grams infested with pupal stages of C. maculatus often were misclassified with the green grams infested with C. maculatus larval instars III and IV. The BPNN model correctly identified 92.2±1.9% green grams infested by C. maculatus larval instar 1 Figure 3. Pupal stage of infestation had the lowest classification accuracy with the BPNN model (84.4±10.1%). In both the SVM and BPNN classifiers, green grams with larval instar 1 and pupae had the highest and lowest classification accuracies, respectively. Developed linear and quadratic (LDA & QDA) analysis model for identifying cowpea beetle infestation in mung bean and got classification accuracies of 63.0% and 84.3% for larval stage and 75.5% and 94.3% for identifying pupal stages of cowpea beetle. Four way classification LDA&QDA models yielded <70% accuracy other than Larval instar IV stage(9). Machine learning methods (SVM and BPNN) increased the classification accuracies to >80% for all the hidden infestations of cowpea beetle in green gram.

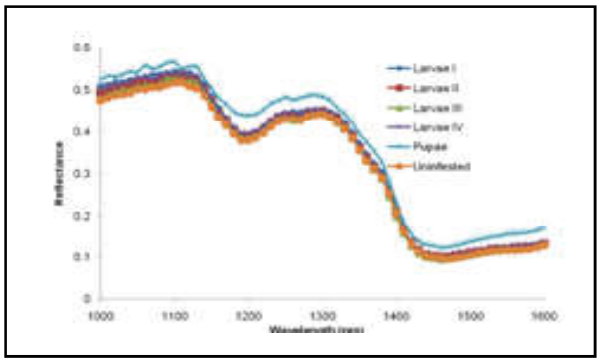

Fig.2 Reflectance spectra of uninfested green grams and green grams infested with hidden stages of C. maculatus.

Table 1 Top Ten Wavelengths and Weights of BPNN Classifier

Rank	Wavelength (nm)	Weight
1	1100	0.16854
2	1010	0.15682
3	1400	0.15149
4	1060	0.14988
5	1540	0.13972
6	1040	0.13329
7	1190	0.12807
8	1180	0.12282
9	1200	0.12188
10	1040	0.12034

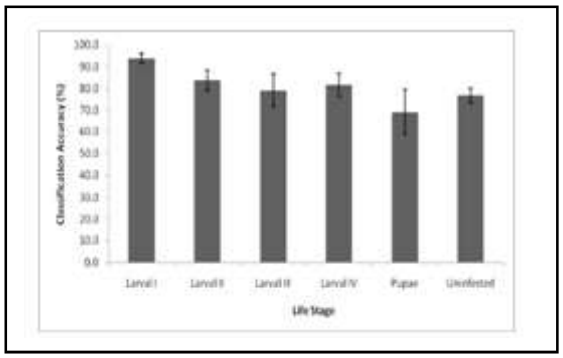

Fig.3 Classification accuracies of SVM classifier

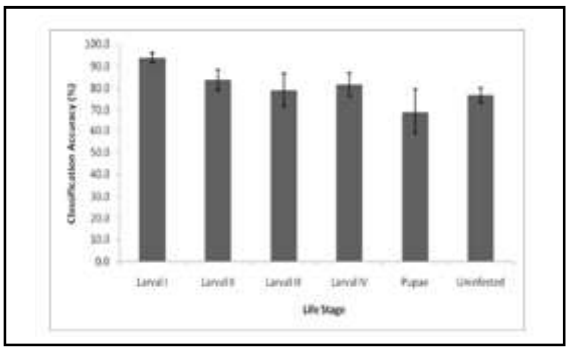

Fig.4 Classification accuracies of BPNN classifier

4. CONCLUSION

The BPNN classifier correctly classified >84% of all hidden stages of C. maculatus infestation in green grams, and >91% of uninfested green grams. The SVM classifiers had more than 80% classification accuracy except for larval instar 3 and pupal infestations and more than 77% of uninfested beans were correctly classified from infested beans. Both the classification models had higher classification accuracy for detecting larval instar I stage of C. maculatus in green grams. Wavelengths of 1100 nm, 1010 nm, and 1400 nm proved crucial in identifying concealed infestation in green gram. These findings could contribute to the creation of a multispectral imaging system for real-time insect detection in grain handling facilities. Employing preprocessing methods such as multiplicative scatter correction (MSC) and standard normal variate (SNV) on spectral data is anticipated to enhance classification accuracy for detecting hidden infestations in green gram.

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INTRUSION DETECTION USING 1D-CONVOLUTIONAL NEURAL NETWORK MODEL FOR IOT APPLICATIONS

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Abstract

The Internet of Things (IoT) has grown significantly over the past ten years, and this has sparked ground-breaking advancements in the network business. Common IoT systems include smart cities and homes, wearable technology, traffic control, health services, and resource efficiency. The effectiveness of such smart devices could affect the end - user, corrupt their private data, and expand threats and risks online. Cyber-attacks make this IoT-based smart city development dangerous. It is necessary to know how to design a reliable model which can defend IoT devices against attacks and threats. In this paper, a Convolutional Neural Network model is proposed to detect intrusion in IoT networks. The input dataset is preprocessed to make it more reliable and consistent for experimentation. From the preprocessed data, the relevant features are selected using Correlation based Feature Selection(CFS) method. The model efficiently identifies the feature set that has high correlation with the classification classes. Using the selected features, a Convolutional Neural network (CNN) has been employed to identify malicious assaults. The BoT-IoT dataset was used to test this suggested model, and the results demonstrate its performance with an accuracy of 92.65% at learning rate 0.003.

Keyword: *BoT-IoT, Correlation based Feature Selection, CNN, Deep Learning, Intrusion Detection System, Internet of Things*

1.INTRODUCTION

Significant advancements in telecommunications networks and the emergence of the Internet of Things concepts have been brought about by revolutionary shifts in the everyday use of electronic services and applications. The Internet of Things (IoT) is a communications paradigm wherein devices function as entities or "things" that may interact with one other, sense their environment, and exchange data via the Internet [1, 2].

In intelligent environments, sensors work together to complete tasks. Wireless sensors, IPv6, and wireless communication techniques all contribute to the growth of smart environments. These environments can take many different forms, such as smart homes and cities and smart healthcare systems.When smart environments and IoT systems collaborate, smart items become more efficient. However, a number of security risks, such as Distributed Denial-of-Service (DDoS) and Denial-of-Service (DoS) attacks, can affect Internet of Things (IoT) systems. The applications for smart environments and IoT services on an IoT network are harmed by such attacks. IoT system security is now seen as crucial and a primary concern as a result.

Smart cities and smart residences are only two examples of the many application areas and related services that the Internet of Things has been used to generate recently. These "smart environments" attempt to improve human comfort and productivity by addressing concerns related to energy usage, living conditions, and industrial needs [3,4]. This goal is directly tied to the notable proliferation of IoT-based services and applications across several networks.Network layer is where the intrusion happens in an IoT enabled system. The system to detect intrusion functions under strict conditions of limited processing power, quick response, and improveddata processing when used in IoT-based intelligent devices.

There are a wide variety of dataset to simulate an intrusion detection system in a network. BoT IoT is one such dataset that consists of both real and simulated IoT network traffic and a variety of threats and a model for intrusion detection is designed for this dataset.

2. RELATED WORKS

Devrim Akgun *et al.* proposed an IDS model using DNN, CNN and LSTM on CIC-DDoS2019 dataset to recognize DDoS assaults and obtained 99.99% accuracy in binary classification and 99.30% for multi class accuracy [5,6]. They implemented Info Gain Attribute Evaluation methodology to perform feature selection.

Yesi Novaria Kunang et al. [7,8] proposed a best suited model using DAE and DNN to identify attacks in NSL-KDD and CSE-CIC-IDS2018 datasets. Feature extraction was based on DAE. The model produced accuracy of 83.33%.

A Filtered DL Model for detection of intrusions using a Data Communication Approach was proposed by Pampapathi B M et al. [9,10] and yielded an accuracy of 96.12%. They used TON_IoT data sources to test the model.

A recurrent deep learning-based feature fusion method incorporating RNN, LSTM, and GRU was proposed by Vinayakumar Ravi et al. [11]. Many datasets, such as the SDN-IoT database, KDD-Cup-1999, UNSW-NB15, WSN-DS, and CICIDS-2017, were used to propose the system. RNN, LSTM, and GRU had classification accuracy for network attacks of 91%, 93%, and 93%, respectively.

Christiana Ioannou andVasos Vassiliou evaluated C-SVM and OC-SVM to classify attacks in IoT network [12]. They achieved 100% accuracy in the same network topology and 81% accuracy in an unidentified topology in C-SVM algorithm. In OC-SVM, the accurate prediction was only 58%.

Popoola, S.I et al. proposed Hybrid deep learning model that worked on BoT-IoT dataset. Dimensionality reduction was carried out utilizing LSTM Autoencoder and the network traffic was classified based on Bidirectional LSTM[13,14].

3. DATASET DESCRIPTION

The BoT-IoT dataset includes a combination of both regular and botnet traffic. It consists of 73 million records with 42 features out of which only 20 necessary features are considered with the file size of 69.3 GB. *h source IP.*

Table 1 Feature set for CNN classification model

Feature Number	Feature	Description
f1	pkSeqID	Packet sequence identifier
f2	Proto	Textual summary of transaction protocols in network communication
f3	S__addr	IP address of source machine
f4	S__port	Port number of source machine
f5	D__addr	IP address of destination machine
f6	D__port	Port number of destination machine
f7	state__number	Numerical value of feature state
f8	Sequence	Sequence number
f9	Mean	Average time spent on merged records
f10	Std_dev	Standard deviation of merged records
f11	Min	Minimum time spent on merged records
f12	Max	Maximum time spent on merged records
f13	S_rate	Source-to-destination packets per second
f14	D_rate	Destination-to-source packets per second
f15	N__IN__Conn _P_SrcIP	Number of incoming connections for each source IP.
f16	N__IN__Conn _P_DstIP	Number of incoming connections for eachdestination IP.

The dataset covers attacks including Information theft, DoS and DDoS which is further grouped based on the protocols. To make dataset handling easier, 5% of the dataset is extracted with best features that compromises 1.07GB file size and 3 million fields. Table 1 and Table 2 contain a list of features and the attack types in Bot-IoT dataset[15].

Table 2 Instances Under Attack in the Bot-IoT Dataset

Bot-IoT	Category	Total number of Occurrences
Normal		107
Attacks	DoS	330112
	DDoS	835307
	Reconnaissance	18163
	Information theft	14

4. PROPOSED SYSTEM DESIGN

The proposed system discusses the architecture for detection of the attacks in BoT- IoT dataset. It includes

data acquiring, data preprocessing, feature selection, model building and evaluation for attack detection. The process involved in each step is explained underneath.

4.1 System Architecture

Data preprocessing is done to improve the value of the dataset using techniques including data cleaning, standardization and label encoding. The feature selection phase is done to extract the relevant features using the CFS algorithm. Next, the CNN classifier model is implemented for the detection of the abnormal behavior or attacks in the IoT network with the selected features. The overall architecture of the attack detecting model is given in Figure 1.

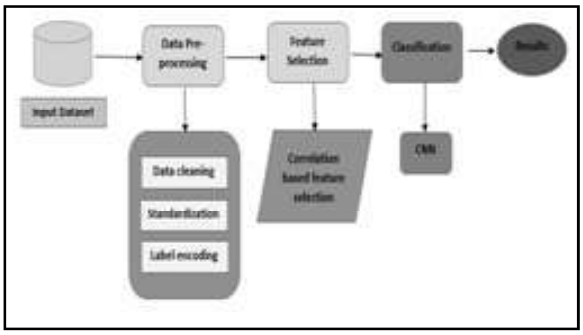

Fig.1 Overview of Attack Detection using CNN Model

4.2 Data Preprocessing

Preparing data for analysis in data mining and machine learning requires a crucial step called data preparation. By cleaning and preparing the data to ensure correctness, consistency, and completeness, data preprocessing aims to convert raw data into a format appropriate for analysis.Several processes are involved in this process, including data cleaning, integration, transformation, reduction, and discretization. Finding and fixing mistakes including missing numbers, duplication, outliers, and inconsistencies is known as data cleaning.

Most frequently, duplicate data is created during the data collection procedure. This usually occurs while receiving data from clients or many devices, or when combining data gathered from several sources. Additionally, any unnecessary observations must be eliminated from the dataset.

Exceptional quantities in a dataset are called outliers. They can skew the study and go against presumptions since they differ noticeably from other data points.Eliminating them is a judgement call that is based on the analysis. Eliminating undesired anomalies will enhance the functionality of the data being handled.

Errors in structure such as odd name standards, typos, or improper capitalization might lead to mislabeled categories; they should be recognized and corrected.

Second, the dimensionality reduction is done using Z score normalization or standardization technique. Many times, various variables fluctuate on different scales, or one variable may change exponentially while another varies linearly. Scaling facilitates the transformation of the data so that algorithms may more easily extract a meaningful relationship between variables. The procedure of centering a variable at zero and standardizing the variance at one is referred to as standardization. To accomplish this, subtract each observation's mean and divide the result by the standard deviation.

The quantitative data is then scaled using Z score normalization or standardization technique. A feature F is standardized using mean and standard deviation using the Eq. [1].

$$F\_new = (F - M) / S \qquad (1)$$

where F represents the features, M represents the average and S represents the standard deviation. Theresulting z-score represents the standard deviations that the feature value is away from theaverage. If the z-score is greater than zero, it means that the feature value is above the average, while z-score is lesser than zero, it indicates that the feature value is below the average.

4.3 Feature Selection Using Correlation Based Filter (CFS)

CFS algorithm is a method for selecting appropriate features from a dataset by evaluating the correlation between features and target variable. CFS considers both the significance and redundancy of each feature with respect to the target variable. The CFS algorithm works by calculating a merit score for each feature based on its correlation with the target variable and its correlation with other features. The merit score is calculated using highly correlated features subset with respect to the target variable but with low redundancy compared to each other. The CFS algorithm can be summarized in the steps below:

Algorithm: Correlation based Feature Selection1. Determine the correlation coefficient between every attribute and the intended variable.2. Determine the correlation betweenevery feature pair.3. Choose the subset of characteristics that exhibits a strong correlation with the intended variable.4. Calculate the merit score for each feature of a subset using equation 3.2 that considers thecorrelation of features with the target variable and its redundancy with other features.5. Determine the final feature set by ranking the features based on their merit scores, choosing the top k features.

The merit score for feature i can be computedusing the formula given in Eq. [2].

Merit(i) = (k * Corr(i, C)) / sqrt((k + n) * Var(i)) (2)

where:
- k is the total number of features that have been chosen (not including feature i).
-n is the total number of features
-Corr(i, C) is the correlation amongeach feature i and the target variable C
- Var(i) is the variance of feature i

The merit score measures the relevance of a feature i to the target variable C, and its redundancy with other selected features. A higher merit score indicates a feature is more relevant and that is less redundant with other features. The CFS algorithm selects the top-k features with the highest merit scores and uses them as the final feature set for analysis. The features sequence, std_dev, N_IN_Conn_P_SrcIP, min, state_number, mean, N_IN_Conn_P_DstIP, d_rate,s_rate, max and attack are selected using this algorithm. These features are given as the input the CNN model. The attribute attack is fixed as the target feature.

4.4 Classification Model Using Convolutional Neural Network

The Bot-IoT dataset is used to construct and generate the CNN model for attack detection. The activation function of LeakyRelu, as presented in Equation [3], is employed to address the issues arising from dormant neurons. Moreover, the sigmoid activation function in Eq. [4] is used to stop output value jumps.

$$f(x) = \max(0.01 * x, x) \quad (3)$$

$$f(x) = \frac{1}{(1+e^{-x})} \quad (4)$$

There are ten 1D convolutional (conv1d) layers in the suggested model. Two conv1d layers (number of filters = 16, kernel size = 2) and a max pooling layer (pool size = 1) are present in the first iteration. Two conv1d layers (number of filters = 32, kernel size = 2) and a max pooling layer (pool size = 1) are present in the second repeat. The third iteration features a max pooling (pool size = 1) and two conv1d layers (number of filters = 64, kernel size = 2). The fourth iteration features a max pooling with a pool size of one and two conv1d layers with a total of 128 filters and 2 kernels. Additionally, the last repeat has a max pooling (pool size = 1) and two conv1d layers (number of filters = 256, kernel size = 2). A dropout layer (rate = 0.2) exists in the first dense layer (the total number of nodes = 128) and a dropout layer (rate = 0.2) exists in the second dense layer (the total number of nodes = 64). There are 32 nodes in total and a dropout layer (rate=0.2) in the final dense layer. LeakyReLU or Sigmoid activation functions, respectively, come after the layers.

Finally, Adam's optimizer is used to optimize the network. The Adams optimizer is an algorithm employed in machine learning to optimize the performance of Deep Neural Networks (DNN). It is a variant of the optimization technique known as Stochastic Gradient Descent (SGD) algorithm, and it combineselements of both momentum-based methods andRMSProp.

5. EXPERIMENTAL RESULTS AND DISCUSSION

Once the model is trained, the learning rate is changed to achieve the highest accuracy and least amount of loss. 84.39% of accuracy is obtained when the learning rate is 0.001. The accuracy improved to 91.38% for the learning rate 0.006 and the maximum accuracy of 92.65% and the loss of 0.00035 is obtained for the learning rate 0.003 at epoch 9. Figure 2 and 3 represents the accuracy and loss obtained at each epochs respectively for the proposed classification model.

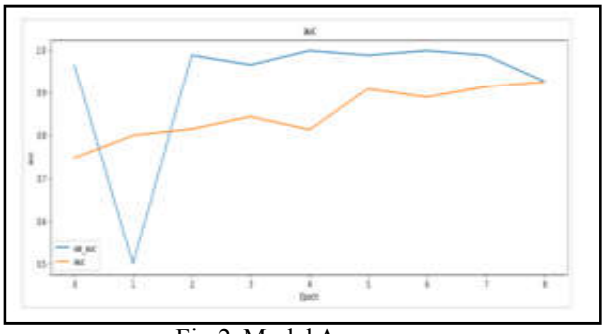

Fig.2 Model Accuracy

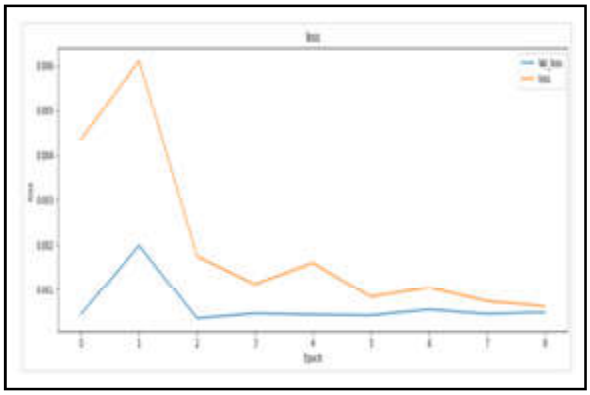

Fig.3 Loss for the model

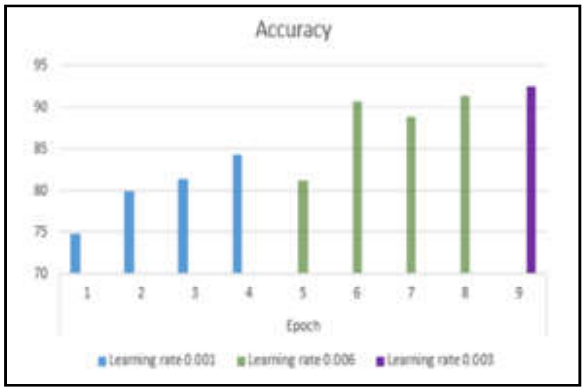

Fig.4 Accuracy for different learning rates

Plotted between TPR and FPR is the Receiver Operating Characteristics Curve (ROC curve). The ROC curve for the classification model mentioned above is shown in Figure 5.

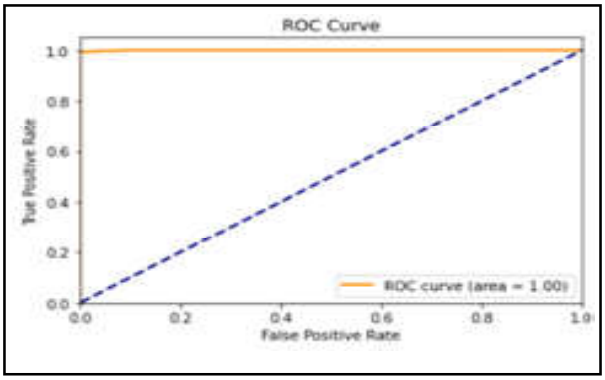

Fig..5 ROC curve for the classification model

5.1 Performance Analysis

Table 4 displays the confusion matrix that was derived for the suggested CNN model. Figure 6 presents the results of the evaluation of the metrics using the developed model. The accuracy of the suggested model was 92.65%.

Table 4 Confusion Matrix Evaluation

Actual class	Predicted class	
	Normal	Attack
Normal	92.54	7.46
Attack	7.24	92.76

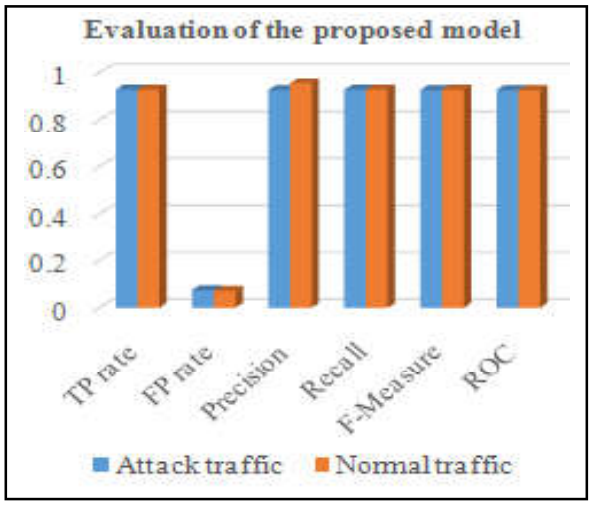

Fig.6 Evaluation of proposed Attack Detection model

Figure 7 shows the detection performance of the class of attacks including Reconnaissance (95.6%), DoS (96.7%), DDoS (84.7%), Information theft (96.8%) and Normal (92.7%) for the dataset used.

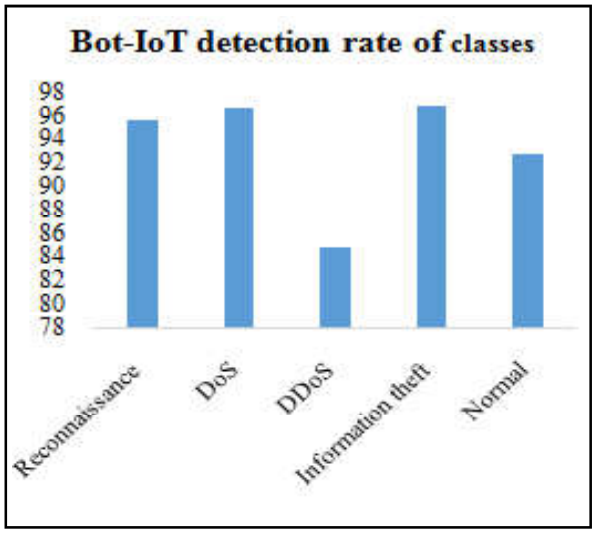

Fig.7 Detection rate of Bot-IoT

6. CONCLUSION

IoT enabled systems are facing severe threat in security related issues during data transmission over a network. Detection and deterrence of IoT attacks over a network is a must and a necessary concern. Here, the attacks are detected in BoT-IoT dataset using CNN model. Preprocessed data are used, and the suitable

characteristics are chosen based on its correlation with other features. The features are then scaled and trained using the recommended model where the LeakyRelu and sigmoid activation functions are usedThe trained model identified both normal and attack transmission with a 92.6 percent accuracy rate. To increase the classification accuracy, a hybrid model will be suggested and the feature selection model will be modified in the future.

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DESIGN AND FABRICATION OF SMART GEARBOX

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Abstract

In the present day, the machines we are using are based on the mechanical gearbox. If two gears are required separate and individual gear boxes are kept. It consumes lots of space and a connection between two gears has to be established. Our project mainly consists of using or connecting two gears into a single gear box which reduces space cost and resources. In the first stage, Power is given to the bevel pinion which acts as the input gear. The input shaft rotates it meshes with the bevel gear as it is mounted on the intermediate shaft1, the shaft rotates with reduced speed. In the second stage, as per spur pinion is mounted on the same intermediate shaft 1, it also rotates at the same speed as the bevel gear. Spur pinion meshes with spur gear as it is mounted on the intermediate shaft 2. At this stage, two shafts are parallel to each other. In this third Stage As the worm (2Start) is cut on intermediate shaft 2 it rotates at the same speed as the spur gear. As the worm meshes with the worm wheel, the wheel rotates. As it is mounted on the output shaft, the output shaft also rotates with speed. At the final stage, we can get the total velocity ratio. At this stage, the two shafts are non-intersecting, non-parallel but at 900 to each other. The gears are combined to form a single mechanism. Input is given to the gear and the shafts give output.

Keywords: *Gearbox, Shafts, Reduced Space/Cost, Non-intersecting/Non-parallel, Single Mechanism*

I. INTRODUCTION

The objective of this work is to minimize the maintenance and cost of an industrial machine that uses different types of gearboxes for packaging purposes. Gearbox plays an important role in the system of power transmission. The packaging machine mainly depends on gearboxes to get different outputs. It uses three gearboxes to get different outputs in multiple directions. We intend to reduce the cost and maintenance of the packaging machine by designing a gearbox that can easily switch between outputs, both in terms of power and direction.In implementing the design, the same gearbox can be used instead of three by simply switching the output or direction in an automated way. So, this project includes designing of required gears and shafts and fabrication of the gearbox which could effectively replace multiple gearboxes in the package machine. This will effectively reduce the cost of gearboxes, space, and maintenance required.

2. LITERATURE REVIEW

According to the method of [1] Characteristics study of the gears by way of the CAD/CAE, Apparatuses square measure the chief fundamental transmission part in machines. The quick improvement of the machines in exchange needs a shorter season of the investigation technique. In antiquated, the riggings square measure broke down by fixing the total scientific model as a matter of first importance, considering the profile of the shaper and arranging frameworks connection between the machine and in this manner the shaper. it is a frightfully progressed and long technique. As of late, the CAD/CAE code is all around created and accommodating at spans the mechanical style. all through this paper, the Autodesk Inventor® code is acquainted with modeling the circular apparatuses as a matter of first importance, at that point the models can likewise be moved into the ANSYS worktable for the limited segment examination. The arranged strategy throughout this paper is useful to the specialists to rush up the dissecting technique for gears at stretches the look stage.

A Method for Thermal Analysis of Spiral Bevel Gears, A demonstrating approach for breaking down the three-dimensional warm conduct of winding angle gears has been created[2]. The model surfaces zone unit was created through the use of differential unadulterated science to the

delivering technique for face-milled winding incline gears. The tooth contact examination gives the guideline arches and directions of the two surfaces. This information is then utilized straightforwardly among the Hertz in an examination to chase out the contact size and most weight. Warmth age all through cross-section is resolved as a work of the applied burden, elusive rate, and consistent erosion. A 3 nonlinear limited segment program was utilized to direct the warmth move investigation. This program passable the time-and position-differing limit conditions, saw operational, as applied to a one-tooth model. A model and scientific outcomes' region unit are given.

Static Analysis of Spur Gear Using Finite Element Analysis[3]. In this method, Rigging is during a ll|one amongst|one in each of"> one amongst the chief basic part in a mechanical force transmission , and most modern pivoting apparatus. A couple of prod wheel teeth in real life is generally exposed to 2 kinds of cyclic anxieties: bowing burdens actuating bowing weariness and connect with pressure causing contact weakness. Both such burdens probably won't accomplish their most extreme qualities at an identical purpose of contact weariness. Such disappointments are frequently limited via cautious examination of the issue during the arranging stage and making legitimate tooth surface profile with appropriate assembling techniques. During this paper, twisting pressure investigation will be performed, while attempting to style spike rigging to oppose bowing disappointment of the teeth, since it influences transmission blunder. To start with, the limited component models and arrangement techniques required for the exact figuring of twisting burdens will be resolved.

In Finite Element Analysis of Spur Gear Set[4] . In this method, A Finite Element technique has been created during this work to work out the heap circulation factor, Km, of the AGMA equation for a gathering of prod wheel. From the outset, a prod wheel with flawless involute is demonstrated utilizing a 3- D CAD programming. The model is them is amassed with shafts are having 1, 2, and three degree misalignments. The produced 3-D models were progressively imported to ANSYS workbench to figure the most extreme bowing and connect with stresses utilizing limited component strategy. The outcomes 4 produced were then contrasted and the most extreme bowing pressure results acquired for equal shafts to evaluate the Load Distribution Factor Km. This examination brought about Km estimations of 1.03,1.11, and 1.14.

3. COMPONENT DESCRIPTION

3.1 Gearbox

The primary definition of the gearbox is that it is a contained tools train, or a mechanical unit or element consisting of a series of built-in gears inside a housing. In the most sense, a gearbox capacities like any arrangement of apparatus. It modifies force and speed between a driving gadget like an engine and a heap. The rigging inside an apparatus box can be various kinds from slope riggings and winding apparatuses to worm riggings and other, for example, planetary apparatuses. The apparatuses are mounted on shafts, which are upheld by and pivot through moving component orientation. The gearbox is a mechanical technique for moving vitality from one gadget to another and is utilized to build force while lessening speed.

Gearboxes are used in numerous applications including machine apparatuses, modern hardware, transports, and any pivot power transmission application that necessitates changes to force and speed prerequisite. The gearbox is normally a completely coordinated mechanical segment comprising of a progression of mating gears contained during a lodging with shafts and bearings (to help and resolve loads) and much of the time a rib for engine mounting.

Most of the motion industry makes no differentiation between the phrases gear head and gearbox. But in a few the period gearbox particularly refers to housed gearing as described above while the more widespread period tools head alludes to assemblies otherwise open gearing that installs within some present computing device frame. The last mentioned is focused on to compact or battery-powered mobile designs requiring particularly tight integration and exclusion of additional subcomponents. Here, a grouping of parallel plates may direct the instruments teach shafts (their bearing), and permit blasting to a engine confront.

3.1.1 Clutch Shaft

The clutch shaft of the driving shaft might be a motor to additionally gracefully to different shafts. The driving shaft is associated with using a grip and when the grasp is locked in, the driving shaft likewise turns. The grasp shaft has only one rigging fixed subsequently and it pivots with some speed as a motor driving rod. Likewise, the driving shaft and fundamental shaft are inside a similar line.

3.1.2 Main Shaft

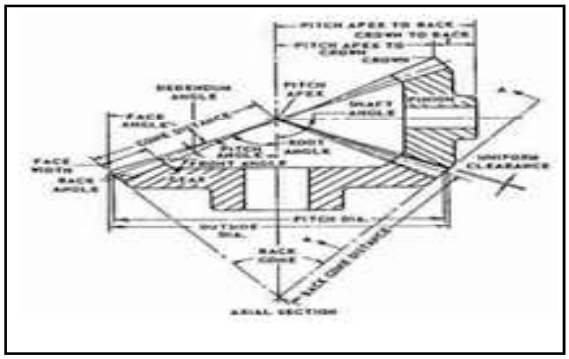
The basic shaft of the yield shaft is which turns at a kind speed and presents the necessary force to the vehicle. The yield shaft is a supported shaft with the goal that apparatuses or synchronizers might need to be moved to interface or withdraw. The fair hardware is the situation wherein no instruments on the yield shaft are locked in with the countershaft. The yield stop is connected to the differential of the vehicle utilizing a twofold hooke's joint.

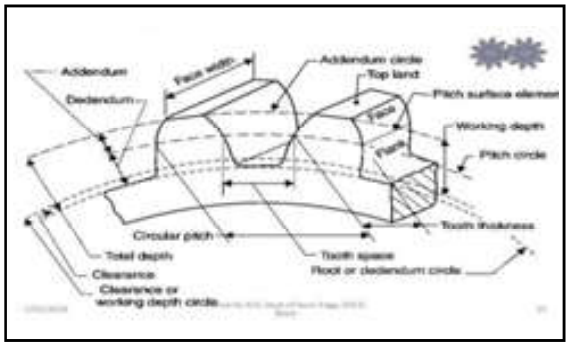
3.1.3 Bearings

Bearings are set up on each end of every shaft. They serve two purposes supply guide and reduce frictional losses, so that most electricity can be delivered.

3.1.4 Gears

Gears are utilized to send power starting with one shaft and then onto the next. The amount of force sent with the guide of apparatuses depends on the scope of teeth and the size of the rigging. The higher the rigging proportion, the higher the force/increasing speed and the lesser the speed. All the riggings are consistent on their shafts barring the ones on the first shaft. They can slide into both of the headings close by the pole. On the off chance that the proportion is expanded than 1, the vehicle will have a high quickening and if the proportion is expanded than 1, it will go at over the top speed.





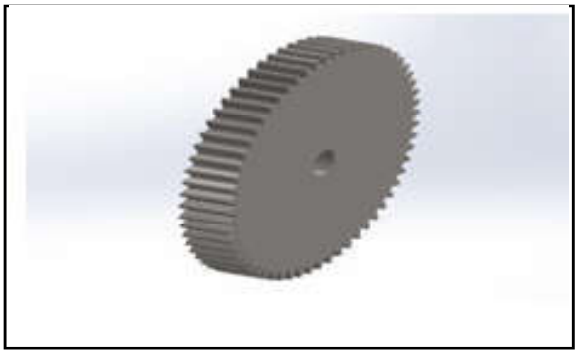


Fig.1 Spur Gear Fig .2 Spur Gear Nomenclature

3.2 Spur Gear

Spur Gear or straight decrease gears are the most straightforward kind of apparatus. They comprise a tube-shaped plate with tooth anticipating radially. Even though the finish is not straight-sided (however by and large of exceptional structure to increase a consistent power proportion, often involute yet more uncommon cycloid), the region of each polish is straight and adjusted corresponding to the pivot of turn. These instruments work together viably just whenever outfitted to resemble shafts.

3.3 Bevel Gear

Angle hardware is molded like a rectangular cone with a limit of its tip cut off. while two slant gears work, their fanciful vertices should involve the equivalent point. Their pole tomahawks furthermore meet at this factor, shaping a discretionary non-right away mentality among the poles. The edge between the poles can be anything except zero or one hundred eighty degrees. Angle gears with indistinguishable numbers of tooth and shaft tomahawks at 90 territories are called miter hardware.

Bevel gears are ordered in various sorts concerning math. Straight-angle gears have cone-shaped pitch floor and teeth are straight and tightening nearer to the zenith. Winding incline gears have bended teeth at a viewpoint allowing teeth contact to be progressive and clean. Hypoid gears have been widely used in vehicle back axles.

Fig.3 Bevel Gear

3.4 Worm and Worm Wheel

Worms take after screws. A PC infection coincides with a PC infection wheel, which appears to be a lot like a prod instrument. Trojan pony and malevolent program hardware sets are the simple and minimal way to increase a high force, low-speed gear proportion. for instance, helical apparatuses are regularly confined to devices proportion of under 10:1 while Trojan pony and rigging units change from 10: to 500:1. A downside is the potential for good estimated sliding movement, prompting low proficiency.

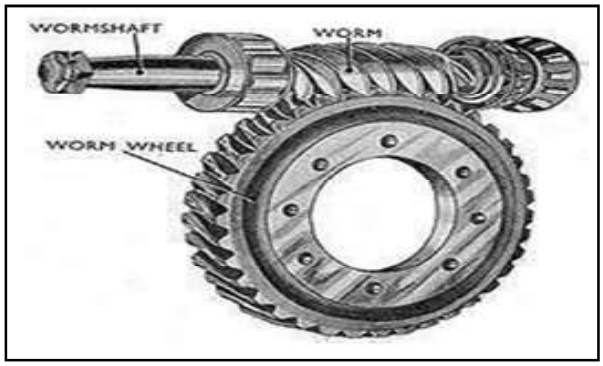


Fig.4 Worm Gear

The primary benefit of Trojan horse gears is their ability to provide excessive reduction ratios and correspondingly excessive torque multiplication. They also can be used as velocity reducers in low to medium-speed packages. because their reduction ratio is primarily based on the range of gear enamel on my own, they are more compact than other styles of gear.

3.5 Shaft

Shaft structure is the basic detail of machines. They are the detail that helps to turn components like riggings and pulley and it flips are themselves upheld by methods for bearing resting inside the inflexible contraption lodging. The poles complete the capacity of communicating power from one turning part to some other upheld by methods for it or connected to it. Subsequently, they're exposed to force because of solidarity transmission and twisting second because of responses at the benefactors which can be bolstered by methods for them. Shafts are to be noticeable from axles which furthermore help pivot donors anyway do now not communicate vitality.

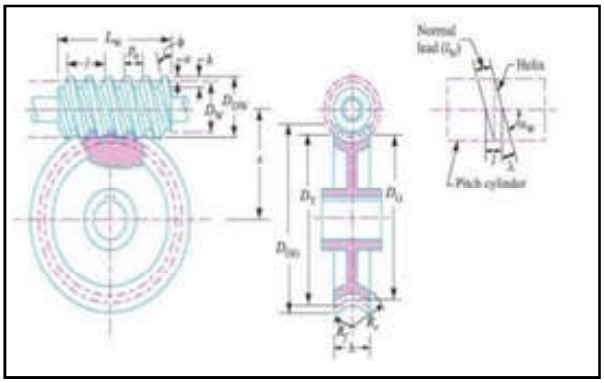


Fig.6 Worm Gear Nomenclature

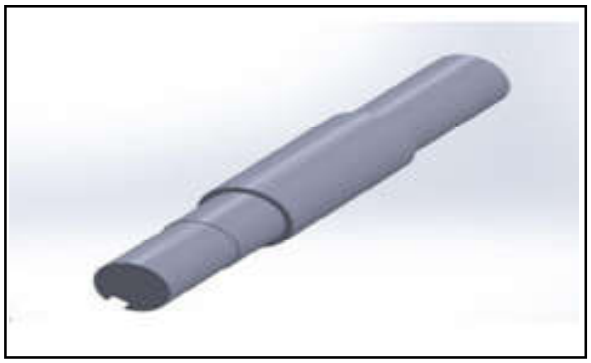


Fig.7 Shaft

Shafts are typically made to adjust move fragments and might be strong or whole. The poles are sorted in a split second, turned, bendy, or enunciated. Straightforwardly shaft is generally basic to be utilized vitality transmission. Such shafts are ordinarily structured as ventured barrel-shaped bars, That is they've differing breadth along their length, even though steady measurement shafts would be smooth to grace. The ventured shafts compare to the greatness of stress which varies along the period. in addition, the uniform measurement shafts aren't good with meeting, dismantling, and upkeep such shafts could entangle the affixing of the segments appropriate for them, specifically the bearing, that have obliged against sliding in the pivotal course. while deciding the state of the ventured shaft it is borne as a main priority that the measurement of each move fragment should be with the end goal that each part prepared legitimately to the pole has advantageous get section to its seat.

3.6 Bearing Adaptors and Caps

A bearing is a mechanical element that limits relative motion to only desired motion and at an equivalent time it reduces the frictional restriction to the specified motion. counting on the planning of the bearing, it's going to allow free rotation around a hard and fast axis (such as the case of shafts) free linear moment, or both in the same cases.

Fig.8 Bearing Adaptors

Bearings could also be classified as consistent with the sort of operation, the motion allowed, or the direction of the load applied to the parts. An input bearing adaptor is employed for holding two input bearings. All bearing caps and stoppers are wont to close the bearing seating bores in housing and also act as a stopper for needle bearing outer race. so that they prevent sliding movement of the bearing. In adaptor mounting, a tapered bore bearing is mounted onto a cylindrical shaft through the utilization of a tapered adapter sleeve. Adapter sleeves are the foremost commonly used components for locating bearings with a tapered bore onto cylindrical seats as they will be used on plain shafts or stepped shafts. an impact cap may be a rigid, semi-circular part that matches around one-half an impact and secures it. Oil the new lower bearing and install it within the bearing cap.

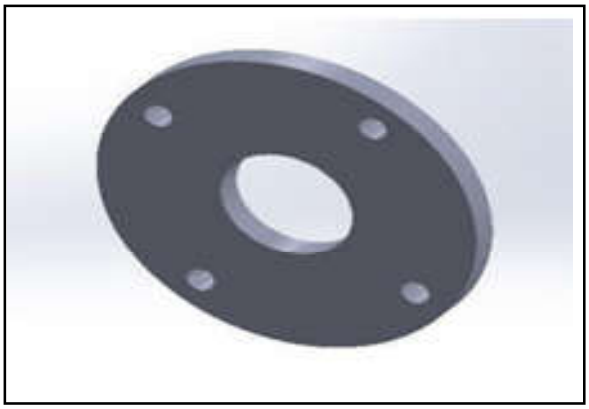


Fig.9 Bearing Cap

3.7 Spacers

A spacer is utilized to build the space between the segments being attached. Spacers are now and again a length of cylinder through which latch are embedded, a brief spacer may likewise therefore take after a thick clothes washer. Washers are every so often utilized as little spacers. Spacers are much the same as deadlocks, anyway, stalemates incorporate a strung shaft or opening, allowing them to be outfitted without a further clasp. These definitions aren't in every case carefully completed and it's miles conceivable to find strung deadlocks alluded to as spacers in bunches of lists.

Fig.10 Spacers

Most extreme spacers have an leeway empty through which a jolt is embedded. This implies the spacers do not connect with the strings of the jolt. Since the spacer can't be straightforwardly fixed, a circular external profile is greatest, not uncommon. Some spacers have a hexagonal profile joined with a straightforward opening. Those are ordinarily built from an incredibly smooth material comprehensive of nylon or metal. They might be utilized inside the equivalent transformed into a traditional spacer anyway the additional adaptability that they might be strung onto a stud or self-tapping screw utilizing the outside lofts in their hexagonal profile to utilize force. This sort of spacer can, therefore productively become a deadlock.

3.8 Circlips

A Circlip is a sort of fastener together with a semi-bendy ring with ends open. It prohibits lateral motion between the exceptional components of a machine however allows rotary movement.The phrase circlip is a portmanteau (combination of two words) of circle and clip. Circlip is also called C-slip, snap clip, Seeger ring, or Jesus ring. Circlips can be broadly divided into two most important kinds, internal circlip, and external circlip. The internal circlip is mostly utilized for bores and the external circlip is utilized for shafts

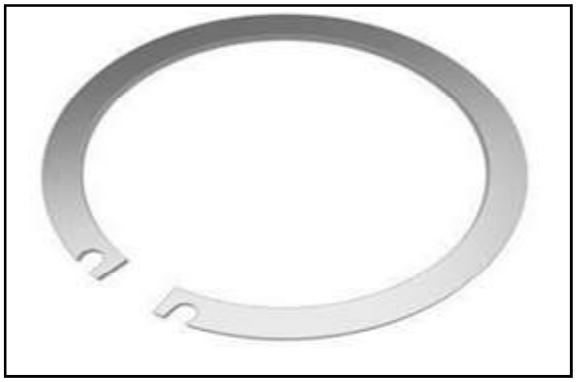


Fig.11 Circlip

3.9 Keys

A key is a system segment arranged in a center point bearing into the mating part, alongside pulleys, and gears. The basic limit of the ways to save you is the relative rotation between the post and mating part. At the breaking point of the undertakings, the helper segment of the keys is to prevent the relative rotation between the shaft and mating part. In a huge segment of the application, the discretionary quality of the keys is to save you relative exercises in the center course of the shaft.

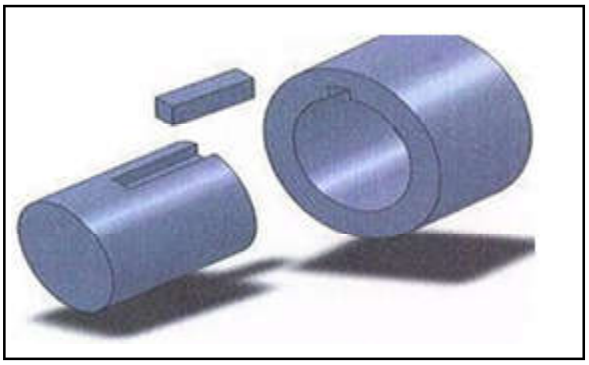


Fig.12 Key Setting

The cutting of the significant thing approaches diminishes the quality and worry of the pole. On occasion, setscrews are utilized to situate the key solidly inside the key path and to forestall the pivotal development of the segments. Keys are named square key, rectangular key, Flat key, Tapered key, Saddle key, Woodruff key, and Tangent key.

3.10 Bolts And Nuts

Screw mechanical hook is normally used with a nut for interfacing two or extra parts. A slung joint may be destroyed and reassembled; considering this clasp or screw catch is used to an extra degree some other sort of mechanical lock and feature had a vital effect on the progression of mass-made articles and metallic structures. The clasp joins a head and a barrel-molded body with screw strings near a piece of its length. The nut is the woman individual from the pair, having internal strings to fit those of the clasp.

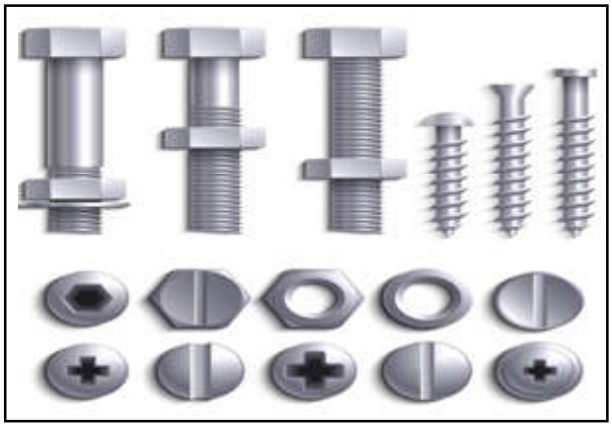


Fig.13 Nuts and Bolts

4. METHODOLOGY

4.1 Existing Methodology

Per the writing assessment in traditional, the apparatuses are broken down with the guide of setting up the total numerical form for one thing, considering the shaper profile and organizing frameworks pursuing between the framework and the shaper. it's miles a truly entangled and time-consuming process. The CAD/CAE programming is exceptional and valuable inside the mechanical format. Autodesk Inventor programming is added to variant the circular apparatuses leading and afterward the models can be moved into ANSYS Workbench for the limited component examination.

4.2 Proposed Methodology

4.2.1 First Stage (Input)

Power is given to the bevel pinion (20T) which acts as the input gear. The input shaft rotates it meshes with the bevel gear (40T). As it is mounted on the intermediate shaft1, the shaft rotates with reduced speed so we can get a velocity ratio of 2:1 this stage two shaft axes intersect at 90^0.

4.2.2 Second Stage (Intermediate)

As per spur pinion (20T) mounted on the same intermediate shaft 1, it also rotates at the same speed as bevel gear. Spur pinion meshes with spur gear (60T) as it is mounted on the intermediate shaft 2, the shaft also rotates with a speed ratio of 3:1. So we can get a total

velocity ratio is 6:1 in this stage. At this stage, two shafts are parallel to each other.

4.3. Third Stage (Output)

As worm (2Start) is cut on intermediate shaft 2 it rotates at the same speed as spur gear. As the worm meshes with the worm wheel (40T), the wheel rotates. As it is mounted on the output shaft, the output shaft also rotates with a speed ratio of 40:1. At the final stage we can get a total velocity ratio of 240:1. At this stage two shafts are non-intersecting, non-parallel but at 90^0 to each other.

5. CALCULATION

5.1 Spur Gear Calculation

Material: Hylam
Gear Ratio: 3:1
No. of Teeth: Pinion: 20T Gear: 60T
Module: 3mm Pressure Angle: 20°
Centre Distance: 100mm

Table 1 Calculations of Standard Spur Gear

ITEM	SYMBOL	FORMULA	EXAMPLE	
			Pinion	Gear
Module	m	Set value	3	
Reference Pressure angle	α		20 deg	
Number of teeth	z		12	24
Centre distance	a	$Z_1 + Z_2\, m\, 2$	54.000	
Reference diameter	d	Zm	36.000	72.000
Base diameter	d_b	$d \cos \alpha$	33.829	67.685
Addendum	h_a	$1.00m$	3.000	3.000
Tooth depth	h	$2.25m$	6.750	6.750
Tip diameter	d_a	$d + 2m$	42.000	78.000
Root diameter	d_f	$d - 2.5m$	28.500	64.500

5.2 Bevel Gear Calculation

Material: Hylam
Gear Ratio: 2:1
Shaft angle: 90 degree
No.of Teeth:
Pinion: 20T
Gear: 40T
Module: 2.5mm
Addendum :
Pinion: 3.4mm
Gear: 1.6mm
Dedendum :
Pinion: 2mm
Gear: 3.8mm

Table 2 Straight Bevel Gear Calculation

No.	Specifications	Symbol	Unit	Formula	Straight Bevel Gear	
					Pinion	Gear
1	Shaft angle	Σ	Degree	Set Value	90°	
2	Module	m_n	mm		2	
3	Pressure angle	α	Degree		20°	
4	No. of teeth	z	—		20	40
5	Spiral angle	β	Degree		0°	
6	Facewidth	b	mm		15	
7	Input torque	T_1	N·m		1.6646	—
8	Reference diameter	d	mm	zm	40	80
9	Reference cone angle	$\delta_1 \cdot \delta_2$	degree	$\tan^{-1}\left(\frac{z_1}{z_2}\right)$ $\Sigma - \delta_1$	26.56505	63.43495
10	Center reference diameter	d_m	mm	$d - b \sin \delta$	33.292	66.584
11	Tangential force	F_t	N	$\frac{2000T}{d_m}$	100.0	
12	Axial force	F_x		$F_t \tan \alpha \sin \delta$	16.3	32.6
13	Radial force	F_r		$F_t \tan \alpha \cos \delta$	32.6	16.3
14	Output torque	T_2	N·m	$\frac{F_t d_{m2}}{2000}$	—	3.329

5.3 Worm and Worm Gear Calculation

5.3.1 Worm

Material: Hylam Gear ratio: 40:1
No of Teeth: Pinion: single start
Gear: 40T Module: 3mm Centre Distance: 76.2mm(standard) Diameter Factor: 10.8mm

5.3.2 Worm Wheel

Module: 3mm Pitch Diameter: 120mm
Tip Diameter: 126mm Root Diameter: 21mm
Addendum: 3mm

Table 3 Calculation of Worm and Worm Wheel

Item	Symbol	Formula	Example	
			Worm	Wheel
Axial Module	m_x		3	
Pressure Angle	α_n		20°	
No. of Threads, No. of Teeth	Z_w, Z_t		∀	30 R
Standard Pitch Diameter	d_1, d_2	$Z_1 * m, Z_2 * m$	44.000	90.000
Lead Angle	γ	$\tan^{-1}\frac{m_x z_w}{d_1}$	7.765°	
Centre Distance	a_x	$\frac{d_1 + d_2}{2} + X_{a_2} m_x$	67.000	
Coefficient of Profile Shaft	X_{a2}			0
Addendum	h_{a1}, h_{a2}	$1.00m_x$, $1.00 + X_{a2} m_x$	3.000	3.000
Whole Depth	h	$2.25m_x$	6.750	
Outside Diameter	d_{a1}, d_{a2}	$d_1 + 2h_{a_1}$, $d_2 + 2h_{a2} + m_x$	50.000	99.000
Throat Diameter	d_{th}	$d_2 + 2h_{a2}$	–	96.000
Throat surface Radius	n	$\frac{d_1}{2} - h_{a1}$	–	19.000
Root Diameter	d_{f1}, d_{f2}	$d_{a1} - 2h_x$, $d_{a2} - 2h$	36.500	82.500

6.CONCLUSION

The problem statement is to design a gearbox that eliminates the use of multiple gearboxes. The fabricated gearbox is customized based on the speed requirements in the required directions. Using a bevel gear, spur gear, and worm wheel satisfies almost all the requirements. It can provide output at different stages. For example, we can get output at the spur gear and worm wheel as well. Also, it can be possible to get output parallelly as well as in a perpendicular direction.

The current implementation of this gearbox is recognized as effectively reducing the maintenance of the packaging machine. It can also be customized for any speed. Another customization we have proposed is to provide switches to operate at the required speed at any output stage in an automated way.

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[2] S.A.Austin, "The Vibration Damping Effect of an Electro-Rheological Fluid", ASME Journal of Vibration and Acoustics, Vol.115, No.1, 1993, pp. 136-140.

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