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Pest Detection in Crop using Video and Image Processing

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Abstract: Detection of pests of various species is one of the compelling tasks in pest management involving detection and classification which is much more difficult than common object detection because of the apparent differences among pest species. Early diagnosis of pest is more essential to enhance the production of healthy crops as well as to diminish the economic loss. However, one major challenge is the difficulty in determining the physical, chemical, and biological changes in plants during the asymptomatic stages of an infection. To overcome these challenge, a huge count of traditional techniques were formulated. Many algorithms were introduced to detect the pests from leaves. Such techniques are not efficient for all the types of pest. To overcome the above said problem, this paper deals with pest detection, identification using segmentation and classification algorithms.
Keywords: Image processing, segmentation, SVM, mean square error, Convolutional Neural Network.

I. INTRODUCTION

In our country India larger portion of the population depends on agriculture. Sizeable agricultural yield is lost every year, due to rapid infestation by pests. Research in agriculture is envisioned towards increase of production and food potentials at reduced spending in turn increase the profit. Right away many countries looking for non-chemical control methods for pest's control or leaf infections. Minimal use in pesticides is anticipated in pest control to cope with various problems affected by over-use of pesticides: affecting the pH of soil, polluting water bodies and harming necessary worms that help in the betterment of crop yield which results very harmful to the crops, soil, air, water resources, humans and the animals. Hence, with these parameters in mind, it is necessary to use the chemicals in adequate amount. With the help of our technology, a farmer can easily monitor the area after initial plantation and irrigation to check which area of their lands is being affected by disease, pests and weeds [21].

If we can detect pest at early stage we can spray organic pest control products which are environmental friendly in the place of pesticides. This can be accomplished by regularly observing the plant field by obtaining images or video using a digital camera. Several methods based on image processing have come to light to address this issue. Most of the algorithms focused on pest identification and detection, limited to a greenhouse environment. This is the major source of income to the nation. Recognition of pest at early stage diminishes the use of pesticides [11] [16]. Agriculture is the backbone of Indian economy because most of the parts of the India are related from village and villagers directly depend upon the farming. Approx 75% of Indian population depend on farming. India also ranks 2nd position among most essential producer of fruits and vegetables [22] [8]. Pest monitoring is a crucial component in pheromone-based pest control. In widely used trap-based pest monitoring, captured digital images are analyzed by human experts for recognizing and counting pests. Manual counting is labor intensive, slow, expensive, and sometimes error-prone, which precludes reaching real-time performance and cost targets. Our goal is to apply state-of-the-art deep learning techniques to pest detection and counting, effectively removing the human from the loop to achieve a completely automated, real-time pest monitoring system [1] [4] [7]. However, the cultivation of crops for optimum yield and quality produce is highly essential. A lot of research has been done on greenhouse agro systems and more generally on protected crops to control pests and diseases by biological means instead of pesticides. Research in agriculture is aimed towards increase of productivity and food quality at reduced expenditure and with increased profit, which has received importance in recent time. In this paper, the foreground and background helps to detect the changes in image sequences by taking difference between the current frame and the reference frame. Subsequently, object tracking is performed by deploying the moving average algorithm. A moving average algorithm is a time series constructed by taking averages of several sequential values of another time series. Further, to facilitate more efficient real-time object tracking in video, the segmentation process will be accomplished using Segmentation algorithm. Consequently, from the segmented frames the most relevant features corresponding to edges, color and textures will be extracted.

II. RELATED WORK

A strong demand now exists in many countries for non-chemical control methods for pests or diseases. In fact, in production conditions, greenhouse staff periodically observes plants and search for pests. This manual method is very time consuming. With the recent advancement in image processing techniques, it is possible to develop an autonomous system for disease classification of crops. The only way to stop the effect of these pests is pesticides. But excess use of the pesticides is very harmful to the crops, soil, air, water resources and the animals which came in contact with the pesticides. Pesticide residues have also been found in rain and groundwater. The use of pesticides decreases the general biodiversity in the soil. Excess of pesticides results in reduced nitrogen fixation and thus reduced crop yields. Animals may be poisoned by pesticides.

Prabira kumar Sethy-2017 et.al, the authors presented Detection and Recognition system. SVM with Bag of Words approach were used to detect and classify the pests in the captured image by collecting five different type of pest present in Paddy crop [1].

ApurvaSriwastwa-2018 et.al, Large amounts of crops are destroyed every year due to pests. Pest detection and identification is needed to ensure good productivity in agricultural crops. Early detection of pests in images is very crucial for effective management of pest control. Therefore, identifying the pest in the image has been a challenging task. In this paper, we use colour based image segmentation method to efficiently detect the pest. The extensive simulation results on various pest images show that the proposed method to performs the existing Otsu's method and edge detection segmentation. [2].

K.Thenmozhi-2017 et.al, were applied digital image processing techniques for crop insects images to perform preprocessing, segmentation and feature extraction to detect the shape of insects in the sugarcane crop. Sobel edge detection is applied to segment the insect image against background. Shape of the insect can be recognized by nine geometric shape features like round, oval, triangle, rectangle shapes etc. by feature extraction [3].

Abhishek Dey-2016 et.al, was proposed a method for detecting white fly pest from leaf images of various plants. Image pre-processing techniques such as noise removal and contrast enhancement are used for improving the quality of image thus making it suitable for further processing. Then, k-means clustering method is used for segmenting pest from infected leaves, texture features are extracted from those segmented images by statistical feature extraction methods. Various classifiers like Support Vector machine, Artificial Neural Network, Bayesian classifier, Binary decision tree classifier and k-Nearest neighbor classifier are used to distinguish between healthy leaf images from white fly pest infected leaf images [4].

Mostafa Bayat-2016 et.al, have proposed four methods for the diagnosis and classification of the diseases of corn leaf using image processing and machine vision techniques. In the first method, the affected parts were separated from the healthy parts using the histogram adjustment; subsequently, a two-layer Perceptron Neural Network was used to categorize the final results and diagnose the disease type. The results indicate that Neural Network with an average of 65.15% is able to correctly diagnose the disease of the corn leaf. In the second method, different types of Laplacian filters, Canny and Sobel were applied on the leaves; after the separation of the affected parts, the classification and diagnosis phase were implemented. The results revealed that the algorithm with the accuracy of 67.94%, can correctly diagnose the disease. In the third method, using the analysis method of principal components, data dimension was reduced, and then was sent to the Support Vector Machine classifier for the diagnosis of the disease. This algorithm is able to correctly diagnose the disease with an accuracy of 75.28%. Furthermore, the algorithm is able to diagnose Class 5 and 4 diseases in a more accurate way. Finally, in the fourth method, a combination of Gabor filter and visual features was used in order to diagnose the type of disease. [5].

Pavithra N-2017 et.al, was selected saturation color model as the best suited color model. Otsu and manual thresholding were tried and the best results were obtained in manual thresholding. Noise removal is done by using erosion and dilation process [6].

Limiao Deng -2018 et.al, proposed a rapid detection and recognition of insect pests, methods inspired by human visual system were proposed in this paper. Inspired by human visual attention, Saliency Using Natural statistics model (SUN) was used to generate saliency maps and detect region of interest (ROI) in a pest image. To extract the invariant features for representing the pest appearance, we extended the bio-inspired Hierarchical Model and X (HMAX) model in the following ways. Scale Invariant Feature Transform (SIFT) was integrated into the HMAX model to increase the invariance to rotational changes. Meanwhile, Non-negative Sparse Coding (NNSC) is used to simulate the simple cell responses. Moreover, invariant texture features were extracted based on Local Configuration Pattern (LCP) algorithm. Finally, the extracted features were fed to Support Vector Machines (SVM) for recognition. Experimental results demonstrated that the proposed method had an advantage over the compared methods: HMAX, Sparse Coding and Natural Input Memory with Bayesian Likelihood Estimation (NIMBLE), and was comparable to the Deep Convolutional Network. [7][17].

M.A.Ibrahim-2018 et.al, proposed automatic pest detection method for greenhouse monitoring against pest attacks. One of the more harmful pests that threaten strawberry greenhouses is thrips (Thysanoptera). Therefore, the main objective of this study is to detect of thrips on the crop canopy images using SVM classification method. A new image processing technique was utilized to detect parasites that may be found on strawberry plants. SVM method with difference kernel function was used for classification of parasites and detection of thrips. The ratio of major diameter to minor diameter as region index as well as Hue, Saturation and Intensify as color indexes were utilized to design the SVM structure. Also, mean square error (MSE), root of mean square error (RMSE), mean absolute error (MAE) and mean percent error (MPE) were used for evaluation of the classification. Results show that using SVM method with region index and intensify as color index make the best classification with mean percent error of less than 2.25% [8].

Susumu Genma-2017 et.al, presents an image retrieval method based on local regression and global alignment (LRGA) algorithm and relevance feedback for insect identification. Based on LRGA algorithm, the proposed method enables estimation of ranking scores for image retrieval in such a way that the neighborhood structure of the database can be optimally preserved. This is the biggest contribution of this paper. Then our method measures relevance between the query image and all the images in the database and realizes retrieval of images based on the measured relevance. Furthermore, if positively labeled images obtained by a user are available, they are used as the query relevance information for the relevance feedback to improve the retrieval results. Experimental results show the effectiveness of our method [9].

Nguyen Tuan Nam-2018 et.al, proposed a method of identifying various types of trapped insect species by making prediction based on available images using Deep Convolutional Neural Network (CNN). Using a database of 200 pictures including approximately 3,000 insects of 6 kinds, the accuracy rates of detection and classification are about 84% and 86% respectively [10].

Preethi Rajan-2016 et.al, proposed an automatic pest identification system using image processing techniques. Color feature is used to train the SVM to classify the pest pixels and leaf pixels. Morphological operations are used to remove the unwanted elements in the classified image [11].

Shradha Verma-2018 et.al, presented a survey on the current techniques and prediction models, based on Image processing and the role of Internet of Things (IoT), being applied for identification, detection as well as quantification of Tomato plant diseases [12].

Muhammad Danish Gondal-2015 et.al, proposed Computer vision techniques provide effective ways for analyzing the images of leaves. Support Vector Machine (SVM) is used for classification of images with and without pests based on the image features [13].

Benlan Shen-2018 et.al, Computer vision is widely used in pest image detection and recognition. However, the images tend to be of low magnification because of the sparse deployment of cameras in the farmland. High-magnification imaging is made possible with fewer cameras for agricultural pest detection and recognition using the local zoom system. The experimental set-up is built to validate the system's basic principle and is well used for the imaging of aphids on plant leaves. The results demonstrate that the system performs well for imaging of pests at different local magnifications [14].

Shuanglu Dai-2017 et.al, proposed a convolutional Riemannian texture with differential entropic active contours to distinguish the background regions and expose pest regions. An image texture model is firstly introduced on the Riemannian manifold. A convolutional Riemannian texture structure is then explored to reduce the environmental background textures and highlight potential pest textures. Subsequently, a differential entropic active contour model is developed to estimate the foreground and background distributions. Finally, the estimated foreground and background distributions are used to distinguish pest textures and environmental textures. The final detected regions are obtained by maximizing pixel-wise posterior probabilities on the estimated distributions. Experimental results show that effective detections can be achieved by the proposed method on forestry pests imaging datasets [15].

K. Dimililer-2017 et.al, developed an intelligent insect classification system that would be capable of detecting and classifying the eight insects most commonly found in paddy fields. The developed system comprises two principal stages. In the first stage, the images of the insects are processed using different image processing techniques in order to detect their geometric shapes. The next stage is the classification phase, where a back propagation neural network is trained and then tested on processed images [16].

Karen Lucero-2018 et.al, proposed a system automatically detects two defoliating pests on potato and bean crops: Mexican Bean Beetle (MBB) and Colorado Potato Beetle (CPB) in the adult stage. The neural classifiers utilized for the beetle detection are RSC (Random Subspace Classifier) and LIRA (Limited Receptive Area). The MBB images that were employed as inputs to the classifiers were obtained on Mexican plantations. The CPB images were collected from various Internet sources. The results obtained with both classifiers on image databases. The RSC classifier demonstrates the better result for recognition, which is 89%, while LIRA presents are cognition rate of 88%. These results are good for pest detection and can be used for the diagnosis of pest locations in crops. The purpose was to contribute to the development of automatic detection applications based on images of potato and bean plantations. In Mexico and other countries, it is of great importance to solve pest problems in agriculture. Pest detection in the adult phase is of high priority because of the high rate of crop defoliation and destruction [18].

Hanyurwimfura Damien-2018 et.al, introduces a design of a prototype of an automated system that will be able to detect the presence of a fall armyworm in the field. The system will use the new technology of Internet of Things (IoT) where sensors are used to identify the pest location. Once the presence of the pest is detected in the farm, the system will be able to give the information of the affected crop and notify the farmer through his/her mobile phone who will immediately react accordingly. Through the authorization from the farmer, the system will be able to pump pesticides to kill both larvae and eggs of fall armyworm on the affected crop. This automated system will save the farmer's time, as it will monitor the crops while the farmer is occupied with other activities. Lastly the system will help to increase the production of maize in Rwanda since the crop will be safe from the pest [19].

BalajiVeeramani-2017 et.al, provided evidence to the usefulness of Deep Sort indiscriminating haploids from diploid seeds in the double haploid induction process, and to its robustness amidst variations arising from biological factors and image acquisition. We establish such robustness using thousands of seed images obtained in an industrial scenario from different genetic backgrounds. Our visualizations indicate that embryo's features are being extracted by the network, which may be used further to classify the seeds, as are carried out manually by agricultural field workers. The deeper architectures provide better classification accuracies as compared to shallower architectures. The approach used to classify corn seed images into haploid or diploid categories could be extended to other agricultural applications. A few of these include sorting seed images of crops such as soybean, canola, etc. into various categories. The combination of different deep network architectures with a variety of sensors offers enormous possibilities, and will contribute to next generation agricultural phenotyping [20].

III. PROPOSED METHODOLOGY

Pest detection and identification of pest in agricultural crops is essential to ensure good productivity. It is a major challenge in the field of agriculture; therefore effective measures should be developed to fight the infestation while minimizing the use of pesticides. The techniques of image analysis are extensively applied to agricultural science, and it provides maximum protection to crops, which can ultimately lead to better crop management and production. Monitoring of pests infestation in image processing are with still images and it relies on manpower, however automatic monitoring has been advancing in order to minimize human efforts and errors. Hence, this proposal intends to propose a new Image and Video processing based pest detection framework with five major phases, viz.

1) Acquisition of Image or Video frames.
2) Preprocessing for Image, Foreground and background estimation and Object tracking for Video frames.
3) Segmentation
4) Feature extraction and
5) Classification.

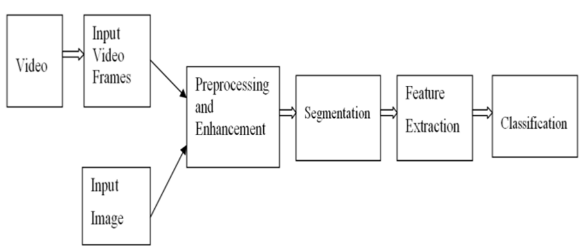

Figure 3.1: Architecture of Proposed Pest Detection Framework

A. *Image Processing*

1) *Image Acquisition:* The first step of every image processing application is image acquisition or image capturing. The images of leaves are captured by using the digital camera and it will be stored it in any of these formats like .PNG, .JPG, .JPEG etc. Next step is pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. Preprocessing involves
2) *Image Resizing:* If the input image has the resolution of [1024*1600] then the processing of the system may be slow due to the higher resolution. Hence we need to convert it to the required size. For example 255*255 by using inbuilt MATLAB functions.
3) *Image Restoration:* It is a simple process of taking the corrupted pixels of image and cleaning them. The restoration process allows the user to adjust image contrast, brightness and the other features of the image. It is not a de-noising method, but allows the user to smoothening image by using the simple method like point spread function, vainer filter and de convolution method etc.
4) *Image Enhancement:* Is used to enhance the quality of the image, resize the image to the standard size and image enhancement is perform using median filtering. Basically it improves the quality of image by adjusting contrast, brightness.

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5) *Image Segmentation:* The enhanced image is segmented based on the color bands of the l a*b*. We are using L*a*b* color model because the LAB color space is particularly useful for boosting colors and definition in images due to the way it handles colors when compared to RGB and CMYK. Rather than describing how colors should appear on a screen or in print, LAB is designed to approximate human vision. The segmentation will be achieved by using the k means and the EM clustering at multiple levels.
6) *Feature Extraction:* Based on the selected clusters various features such as Mean, Standard deviation (SD), Entropy, RMS, Variance, Smoothness, Kurtosis, Skewness, IDM, Contrast, Correlation, Energy, homogeneity are calculated by using GLMC (Gray Level Co-occurrence Matrix) which will help to find the pest and the percentage of the affected area.
7) *Classification:* SVM (Support Vector Machine) is a type of the supervised machine learning method which will examine data and identify the similar type of the patterns, which are used for the later classification. Classification is done by using SVM Based on 500 iterations. Pest will be detected and classified.
8) *Video Processing:* Initially, from the extracted moving frames of the video sequences, the background as well as the foreground information will be extracted. The foreground and background helps to detect the changes in image sequences by taking difference between the current frame and the reference frame. Subsequently, object tracking is performed by deploying the moving average algorithm. Further, to facilitate more efficient real-time object tracking in video, the segmentation process will be accomplished using Segmentation algorithm. Consequently, from the segmented frames the most relevant features corresponding to edges, color and textures will be extracted. The extracted features will be subjected for classification process to detect the pest by using Classification Algorithm**.**

The architectural demonstration of proposed pest detection framework is illustrated in Figure 1.

IV.RESULTS AND DISCUSSION

This research was conducted for 12 different types of pest with different images for each pest. Pest image whose detection and classification is to be done is loaded and enhanced by clicking on the 'ENHANCE IMAGE' button on the GUI. Similarly clustering and segmentation is done by clicking the assigned button on the GUI. Color based segmentation is performed and detection is performed using K-Means clustering algorithm and EM (expectation and maximization).L*a*b method is used for color based segmentation. The clustering output is then used to measure the quantity such as entropy, smoothness, kurtosis, RMS value, energy, correlation, entropy and the other parameters. For classification using SVM, 'Classify by SVM' button is clicked on the GUI. Pest will be detected and classified based on 500 iterations and a dialog box appears with a message 'pest found' and the name of the pest detected appears on the same GUI window. The decision making system performs more the 500 iteration to detect the pest with the help of SVM classifier. Hence using the proposed system pest can be easily detected and classification of pest is possible at the early stage with minimal effect on the agricultural field. The percentage of affected area will also be detected and displayed on GUI window.

Each Pest image is used to extract features like Mean, Standard deviation, Variance, Energy, Homogeneity, Contrast, Skewness, Root Mean Square, Kurtosis etc. for 12 different species of pests. These features are used for the classification of pests. The graph of all the features for corresponding pests can be seen in the plot below.

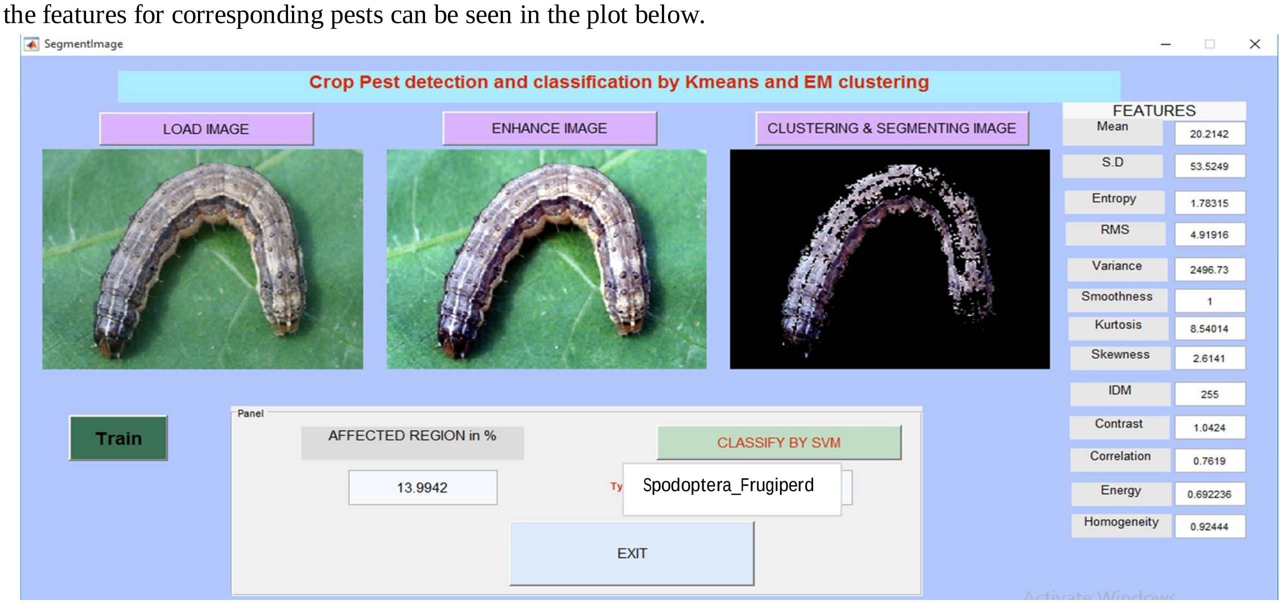
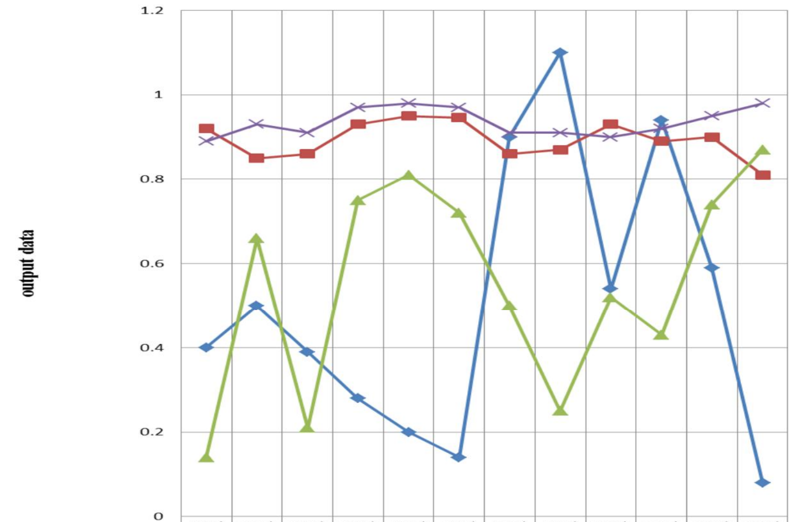
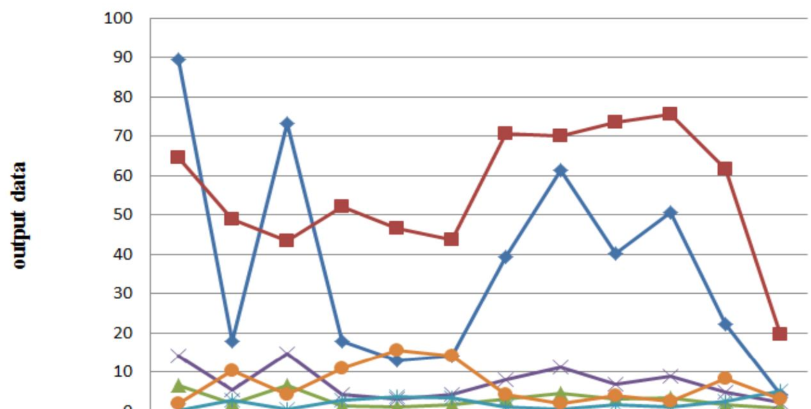


Fig 4.1: Results of crop pest detection by K-means and EM clustering



	pest 1	pest 2	pest 3	pest 4	pest 5	pest 6	pest 7	pest 8	pest 9	pest 10	pest 11	pest 12
contrast	0.4	0.5	0.39	0.28	0.2	0.14	0.9	1.1	0.54	0.94	0.59	0.08
correlation	0.92	0.85	0.86	0.93	0.95	0.946	0.86	0.87	0.93	0.89	0.9	0.81
energy	0.14	0.66	0.21	0.75	0.81	0.72	0.5	0.25	0.52	0.43	0.74	0.87
homogeneity	0.89	0.93	0.91	0.97	0.98	0.97	0.91	0.91	0.9	0.92	0.95	0.98

Fig 4.2: Plot of pest features for 12 species.



	tetranychus_urticae	romalea_guttata	cicadellidae	ostrinia_nubilalis	diabrotica_undecimpunctata	leptinotarsa_decemlineata	anasa_tristis	tenthredo_scrophulariae	spodoptera_frugiperda	armadillidium_vulgare	phyllocnistis_citrella	dermaptera
MEAN	89.61	18.02	73.21	18.05	13.175	14.21	39.37	61.53	40.13	50.8	22.37	4.37
SD	64.63	48.88	43.39	52.23	46.61	43.66	70.8	69.94	73.64	75.5	61.68	19.58
ENTROPY	6.8	1.93	6.69	1.55	1.15	1.66	3.23	4.71	3.16	3.46	1.61	0.87
RMS	14.32	5.62	14.85	4.27	3.09	4.44	8.16	11.32	6.97	8.85	5.04	2.28
SKEWNESS	0.2	2.86	0.48	2.98	3.67	3.39	1.16	0.64	1.611	1.1	2.63	5.32
KURTOSIS	1.99	10.49	4.47	10.91	15.55	14.1	4.3	2.07	4.09	2.72	8.42	3.17

Fig 4.3: Plot of pest features for 12 species.

V.CONCLUSION

The process of detection and identification of pest from an Image and Video is useful for farmers to know about pest detection and pest affecting their crop. In this research, we proposed k-means and EM clustering algorithms for detection of twelve different types of pests namely tetranychus urticae, romalea guttata, cicadellidae, strinia nubilalis diabroticaundecimpunctata leptinotarsadecemlineata, anasatristis, tenthredoscrophulariae, Spodopterafrugiperda, armadillidiumvulgare, Phyllocnistis citrella and dermaptera. Identification of the pest by feature set extraction using SVM stored in the database as the training, in which the feature values are recovered and stored in the system database. Identification of infected area of the crop can be done.

VI.FUTURE SCOPE

In the future, using same method of identification and classification can be done for various other species of pests. Identification and classification of pests from early stages of growth can also be done as an enhanced feature.

Different classification algorithms like Artificial Neural Networks, Convolutional Neural Networks, Deep Neural Networks etc. cab be implemented for further research.

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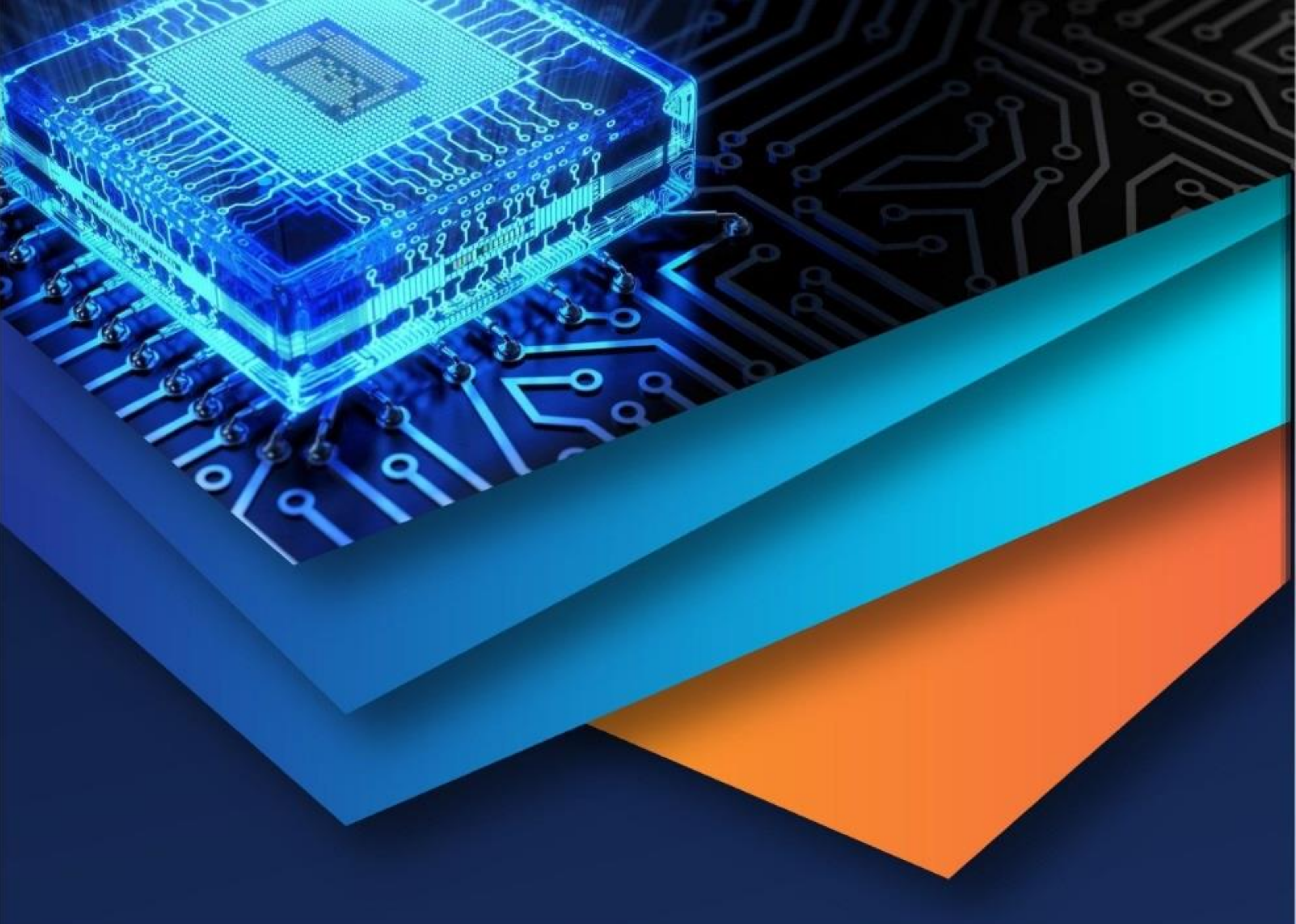

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IMPACT FACTOR:
7.129

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