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Detection, Classification and Identification of Pest in Crops Using Video Segmentation Techniques

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Abstract: Agriculture is an important component of every individual's livelihood. During farming infestation of insect pests in crops are inevitable. Manual detection and identification of type is the most challenging process. The proposed architecture will pave a way to develop an automatic detection system to do the identification of pest present in videos. Through this system, the pest infestation can easily be identified and suitable management techniques can be applied early to improve the quality of crops. The proposed architecture incorporates the following techniques for effective detection insects in crops: key frame extraction by calculating a threshold from histogram difference of consecutive frames, best frame selection by finding PSNR and MSE value of key frames, filtering, color image segmentation through K – Means clustering segmentation, feature extraction through Neural Network techniques with a pre trained network VGG19 and classification by using multi class SVM classifier. By using this proposed algorithm, this system identifies five types of pests namely, tuta absoluta, fall armyworm, leaf hopper, epilachna beetle and corn borer with accuracy of 98.46%.

Keywords— Key frame extraction, K-Means clustering Segmentation, Convolutional Neural Networks (CNN), VGG19, Support Vector Machine (SVM)

I. INTRODUCTION

Agriculture is the backbone of the Indian economy. It is the source of livelihood in all over the world. Different crops are grown in different seasons. Primary goal of a farmer is having optimum yield and quality production. However, during farming, the infestation of pest in crops is unavoidable. The infestation is always a nightmare to the farmers as it significantly reduces the quality and quantity of the agricultural products [1]. It is important to prevent and control the infestation. Different techniques and approaches have been used by farmers to manually detect the pests. These manual techniques include black light traps and sticky traps. In addition to the methods mentioned above there are other programmatic ways such as, dynamic surveys, and usage of real time monitoring systems are there for pest population management [2]. Manual examination of wide crop fields is extremely time consuming process and less efficient [3].

There are many categories of pests that can be found in farmlands. In such cases identifying each type of pest regardless of their period of growth requires availability of experts [3]. Due to rapid advancement in computer technology, it is much easier to integrate computer science with agricultural science. In this manner, image processing techniques with machine learning can be combined together with agricultural science to identify the type of pest for adopting suitable and effective pest management mechanisms.

The primary aim of this research work is to develop an automatic detection system to detect and identify the type of pest by using image and video processing techniques along with the Convolutional Neural Networks. The proposed algorithm used to model high-level abstractions in video data across multiple processing layers fed with more than 10 video images of diseased and healthy plants into the network and trained it to recognize patterns in the data. The proposed architecture involves the following four phases: Video acquisition from mobile camera and key frame selection, segmentation of region of interest, feature extraction, classification and detection. Using this system, identification of pests like tuta absoluta, fall army worm, leaf hopper, epilachna beetle and corn borer are made easier. This system gives some control measures for pest management along with the result of identification.

II. RELATED WORK

[4] Uma Rani, Amsini (2016) has stated that the primary aim of their study is to develop a software solution to detect and identify the pests such as aphids, whiteflies and thrips along with the calculation of accuracy of infected areas in leaf images. The proposed work consists of image acquisition by preparing image dataset for input image selection, pre-processing by enhancing the contrast of the image, segmentation through K –Means clustering with 3 clusters, classification and measuring the accuracy of the infected area by using multi class SVM classifier. This proposed architecture is built with the accuracy of 98.3871%.

[1] Bashish, Braik and Ahmad (2011) has conducted a comparative study in which their primary aim is to develop, implement an automation system to detect and identify the leaf diseases such as Early Scorch, cottony mold etc. They compare the accuracy and computational time of 5 classification models which are developed by them, based on the color features Hue, Saturation, and Intensity for calculating the accuracy. The proposed solution uses K-means clustering for segmentation, CCM for feature extraction, neural network based back propagation algorithm for classification. Here among the models Model M1 has shown more accuracy with less computational time by using only two color features such as Hue and Saturation for classification while model M4 which uses only intensity as color feature shows less accuracy. Overall accuracy of this system is 93%.

[2] Xia, Chen, Wang (2018) has conducted a comparative study which deals with detection and classification of insects using Convolutional Neural Network (CNN). This paper primarily compares the performance and computational complexity with different pre trained models ZF Net, VGG16, VGG19, ResNet and also with other methods such as Single Shot Multibox Detector, Fast RCNN. The workflow of this solution has data set preparation and augmentation, applying CNN for feature extraction and training the Region Proposal Network (RPN) classification network. The features are detected automatically by loading the dataset into the pre-trained network such as VGG19, VGG 16, ResNet. Then the features are passed to the RPN for further classification. By comparing the learning rates, VGG19 is chosen as best and ZF Net as least performed model.

III. METHODOLOGY

The architecture of the proposed system is:

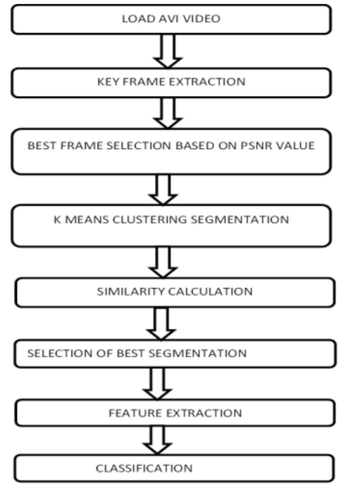


Figure 1 Flow chart of proposed system

Phase I: Key frame and best frame extraction from video

[5] A key frame contains spatial and temporal information of the video sequence, and hence, they also enable the rapid viewing functionality. In this system, the input video is loaded into the system, to extract key frame, a threshold is computed from calculating the mean and standard deviation of sum of histogram difference between consecutive frames [6]. Each frame is compared with threshold, frame which has values greater than threshold is selected as key frames. The best frame is selected by computing the Peak Signal to Noise Ratio (PSNR) and Mean Squared Error (MSE) value for the frames. A frame with maximum PSNR value and minimum MSE value is selected as best frame. The result of this phase is shown in Table 1 and Figure 2, 3 and 4.

Table 1 Key frames extracted from input video

 *Figure 2 Key frame 1*	 *Figure 3 Key frame 2*	 *Figure 4 Key frame 3*
PSNR value: 30.7330 MSE value: 54.9266	PSNR value: 32.0738 MSE value: 40.3367	PSNR value: 26.2739 MSE value: 153.3507

Figure 5 Selected Best frame based on PSNR and MSE value

Phase II: Segmentation of pest

In this proposed system, the color image segmentation method K-means clustering segmentation is performed by applying the input image with a device independent L*a*b color space. Applying the color transformation specify various transformation parameters [1]. The transformed image is then reshaped. The cluster index and the cluster distance are calculated. Based on the index value the input image is labelled. Based on the cluster value, the image is segmented into 4 clusters. The result of segmentation is gained by selecting the resultant cluster manually by its cluster index. Performance of segmentation is measured by calculating the Dice and Jaccard index values. The range of these similarity index values is between 0 and 1, i.e., when the similarity value is 1 the segmentation is the best segmentation, if it is 0 it is the worst segmentation. The result of segmentation phase is shown in Figures 6-11. Similarity index values of the clusters are shown in Table 2.

Figure 6 input image

Table 2 Segmentation and similarity values of clusters

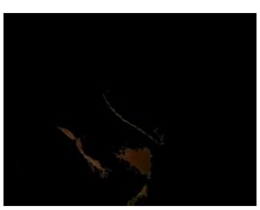
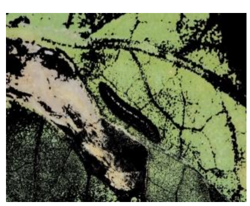
 *Figure 7 cluster 1*	 *Figure 8 cluster 2*
Dice index: 1 Jaccard index: 1	Dice index: 0.9993 Jaccard index: 0.9986
 *Figure 9 cluster 3*	 *Figure 10 cluster 4*
Dice index: 0.738 Jaccard index: 0.5849	Dice index:0.8871 Jaccard index:0.7987

Figure 11 Best Segmentation

Phase III: Feature Extraction

Before proceeding to feature extraction phase, the dataset is prepared for extracting the features. Images are collected manually for dataset and data set augmentation is performed in the dataset. In this proposed system, the feature extraction is done by using the Convolutional Neural Networks. A pre-trained network VGG19 is used for feature extraction. VGG19 produces a feature vector of size 4096 dimensions. It extracts the following features from the image: shape, color, texture features, object position, location information and pose variation of object. The dataset is loaded into the pre-trained network VGG19 and it automatically separates the dataset into training dataset, test dataset and extracts all the features mentioned above. Table 3 shows some of the features extracted from the image.

Table 3 Sample feature values

3.20373	0.46722	3.72816	3.070331
3.09776	-0.45783	3.87376	3.114063
2.91039	-1.65385	3.96012	1.446489
6.12272	-4.03926	4.27045	-1.05013
0.16789	-2.85553	1.91465	-3.33021

Phase IV: Classification and identification

In this proposed system, since this method involves several categories of pests and insects, multiclass version of Support Vector Machines (SVM) is used. The resultant feature vector of training and test dataset are passed into a multiclass SVM classifier. SVM creates class labels for training and test dataset. Based on the input image features, training and test dataset features, this phase classifies and identifies the type of pest. The result of classification phase is shown in Figure 13. The performance of the classifier is measured by calculating the following metrics: accuracy, sensitivity, specificity, precision, false positive rate etc. The performance metrics of the classifier is shown in Figure 14. The following flow chart describes the classification process:

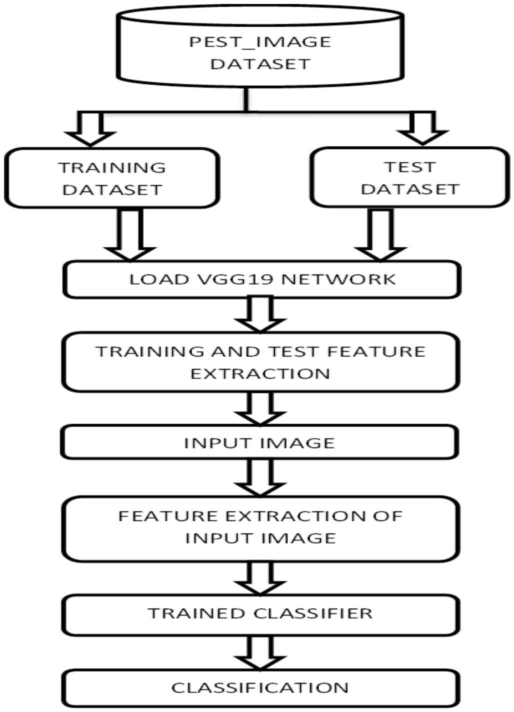


Figure 12 Flow chart of classification phase

Figure 13 classification output

Over all values

Accuracy: 0.9846
Error: 0.0154
Sensitivity: 0.9846
Specificity: 0.9962
Precision: 0.9857
FalsePositiveRate: 0.0038
F1_score: 0.9847
MatthewsCorrelationCoefficient: 0.9812
Kappa: 0.9519

Figure 14Performance metrics of classifier

IV. RESULTS AND DISCUSSION

The architecture of the proposed system is shown in Figure 1. The proposed system segments and identifies the pest by following the architecture discussed above. Figure 2, 3 and 4 shows the key frames extracted from the input video. PSNR and MSE values for the above frames are calculated. Based on the results, Figure 5 is chosen as the best frame, which is used as input for next phase. The result of K-means segmentation clustering is shown in Figures 7 – 10 and their Dice and Jaccard similarity index is calculated. Figure 11 shows the best segmentation which has the Dice and Jaccard index value 1. Table 3 shows some of the values of features extracted from the input image. Figure shows the flow chart of classification phase of the proposed architecture. Result of classification and the performance metrics of the multiclass SVM classifier are shown in Figures 13 and 14. The performance metrics indicates that the proposed architecture has higher accuracy with lower error rate. The table below shows the results of comparison of accuracy of the proposed system with other works.

Table 4 Accuracy comparison with other works

WORKS	ACCURACY (in Percentage)
[7] Sladojevic, Arsenovic, Anderla, Culibrk and Stefanovic (2016)	96.3
[1] Bashish, Braik and Ahmad (2011)	93
[4] Uma Rani and Amsini (2016)	98.38
[2] Xia, Chen, Wang, Zhang and Xie (2018)	89.22
[3] Gondal and Niaz (2015)	98
Proposed System	98.46

V. CONCLUSION AND FUTURE SCOPE

There are many methods and techniques are used for the pest detection and disease detection. Types of pests like aphids, whiteflies, thrips, etc., are detected and identified from the leaves [8]. Many studies have used the Neural Network techniques for the classification and identification purposes, but the limitation is it uses binary classification methods. This proposed system uses Convolutional Neural Networks with pre-trained network VGG19 and multiclass SVM classifier. The use of CNN has reduced the process of extracting separate features and selecting best among them. Though this system is computationally complex it does produces the results of with greater accuracy. By using the above mentioned architecture this system identifies five types of pests namely tuta absoluta, fall army worm, leaf hopper, epilachna beetle and corn borer with accuracy of 98.46%.

The proposed architecture is limited to use only AVI format videos for video processing which can be changed in a way that support for any format of video will be given This system uses the K-means clustering segmentation, in which the selection of best segmentation needs to be manually done by the end user. So, this system strongly relies on the segmentation selection. Thus better segmentation techniques can be applied to avoid manual segmentation selection. More number of species can be introduced to the system to increase the efficiency and reliability of the system. Android version of this system can also be implemented.

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