

A Comparative Analysis of Machine Vision Algorithms for Insect Pests Classification

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Abstract

Insect pests are the one of the important biological factors, that has become an important cause of crop yield degradation. However, their identification and detection in the early stages is a very significant task to minimize the overall losses. The conventional techniques with naked eyes to identify the pests is very exigent and require domain specific expertise. It is extremely time-consuming and tedious task to identify the pests in the initial stages with conventional methods. To minimize these issues, some highly developed methods are required to detect insect pests accurately in agriculture. The continuous emergence of machine vision in image processing helps in this regard. This paper presents a comprehensive review to identify the insect pests in the early stages with the help of machine vision techniques. Based on this, a comparative analysis of different classifiers has also been presented.

Keywords: Artificial intelligence, smart agriculture, classification, pest detection

1. Introduction

Agriculture is an important source for any nation's development. It is one of the important foundations for any country and plays a vital role in human survival. For developing nations, it is a basic need to increase the production of farming products with good quality that leads to better health impacts on its population [1]. Agriculture should need to increase productivity to ensure food security for the regularly growing population. But it is very difficult for the farmers to get the full yield productivity [2]. Many agronomic factors that affect the yield capacity of crops are faced by farmers worldwide. Pests are one of them that leads to the degradation of crop yield. This provokes the researcher's attention on agriculture to make it more precise with the help of efficient technologies.

Pests are living organism that takes feed from plants and, they become a cause of some serious diseases in plants [3]. Pest detection in plants is the most important step for good farming productivity. Generally, farmers use traditional methods for pests identification with the help of leaf symptoms or direct pest observation with naked eyes. It requires continuous attention and experience for exact monitoring. This method is not sufficient in the case of the big farm because lots of damage happen when symptoms are detected. If timely prevention measures are not done by the farmers, it can lead to high yield loss in crops.

Artificial intelligence is widely used and gives more effective and accurate results in multiple directions. Many ample kinds of research are already done in this area, and it is successfully applied in the military, industries, robotics, and agriculture [4]. Automatic pest detection methods with the help of classification techniques can help the farmers to detect the pest fast and accurately without any prior knowledge about the pests. This study's aim is to provide a systematic understanding of the different classification techniques used in pest detection.

2. Literature Survey

Pests are one of the agronomic factors that affect the yielding of crops. A related literature survey has been conducted on the works that used pest classification with the help of artificial intelligence techniques. The survey focuses on Support Vector Machine (SVM), Convolutional Neural Network (CNN), K-Nearest Neighbors (KNN), Naïve Bayes (NB) classifiers methods used in the automatic identification of pests.

Support Vector Machine follows supervised learning to train a model. SVM requires a hypothesis space and a loss function. It finds an optimal hyperplane as a solution to a problem. Many researchers have used SVM for pest detection in the early stages. SVM is a powerful tool for binary classification. Rani et al. [8], used an SVM classifier for the successful classification of whiteflies, aphids, and thrips. The authors proposed a model for the detection of the infected region of leaves due to pests with maximum accuracy of 98%. The work used five layers of architecture for pest detection such as gathering the image data, pre-processing, segmentation, SVM classifier, and evaluating the correct occurrences in the infected area. Rajan et al. [9], proposed an automatic pest detection model that classifies whiteflies, aphids, and cabbage moths using an SVM classifier, which produced a detection accuracy of 95%. The authors used color features for SVM training. After training the model, morphic operations were used for the removal of unwanted elements into the images. Xiao et

al. [10], used an image-processing methods for the rapid detection of pests in the vegetable. The work used bag-of-words and a support vector machine model to detect four types of vegetable pests such as *Phyllotreta striolata*, whiteflies, *Plutella xylostella*, and aphids. The experiment showed 91.56% of accuracy in pest classification. Shuhan et al. [11], proposed an automatic pest detection model with the help of SVM classifiers that used different morphological features of *Locusta* pests.

Naive Bayes (NB) is a supervised classifier based on the Bayes theorem. It is a simple but powerful method for prediction. It shows the probability of happening when some features occur. Many researchers used NB for classification. Markovic et al. [12], made a comparison study with different machine learning algorithms to detect pests. In the study, the Naive Bayes classifier attained an accuracy of 75% to detect *Helicoverpa armigera* pest. Kasinathan et al. [13], experimented on 5 and 9 insect classes. To detect the highest prediction accuracy, the authors used multiple machine learning algorithms. In the experiment, NB successfully classified 9 and 5 different categories of pests with the accuracy ratio of 55% and 45% respectively. Anatomy et al. [14], proposed a model with the help of a NB classifier to detect *Gesonía gemma swinhoe* in soybean crops. The proposed model achieved an accuracy of 90% to predict *G. gemma* pest.

KNN (K-Nearest Neighbors) is a non-parametric classification technique used for statistical estimation, pattern recognition and classification. It is a simple and effective method for classification. To classify a data record 'x', some nearest values or neighbors are retrieved by the method. It forms a neighborhood of 'x' and, a distance-based method is used for correct classification. Muammer et al. [15], evaluated the performance of different deep neural network architectures for disease and pest classification with the help of different classifiers. The authors proposed an architecture that used a pre-trained network to extract features and a traditional classifier for correct classification. In this, they used a dataset of 1965 images having five plant diseases and 3 pest classes. The model showed 89% accuracy with the KNN classifier. Wen et al. [16], made a study to compare the accuracy of the different classifiers. In the study, 5 pest species were used to evaluate the prediction accuracy of six classifiers. The model used 464 images of five classes and attained 77.4 % of accuracy with the help of the KNN classifier.

Convolutional Neural Network is the advanced neural network inspired with the visual cortex of a living creature. CNN takes the image as input and converts it into useful features. The complexity of features increases layer by layer. CNN uses these features to

predict the accurate label of the class with some specific optimization algorithms [25]. Gua et al. [17], introduced an enhanced version of the YOLO v3 algorithm to detect pests in tomato plants. The model showed 92.39% of accuracy in the classification of 12 classes (Leaf miner, whiteflies). Liu & Wang [18], proposed PestNet. It is an end-to-end CNN model and used a region-based approach for pest detection. The model used 88670 pest images of 16 categories for training. It used Region Proposal Network (RPN) to provide the region of interest effectively and achieved 75.46% of prediction accuracy. Truong et al. [19], proposed a CNN model for the identification of pests in pomelo leaf such as black bugs, snails, mealybug, scales insects. The model attained an accuracy of 99.35 % for the correct identification of pests. Hossian et al. [20], used a CNN model for pest detection and achieved an accuracy of 93.46%. In the study, a dataset of 6 pest classes (caterpillar, bug, grasshopper, etc.) was prepared by the researcher having 1600 images. The targeted dataset was split into train and test sets. The model used 60 epochs to get the best-known accuracy. Food and Agriculture organization of India measured that 20 - 40% of losses in crops are done by the pests alone. In this regard, Deepika et al. [23], proposed a model deep neural network based on Region based CNN. The model successfully identified the different categories of insect pests (caterpillar, spider mites, whiteflies and root knot) with an accuracy of 99%.

3. Pest Detection System

In plants, pests are identified with the help of pests images. An accurate pest detection system requires a large images dataset of pests and classifies pests accurately with the help of some classification techniques [21]. Pest detection system with the help of artificial intelligence is shown as a block diagram in Figure 1.

3.1 Image Acquisition and annotation

Images are the 2D functions $f(x,y)$ where x denotes x -axis and y denotes y -axis, the two coordinates of dimensions. Image acquisition is related to image data collection [5]. First, the good quality of images are acquired with the help of scanners or cameras in controlled or uncontrolled environments. After the collection of images, the collected images are divided into some meaningful classes.

3.2 Pre-processing

Standardization of images is related to image pre-processing. In this step, many operations such as image resizing, denoising the image [24], enhancing image quality [6],

balancing the contrast of the image, etc., are applied on images to get better image quality for processing. It is responsible for features enhancement in images that increase the accuracy of the system.

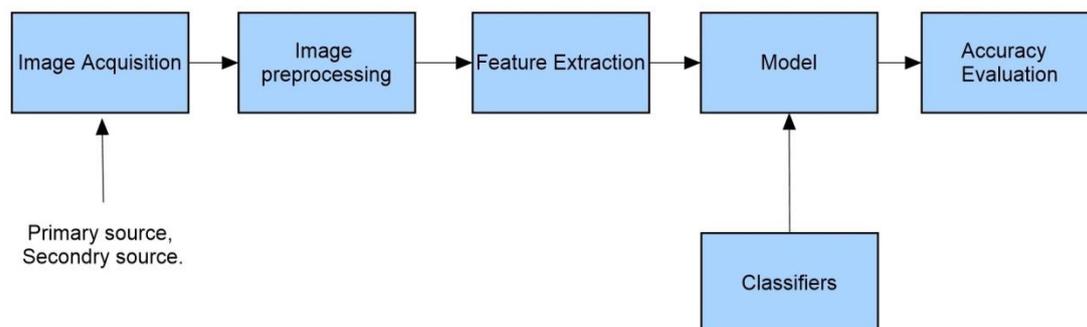


Figure 1. Block Diagram of Pest Detection System

3.3 Feature extraction

Feature extraction is an important step in image processing that reduces the dimensionality of images and boosts prediction process. It is used to obtain maximum information without any information loss in any dataset. In image processing, feature may be related to the texture, geometric, color, and statical which are further divided into subcategories [7].

3.4 Model

In this step, a classifier is used to perform the prediction of accurate class of pests. If the input image has the presence of pest, some further computation are performed on target image for correct class prediction. A number of classifiers are used by the researchers such as SVM, Navie Bayes, KNN, and CNN [22] to perform the classification task.

3.5 Accuracy Evaluation

Finally, the prediction accuracy is evaluated for a specific classifier. It shows the frequency of correct prediction.

4. Comparative Analysis

A comparative analysis of different types of classifiers used in pest detection is summarized and is given below in Table 1.

Table 1. Different Machine Vision Classifiers for Insect Pests Detection

Method	Publication	Species	Accuracy
Support Vector Machine	[8]	Whiteflies, aphids, thrips	98%
	[9]	Whiteflies, aphids, cabbage moth	95%
	[10]	Phyllotreta striolata, whiteflies, plutella xylostella, aphids	91 %
	[11]	Locusts	96 %
Naive Bayes	[12]	5, 9, and 24 classes of pests	75%
	[13]	5 and 9 classes	55%
	[14]	G.gemma	90%
KNN	[15]	Peach sphaerolectanium prunastri, Walnut leaf mite, Erwinia amylovora	89%
	[16]	Grapholita Prunivora, Choristoneura rosaceana, Platynota idaeusalis, Cydia pomonella, Argyrotaenia velutinana	77.4%
CNN	[17]	12 classes	92.39%
	[18]	16 classes	75.46%
	[19]	Black bug, snails, mealybug, scale insects	99.35%
	[20]	Caterpillar, bug, grasshopper total 6 classes	93.46%
	[23]	Pod borer, Whitefly, caterpillar, Root-knot, Spider mites	99%

5. Discussion

In this study, a comparative analysis of different artificial intelligence classifiers used for the recognition of pests in crops is discussed. The publication name, species classes, and accuracy of classifiers are summarized in Table 1. SVM classifier is used by many researchers for the identification of pests. In pest detection, SVM has achieved 98% of accuracy to detect whiteflies, aphids, and thrips pests in the early stage automatically. Naive

Bayes is a good method for pest classification, and has successfully classified pests of different categories. It has achieved 90% accuracy for the successful classification of a wide range of pest classes. KNN is an advanced method for classification and has achieved an accuracy of 89% and 77.4% to detect pests. Conventional neural network has used automatic feature detection and classification task for prediction. CNN has achieved an accuracy of 99.35% to detect black bugs, snails, mealybugs, scales insects in crops. So, the choice of the classifier is a significant step to detect pests in crops that prevent crop degradation. Other than these, most of the datasets are collected from controlled environments. However, the model has achieved a good prediction ratio at the training time, but in a real-time, the environment performance of the system is not good. To achieve, better accuracy in real implementation, authors are required to focus on real-time datasets for model training.

6. Conclusion

Pest detection in crops is one of the important steps in farming. Many machine vision classifiers have been developed by the researchers for this purpose. Some popular classifiers used for pest detection have been discussed in this paper, and a comparative analysis of different classifiers has been made. The aim behind this study is to provide an idea that helps in the selection of the best possible classifier for pest classification. The accuracy of selected classifiers is not fixed. Other than this, it is also a very tedious task to detect all categories of pests with the help of any single classifier. For this reason, the research can be extended for developing a system that can detect various categories of pests with satisfactory accuracy.

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