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Image Processing an Emerging Technique for Early Detection of Pest and Diseases

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ABSTRACT

Agriculture is a prime and foremost important sector for almost all developing countries. Agriculture production is hindered and declined by the pest and diseases which imposes a threat to food security. Therefore, it becomes necessary to fast and accurate early detection and diagnosis of the pest and diseases to safeguard crops from enormous yield losses. Conventional pest detection and diagnosis are time-consuming, and relied on plant protection experts. Recent advances in information and communication systems opened digital agriculture, and pests and diseases are quickly detected and diagnosed using newly emerging technology call "image processing". This article attempts to enlighten the advanced technological knowledge of image processing, and its success in the detection of economically important crop pests and diseases around the world.

INTRODUCTION

Agriculture is the backbone of any developing countries economy and a major contributor to that country's GDP. There is an 80% probability that the world population will hit 9.6 billion in the year 2030, and will constantly demand to increase the current food production by 2 % every year (Gerland et al. 2014). The available land for crop cultivation is limited, therefore, the only way to overcome the hunger is to increase the productivity per unit land area using high yielding varieties. But from time to time the emergence of catastrophic pest and disease outbreaks constantly posing threat to the agriculture sector. According to FAO statistics, 20-40% of the global crop yield is reduced each year due to the damage wrought by plant pests and diseases. In India alone, 18% of the total crop production is being lost every year, and an estimated monetary value of Rs. 60,000 Crores. If all forms of crop loss are avoided, it would be enough to feed additional 100 million people.

These unwanted huge losses can be avoided by early detection of crop pests and diseases. In the agriculture sector, especially in developing and least developing countries, farmer's knowledge on accurate detection of the pest and diseases is minimal and without proper diagnosis, farmers indiscriminately apply nasty pesticides (Ayan et al. 2020). Over application of unwanted toxic pesticides has led to health hazards to humans and biodiversity.

Pest and disease management in digital era

Integrated pest management emphasizes the accurate and timely identification and control of weeds, insects, and diseases. Pests above threshold levels may lead to a decline in the general health of agricultural and horticultural crops, cause structural damage, and threaten human health

and safety. If pest problems are left untreated for too long, they may lead to a substantial economic loss (Barbedo 2020). Even though the pest management information may be available, accurate identification of the pest, disease, and the host plant is the first step in initiating an integrated pest management program. Accurate diagnose of the pest, and diseases are not only important to take needed remedies but also to develop a pest and disease forecasting and early warning system for prevention before the attack (Tonnang et al. 2017). For example, the locust watch and migration forecasting system safeguarded millions of tons of food and feed in the Indian subcontinent and African countries. Accurate and rapid diagnosis can help producers avoid costly mistakes (treating for the wrong pest, applying a fungicide when no fungicide is warranted, etc.).

Pest identification and diagnosis can be difficult and often require consultation with a plant protection specialist. The conventional approach is to collect samples and deliver them by mail to a specialist for identification (Xin et al. 2002). Regular package delivery methods can take days, leading to delays in pest control recommendations. Sometimes, mailed samples deteriorate during shipment and become unsuitable for diagnosis. Farmers are expecting fast and accurate pest and disease detection methods to escape from disasters.

Image processing and its impact in crop pest and disease detection

Recent advances in Information Technology developed the Distance Diagnostic and Identification System (DDIS) for quick identification of pests and diseases (Figure 1). DDIS allows users to submit digital images obtained in the field for rapid diagnosis and identification of pest insects, weeds, diseases, and animals. This system provides a digital image library with associated GPS location, crop, and pest or disorder data that can be used in future educational programs. The process of DDIS has four steps: 1) observe a pest, unknown plant, or symptom, 2) capture images through a digital camera with or without the use of a microscope, 3) submit the sample, with the option to revise the sample after initial submission and 4) await diagnosis by a clinic or specialist (Xin et al. 2002). Turnaround time can range from hours to days, depending on the communication with the correct specialist, the quality of the image and associated information, and whether the pest can be diagnosed by images alone. DDIS is an effective communication tool for the county Extension officers, state specialists, clinic and lab diagnosticians, and external experts. DDIS provides a way to assist their clientele with rapid pest identification and diagnosis. The accuracy of the DDIS is highly dependent on the quality of the images captured (Xin et al. 2002). The DDIS method has now improved and is now coupled with the different image processing, therefore, no need for the specialist to diagnose any pest or diseases.

Automated field pest and disease detection and recognition using mobile vision technique is a hot topic in modern digital agriculture. These modern image detection techniques designed in a way to access the pest and disease or pest collection museum's databases developed, for example, Digital automated identification system (DAISY) is an automated species identification system optimized for the rapid screening of invertebrates (e.g. insects) by non-experts (e.g. parataxonomists), to classify the pest and diseases. Information updated DAISY can be able to process more than 300+ taxon datasets in less than a second in a multiple user environment and able to provide complete information about the sample image (Weeks et al. 1999). DAISY is capable of deep learning, knowledge encapsulation, pattern based data mining, and (image based)

content search using a combination of smart data caching and OpenMP. There are several approaches are being used in the image processing system to classify the images such as Artificial Neural Networks (ANN), Naives Bayes classifier, fuzzy logic analysis, particle swarm optimization (PSO), membership function combination of classifiers, orthogonal locally discriminant projection algorithm (OPDPA), minimum path evaluation theory, fractal dimensions, support vector machine (SVM), discriminant analysis, AdaBoost algorithm, and rule set theory (Dhingra et al. 2018).

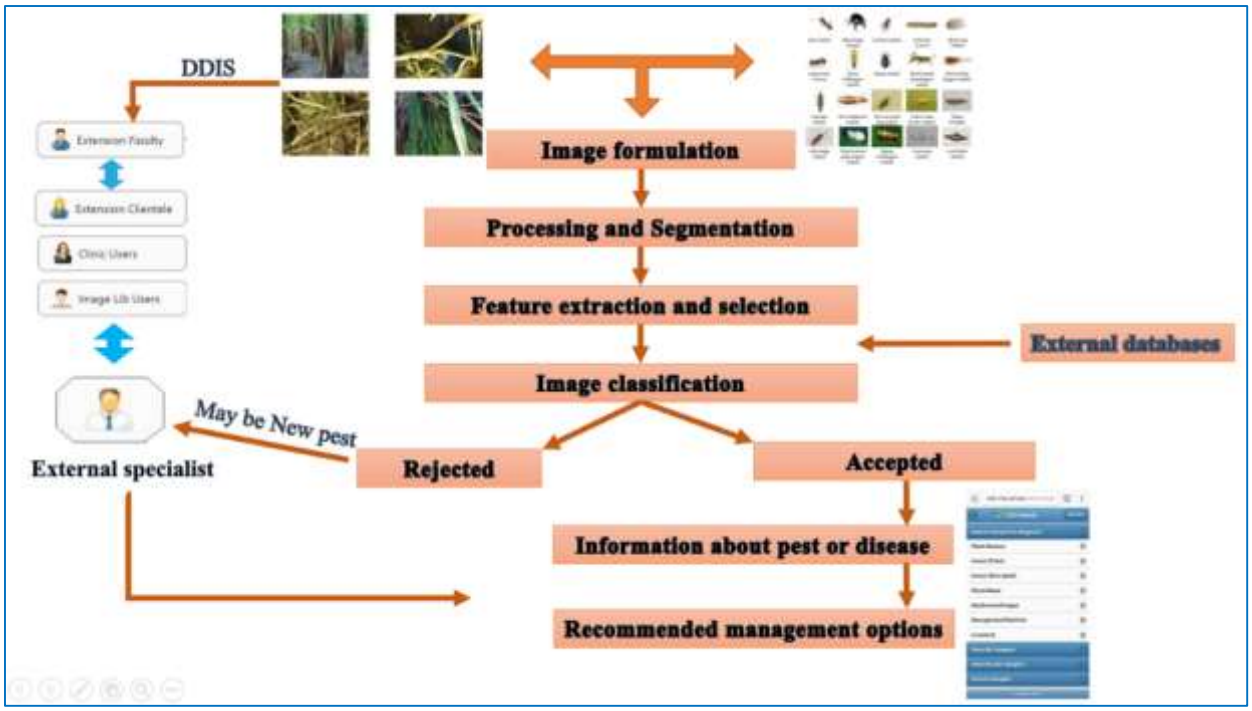

Fig. 1: Schematic representation of coupled DDIS and automated image processing for pest and disease detection

The standard steps of the image processing system are (1) Clear image capture; (2) Resize the images (3) colour conversion (4) segmentation (4) reduction of noise (5) pest and disease detection (6) Feature extraction (7) Feature selection (8) image classification (9) evaluation pest and disease categories and (10) performance measures.

The automated system containing software will do all the processes once the clear image loads and will give the output within a minute. Bu using this automated image processing several insect pests and diseases are detected at their early infestation/infection stages, and with the immediate recommendation given by the software, that pest and diseases controlled or managed successfully (Venugoban and Ramanan 2014; Kumar and Raghavendra 2019). The successful history of the crop-wise disease and pest detection in the past five years is summarized in table 1. Other than these, several common pests were also detected using different image classification system (Thenmozhi and Srinivasulu Reddy 2019; Barik et al. 2018).

Table 1: Diseases and insect pest detected through image processing technology

Crop	Diseases	Insect pest
Cucumber	Downy & Powdery mildew, brown spot & angular leaf spot, anthracnose	-
Grapes	Scab, rust, Downy mildew, powdery mildew & anthracnose, Black rot,	-
Cassava	mosaic disease, Brown spot	-
Okra	yellow vain mosaic virus	-
Tea	leaf diseases	-
Rice	Brown spot, bacterial blight, rice blast and sheath rot, tungro	brown plant hopper, yellow stem borer, green leaf hopper, leaf folder, green horned caterpillar, hispa, Rice ear head bug, Zig-zag leaf hopper
Citrus	Canker, Greasy spot, melanose and scab, Greening	-
Orchard		Codling moth, Red banded leaf roller, Oblique banded leafroller, Tufted apple budmoth, Lesser appleworm, Oriental fruit moth, Apple maggot and Cherry fruit fly, locust, grasshoppers
Maize	Blight, sheath blight & southern blight, leafspot	Fall armyworm, Pyralidae insect
Sugar beet	Cercospora leaf spot	-
Sugarcane	ugarcane ring, rust & yellow spots	-
Tomato	Powdery mildew & early blight, Late blight, septoria leaf spot, down mildew, blast & rust teak.	-
Wheat	Powdery mildew, leaf & stripe rust, leaf blight	-
Vegetables	downy mildew & powdery mildew, Early blight, Late blight & powdery mildew	Leafminers caterpillar *Tuta absoluta*, whiteflies, Thrips, spinach flea beetle
Orchid	Black spots, virus & yellow spots	-
Watermelon	Downy mildew & anthracnose	-
Cotton	Grey mildew & bacterial blight	Mite
Tobacco	Anthracnose & frog eye	whiteflies, aphids and thrips
Phalaenopsis	Bacterial [bacterial soft rot, bacterial brown spot, Phytophthora & black rot	-
Rubber tree	Corynespora, frog eye & Collectotrichum	-
Soybean	Frog eye, rust bacterial blight, downy mildew & sudden death syndrome	-
Betel vine	Rotten	-
Sunflower & oat	Rust & blight	-
Pecan nut		Pecan Weevil

Adopted and Updated from (Dhingra et al. 2018)

Key factors need to considered while designing advanced image processing systems are as follows (Ngugi et al. 2020; Kumar and Raghavendra 2019).

1. Quality (resolution) of the pest or disease image
2. Number of quality images used to machine learning
3. Large number of data set need to be considered in large amount.
4. Need to acquired highly contrast images to prevent the background effect and noises.
5. Segmenting the exact spot in a plant part into meaningful disease.
6. Preparation of training and testing samples from input image.
7. Entomologist or pathologist assistance for clear classification in recognizing segmented spot into meaningful image.
8. Take the photos in all the environments and directions to prevent the color and contrast effect when climate changed.
9. Select the phots of live, processed and museum specimen to increase the accuracy

Image processing software or application developers suffers from serious challenges including the complexity of the wild environment, detection of tiny size pest, and classification of multiple classes of pests. While recent deep learning-based mobile vision techniques have shown some success in overcoming the above issues, one key problem is that towards large-scale multiple species of pest data, imbalanced classes significantly reduce their detection and recognition accuracy.

CONCLUSION

Pests and diseases are major hurdles to agriculture. Fast and accurate detection and diagnosis are highly being preferred by commercial farmers to prevent the further advancement of pest and disease outbreaks. In the digital ear, an image processing system including mobile applications, coupled with databases, is a blooming technique for fast and rapid detection, diagnosis, and proposes suitable sustainable management options within a minute and prevent from over-application of unwanted nuisance pesticides which can cause health and environmental damage.

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