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Computer Vision based Plant Disease Detection with Automated Site Specific Application of Pesticides

Pratyusha Kangutkar[1], Rudra Tarte[2], Nagarjuna Vatti[3] and Nitin Sakhare[4]

[1] Btech Student Computer Engineering, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India

[2] Btech Student Computer Engineering, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India

[3] Btech Student Electronics & Telecommunications Engineering, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India

[4] Assistant Professor Computer Engineering, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India

Abstract

In the field of Agriculture, crop diseases are the major setbacks which hamper the growth of this field. India loses a significant percentage of agricultural yield due to this very reason. Over dosage of pesticides to prevent these diseases is a problem which causes soil infertility and harm to the health of farmers. There has to be a proper balance between understanding these diseases and the knowledge of giving optimal dosage of pesticides to get the best possible yield. By leveraging the AI technology we intend to develop a system which not only detects the plant diseases but also identifies, locates and provides relevant suggestions for using the right pesticide and the required dosage to tackle the diseases. Also, the hardware system we propose will automatically spray the relevant pesticide on the infected crop region at required time. All these features will reside on the users' smartphones. Using this technology, plant diseases can be easily tackled and it will no longer be a problem for the farmers.

Keywords: *Computer vision, Web scraping, Google APIs, android application, automated hardware.*

1. Introduction

Agriculture is the base of any region or country. It is one of the main sources of economy for many of the farmers. Though the farmers have basic knowledge of crops and soil, they lack knowledge of crop diseases and their cure. It has been documented that the amount of agricultural yield lost as a result of crop diseases is 15 to 25%[1]. The farmers have no knowledge of the amount of pesticides to use and the overuse of pesticides can harm both the crops as well as the farmers causing various health issues that include scorching eyes, exanthema, blindness, cancer, reproductive damage and many other sufferings which in severe cases may lead to death[2]. Due to the losses suffered by the farmers, there are cases of the farmer committing suicide[3]. Though the main cause is not loss of crops, it is one of the reasons for the farmer's loss.

The diseases are currently detected by the naked eye of the farmer. The farmer uses pesticides on the entire field which can cause soil infertility. There are methods like quarantining the infected crop so that the disease does not spread to other crops, but this method does not guarantee the stop of spreading the disease. Crop rotation is used to avoid diseases and pests. The phytosanitary potential is decreased by 2-6 times compared to its level in permanent crops[4]. This method, though effective, is not applicable to all crops.

Plant diseases are either fungal, bacterial or viral. Disease causing fungi take their energy from plants on which they live. Fungi can lead to multiple plant diseases like anthracnose, botrytis rots and downy mildews. They harm plants by destroying cells or causing stress. Bacterial diseases are classified into four broad categories depending on the extent of damage to plant tissue and the symptoms that they cause, which are vascular wilt, necrosis, soft rot, and tumours. Diseases spread quickly through water,wind , soil, humans, tools and machinery, etc. On a global basis, 16% loss is suffered by farmers due to microbial diseases [5].

The symptoms of the diseases are visible on the surface of the leaves. Symptoms are usually changes in colour or shape of leaves. Knowing this and the loss faced by the farmers, we decided to solve this problem. In our solution, we are using

computer vision to detect the diseases based on the image of the infected leaf. Computer vision is a field of artificial intelligence that involves processing of images or videos to identify or classify objects. After classification of disease, we will provide information on the disease and recommend pesticide for cure. Web scraping is a technique to extract data about a term from different websites and will be used to provide the required information on the pesticide.

Google provides application programming interfaces (APIs) which help programmers to use their services. We will be using Google maps API to store the location of the infected crop so that it would be easy for the farmer to locate his crop in a large farm. We will be adding a reminder feature to notify the farmer about application of pesticide using Google calendar APIs. Dosage of pesticide and range of application will be given as overuse of pesticides is harmful.

The hardware system design will automatically spray the pesticide on the infected crop region at required time. It will be automated using IoT. The hardware design will be easy to use and will have a capacity to hold the required amount of pesticide. It will be battery operated and will run on solar power. It will have a rotating nozzle and can spray the pesticide upto a good distance. It will be lightweight and portable.

The solution will be available on android mobile phones and thus will be user friendly. It is a scalable and cost-effective solution which will reduce the loss of crops due to diseases. In the field of agriculture, this solution will be feasible and has great scope in the future. New features can be added to the mobile application like delivery of pesticide required or increase of range of crops and their diseases. Additional features to the hardware design can also be included.

2. Related Work

Sammy V. Militante,Bobby D. Gerardo and Nanette V. Dionisio (2019) provided a solution to tackle the problem of plant diseases as well as identify multiple varieties of plants. The deep learning models used by them to discover the presence or absence of any particular disease are trained using 35,000 related images and have an accuracy rate of 96.5% for detecting plant disease and 100% for identifying the plant variety[7].

The study provided by Omkar Kulkarni(2019), uses computer vision and deep learning To solve the problem of crop diseases. The model has been trained using a public dataset which contains images of healthy and diseased crop leaves. The model, based on pattern of defect, classifies images of leaves into respective categories of disease[8].

In the study by Aakanksha Rastogi,Ritika Arora,,Shanu Sharma(2015),, machine vision technology and digital image processing has been used for identification of leaf disease and grading. The plant is recognised in the first phase followed by classification of leaf using Artificial Neural Networks. The disease detection is done in the second phase followed by grading on the basis of amount of disease[9].

The study by Adedamola Adedoja, Pius Adewale Owolawi,Temitope Mapayi(2019), uses a deep-learning approach to solve the problem of diseased plants. For the convolutional neural networks, the study uses NASNet architecture and then the model is trained using a public dataset. The model achieved an accuracy of 93.82%[10].

In a research by Sumair Aziz ,Ovais Mughal, Sir Syed and Arsalan Khan (2019) uses computer vision framework to identify and classify plant diseases. Local Tri-directional Patterns (LTriDP) is used to extract discriminant information and through multiclass support vector machines (SVM) classification is done. The system has achieved overall accuracy of 94%[11].

The paper by Sachin D. Khirade and A.B. Patil(2015),discusses the different methods like image processing, image acquisition, image pre-processing, image segmentation, feature extraction and classification used for detection of plant diseases. The segmentation and feature extraction algorithm has also been discussed[12].

In the study " by John C. Valdoria ,Arlene R. Caballero Brian Irvin D. Fernandez and John Marco M. Condino(2019), usual diseases on terrestrial plants in the Philippines are detected through the use of image processing through Deep Learning Neural Network. To capture the images of plants, Android smartphones were used and to detect the diseases Deep Learning Neural Network Algorithm was used [13].

The paper by Vijai Singh , Varsha and A K Misra(2015) has presented automatic detection by image segmentation technique and classification of plant diseases. It also presents a survey on different techniques used for detection. Genetic algorithm is used for image segmentation [14].

The study by Melike Sardogan, ,Adem Tuncer and Yunus Ozen(2018) presents detection of tomato plant leaf diseases using Convolutional Neural Network (CNN) model and Learning Vector Quantization (LVQ) algorithm. The CNN model is used to automatically extract and classify the features. The output feature is fed to the LVQ and the model can detect 4 different types of tomato leaf diseases [15].

The research paper by N Gobalakrishnan K Pradeep C J Raman L Javid Ali M P Gopinath(2020) is a survey paper on all the techniques carried out for image based detection of plant diseases [16].

In a paper by Umut Barış Korkut, Ömer Berke Göktürk and Oktay Yıldız(2018) present detection of plant diseases using different machine learning and image processing methods. Feature extraction is done by using the transfer learning method and the model achieved 94% accuracy[17].
Developing image processing technique for detecting plant diseases and alarming has been presented in a study by Pradeep Kumar Mugithe ,Rohit Varma Mudunuri B Rajasekar , and S Karthikeyan(2020) Techniques like image acquisition, image processing, image segmentation, feature extraction, classification and disease categorization have been used. Buzzer system has been used to alert the farmer[18].
The study by U. Shruthi ,V. Nagaveni and B.K. Raghavendra(2019).presents stages of general plant diseases detection system and comparative study on machine learning classification techniques for plant disease detection. Convolutional Neural Network gives high accuracy and detects more diseases of multiple crops has been observed in this particular survey[19].
For detecting chilli plant leaves diseases, the paper by Abdul Hafiz Bin Abdul and Rahimi Zahari and Tiong Hoo Lim(2019) presents an algorithm using artificial intelligence based image processing. It focuses on using k-method clustering and Support Vector Machine (SVM) algorithms for image segmentation and classification [20].
Automatic disease detection and classification using artificial intelligence has been presented in the paper, by Pushkara Sharma ,Pankaj Hans and Subhash Chand Gupta(2020) . Steps like image collection, image preprocessing, segmentation and classification have been used to increase crop productivity in agriculture[21].

3. Problem Statement

Looking at the related work and reading the different methods used to solve this problem, there are a few drawbacks like no automatic spraying of pesticide or no reminder given for easy use of software and hardware. The cost of existing mechanisms for pesticide spraying is not affordable to every farmer. Our proposed solution is for real time detection of plant diseases and simultaneous site-specific application of pesticides by hardware design. It is an easy to use and feasible solution for all users.

4. Proposed Methodology

The infected crop will be scanned by the users with the camera of their smartphone. The scanned image will be compared to the images in our dataset by machine learning algorithm and then will be classified accordingly. The required information about the disease and the related pesticide will be provided using web scraping. Depending on the disease spread and intensity, dosage of the recommended pesticide based on web scraping will be provided. The coordinates of the infected crop region will be stored using Google maps API to locate that region easily. The user can set a reminder for timely application of pesticide on infected regions. The user can set two types of reminders, one in which the user will enter the type of crop and date of sowing in the application and depending on this information preventive pesticide application reminders will be given for that crop, for example, before flowering or fruiting. The other type of reminder will be for application of pesticide after disease detection for proper cure of crop. For the user who linked the hardware system to application, automatic spraying of the pesticide will be done by the system design.

The main purpose of this project is to identify the plant disease precisely and provide the right knowledge about site specific pesticide dosage. The most commonly proposed solution for achieving this task is using drones. No doubt that using drones is an ideal approach, but there are some factors which make this solution quite impractical. Drones are very expensive.A basic agricultural drone, with a payload capacity of INR 13-15 litres and a good battery life costs INR 3-10 Lakhs and above. This is very expensive for most of the farmers to afford. Moreover, drones are very fragile & sophisticated systems. They require timely and proper maintenance. It is also very difficult to operate a drone unless there is sufficient training. Considering all these factors, there is a need to develop a system which overcomes all these problems. The authors, in this paper propose a new approach for this problem by developing a simple to use and cost-effective hardware design for automated pesticide spraying.

Fig.1.Flowchart

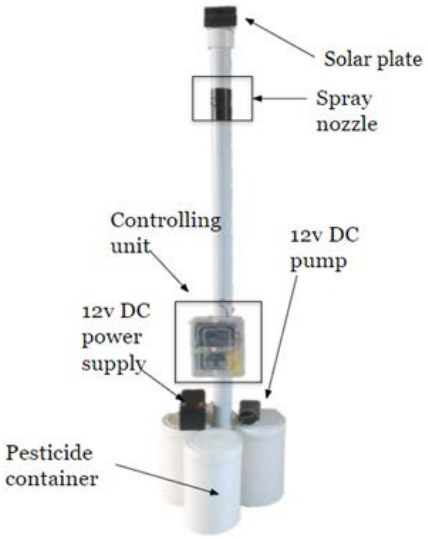

Fig.2. Automated pesticide spraying mechanism

Fig.2. shows the system design of an automated pesticide spraying mechanism. The proposed hardware system (node) is very simple and durable as compared to complex technologies like drones. It consists of a pesticide container, DC motor pump, spray nozzle, micro-controller unit and a solar cell. Since it has a very low power consumption rate, it is also capable enough to run on abundant sources of energy, solar energy, in order to have a longer and sustained working life.Wherever the plant disease is detected by the user with the help of mobile application, the nodes are to be placed at those locations.

After placing these nodes the user can control these nodes wirelessly using his/her smartphone.The entire system works by establishing a wireless communication network between 3 devices; those are smartphones, ZigBee coordinator and pesticide spraying mechanism. The communication protocol used here is ZigBee.It is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power wireless IoT networks. The Zigbee standard operates on the IEEE 802.15. 4. The communication in this protocol happens in unlicensed bands including 2.4GHz, 900MHz and 868MHz. Apart from choosing other powerful technologies like Wi-Fi or Bluetooth, the project was developed on ZigBee to leverage some of its unique advantages. Unlike Wi-Fi, ZigBee is a low power device. The power consumption of ZigBee is 25% less as compared to WiFi [22]. This makes the pesticide spraying mechanism more durable and runs for a longer period of time. Moreover the communication range of ZigBee can extend upto 40km. This is a great advantage for achieving long range communication. Fig.3. represents the interconnectivity of ZigBee coordinator, pesticide spraying mechanism and smartphone.

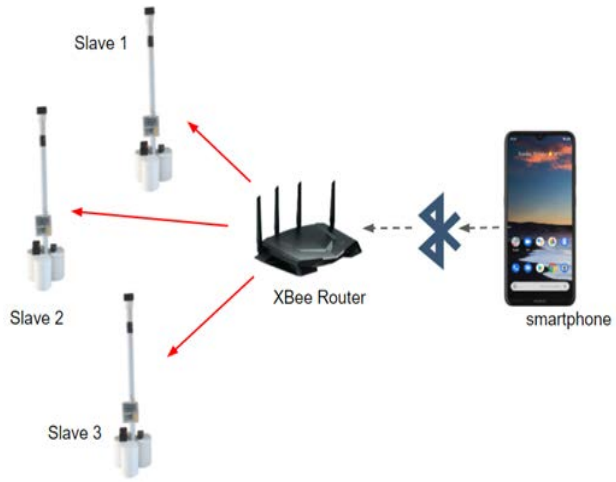

Fig.3. Interconnectivity of hardware devices

Whenever the pesticide is to be sprayed the user will send a command using the android application from his/her smartphone. The command sent will be received by ZigBee coordinator via Bluetooth. The ZigBee coordinator acts as a master and sends the command to the designated slave via IEEE 802.15.4 protocol. As ZigBee devices cannot directly communicate with android devices, the ZigBee coordinator acts as a bridge between smartphones and the pesticide spraying mechanism. The command transmitted by the co-ordinator will be received by the slave planted in the field and the pesticide spraying mechanism is triggered for a certain interval of time. This allows the pesticide spraying mechanism to discharge a set amount of pesticide from nozzle onto that specific site of the field. Thus, the entire process is automated thereby eliminating the need of manually spraying the pesticides. As the mechanism discharges the exact amount of pesticide as needed, there is no danger of over dosage. Moreover the system being wireless also ensures the safety of farmers by preventing the exposure to hazardous chemicals.

4.1 Security Aspects:

An anti-theft mechanism is also integrated with the pesticide spraying mechanism. Unlike power draining sensors like GPS a simple accelerometer is used for this device. An accelerometer is an electronic sensor that measures the acceleration forces acting on an object, in order to determine the object's position in space and monitor the object's movement [23]. Here the accelerometer is used to measure the change in altitude of the pesticide spraying mechanism. Once the pesticide spraying mechanism is fixed in the ground at a particular location, the current altitude value is saved as threshold and the system is armed. In order to steal the device, it has to be uprooted from the ground. In that case, the altitude value of the accelerometer changes as compared to the threshold value. If the device is uprooted without users' permission an alarm will be triggered and a notification will be sent to the user indicating the theft. This helps the user to immediately respond to the situation.

5. Conclusion

Crop diseases are the global catastrophe which makes it difficult to increase the agricultural outcome and also to meet ever increasing demand for food. Overuse of pesticides make soil infertile and make the land unfit for cultivation. Moreover, the frequent exposure of farmers to these pesticides leads to death. There is a need to solve the existing problems with a feasible solution. The proposed solution is simple, cost effective and affordable to farmers as compared to other solutions. The solution is user friendly and will reduce the loss of crops due to diseases and also reduce the deaths by pesticide poisoning. New features like pesticide delivery and fertilizer recommendation can be added to the application.

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