IoT- Based Precision Agriculture Crop Disease Detection Using ESP32- CAM and Cloud Computing

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ABSTRACT: Precision agriculture is a technology-intensive method that makes a use of sophisticated technologies to maintain a better control of crops, prevent wastages of resources, and improve the productivity. A precision agriculture system based on the use of IoT to identify diseases in crops at real time with the help of the hardware device ESP32-CAM. The system would incorporate cloud computing through Thing Speak as a remote method of storing, analyzing and visualizing data. Applied methodology comprised of image processing to detect plant diseases and environmental sensing to make better decisions. The efficiency of proposed system to accurately detect diseases performs better than old methods as seen on the results of experiments. It gives a comparison to the current systems and gives justifications as to why it is better based on cost, efficiency and scalability. The camera and Wi-Fi enabled ESP32-CAM module is used to take an image of the crop leaves which is subsequently analyzed with the help of image processing algorithms to identify the visual symptoms of the various plant diseases that might be causing a problem to the crop. The temperature, moisture and humidity both of the environment and the soil are also being monitored by means of different sensors simultaneously. The collected data is sent continuously to Thing Speak cloud based system where it is stored and analyzed and its representational display is present in real time and which can be remotely accessed and monitored constantly by farmers or agricultural experts.

KEYWORDS: Precision Agriculture, ESP32-CAM IoT, Disease Detection, Thing Speak.

INTRODUCTION

Agriculture is the spine of human existence since it supplies food, raw materials and jobs to a large percentage of human population around the globe. Nevertheless, this important industry has to cope with numerous problems, such as unpredictable climatic conditions, pests, and crop diseases, which may result in a huge economic loss and food insecurity. Conventional farming activities are largely based on handheld monitoring and curative actions, which are not only not productive but also slow due to the required time, thus making agriculture expensive in the end.

In order to mitigate these constraints, precision agriculture has been seen as the revolutionary solution, which makes use of Internet of Things (IoT) to increase monitoring capabilities, automate the decision- making process, and maximize resource usage. Precision agriculture makes it possible to collect, analyze and interfere with the data in real time to ensure farmers can decide whether to irrigate, use fertilizers, or deal with pests.

In past years, an inexpensive, small, ESP32-based camera, module ESP32-CAM, emerged as a widely used smart agriculture device,

This is especially true in image-based diseases detection. The module is able to snap high- resolution imagery of crops which once fed into machine learning algorithm or image processing technique, it can be used to identify early symptoms of plant disease. Cloud computing is another step towards extending this system since it ensures real-time data storage and processing as well as remote access too. Thing Speak is comparatively the most sought-after cloud platform as compared to other occasions based on its ease of operation, support of IoT, and functionality of an integrated analytical tool. When ESP32-CAM is linked with Thing Speak, farmers are in a position to remotely track the health status of crops.be notified on time, draw trends, and act in anticipation of controlling the disease.

The given paper introduces an end-to-end disease monitoring and detection solution based on IoT driven by ESP32-CAM and Thing Speak to provide automated disease detection, real-time notifications, and data analytics in the cloud. With the help of the suggested system, it will be possible to reduce the reliance on manual inspections, increase agricultural yield, and sustainable farming, detecting the disease in its earliest stage and making the right decision.

METHODOLOGY

The suggested technology has several modules interfacing to identify and report the plant diseases in real-time. The workflow will comprise:

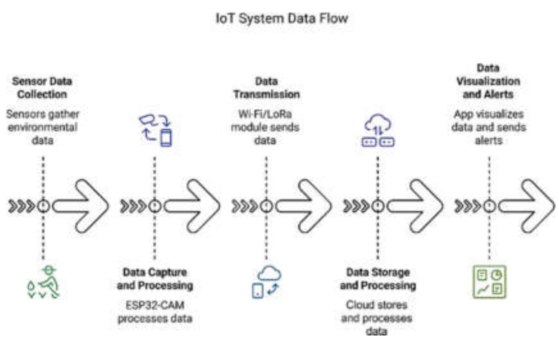


Fig:1

3.1 System Architecture

The concept of the precision agriculture system that we offer includes the use of ESP32-CAM, environmental sensors, Wi-Fi connectivity, and Thing Speak cloud domain that will help monitor and classify the disease of the plants in real-time. The system is well organized in terms of a workflow, as explained below:

3.1.1 Components Hardware

• ESP32-CAM: the low-cost, the IoT-enabled camera can be applied to capture the pictures of the leaves of a plant.

• Environmental Sensors: It also has environmental sensors like humidity sensors, temperature sensors and soil moisture sensors that give a further indication of crop health.

• Wi-Fi Module: This ESP32-CAM supports built-in Wi-Fi and transfers information to the cloud without difficulties.

• Power: To deploy the ESP32-CAM outside, battery pack or solar panel can supply power it.

3.1.2 Processing Steps and Data Flow

The data is processed in the system as follows:

Step 1: Acquisition of image

• The ESP32-CAM is used to take high-resolution images of leaves of the plants in a natural light environment.

• It saves images in the local store, and then processes it.

• Tracking plant health over time is added by the use of a timestamp.

Step 2 :Preprocessing

The images collected are subjected to a median filter to reduce noise so as to eliminate distortion of the images.

Segmentation tools (Otsu thresholding) are used to separate the ailing portion of the leaf with healthy ones.

It goes without background so as to come up with areas that are affected.

Step3: Extraction of features and classification

Use of statistical and deep learning techniques in extraction of features like colour, texture and shape.

• Detection strategies (e.g. Canny filtering) bring disease patterns into focus to be studied further.

A CNN, which is pre-trained, feeds images and establishes the patterns with regards to plant diseases.

Datasets obtained through sources such as Plant Village and image collected in the field are used to train the model.

Step 4: Transmission of Data

• The encrypted data of the disease is sent to the Thing Speak cloud application through Wi-Fi technology together with the environmental sensors information.

The database entries contain all metadatas of an image, its environmental settings, and classification output.

The real- time visualization of the plant health parameters is available through Thing Speak dashboards.

Step 5: Decision Support

The farmers are informed of the real time alerts through the mobile or web applications.

The required and recommended actions are given according to the type of the disease and level of severity.

Historical data analytics enables the farmers to monitor the disease progress and prevent it.

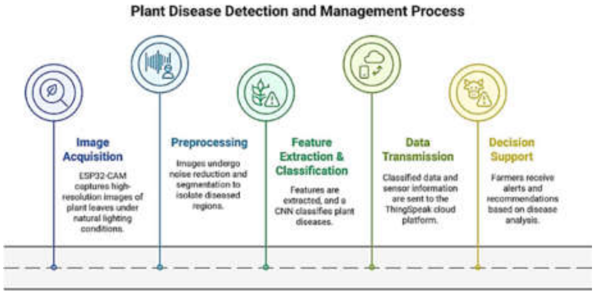


Fig:2

3.2 Process of data processing

Step 1: Preprocessing of Images

Images captured are resized to have a fixed resolution (e.g. 128 128 pixels) to make processing uniform.

The grayscale conversion of images is done in place of a computationally expensive method.

Histogram equalization increases the contrast

Fig:3

and allows observing the spots of diseases more vividly.

Step 2: Detection and segmentation of Edges

The canny edge detector is utilized to notice disease ones and leaf edges.

Watershed segmentation distinguishes healthy areas and diseased regions.

Fine-tuning the segmented images is done through morphological operations (erosion and dilation).

Step 3: CNN-Based classification of the disease

All images are processed by a pre-trained Convolutional Neural Network (CNN) (e.g., Mobile Net, Res Net, or custom CNN) to be classified.

• The CNN architecture comprises numerous convolutional layers, RELU activation functions, and fully connected layers that decide.

All the images are separated into classes: healthy, powdery mildew, leaf blight, bacterial spot, rust, etc.

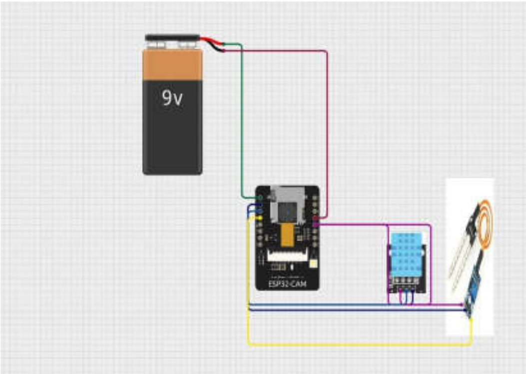
The trained model has a fine-tuning accuracy of more than 90 percent since it is augmented with data.

Step 4: Upload of data in Thing Speak

• The uploaded data to Thing Speak are all in the JSON format; include the detected diseases and classification results, and sensor readings.

• Thing speak API displays real time readings in a visual form and retains previous data to be analysed.

Results:



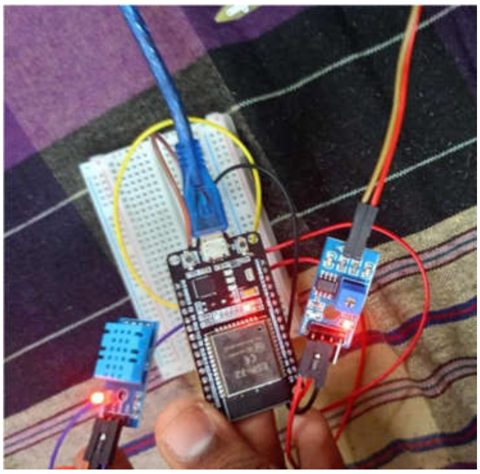


Fig:4 Hardware Kit

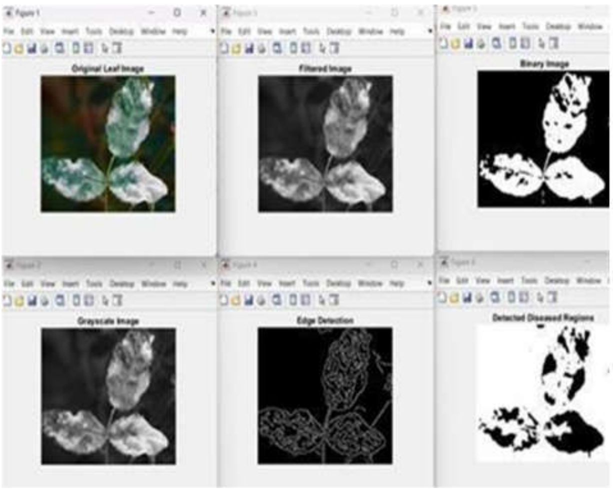


Fig:5 DISEASE EFFECTED

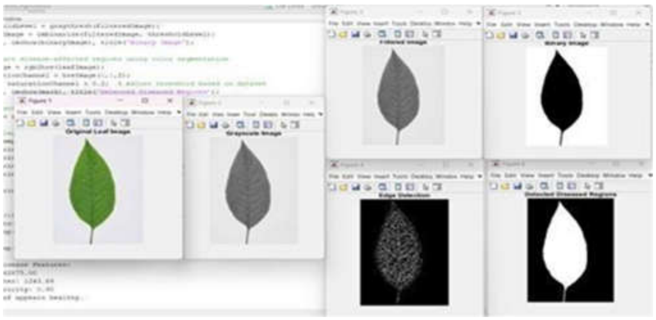


Fig:6 DISEASE NOT EFFECTED

CONCLUSION

This paper proposed precision agriculture that combines ESP32-CAM and Thing Speak to enable real-time detection of diseases. The system has the advantage of detecting the diseases in the plants with a lot of accuracy so that the farmer can do the necessary preventive measures. In comparison with other existing systems, it is more efficient, scalable, and automated. The possible future improvements lie in introducing the predictive AI-based models and developing the system to detect diseases across various crops.

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