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Automatic Irrigation and Crop Monitoring System Using IoT and Deep Learning

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Abstract

One of the biggest problems faced by Indian farmers is the lack of effective irrigation and monitoring techniques. Manual disease monitoring techniques require the full attention of farmers day and night and may lead to the detection of disease at a stage beyond reversal. Conventional irrigation methods require immense effort and lead to the misutilization of water. It also results in a decrease in crop yield as a result of water being given as an approximate quantity, irrespective of the type of the crop. The proposed system is a fully automated farming system, which includes a smart irrigation system using IoT and a deep learning model to detect leaf diseases. Currently, this model pertains to the potato crop, however it can be easily modified according to one's cropping needs. The crop's water requirements are taken care of by the Smart Irrigation system, in which a soil moisture sensor detects the moisture content in the soil, and based on the threshold, turns on and off the pump to ensure adequate water supply to the crop. Alongside the irrigation system, a deep learning disease classifier model is integrated, in which the images of the crop is taken automatically in regular intervals. These images are used as the test data to identify the current health status of the plant, by classifying it as either healthy or unhealthy.

Keywords: Smart irrigation system, IoT, Deep learning, Disease classifier

1. Introduction

Irrigation is the method of distributing water to land to aid in the growth of crops;

however, due to the need-blind uniformity of water supply, there are numerous types of irrigation systems, all of which require a lot of labour and yield mediocre harvests. Another crucial aspect of agriculture is regular monitoring of crop, for early detection, and classification of crop disease, can potentially prevent losses acquired via misdiagnosis or delayed action. The deep learning model, integrated with the IoT irrigation subsystem, focuses on the crop monitoring aspect, and detects crop disease, with good accuracy.

The requirements of present society, which call upon high yield, superior quality, and efficient production, cannot be satisfied by traditional cropping techniques. Thus, it is very important to turn towards modernization of existing methods and use the technology to accomplish the current cropping needs. Being able to connect to high-speed internet, reliable, low-cost satellites and mobile devices fuel modern agriculture trends.

Soil health parameters, like moisture and pH level, that are essential to acquire optimum yield, can be monitored using IoT applications. In order to solve these issues, the autonomous irrigation subsystem keeps track of the moisture levels in the soil and modifies the water delivery as necessary. Additionally, this deep learning model can assist in disease classification leading to more accurate and earlier diagnosis, thus increasing crop yield.

The proposed fully automated farming system consists of two integrated subsystems, a smart irrigation subsystem using the Internet of Things, taking care of the crop's water requirements, and a deep learning model to detect leaf diseases. A soil moisture sensor, as part of the irrigation subsystem, regulates the supply of water via a pump, based on any determined crop-specific threshold. The integrated deep learning disease classifier model captures images of the leaf periodically, and syncs to Google Drive, to identify the current health status of the leaf.

2. Related Work

Using Internet of Things (IoT)-based communication feature, H.G.C.R. Laksiri, H.A.C. Dharmagunawardhana, and J.V. Wijayakulasooriya [1] developed a drip irrigation system that could regulate water flow to plants based on soil moisture levels, so that a remote user to monitor soil moisture conditions and manually adjust the water flow. By providing the farmer with field support, H. Hamza Beneyza, Mounir Bouhedda, KhaoulaDjellout, and Amina Saidi [2] aimed to increase the effective use of water. This was accomplished by using an ESP8266 Wi-Fi module to connect to ThingSpeak and a soil moisture sensor to monitor the state of the soil. According to Shiny Rajendrakumar, Prof. V K Parvati, and Prof. Rajashekarappa [3], traditional irrigation systems involve human watering of crops and use a lot of water. Automated irrigation systems, on the other hand, can save up to 97% more water than conventional techniques. An irrigation system was developed by Divya J., Divya M., and Janani V. [4] to automate field monitoring and give information via a mobile app. The equipment used to inspect the soil includes a pH sensor, a temperature sensor, and a humidity sensor. In an effort to make agriculture smarter, R. Nageswara Rao and B. Sridhar [5] proposed a technique that uses automation and IOT. A Raspberry Pi-based autonomous irrigation IoT system has been suggested to modernise and improve crop productivity. A system that employs real-time input data and is based on the Internet of Things was proposed by Shweta B. Saraf and Dhanashri H. Gawali [6]. An Android phone is used by a smart farm irrigation system to remotely monitor and control drips using a wireless sensor network. Hamza Benyezza, Mounir Bouhedda, KhaoulaDjellout, and Amina Saidi [7] focused on strengthening the efficient use of water.

3. Methodology

The proposed system is to develop an end-to-end farming system, consisting of an efficient automatic irrigation subsystem and a crop disease classifier. IoT and Convolutional Neural Network are used to accomplish automatic crop-specific irrigation and the disease classifier respectively as shown in Figure 2. First, the crop is automatically irrigated as per moisture needs, with the support of the soil moisture sensor, in the Automatic Irrigation System. The Deep Learning Model classifies the leaf as Healthy, Late Blight, or Early Blight based on the trained CNN model. Both of these subsystems are integrated using automatic picture capturing and syncing, at regular intervals, of the crop from the Automatic Irrigation System to the Deep Learning Model as test data.

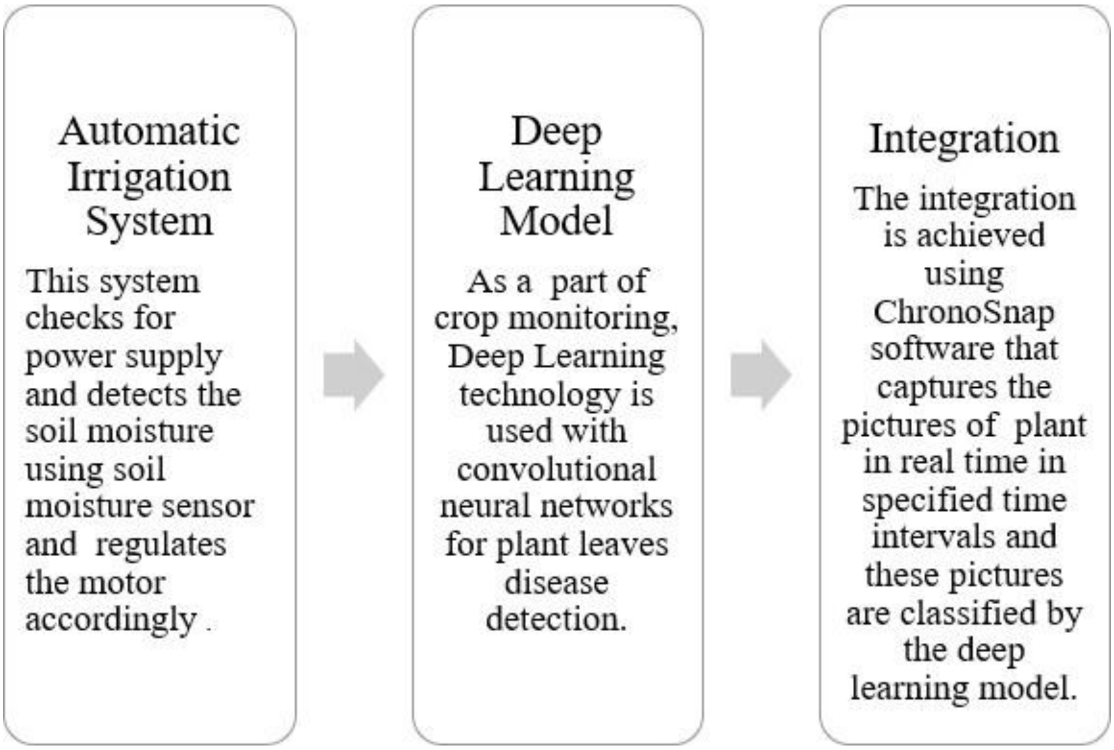

Figure 1: Subsystems

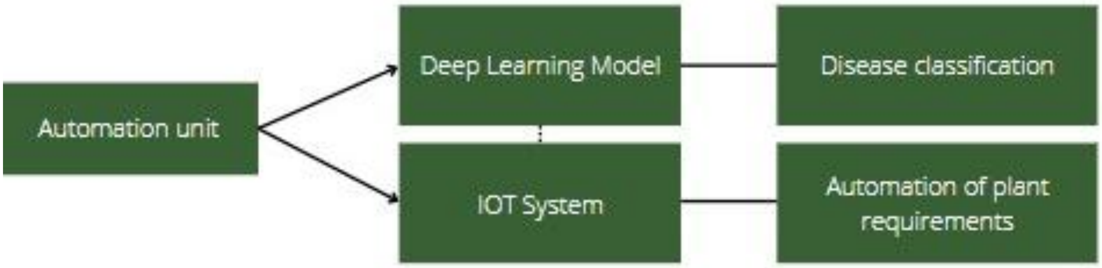

Figure 2: System Architecture

The architecture of the system, given above in Figure 2, depicts the bipartite nature of the proposed automation unit. This unit consists of two subsystems, a deep learning model to assist in disease classification and an IOT subsystem to help in automatic irrigation of crops based on specific requirements.

4. Technologies used

IoT System

IoT irrigation systems leverage local soil moisture data from under-the-ground sensors to assist wise watering schedule decisions. Precision watering in smart irrigation also deals with water supply efficiencies, which is one of the system's main benefits. With the use of inexpensive soil and humidity sensors and an IoT network, the suggested system uses a circuit relay to detect soil moisture and adjust the motor accordingly.

Node MCU

The ESP8266 Development Board, often known as the open-source NodeMCU firmware, is a low-cost development board created for Internet of Things (IoT) applications. Applications that call for an internet connection on the device can use it. An ESP8266-based open-source platform called NodeMCU as shown in the figure 3 connects items and makes Wi-Fi data transfer possible.

Figure 3: ESP8266 Node MCU

DC Motor:
A DC Motor is an electrical device that converts electrical energy into mechanical one. The speed of DC Motor can be controlled over a wide range, using either a variable supply voltage or by changing the strength of the current in its field windings. Small DC motors are used in appliances.

Figure 4: DC 5V water pump

The circuit diagram for the automatic irrigation system is depicted in the Figure 5. The soil moisture sensor is connected to NodeMCU and it is connected to the DHT11 sensor. The motor is connected to the relay module. This relay module is controlled by the NodeMCU. The pump requires 5V which is supported by an external battery.

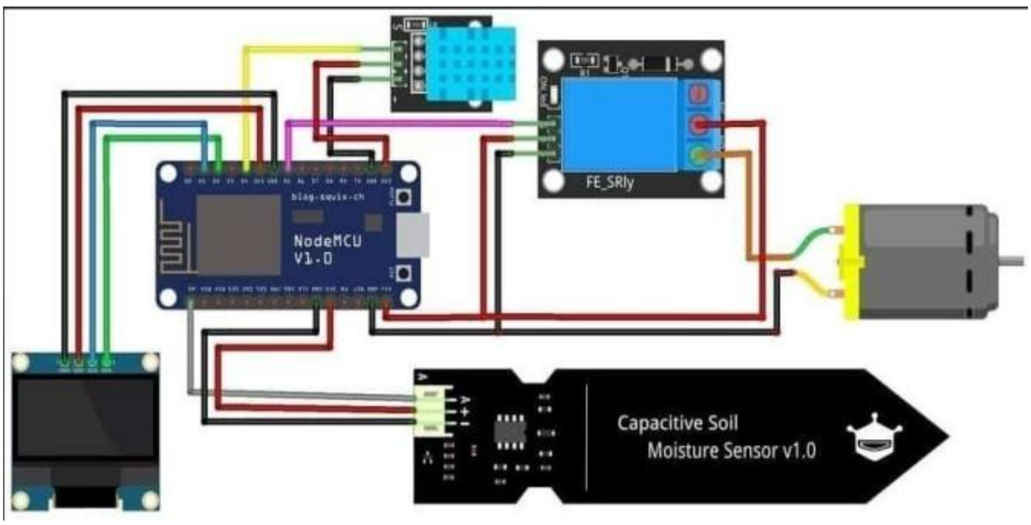

Figure 5: Circuit Diagram

Connections:

The connections are made according to the circuit diagram as shown in Figure 6. NodeMCU acts as a microcontroller that is connected to the power supply. Soil Moisture sensor, Relay Module, temperature and humidity sensor are connected to the NodeMCU. The relay is also connected to Water Pump to produce the output. An external battery is used to support the 5V Water pump.

Figure 6: Hardware Connections

5. Deep Learning based Crop Disease Classification Model

To monitor the required crop, a deep learning classifier is used to periodically check for plant disease. Convolutional neural network (CNN), is used for plant leaf disease detection. Convolution neural networks are used for the image classification task. They automatically detect the important distinguishing features of an image without any supervision, using multiple filters.

The hyperparameters of the CNN model were passing the entire training dataset through the algorithm for 50 epochs, with a batch size of 32. To improve the accuracy and decrease the loss, Adam optimizer was used, and the activation function used was ReLU. The dataset related to potato crop has been taken from Kaggle to build the model, as farmers are facing economic losses due to diseases such as Early Blight and Late Blight in potatoes. If these are detected early, massive losses can be prevented from incurring. In summary, the classifier predicts whether the plant has Early Blight, Late Blight, or if it's healthy.

The Deep Learning Classifier, as shown in Figure 7, consists of two steps, the data cleaning and pre-processing stage, followed by the model building stage.

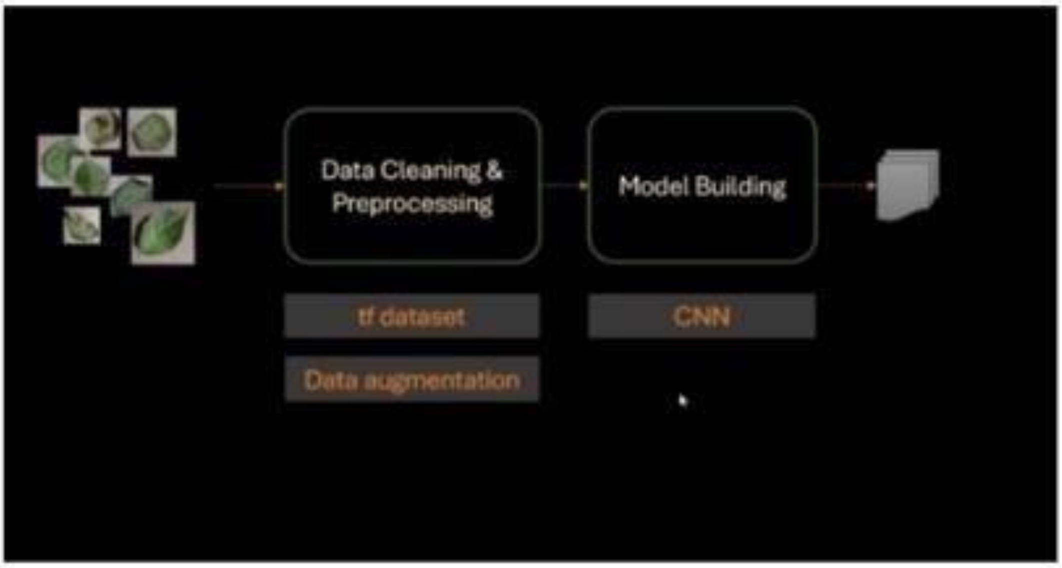

Figure 7: Architecture of Deep learning classifier

Datasets

Plant Village dataset contains 2,152 images out of which Potato Healthy, Potato Late Blight and Potato Early Blight folders are used. Figure 8 is a sample of the specified dataset used to train the model.

Figure 8: Data Collection

Integration of Automatic Irrigation System and Deep Learning Model

A fully automated system is achieved by the integration of an automatic irrigation system and a deep learning model. For this purpose, ChronoSnap software is used which takes pictures of the plant that are automatically irrigated every day. The pictures are taken according to the specified interval. The pictures are stored in the storage and automatically synced with google drive so that they can be used as test data to identify the current health status of the leaf. The prediction code uses these images automatically and predicts them as one of the three classes that is Early Blight, Late Blight, and healthy. Figure 9 depicts the ChronoSnap to capture the pictures.

Figure 9: ChronoSnap to capture pictures at specific intervals

6. Results and Discussions

To achieve a fully automated system, an implementation of an automatic irrigation system using Internet of Things was developed as shown in Figure 10. The pump is regulated based on the moisture content in the soil.

Figure 10: Plant Irrigation using IoT

The health of the plant is monitored using a deep learning model which classifies the plant as Late Blight or Early Blight or Healthy.

Figure 11: Image captured by ChronoSnap

Figure 12: Images stored by ChronoSnap

Integration is achieved using the ChronoSnap software. Pictures are captured at specific intervals and stored in the internal storage and synced automatically to predict the image, as shown in Figure 11 and Figure 12 respectively. The image is automatically synced to Google Drive and is predicted as either Late Blight, Early Blight, or as Healthy as seen in Figure 13.

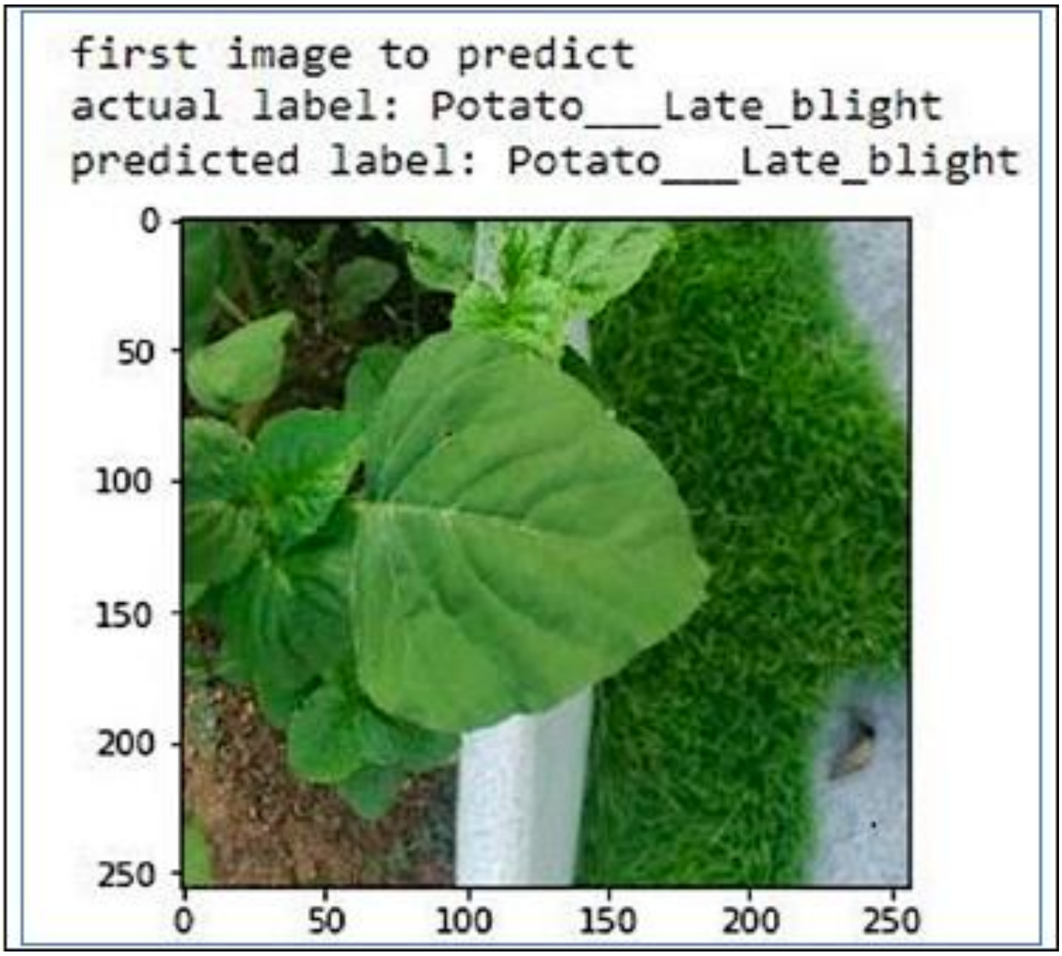

Figure 13: Disease classification

7. Conclusions

An automated irrigation system is developed using IoT and Deep Learning. Soil moisture sensor has been used to detect the moisture level based on which pump is regulated. Disease classification model is developed using Convolution Neural Network. The integrated model captures the pictures regularly and prediction is done to know the current health status of the plant. The future enhancements include adding more components to the IoT system such as the NPK sensor, light sensor and diversifying the CNN model that can been used for the disease prediction of variety of crops.

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