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IOT Based Smart Irrigation and Plant Disease Detection

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Abstract-Water is the most essential contribution for upgrading agricultural productivity and therefore expansion of water system has been a key format in the improvement of farming in the nation. It is the important source in human life. Around 80 % to 90 % water used in agriculture field. As due to day by day growth in globalization and population water consumption is also increases. There is challenge in front of every country to reduce the farm water consumption and provide fresh and healthy food. Currently the automation is one of the important roles in the human life. It not only provides comfort but also reduce energy, efficiency and time saving. Now a day the industries are using an automation and control machines which are high in cost and not suitable for using in a farm & garden field. Apart from irrigation, plant needs to be free of diseases. This paper propounds a design for an automated irrigation system for efficient water management, intruder detection system and detection and prevention of diseases of plants from getting spread. This work will help the farmers to irrigate the agricultural land in a very efficient manner with automated control for soil temperature, moisture sensing to ensure plants is watered when there is demand, live streaming, forecast lookup from other weather services, detection and prevention of diseases. It uses raspberry pi 3, NodeMCU micro-controllers, Wi-Fi module, GSM shield, relay boards and couple of sensors of irrigation and for the detection of diseases it captures the image of the leaves and then analyses it through various steps like acquisition, pre-processing, segmentation and clustering done in raspberry pi. The analog data received from the sensors are transmitted by nodeMCU as digital signal via Wi-Fi Module to the Raspberry Pi 3. The system can notify the administrator if water shortage arises in the main water supply and an administrator can also communicate with the system by sending SMS (Short message service) of a particular keyword. The intruder detection system is done with the help of PIR sensor where the birds are repelled from entering into the field This system can be applied in agricultural land as well as small pot plants. The farmer can access the server about the field condition anytime, anywhere thereby reducing the man power and time. The objectives of this paper were to control the water motor automatically, monitor the plant growth using webcam, detect the disease of plant, intruder detection, and we can also watch live streaming of farm on smart phones by using Wi-Fi.

Index Terms- Automation, Irrigation, IOT, Raspberry Pi, ESP-8266, Sensors, Intruder Detection System, Image processing, segmentation.

I. Introduction

India is the largest freshwater user in the world, and the country's total water use is greater than any other continent. The agricultural sector is the biggest user of water, followed by the domestic sector and the industrial sector. Groundwater contributes to around 65% of the country's total water demand and plays an important role in shaping the nation's economic and social development. The requirement of building an automation system for an office or home is increasing day-by-day. Automation makes an efficient use of the electricity and water and reduces much of the wastage. The need of automated irrigation system is to overcome over irrigation and under irrigation. Over irrigation occurs because of poor distribution or management of waste water, chemical which leads to water pollution. Under irrigation leads to increased soil salinity with consequent buildup of toxic salts on the soil surface in areas with high evaporation. Another problem faced is plant diseases during growth, due to the unpredictable climatic changes, there is lack of nutrients and minerals to the crops. This leads to deficiency diseases which in turn affects the crop productivity. Plants get affected not only due to deficiency but also caused due to micro-organisms like fungi, bacteria, virus and mites. This kind of borne diseases are very dangerous as they affect large farming. And so, it is very important to take steps for maintaining the crops. Manual observation over the health of the crops might result in errors and may even be difficult in case of large acres of land. Generally, whenever there is disease to a plant, we can say that leaves are the main indicator of the disease caused to the plant. Mostly we can see the spots on the leaves of it due to disease. However, when the amount of disease to the plant is large then the whole leaf gets covered by the disease spots. With the help of sensors and GSM shield, controlled by Raspberry Pi 3 microcomputer, we designed a system to automatically sprinkle accurate amount of water by detecting soil moisture, daylight intensity, water level and warn the administrator about intruder or plant disease through SMS or Email. In a Smart Irrigation System, the Raspberry pi is combined with Cloud Computing to provide the communication between the person and the system. Cloud is a service provider or a type of internet-based computing that provides shared computers processing resource and other devices on demand.

Figure 1 Smart Irrigation System

II. Literature Review

Numerous researchers have worked with automatic water sprinkling or irrigation system and plant diseases detection. They opted for different metrics for determining the soil condition and quantity of water and algorithms for finding out diseases. They also discussed different sources of power for the sensors. Besides, the technology for creating network among the sensors and design of control system were also heavily discussed by the scholars. In this paper, a similar system is discussed that will distribute water to trees or agricultural land. An irrigation system using a wireless sensor network and GPRS was implemented [1] . The authors used ZigBee protocols for networking. In this paper, our proposed system uses a GSM shield for SMS based communication and GPRS for data communication which strengthens the system's control and management. Joaquín Gutiérrez et al. [2]developed an automated irrigation system. The author in [3] proposed a review paper on automatic irrigation system based on RF module. They pointed out some glitches with existing system like security problems and slow communication speed. In this paper, the proposed system uses a Raspberry Pi microcomputer and GSM shield, which provide a robust security and enable high speed communication. Karan et al. [4] discussed a sensor based automated irrigation system that used MAX232 dual driver/receiver, GPS, WSNs and microcontroller. All of these connected by the internet controls the entire system. The system is very efficient in a large scale, but its cost-effectiveness reduces when applied in relatively small fields or gardens. For the image processing part, the author [5] discussed plant monitoring using image processing. the author in [6] discussed the same but identified the cotton plant diseases. the author [7] provided measures to stop the diseases and their treatment using various measures. T.V.S.Sankeri [8] discussed techniques used for image segmentation.

III. Proposed System

A. System Architecture

The propounded system consists of one central raspberry pi microcomputer, nodeMCU, different types of sensors, servo motor, relay modules, GSM shield, water pump and water tank (fig.2). The sensors are placed in various positions on land. We used soil moisture sensor, daylight sensor and water level sensor. These sensors send their data to the nodeMCU. The nodeMCU receives analog data from the sensors. Several sensors are planted throughout the land for collecting data from sensors. After receiving data, the nodeMCU throws the data over IP via Wi-Fi so that the raspberry pi can catch them. The audience in the field is also connected to a servo motor, so that it can control the water supplying gate. We used Raspberry Pi 3 microcomputer which has latest technology with very fast processing power. It also has wireless communication feature. The Raspberry Pi goes through each IP listed in it, requests for data, then it receives the data and processes them. The Raspberry pi is set in the water tank connected with a water level sensor, which prompts the GSM shield if necessary. Our system uses a GSM shield to connect to the internet and communicate with the administrator through SMS service. It has a SIM card slot and through SIM it uses mobile operator's GSM and GPRS service. The GSM shield uses GPRS to connect to the internet and find weather forecast. The weather forecast information helps to take precaution in determining the proper quantity of water. With all the received data, the raspberry pi computer makes the decision whether to supply water or not. If the conditions are met, the raspberry pi commands the relay module to activate the water pump for a specified duration after which the computer commands the relay module to stop the pump. Water is pumped to specific area, not the whole land area. The sensors provide all the data from which quantity of water and which pump to activate can be inferred

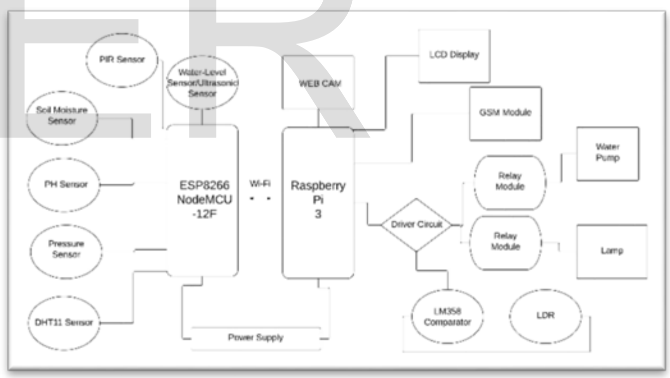

Figure 2 Proposed System Design

The water level sensor located at the water tank provides data from which the remaining amount of water in the tank can be calculated. If remaining water is not sufficient for proper water supply then the computer commands the GSM shield to notify the administrator through SMS about water shortage. Also, several water level sensors are placed on the land to keep track of accumulated water. As some plants are prone to harm if water accumulates around their roots. The whole system will be communicating with each other by a wireless router.

B. Disease Detection

The detection of plant diseases is done through image processing techniques. The images of the plant are captured by a digital camera which is interfaced with the raspberry pi board. Various image processing techniques are applied on the acquired image to obtain the features for further analysis. This method of image processing involves a series of steps. They are:

1) **Image acquisition: -** The RGB images from the plant are acquired by the camera module. The camera is of 21 mega pixels and thus the RGB images are obtained with high clarity.
2) **Conversion of the RGB image into HSV format: -** The RGB images are converted into Hue Saturation Value color space, which is an ideal tool for color perception. The RGB is used as an ideal representation for color generation. Hue is nothing but a color attribute that represents the pure color like the perseverance of the observer. Saturation is described as the representation of the amount of white light added to the Hue of the image or it is referred to relative purity. Value is referred to the amplitude of light. The Hue component is taken into analysis whereas the Saturation and Value components are dropped in the analysis as they do not provide any extra information for analysis.
3) **Green pixel masking: -** Masking is defined as the process of setting the pixel value in an image to zero or any other background value. The pixels that are mostly colored in green are identified from this step.
4) **Removing green pixel masks: -** It is followed by setting the green pixels to zero based on the specified threshold value that is computed for the pixels. The red, green and blue components in the pixel are given a value of zero by RGB component mapping. Here the healthy areas in the leaf are represented through the green colored pixels and so they do not help for identification of diseases.
5) **Segmentation: -** The infected portion of the leaf is extracted and segmented into number of segments that are of equal size.
6) **Obtaining the useful segments from the processed image: -** All the segments do not contain significant information. The segments that have considerable amount of information are chosen for analysis.
7) **Color co-occurrence method: -** The texture features are derived from the statistical distribution of observed combinations of intensities at positions specifically relative to each other in the image.
8) **Evaluate the texture statistics: -** The contrast, local homogeneity, energy, correlation is computed for the hue content of the image. The contrast returns an intensity value between a pixel and its neighbor which is given by

$$Contrast = \sum_{i,j=0}^{n-1} (i,j)^2 C(i,j)$$

Homogeneity is the value of closeness of distribution of elements which is given by

$$\mathbf{Homogeneity} = \sum_{i,j=0}^{n-1} \frac{C(i,j)}{(1+(i-j)^2)}$$

Energy gives the sum of square elements which is given by

$$\boldsymbol{Energy} = \sum_{i,j=0}^{n-1} C(i,j)^2$$

The energy is 1 for a constant image. Correlation is a measure of how a pixel is correlated with its neighbor pixel. It can be found by

$$Correlation = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} \frac{\{i \times j\} \times P(i,j) - \{\mu_x - \mu_y\}}{\sigma_x \times \sigma_y}$$

After performing these series of steps, the Raspberry PI indicates the presence of disease in the plant. The name of the disease along with the control measures is indicated in the output. Further these data are stored in the cloud platform and eventually forwarded to the client.

C. Sensors

1. ESP8266 NodeMCU-12E NodeMCU is the more popular development board for the vastly popular Wi-Fi Internet of thing chip from Espressif, the ESP8266. It uses the Lua scripting language to make it simple to run user programs on the ESP8266 without any recompilation. The board consists of an ESP-12E module, CP2102, and USB connector for power. All the pins of the ESP-12E are brought out on compact and narrow board design to make it breadboard friendly. We can use the nodemcu firmware or the Arduino development environment.

Figure 3 ESP8266 NodeMCU-12-E

2. Soil moisture sensor
Soil moisture sensor is a low cost and user-friendly device, which is used as to detect soil moisture value. Different crops required the different level of moisture so that productivity increases. By using soil moisture value, farmers should know about how much water is present in the farm. Human intervention is not needed. In soil moisture sensor is low

power device operated in 3.3V-5V. soil moisture sensor has both digital and analog outputs

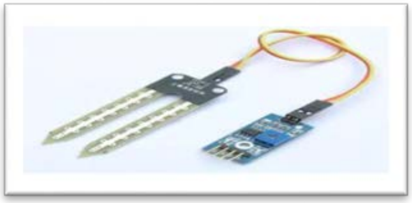

Figure 4 Soil Moisture Sensor

3. Relay

The relay is the switch (turn on and off) which operates electrically or electromagnetically [5]. In this paper, the relay is used for turning on and off the water pump.

Figure 5 Relay Module

4.DHT22

DHT22 is more accurate, low cost and more precise temperature and humidity sensor. DHT22 has an ability to collect digital signal with humidity and temperature sensing technology. This sensor consumes less power and produces output reliable and stable.

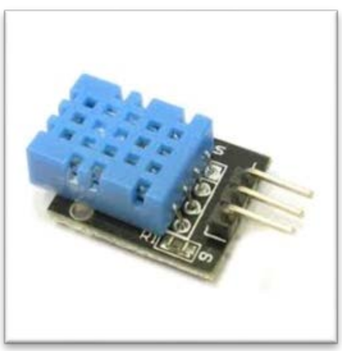

Figure 6 DHT22 Sensor

5.PIR SENSOR

It is a Passive Infrared sensor which detects the motion with the variation of Infrared radiation. It can cover up to 10 meters at an angle of ±15 degrees. PIR is as same as outdoor light with the motion detector and reacts to movements made by objects that radiate heat.

Figure 7 PIR Sensor

6. PH SENSOR

PH is the measure of acidity or alkalinity of water solution which is determined by the relative number of hydrogen (H+) or hydroxyl (OH-) ions present. The pH value (below 7) is said to be acidic and (above 7) is said to be basic. The PH of a solution can changes with temperature respectively.

Figure 8 PH Sensor

7.PRESSURE SENSOR

The differential Pressure transmitter is used for measuring trace of differential pressure, PCB will transduce it to differential pressure signal thereby it can be used for weather forecasting.

Figure 9 Pressure Sensor

D. Diseases

Leaf miners are the insect family at larval stage. They feed between upper and lower part of the leaf. Due to insect on very much amount in plant, it is severely damaged. On a single leaf the number of maggots can be six. Therefore, it can severely damage the leaf of plant. It can restrict plant growth, leads to reduced yields.

Figure 10 Yellow Spot Disease

Hence, we can develop a technique using image processing to detect the disease, to classify it. This will avoid human interference and hence lead to précised unprejudiced decision. Generally, whatever our observation about the disease is just used for the decision of the disease. A symptom of plant disease is a visible effect of disease on the plant. Symptoms can be change in color, change in the shape or functional changes of the plant as per its response to the pathogens, insects etc. Leaf wilting is a characteristic symptom of verticillium wilt. It is caused due to the fungal plant pathogens V. dahlia and Verticillium alabastrum. General common bacterial disease symptoms are brown, necrotic lesions which gets surrounded by a bright light-yellow halo at the edge of the leaf of the plant or at inner part of the leaf on the bean plants. You are not actually seeing the disease pathogen, but rather a symptom that is being caused by the pathogen.

Figure 11 Leaf Miner Disease

IV. Methodology

In this propounded system, we used two types of microcontrollers- Raspberry Pi 3 and nodeMCU. Code written for the nodeMCU imported in every nodeMCU with specific IPaddresses. The analog reading of the sensors is passed to their respective nodeMCUs and then the analog data is converted to digital data for the further data transmission to the Raspberry pi. Python programming language has been used for processing the commands at Raspberry pi that retrieves the sensor reading from nodeMCU. By analyzing these values, Raspberry pi 3 will turn the relay module on or off. The nodeMCU is the micro-controller that will be acting as Server in the proposed system. The Raspberry Pi 3, which is the main controller client in the proposed system has 1.2Ghz 64-bit quad-core ARMv8 CPU, 1GB ram, 4 USB ports, a built in Ethernet port and 40 GPIO pins which can read and write digital data. We have used Raspberry Pi 3, because it has built in wireless module which has 802.11n wireless LAN and Bluetooth 4.1 with BLE feature by which we can transmit the data through the WiFi module. For implementing the system, FC-28 soil moisture sensor module has been used that senses moisture in soil and writes an analog data on the nodeMCU. It has two output ports named A0 and D0. A0 gives an analog output which alters according to the moisture of soil. D0 supplies a digital output which is 1 if there is moisture in the soil or otherwise shows an output 0. A Water Level Sensor has been used to measure the water level in the field and in the water tank that will be connected to the nodeMCU. It possesses 3 pins which are- VCC, GND and Signal. The signal pin transmits analog signals whenever it is powered up. The sensor acts when the level of water level rises or decreases. Only 5v and less than 20mA are needed to operate this sensor. For detecting PH, PH sensor is used, it is capable of sending analog data to nodeMCU according to the PH level of soil. For detecting Pressure, pressure sensor is used, it is capable of sending analog data to nodeMCU according to the pressure of atmosphere. For detecting an Intruder, PIR sensor is used, it is capable of sending analog data to nodeMCU according to the infrared detection. For detecting daylight, Photo Cell has been used that reacts to light. It is capable of sending analog data to nodeMCU according to the intensity of light falls on it. The Arduino GSM Module has SIM 808 chip in it, which can send notification via SMS to cell phones during the shortage of water in water storage. A single channel relay is needed to make a connection with the Raspberry Pi 3, which will trigger the water pump during the shortage of water in the field. Several servo motors will be used to serve water in the right path when there is a shortage of water. A Wireless Router is used to let Raspberry Pi 3 to communicate with nodeMCU. To Detect a disease in plant, webcam sends photos to raspberry pi and it analyzes it using an algorithm and warns the admin about the diseases and remedies to cure them

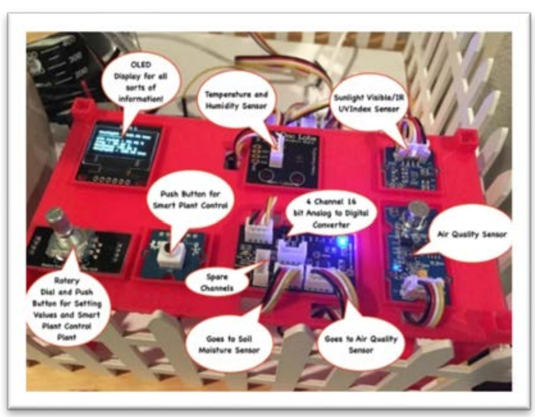

Figure 12 Circuit Connections of The System

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ALGORITHM FOR DISEASE DETECTION

1. The image is captured using the 21 megapixel camera module.
2. The captured image is pre-processed in the Raspberry PI zero board using Image processing techniques that were discussed above.
3. The image analysis is done by following steps:

- Two images are compared and the mean square error between the images is calculated.
- The main condition is that the two images must have the same dimension.
- Minimize the errors until the two images become similar.
- The structural similarity is also calculated between the images.
- The lower range and the upper range color are assigned to the variable.
- Then the image is converted into binary gray for corner detection.
- Assign the binary gray to 32-bit floating point.
- Assign the length of the dots.
- Corner color is assigned to red BGR.
- Find the significant color in the image.
- Merge the masked image using AND operation.
- The images are converted into Gray scale.

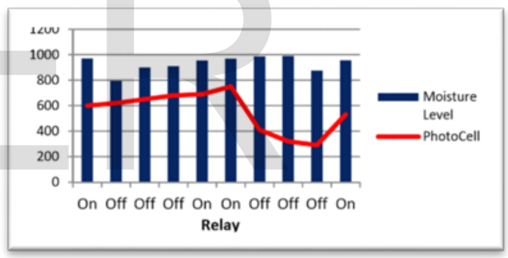
4. The command window displays the output of the processed image indicating the name of the disease along with the control measures.
5. The data about the plant disease is pushed into the cloud platform.
6. The results can be viewed in the mobile or any other display devices like projector, monitor or tablet.
7. The above actions are performed again in the same manner for the detection of any other disease.

V. RESULT

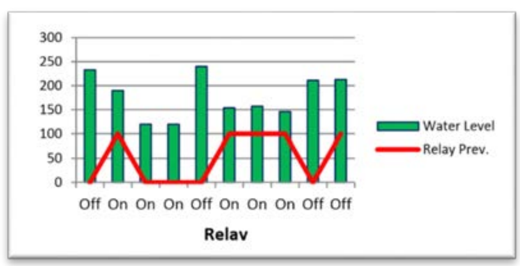
After assembling our system, the reading of the sensors has been checked. We have tested the system response in different situations. The interfacing of Raspberry Pi with NodeMCU, sensors, relay and motor pump is shown in fig. 12 and readings of sensor values and water pump status in different situations are displayed in fig. 13 .

Figure 13 Sensor values and water Pump status displaying in LED

We have plotted our data considering different moisture values and photo sensor values during high photocell value which is shown in Graph 1. In the figure, X-axis resembles relay state and y-axis pointed the value of the moisture and photo sensor. Again, we have blocked in our data considering different water level values and previous relay state in Graph 2. We have taken relay state in X-axis and y-axis indicated the value of the water level and previous relay state. Here, we have considered the on state of the relay as 100 for better understanding of the graph.



Graph 1 Change of relay state envisaging soil moisture and photo sensor values in case of photocell value is high.



Graph 2 Change of relay state considering water level and previous relay state.

For the disease's detection, leaves of powdery mildew, downy mildew, black rot is selected. The database of healthy leaves and diseased leaves is created at the server. This is necessary to compare the images with diseased and healthy leaves. Hence, by comparison, the disease type is classified. Figure 15, figure 16,figure 17 shows the expected output which mainly includes segmented image, grayscale image, feature extracted image of the fig 14.

Figure 14 Downy mildew

Figure 15 segmented image

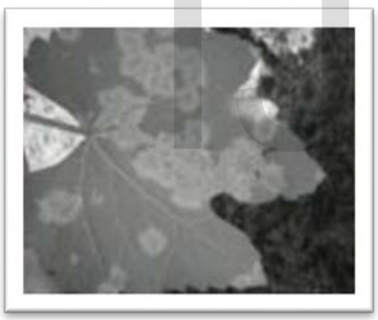


Figure 16 Grayscale image

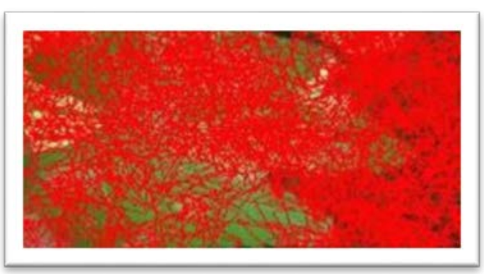


Figure 17 Feature extracted image

VI. Conclusion

Basically, there are three main types of Leaf disease, they are Bacterial, Fungal and Viral. It is important in plant disease detection to have the accuracy in the plant disease detection but at the same time the process should be of high speed. Work can be extended by the use of quad copter for the capturing of images of leaves of the different plants in the farm at field level.

The automatic water enduing method described in this paper can ensure a systematic and scientific approach in taking care of plants which can dramatically improve productivity. Such a system can easily be made, and it is not very costly. With the improvement of sensor technology, the system will become more efficient and useful. For instance, a more accurate weather forecast can help better decision making in supplying water and reducing water wastage. If soil nutrition measuring instrument can be installed, then the system can be re-engineered to make it able to supply fertilizer to the land precisely. One more important benefit of this system is that it gives the name of the pesticide required to use to prevent the disease from spreading. It is providing exact name of pesticide as per the disease, to save labor price by eliminating need of labor for regular observation of plants to check whether it is affected by any disease or not. To conclude, the system will help utilizing water resource wisely and reducing the human effort in maintaining crops which will consequently decrease damage from human errors.

Figure 18 UI of the Mobile APP

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