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Plant Disease Detection using IoT

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Abstract:
In this paper an automated system has been developed to determine whether the plant is normal or diseased. The normal growth of the plants, yield and quality of agricultural products is seriously affected by plant disease. This paper attempts to develop an automated system that detects the presence of disease in the plants. An automated disease detection system is developed using sensors like temperature, humidity and colour based on variation in plant leaf health condition. The values based on temperature, humidity and colour parameters are used to identify presence of plant disease.

1. INTRODUCTION

India is a land of agriculture. Two-third of population relies upon agriculture for their livelihood. It is the basic foundation of economic development of the country. The agriculture also provides employment opportunities to very large percentage of population.

Plant health condition plays a vital role to earn good profit for the farmers. Proper monitoring of plant health is required at different stages of plant growth in order to prevent disease affecting plants. Existence of pests and disease affect the estimation of crop cultivation and minimizes crop yield substantially. Present day system depends on naked eye observation which is a time consuming process. Automatic detection of plant disease can be adopted to detect plant disease at early stages. Various disease management strategies have been used by farmers at regular intervals in order to prevent plant diseases. Some of the sample images of disease affecting plant leaves are shown in the Figure.1.

Figure.1: Disease affecting on plant leaves

The Internet of Things (IoT) is the connectivity of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network which allow these things to attach and interchange data, generating opportunities for more direct merging of the physical world into computer-based systems, resulting in reduced human intervention. By the year 2050 the global population is set to reach 9.6 billion. So, to nourish this much population, the farming industry must adopt IoT technology. The demand for more food has to be met against the challenges such as intense weather conditions and exhaustive farming practices. Smart farming based on IoT technologies enhances crop production in farming industry.

Detection of diseases in the plant is utmost need for farmers and agricultural experts. The main aim of the proposed system is to detect plant diseases using IoT. In most of the plants the disease inception takes place on plant leaves. Hence, in the proposed work we have considered detection of plant disease present on leaves. The discrimination of normal and affected plant leaf can be measured based on variation in temperature, humidity and colour.

The following papers have been cited during the literature survey to understand the different applications of computer systems in allied areas of the present work carried out. (Mark Seelye et al., 2011) have presented low cost colour sensors for monitoring plant growth in a laboratory. An automated system for measuring plant leaf colour is developed to check plant health status. (Sushma R. Huddar et al., 2012) have presented novel algorithm for segmentation and automatic identification of pests on plants using image processing. The proposed methodology involves reduced computational complexity and aims at pest detection not only in a greenhouse environment but also in a farm environment as well. The whitefly, a bio-aggressor which poses a threat to a multitude of crops, was chosen as the pest of interest in this paper. The algorithm was tested for several whiteflies affecting different leaves and an accuracy of 96% of whitefly detection was achieved. (Murali Krishnan and Jabert.G, 2013) have presented pest control in agricultural plantations using image processing techniques in MATLAB. Images are then subjected to pre-processing, transformation and clustering. (Prof. S. G. Galande, et al., 2015) have presented IoT Implementation for wireless monitoring of agricultural parameters. Wireless system is developed to monitor environmental conditions in agriculture field like temperature, soil pH, soil wet level and humidness beside leaf diseases detection. (Yun Shi et al., 2015) have presented IoT application to monitoring plant diseases and insect pests. IoT technology to percept information, and the role of the IOT technology in agricultural disease and insect pest control, which includes agricultural disease and insect pest monitoring system, collecting disease and insect pest information using sensor nodes, data processing and mining, etc have been described in this paper. (Nimish Gopal, 2016) have presented micro-controller based auto-irrigation and pest detection using image processing. The technique of image analysis is extensively applied to agriculture science to provide maximum protection to crops which can ultimately lead to better crop management and production. (S. Gavaskar and A. Sumithra, 2017) have presented design and development of pest monitoring system for implementing precision agriculture using IoT. India's most of the farmer grow sugarcane but did not get yielding due to bugs and larvae in sugarcane. In this proposed design system used arduino for monitoring the noise and temperature. (Sai Vivek et al., 2017) have presented arduino based pest control using real time environmental monitoring sensors. This paper strives to develop a robot capable of performing operation of dispensing pest control agents, obstacle avoidance for self-guidance on the field without any user interference and create a sterile environment for the optimum growth of the crops in a real time monitored closed environment. (Oliver Schmittmann et al., 2017) have presented a true-color sensor and suitable evaluation algorithm for plant recognition. The system developed is based on free cascadable and programmable true-colour sensors for real-time recognition and identification of individual weed and crop plants using mathematical algorithms and decision models. (Zhang Chuanlei et al., 2017) have presented apple leaf disease identification using genetic algorithm and correlation based feature selection method. A color transformation structure for the input RGB (Red, Green and Blue) image was designed firstly and then RGB model was converted to HSI (Hue, Saturation and Intensity), YUV and gray models. The background was removed and then the disease spot image was segmented with region growing algorithm (RGA). Finally, the diseases were recognized by SVM classifier. (K.Lakshmi and S.Gayatri, 2017) have presented implementation of IoT with image processing in plant growth monitoring system. This work combines image processing and IoT to monitor the plant and to collect the environmental factors such as humidity and temperature.

Plant diseases seriously affect the normal growth of plants, the yield and quality of agricultural products. In recent years, with the dramatic changes in climate, the natural environment of the plant growth has been damaged by pollution, frequent natural disasters, as well as the development of agricultural production. From the literature survey presented above, it is observed that the work on plant disease detection using IoT reported in the literature is scarce. In the present work, this issue is addressed using sensor based technology. This being the motivation, the problem entitled "Leaf Disease Detection using IoT is proposed to assist the farmers technologically. In the proposed work, focus has been on early detection of disease infection on plant leaves.

The paper is organized into four sections. Section.1 gives the proposed methodology. Section 3 describes results and discussions. Section 4 gives conclusions of the work.

2. PROPOSED METHODOLOGY

The proposed system consists of temperature, humidity, and color sensors for collecting data from plant leaves based on variation in temperature, humidity and color of plant leaves. The data collected from the leaves consists of current environmental factors like temperature, humidity and color. The changes that a plant undergoes are captured by the temperature humidity and color sensors and analyzed with the Arduino software. The data collected from temperature, humidity and color sensors are given to Arduino UNO kit from which the information is communicated to the farmers. The system makes use of WiFi shield in order to send the data from the host system to the cloud platform for analysis. The cloud platform that we have used is the www.thingspeak.com. The collected data in the cloud platform is then compared with the dataset in order to detect whether the leaf under consideration is normal or affected. The Figure.2 shows schematic diagram of the proposed work.

- Data acquisition: Here we take samples of different leaves as the input. These leaves are then sensed by the sensors to determine different parameters based on which it is recognized to be healthy or diseased.
- Temperature sensors: The DHT11 is a basic, ultra low-cost digital temperature sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). We use the DHT11 to sense the temperature on the surface of leaf to determine whether it is healthy or diseased.
- Humidity sensor: The DHT11 is a basic, ultra low-cost digital humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). We use the DHT11 to sense the humidity on the surface of leaf to determine whether it is healthy or diseased.
- Colour Sensor: The TCS3200 is a programmable color light-to-frequency converter/sensor. The sensor is a single monolithic CMOS integrated circuit that combines a configurable silicon photodiode and a current-to-frequency converter. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance). We use the DHT11 to sense the colour of leaf to determine whether it is healthy or diseased.
- Aurdino: The Arduino UNO is a widely used open-source microcontroller board based on the ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.[1] The board features 14 Digital pins and 6 Analog pins. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9 volt battery, though it accepts voltages between 7 and 20 volts.Here we are using the Arduino in order to process the data that is being collected from the sensor through the Arduino IDE.
- Cloud platform: Here we make use of "ThingSpeak" cloud platform to send the sensed data to the cloud. This data sent is plotted against the graph to view the change in the temperature, humidity and the colour. Depending on the data that is plotted against the graph we see if the values fall into the same range. If they do so then the leaf is healthy or else it is diseased.

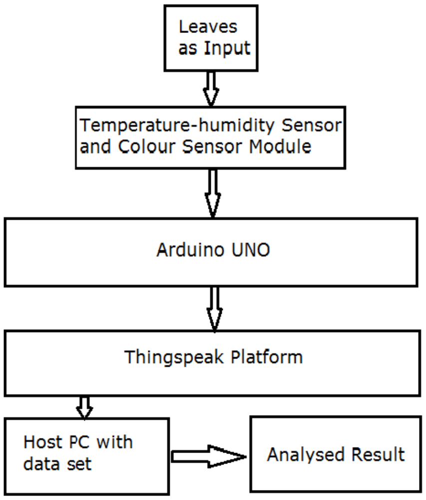

Figure .2: Proposed Work

2.1 Identification of Plant Disease Using Temperature Sensor

The pigments in leaves are responsible for the vivid colour changes in the fall. Temperature, sunlight and soil moisture all play a role in how the leaves will look in the fall. Abundant sunlight and low temperatures after the abscission layer forms cause the chlorophyll to be destroyed more rapidly. We have used DHT11 temperature sensor. The DHT11 sensor senses the temperature of the leaf under consideration. The parameters that are collected from the sensor are sent to the cloud platform through the wifi shield connected to the Arduino UNO board. The data which is recorded for analysis in the cloud platform. We initially record the range of the temperature of a healthy leaf. Later, if the temperature of the leaf under consideration does not fall into that range, then the leaf is said to be diseased. We have considered samples of both normal and affected leaves.

The Concept of identification of plant disease on plant leaves using temperature sensors is given in Algorithm .1.

Algorithm .1: Identification of plant disease using temperature sensor
Input: Normal and diseased plant leaf
Output: Normal or diseased plant leaf
Description: Given temperature range for the leaf to be healthy is 15-30^{0}C

Start
Step 1: Obtain leaf sample for data acquisition.
Step 2: Sense the temperature of the leaf using the DHT11 sensor.
Step 3: Compute temperature of the leaf
if (min temperature < temperature< max temperature)
Display "Leaf is Normal"
else
Display "Leaf is Diseased"
Step 4: Display the output.
Stop

2.2 Identification of Plant Disease Using Humidity Sensor

As plants transpire, the humidity around saturates leaves with water vapour. When relative humidity levels are too high or there is a lack of air circulation, a plant cannot make water evaporate (part of the transpiration process) or draw nutrients from the soil. When this occurs for a prolonged period, a plant eventually rots. When surrounded by warm temperatures in low relative humidity levels, transpiration rates in a plant increase, reducing the need for a grower to fertilize it.

We have used DHT11 humidity sensor. The parameters that are collected from the sensor are sent to the cloud platform through the wifi shield connected to the Arduino UNO board. The data which is recorded for analysis in the cloud platform. We have considered samples of both normal and affected leaves. The concept of identification of plant disease on plant leaves using Humidity sensor is given in Algorithm .2.

Algorithm.2: Identification of plant disease using humidity sensor
Input: Normal and diseased plant leaf
Output: Normal or diseased plant leaf
Description: Given humidity range for the leaf to be healthy is 30-50$^{\%}$

Step 1: Start

Step 2: Obtain leaf sample for data acquisition

Step 3: Sense the humidity of the leaf using the DHT11 sensor.

Step 4: if (min humidity < humidity< max humidity)
Display "Leaf is Normal"
else
Display "Leaf is Diseased"
Step 5: Display the output.

Step 6: Stop

2.3 Identification of Plant Disease Using Color Sensor

Changes in the color of plant tissue are a common symptom of plant disease. Often these color changes are brought about by the yellowing of normal green tissue due to the destruction of chlorophyll or a failure to form chlorophyll. Such repression of leaf color may be complete or partial. The color sensor senses the color of the leaf under consideration which is another parameter that is being used to determine whether the leaf is either diseased or healthy. The sensor records values for, "RED", "Green" and "Blue" value of the leaf. We have used TCS3200 RGB color sensor. The color values that are recorded for the leaf are then sent to the cloud platform by the arduino board for analysis. Later the obtained values of RGB are compared with the threshold value in dataset to determine whether the leaf is healthy or diseased. The concept of identification of plant disease on plant leaves using colour sensor is given in Algorithm .3.

Algorithm 3: Identification of plant disease using coloursensor
Input: Data acquisition
Output: Diseased or Healthy
Description: Given colour range (RGB value) for the leaf to be healthy is 15-30^{0}C

Step 1: Start

Step 2: Input leaf for data acquisition.

Step 3: Sense the colour of the leaf using the DHT11 sensor.

Step 4: if (min RGB value < RGB value< max RGB value)

Display "Leaf is Healthy"
else
Display "Leaf is Diseased"

Step 5: Display the output.

Step 6: Stop

3. RESULTS AND DISCUSSIONS

We have collected 100 sample leaves out of which 50 samples are normal and 50 samples are diseased. The images of the leaves collected are presented in the report. Initially the standard values of healthy leaves are stored in the database. Then we took the healthy leaves from the samples and tested them in the software to check the system accuracy. The Table.1 gives values obtained using temperature sensor based on which healthy or diseased leaves are identified.

Table .1: Temperature sensor values

Leaf	Minimum Temperature in Degree Celsius	Maximum Temperature in Degree Celsius	Obtained Temperature in Degree Celsius	Healthy Or Diseased
1	20	30	47	Diseased
2	20	35	31	Healthy
3	23	35	49	Diseased
4	22	36	56	Diseased
5	21	35	26	Healthy
6	20	35	59	Diseased
7	22	34	28	Healthy
8	29	35	49	Diseased
9	28	38	28	Healthy
10	20	35	45	Diseased

From the Table.1 it reveals that if the leaves under consideration fall within that range specified, then the leaves are healthy, if not then the leaves are diseased. Thus considering temperature values we infer that all the leaves are diseased in the above table 2.1 as their temperature values do not fall into given range. The Table.2 gives values obtained using humidity sensor based on which healthy or diseased leaves are identified.

Table.2: Humidity sensor values

Leaf	Minimum Humidity value	Maximum Humidity value	Obtained Humidity value	Healthy Or Diseased
1	20	52	26	Healthy
2	31	53	91	Diseased
3	20	63	92	Diseased
4	20	62	25	Healthy
5	22	52	93	Diseased
6	23	52	25	Healthy
7	20	53	92	Diseased
8	21	64	95	Diseased
9	20	55	93	Diseased
10	21	60	91	Diseased

From the Table.2 it reveals that the leaves under consideration fall within that specified range, then the leaves are healthy, if not then the leaves are diseased. Thus considering humidity values we infer that all the leaves are diseased in the above table 3.1 as their humidity values do not fall into given range. The Table.3 gives values obtained using colour sensor based on which healthy or diseased leaves are identified.

Table.3: Color sensor values

Leaf	Minimum Colour value			Maximum Colour value			Obtained Colour value			Healthy or Diseased
	Red	Green	Blue	Red	Green	Blue	Red	Green	Blue	
1	-20	10	20	10	45	40	-16	39	23	Healthy
2	76	94	68	82	119	68	114	115	80	Diseased
3	109	115	91	114	124	97	142	115	80	Diseased
4	125	136	102	131	141	108	142	64	23	Diseased
5	10	20	20	30	50	30	22	34	23	Healthy
6	93	107	87	93	124	91	190	111	85	Diseased
7	82	94	68	87	98	68	109	124	119	Diseased
8	85	100	70	88	130	78	255	136	68	Diseased
9	80	115	102	83	120	105	66	39	57	Diseased

From the Table.3 it reveals that the leaves under consideration fall within that specified range, then the leaves are healthy, if not then the leaves are diseased. Thus considering RGB values we infer that all the leaves are diseased in the above table 4.1 as their RGB values do not fall into given range.

We have collected 100 sample leaves out of which 50 samples are normal and 50 samples are diseased. Initially the standard values of healthy leaves are stored in the database. Then we took the healthy leaves from the samples and tested them in the software to check the system accuracy. We have calculated the system accuracy with the formula of precision given in the Table.4.

Table.4: Performance evaluation

	Actual class (observation)	
Predicted class (expectation)	Tp (true positive) Correctly predicted	fp (false positive) Unexpected predicted

Precision is then defined as:

$$\text{Precision} = \frac{tp}{tp + fp}$$

In our system, we have considered two values from above table for result analysis i.e. tp (true positive) and fp (false positive). In tp, values which are correctly predicted are enlisted and in fp, mis-predicted values are considered. The Table.5, 6 and 7 gives performance accuracy of 86% using temperature sensor, 82% using humidity sensor and 88% using color sensor respectively.

Table.5: Performance result using temperature sensor

Total no. Of Samples available	No. of Samples correctly classified (tp)	No. of samples Misclassified (fp)	Accuracy of system in %
100	86	14	86%

Table.6: Performance result using humidity sensor

Total no. of Samples available	No. of Samples correctly classified (tp)	No. of samples Misclassified (fp)	Accuracy of system in %
100	82	18	82%

Table.7: Performance result using color sensor

Total no. Of Samples available	No. of Samples correctly classified (tp)	No. of samples Misclassified (fp)	Accuracy of system in %
100	88	12	88%

4. CONCLUSION

In this work, a system is developed to determine to the quality of the leaves. The proposed method uses the sensor devices to detect the parameters like temperature, humidity and color of the leaves, which are then compared with the dataset to check whether the collected values falls in to the range specified in the dataset. The proposed model can be used in different areas by farmers, industrialists, botanists, food engineers and physicians. The avenues for further work in this area is the pointto use the image processing techniques along with the proposed system to make it more efficient and also accurate to determine the values and to define whether the leaves are diseased or healthy. To build an extended version ofthesystem, we can use the image processing technique that detect the kind of the disease the leaf is affected with and classifies the different diseases among the leaves. Here we can build an automated system so that it is useful for the large scale production and also helps in early detection of the diseases that helps the clients for the better performance and enhances the crop yield.

The proposed system is limited to only detect whether the leaf under consideration is healthy or diseased. This can be further carried out for even recognizing the kind of diseases in the leaves and classification of those diseases. We have limited our work to only to the temperature, humidity and color parameters of the leaves. This can be further enhanced by applying other sensors and combining with image processing concepts. The other limitation is that the determined values for the considered parameters are not precise. We have taken the range of values for those parameters and the range may vary based on the climatic conditions.

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