Plant Growth Analysis and Prediction Using VAEA – (Virtual Agri Environmental Analyzer)

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Abstract - *This paper mainly deals with an advancement in performing agricultural practices using technology. Agriculture is the back bone of our country(INDIA). Agriculture plays a crucial role as a source of Livelihood. Nowadays, IoT is a revolutionary technology that represents the future of computing and communications. Hence the system here works on IOT platform with embedded hardware to create a virtual environment mimicking the natural one. VAEA mainly focuses on the water consumption, climate regulation and terrain improvements. The autonomous system here maintains the optimum conditions for plant growth and analysis by monitoring and observing regularly based on collected information and sends the push notifications to the user and visualizes the data accordingly. VAEA acts a virtual testing environment to test whether a plant can sustain a climate by mimicking the environmental conditions present in the designated region. Embedded system designed here uses IOT platform to communicate with Thingspeak where the data is visualized and sends the notifications through Talkback. The system helps farmers, gardeners to know whether their region and resources available are sufficient to grow a crop of their choice and to know the resources needed. VAEA also helps the farmers and gardeners in monitoring the crop and obtaining maximum yield. The system has a built in camera, which captures the plant images. Using image processing algorithms, the growth of the plant is measured. The system also uses a proximity sensor to measure the growth of the plant. By comparing the growth of the plant in initial stage and after a period of 15-20 days, VAEA predicts the conditions for obtaining maximum yield from a crop. VAEA uses machine learning algorithms to predict the maximum yielding conditions based on past data and reference data.*

Key Words: IOT, Machine Learning, Thingspeak, Sensors (Temperature and Soil Moisture sensor, Soil temperature sensor, capacitive soil moisture sensor, Rain sensor), Image Processing, Actuators (Relay, Grow Lights, Fog system), Raspberry Pi.

1. INTRODUCTION

Internet of Things (IOT) represents a general concept for the ability of network devices to sense and collect data from the world around us, and then share that data across the Internet where the data can be processed and utilized for various interesting purposes [1]. Internet of Things is used with IoT frameworks to handle and interact with data. In the system users can add their sensors and can create streams of data. Applications of IoT are Smart Cities, Smart Water, Security and Emergency, Industrial Control, Smart Agriculture, Home Automation, e-Health etc.

'Internet of Things' is a communication between the devices. [2].

Need for Smart Agriculture:

From survey of United Nations – Food and Agriculture Organizations, [http://www.fao.org/news/story/en/item/35571/icode/] the world-wide food production should be increased by 70% in 2050 for the increasing population. Agriculture plays a crucial role as a source of Livelihood. Agriculture is also one of the main factors of countries' economy. There is need to implement modern science and technology in the agriculture for increasing the yield and growth. By using the robots with IOT technology we can expect the increased production with low cost by monitoring the field factors regularly. [3].

The combination of traditional methods, machine learning algorithms and technological methods of IOT can help in determining the conditions for obtaining maximum yield of a crop.

2. SOFTWARE REQUIREMENT:

2.1 Python:

Python is a high level programming language which is used in many devices including pc's, phones and embedded chips such as Raspberry pi. Python can be used for image processing, machine learning, computer vision and Big data analysis.

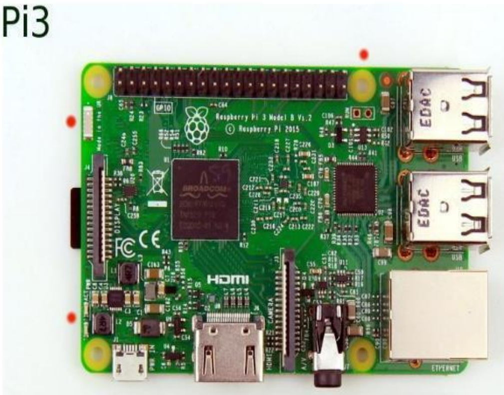
In VAEA, we have used Raspbian OS. The programming is done using python. We have used python as, python's community has built in image processing and machine learning tools.

2.2 Thingspeak:

Thingspeak is an open sources IOT platform built by Math works. The platform uses HTTP protocols to store and retrieve data through the internet. Thingspeak is mainly customized to collect and store data from the sensors used in a system or an application. Analysis will also be done by the Thingspeak platform. The platform uses MATLAB add on tools to analyze the data and predict the future values. After the analysis, thingspeak visualizes the data through a flow chart.

3. HARDWARE REQUIREMENT:

3.1 RASPBERRY PI 3:



Raspberry pi is a single board computer developed by the Raspbian pi Foundation. The board does not include all the peripherals used in a computer. We have used a Raspberry Pi 3 model B in VAEA. This model has a quad core 64-bit ARM cortex A53. The board has clock speed of 1.2GHZ, and a RAM of 1GB of LPDDR2-900 SDRAM.

The board has 4 USB ports. Network connectivity includes 802.11n wireless LAN, Bluetooth 4.0.

PINS:

We have used GPIO pins of the Raspberry pi to connect the sensors present in VAEA. The GPIO pins can be configured to be used as input or output pins. We have used 5volts, 3.3volts pin of the raspberry pi to power up the sensors.

3.2 TEMPERATURE & HUMIDITY SENSOR (DHT 22):

DHT 22 is a sensor which measures the temperature and humidity in the surrounding air using a capacitive humidity sensor and a thermistor.

Specs:

Power supply: 3.3 – 6 volts.

Operating range: 40-80 Celsius.

Sensing period: 2 seconds.

Accuracy: Humidity +-2%RH.

Temperature <+-0.5Celsius.

3.3 SOIL TEMPERATURE (DS18B20):

The DS18B20 is a 1-wire programmable Temperature sensor which is used to measure temperature in hard environments like in chemical solutions, mines or soil. The sensor can be used in liquid temperature measurement also.

Specs:

Operating voltage: 3V to 5V

Temperature Range: -55°C to +125°C

Accuracy: ±0.5°C

Output Resolution: 9-bit to 12-bit(programmable)

Conversion time: 750ms at 12-bit

3.4 CAPACITIVE SOIL MOISTURE SENSOR (SKU: SEN0193):

SKU: SEN0193 is soil moisture sensor which measures soil moisture levels by capacitive sensing. The sensor is made of corrosion resistant material in order to extend the sensor's service life.

The values for different conditions are given below:

Dry: (520 430]

Wet: (430 350]

Water: (350 260]

Specs:

Operating Voltage: 3.3 ~ 5.5 VDC

Output Voltage: 0 ~ 3.0VDC

Operating Current: 5mA

3.5 RAIN SENSOR:

Rain sensor is used to estimate the rainfall.

The rain sensor has a sensor boards with printed leads. The resistance of the sensor board varies depending on the amount of water present on the lead circuit. The wetter the board the more current that will be conducted so that the rainfall can be estimated.

Pins:

A0.......... Analog output

D0......... Digital output

GND..... Ground

VCC...... input: 5v for analog and 3.3v for Digital.

Dimensions:

5.5 cm x 4.0 cm x 0.8 cm.

3.6 RELAYS:

Relays acts as a switch that opens and closes circuits electromechanically or electronically. A relay is generally used to control a high powered circuit using a low power input signal. In a relay, a DC signal is used to control the circuit which is driven by high voltage like controlling AC home appliances with DC input signals from microcontrollers.

Specs:

Trigger Voltage (Voltage across coil): 5V DC

Trigger Current (Nominal current): 70mA

Maximum AC load current: 10A @ 250/125V AC.

Maximum DC load current: 10A @ 30/28V DC.

Operating time: 10msec Release time: 5msec

Maximum switching: 300 operating/minute

3.7 GROW LIGHTS:

Grow lights acts as a source of artificial sunlight. Grow lights consists of LED's, which emit light of similar wavelengths to that of a sunlight. In a closed environment like VAEA, there will be a scarcity of sunlight. In order to overcome this problem, grow lights are used. The key aspects of grow lights are light intensity, duration of light and color of light. The values of these key aspects changes from plant to plant. Most of the plants require blue and red radiations for their metabolism.

As the number of plants increases, the number of grow lights also need to be increased.

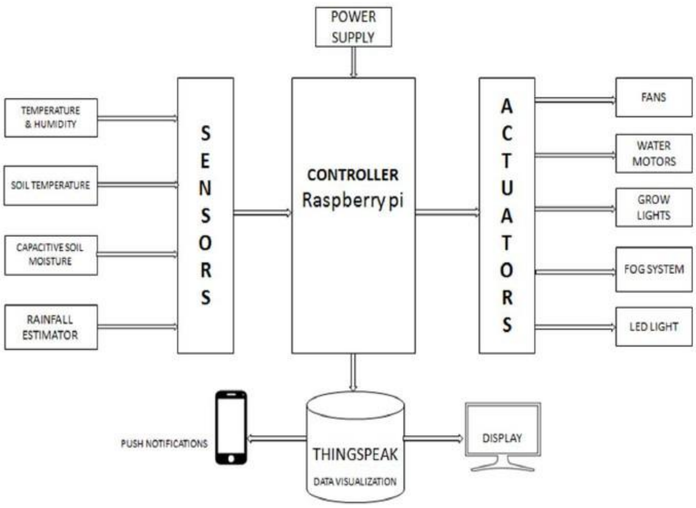
Courtesy: https://www.gardenandharvest.com/growing-accessories/understanding-hid-mhhps-grow-lights-lighting-buyers-guide/

3.8 FOG SYSTEM:

Fog system is used to mimic the cold climate present in hilly areas. A mistifier is used to create fog in VAEA. Mistifier is submerged into a water container. The mistifier produces the fog by oscillating the capillary tube present inside. The mistifier is also used for creating/changing the moisture level in the soil layers. Mistifier helps in the control of layered soil temperature.

4. PROPOSED METHOD:

4.1 BLOCK DIAGRAM:



4.2 METHOD OF IMPLEMENTATION:

To prepare this arrangement, a popular open source IOT device known as Raspberry Pi MCU is used. The board has multipurpose digital GPIOs along with special purpose pins. The board comes with an in-built Wi-Fi module. This Wi-Fi module connects to IOT cloud using internet. The power supply of 5v 1.5 Amps is given through a power bank [4]. The relays connected to the controller are powered through AC source. Since the sensors used here are analog type, hence an ADC MCP3208 is used as the Raspberry pi does not have any special analog pins. As the actuators like water motors, grow lights need AC source, they are interfaced using relays.

Temperature and Humidity sensor (DHT 22) senses the environmental conditions and sends to the controller. Similarly, the soil conditions are monitored by the soil moisture and soil moisture sensors.

Whenever the temperature and humidity reach a threshold value, automatically the fans will turn on. Based on the values of the soil moisture the water will be poured on the plants using the water motor connected. Alternative for the sunlight grow lights are used which provide the necessary radiation for the plants growth and enrichment. Fog system is used to cool the soil level region and to moist the surface.

In the background, the controller sends the collected data from the sensors to Thingspeak cloud where the data visualizations will be done. Thingspeak has a feature to send the notifications using Thingshttp, whenever the threshold values are reached. A display device is used to display all the graphs of data visualizations. The collected data is then analyzed using Linear Regression model [8]. Thus the data will be analyzed to predict the conditions for obtaining maximum crop from a crop.

5. RESULTS:

DESIGNED SYSTEM: **Figure 5.1:**

The surrounding mesh acts as a layer in isolating the inside environment of the system to the outdoor environment. A plastic cover can also be used as an alternative.

SYSTEM WORKING:

Figure 5.2 shows the simulation of VAEA system. The pink effect is due to the switching on of the grow lights. The grow lights mimic the natural sunlight.

Figure 5.2:

DISPLAY DEVICE:

Temperature:

Figure 5.3:

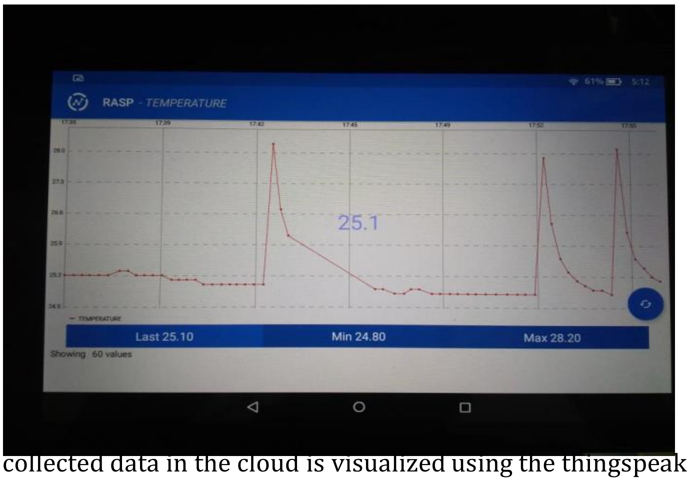


Figure 5.3, 5.4 shows how the collected data in the cloud is visualized using the thingspeak platform. The X-axis shows the time intervals while the Y-axis shows the value range. Image 3 shows the line chart of temperature and image 4 shows the line chart of soil moisture.

Soil Moisture:

Figure 5.4:

NOTIFICATIONS:

Figure 5.5:

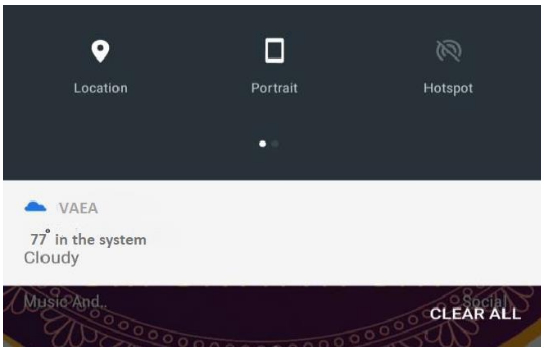


Figure 5.5 shows the notification sent from the VAEA to the user's smartphone.

6. CONCLUSION AND FUTURE SCOPE:

'Internet if Things (IOT)' is a technology which can be used to collect data from different sensors and devices. Monitoring of sensors and devices reduces human power. This system uses Machine learning algorithms to predict the optimum condition for maximum yield of a crop. Therefore, IOT increases reliability, accuracy and efficiency. IOT platform is a onetime investment with easy maintenance and consumes less power. This smart agriculture system has been designed and synthesized in a prototype stage. The developed system is more efficient and beneficial for farmers once the VAEA is built completely.

With the development of IOT platforms and Machine learning algorithms, VAEA efficiency and accuracy can be greatly increased. Currently this system can be used for small plants such as chili plants and tomato plants. By little advancements and modifications this system can be used for all types of crop. The system can be used for green house and temperature dependent plants in horticulture farms. The application of such system in the field will help in advancing the yield of the crops and global production. In future this system can be improved by adding several modern techniques like, solar power source usage and camera integration for pest detection.

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