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Original Article

Greenhouse Farming using IOT

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Abstract *- The Internet of Things consists of objects that have distinctive identities and connected to each other via the web. In other words, monitoring of numerous devices and sensors through the internet. This paper describes the application of the IOT to implement an automatic Greenhouse system. The framework uses a Node MCU board as the main device and all the sensors and devices are connected to it. Using this framework, monitoring of parameters such as pH, temperature, humidity and soil moisture can be done. Here we have created a framework which will gather data by observant periodic conditions of above mentioned parameters. All these activities are a unit and controlled by Arduino uno and Thingspeak.*

Keywords *- Arduino software, Breadboard, DHT11 Temperature and Humidity, Greenhouse using IOT, Node MCU, Soil moisture, Thingspeak.*

I. INTRODUCTION

Internet of Things is the hardware setting/system with various physical devices connected to each other. Through sensors, tools and software systems we are able to manage and monitor the functionalities of the system. The devices can be connected to internet through the wired as well as wired-less technology. IOT deals with massive quantities of information received from different sensors that are deployed within the framework in which maintaining, securing and storing collected data can be done. The applications for IoT devices are commonly divided into shopper, commercial, industrial, and infrastructure areas, and even have a big list of applications in farming. The data collected may be used to analyse the data and automate the farming to boost quality and quantity of the crop and to minimize risk of crop loss due to weather conditions, environmental conditions and pests and efforts are needed to improve the productive of agriculture.

A greenhouse is designed for the protection of plants against different climatic conditions. Greenhouse helps in providing a controlled setting to obtain high-value crops like medicative plants, flowers, etc. Greenhouse technology is that the technique of providing favourable conditions for the expansion of the plants. We can customize Greenhouse to obtain favourable conditions that are required for the growth of a particular plant. By considering all the strategies and techniques, a farmer can be able to read the data of his field through GSM technology (Connected to cloud storage) and get a better yield of the crop.

II. LITERATURE SURVEY

Monitoring the readings and constantly modifying the nutrients and light source is mentioned in this work [1]. Without the manual inspection and providing plants with adequate resources from time to time by automating it through IoT based smart greenhouse farming is mentioned [2]. In this, author focuses on Automation which requires a certain amount of threshold to be set and must be activated when it is crossed [3]. Implementation of gateways can be obtained by MCU and IC is proposed in this work [4]. One of the application such as Home automation for small plants and trees is implemented in this work [5]. In this work conserving water which is a major part for deployment and controlling the environment of greenhouse, is explained in detail [6]. The author describes power consumption of these devices and circuits which is also an issue that needs to be monitored so that no disruption of power can cause any problems in the result [7]. This paper describes the measurement of values/outcome for optimum growth and yield [8]. Description of over drain measurements of greenhouse horticulture and increasing the accuracy and enhancing the durability is proposed in this journal [9]. The author talks about controlling the temperature if it reaches the extreme climatic conditions and taking counter measures [10]. This author talks about data communication mechanisms and an agent based IoT System [11]. The tracking and record keeping of the seedlings from germination to growth stages and provides a traceability model was proposed here [12]. Based on the model the author tracks the variables such as luminosity, humidity, temperature, and water consumption. The author has given brief description of the challenges faced in greenhouse farming [13]. The author has given their vision of IOT enabled greenhouse and explains the system structure and mechanism in detail [14]. In this journal, the author has measured greenhouse gas emission from different kinds of soil and temperature [15]. The effect of increasing soil moisture content on the temperature of soil and heat storage is analysed and shown in this journal [16]. From this journal, a wide variety of soil moisture sensors and their application in automatic irrigation is shown [17]. The author has developed a model of humidity within greenhouse and application in the climate management in greenhouse is discussed [18]. 10 different greenhouse species, at certain humidity is examined and the author describes the effect of humidity on these species [19]. The author gives detail description of passive cooling and dehumidification strategy in closed greenhouse environment [20]. The author investigates the influence of different humidity levels of infection for controlling the pests [21]. Cultivation of tomatoes in the region of adverse conditions was experimented by author while monitoring various parameters like light conditions, optimal air temperature, relative humidity, vapor pressure deficit [22]. Effect of humidity on nutrient uptake by 9 different species which were grown for 24-100 days was experimented and analyzed by the author [23]. Predications of gradients such as temperature, humidity and carbon dioxide were developed with respect to time, ventilation rate and was verified by experimenting on pepper plant [24]. The author has analyzed different means of altering pH levels in soil to grow vegetable in greenhouse environment [25].

III. METHODS

A. Proposed System

The climate/weather and fertilizers play a crucial role in plant growth and yield, but the former one can be a source of environmental pollution that could cause imbalance in climate parameters and consequently, it can damage crop growth and nutrients. To accomplish this, we are aiming at the proposition of a greenhouse observation by engaging a setup of IoT based environment. In this study, we have integrated a Node MCU based embedded system with IoT. Through the Embedded System we can measure all the parameters with pre-set threshold values and are capable of decision-making to turn ON /OFF devices to regulate and maintain unstable climate parametric values. Furthermore, the received information from different sensors is transmitted to the internet to monitor the status of devices.

The projected design is immutable and a combination of diverse electronic components to accomplish different tasks i.e., environmental parameter sensing, temperature and humidity, pH, controlling the operation of attached peripherals, soil moisture and monitoring the values. The hardware implementation of Greenhouse farming using IOT is shown in Fig.1.

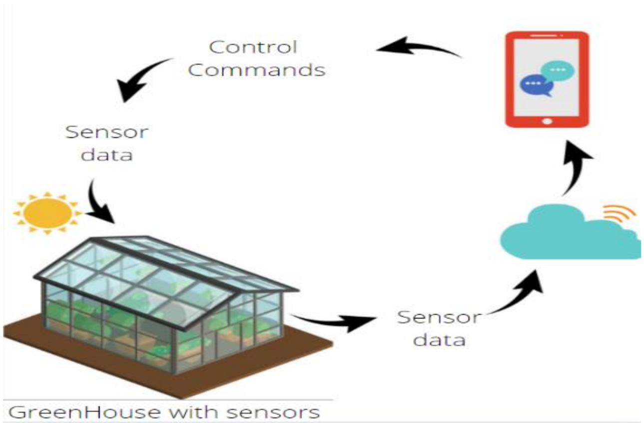


Fig. 1 Hardware implementation of Greenhouse farming using IOT

B. Chi-Square Test

Chi-square distribution provides a measure of correspondence between theoretical frequencies and observed frequencies. It is represented as **$\chi 2$.** It is a statistical hypothesis test which helps us to perform chi-squared distribution under the null hypothesis. Chi-square test helps us to test the goodness of fit of these distributions. We obtain p-value from the chi-square test and this tells us whether the tested results are significant or not. The below equation shows the formula for chi-square test through which we can test the significance of the obtained sensor data. Eq 1 shows the Chi-square formula.

$$\chi^2 = \sum_{i=1}^{N} \frac{(O_i - E_i)^2}{E_i} \qquad \text{......Eq 1}$$

IV. IMPLEMENTATION AND SET UP

A. Node MCU (ESP8266)

Node MCU is an open source IOT platform which is easily accessible and cheap. It includes firmware which runs on the ESP8266 Wi-Fi SOC(System-on-chip). ESP8266 is a SoC that integrates a 32-bit microcontroller, antenna, switches, power amplifier, modules which manage power, and standard digital peripheral interfaces into a small package.

Hardware: ESP-12 module.
Power: Universal Serial Bus.
Performance: 32bit 80MHz Xtensa Tensilica processor.
RAM: 128 KB RAM and 4MB of Flash memory.
Firmware: C/C++ source file.
Number of pins:13(0-12 pins) GPIO (General Purpose input-output). Fig 2 shows set-up of the framework with Node MCU IC.

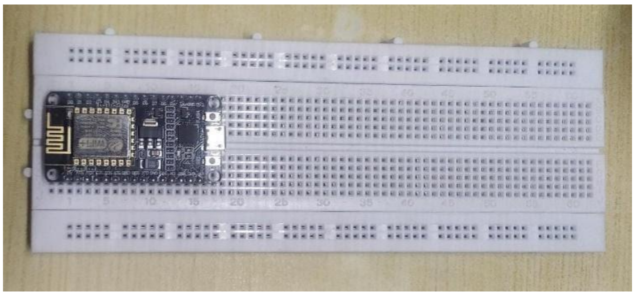


Fig. 2 Node MCU with breadboard

B. DHT-11 sensor

The DHT11 is basically a low-cost digital temperature and humidity sensor which can be connected to the Node MCU. Mainly consisting of a humidity sensor and a thermistor to sense the humidity and temperature. Fig 3 shows the set-up of the framework with DHT 11 sensor.

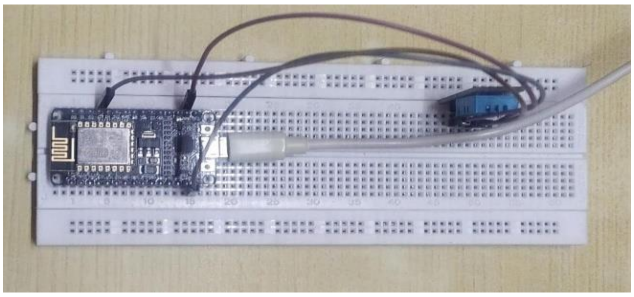


Fig. 3 Experimental setup of IoT based DHT 11 sensor

C. PH Sensor

The main function of the pH sensor is to function as a soil pH meter. They work by measuring the hydrogen ion activity and this is expressed through the potential for hydrogen or 'pH'. The pH scale ranges from 0 – 14. 0 implies extremely acidic, 7 being neutral and 14 being alkaline. Fig 4 shows the set-up of the framework with of pH sensor.

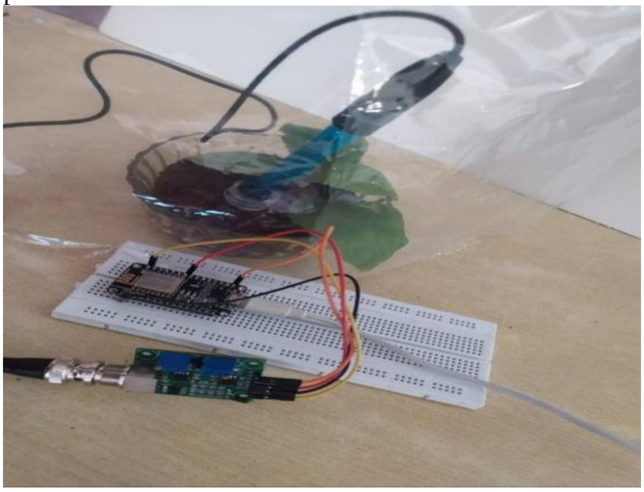


Fig. 4 Experimental setup of IoT based pH sensor

D. Soil Moisture Sensor

Soil moisture sensors measure the volumetric and tensiometric water content in soil. Tensiometric and volumetric are the two primary sensor types that measure soil moisture. Fig 5 shows the implementation of soil moisture sensor.

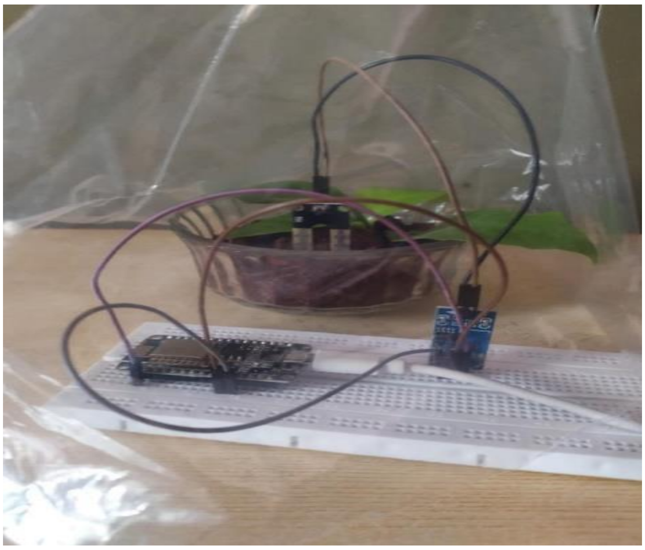


Fig. 5 Experimental setup of IoT based Soil Moisture sensor

E. Arduino Uno application

This environment is basically written in Java and is based on Processing and other open-source software. Arduino is responsible for creating interfaces for user interaction by providing a dashboard on which the user works.

F. Thingspeak

ThingSpeak is an open-source software which allows users to communicate with internet connected devices and visualize the data with the help of applications and social networking sites.

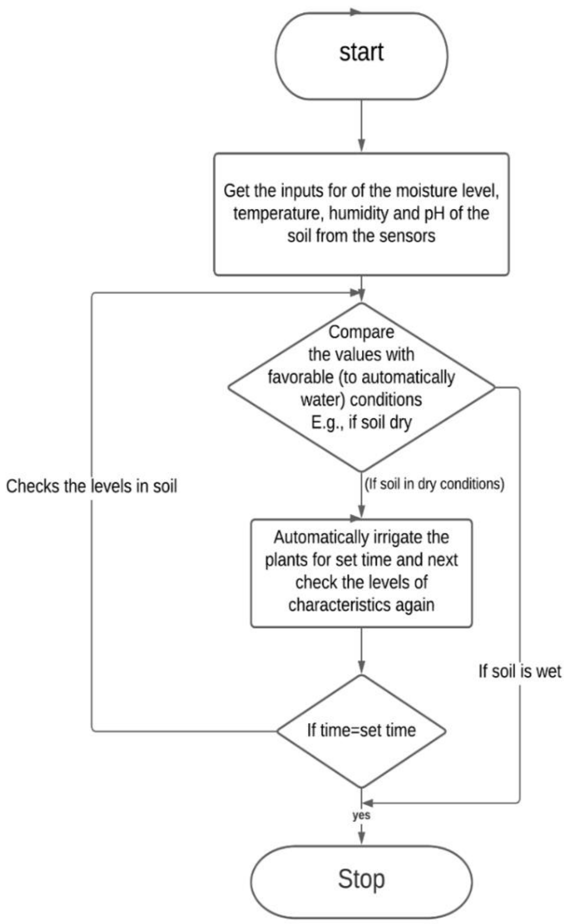
G. Other Components

Implementing USB in an IoT platform chip helps in transferring the features that should be added to an IoT product by plugging in a USB peripheral. A breadboard is a device which is used for prototyping for electronic devices and circuit design. To make it easy to change the circuit we make use of jumper wires for breadboards, other electronic components and tools.

V. RESULT AND ANALYSIS

A. Analysis

The structure of the prescribed working of the embedded system is explicated in the below Flowchart. The circuit is functional and all the sensors initiate sensing and send the data to the embedded system and store it in the database, from the database the values are sent to the electronic device which are connected to the internet. If any of the values are less or greater than the threshold value, the embedded system will detect and send a control signal towards the sensors and indicate the module to switch ON/OFF the matching appliance so that the imbalance value can be normalized.



Flowchart of the proposed system.

Chi-Square Test

Table 1. Tabulation and calculation of the sensor data through chi-square test.

O_i -T (Temperature (μ=28)	O_i-H (Humidity) (μ=80)	O_i-S (Soil Moisture) (μ=6.5)	O_i-pH (pH)(μ=6)	χ2 (Temperature)	χ2 (Humidity)	χ2 (Soil Moisture)	χ2 (pH)
27.7	75	8.14	5.8	0.0032	0.3125	0.4138	0.0067
28.5	76	9.2	5.8	0.0089	0.2000	1.1254	0.0067
28.2	77	9.32	5.8	0.0014	0.1125	1.2234	0.0067
27.9	76	9.40	5.8	0.0003	0.2000	1.2938	0.0067
27.9	75	9.61	5.8	0.0003	0.3125	1.4880	0.0067
28	76	9.71	5.7	0.0000	0.2000	1.5852	0.015
27.9	75	9.71	5.8	0.0003	0.3125	1.5852	0.0067
27.3	74	9.81	5.7	0.0175	0.4500	1.6855	0.015
27.9	75	9.90	5.8	0.0003	0.3125	1.7785	0.0067
28	76	9.90	5.8	0.0000	0.2000	1.7785	0.0067

Where, O_i -T: Observed value for Temperature sensor
O_i-H: Observed value for Humidity sensor
O_i-S: Observed value for Soil moisture sensor
O_i-pH: Observed value for pH sensor.

Table 2. Comparison of experimental and theoretical values by chi-square test(p-values)

Sensors	Temperature	Humidity	Soil Moisture	pH
Experimental	0.9995	0.3258	0.1239	0.9999
Theoretical	0.8898	0.3201	0.1224	0.9988

Table 3. Comparison of experimental and theoretical values by chi-square test (statical values)

Sensors	Temperature	Humidity	Soil Moisture	pH
Experimental	0.0325	10.3125	13.9530	0.0833
Theoretical	0.0325	10.3112	13.9443	0.0801

We have used the chi square test for the analysis and calculated temperature, humidity, soil moisture and pH and also have calculated statistical values in Table 1 (selective value obtained are used for calculation of chi square test). Comparison of the experimental and theoretical values of p-values and statical values which were obtained by chi-square test is shown in Table 2 and Table 3 respectively. The experimental value and p-value obtained was acceptable and hence we accept the null hypothesis by concluding that "The Temperature, Humidity, Soil moisture and pH of the soil is optimal for the growth of the plant in the Greenhouse".
The above analysis is based on the Custom-blended soil i.e., the mixture of red/loam soil, organic manure and peat soil which is more suitable for the plant growth. The above framework can be implemented for different types of soil suitable for the growth of plants in a greenhouse environment.

B. Result

The graphical representation of the Temperature, Humidity sensor, pH sensor and Soil Moisture sensor respectively in which data are analysed by ThingSpeak are shown in Fig 6,7and 8.

The readings obtained by experimental setup of IOT using sensors are plotted with the help of ThingSpeak. Part of the reading is taken and analysed and calculated using the chi-square test. Theoretical values are obtained by solving it manually and also verifying it through Python using the scipy package.

Fig. 6 Graphical representation of Temperature and Humidity sensor

Fig. 7 Graphical representation of pH sensor

Fig. 8 Graphical representation of Soil moisture sensor

Fig 9 shows us the complete implementation of the framework. This shows us the implementation of the framework inside Greenhouse. This framework is portable as well as detachable and can be implemented in any Greenhouse set up with any suitable soil.

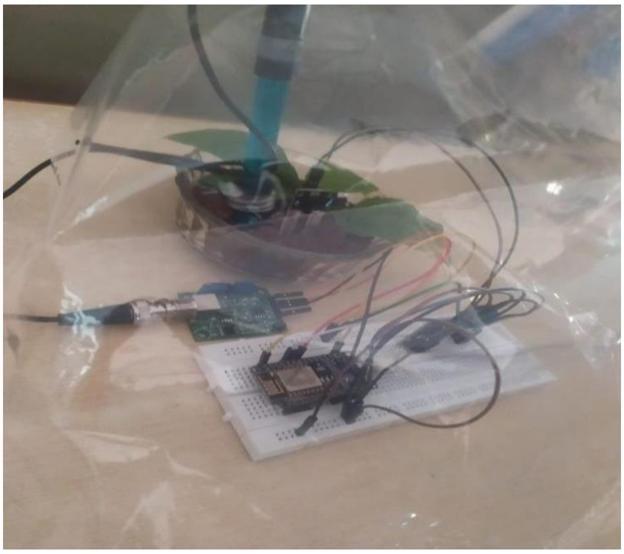


Fig. 9 IOT Framework for Greenhouse

VI. CONCLUSION

The proposed embedded system can be installed in a greenhouse environment to record parameters and data being forwarded to the gateway. The gateway nodes are controlled and this data is sent to the farmers through web browser. Based on the received information, the embedded system gets activated and takes the smart decision. It can be easily implemented at a large scale, for visible growth, good yield and profitability of greenhouse crops.

VII. FUTURE SCOPE

The work can be extended to implement GSM to send an alert using SMS to electronic devices. Other Parameters such as ambient temperature, light intensity & humidity can be measured. Automatic deployment of pesticides and fertilizers into the water can be implemented in future work. A Crop Monitoring System Based on Wireless Sensor Network can be implemented. Implementation of automatic drip irrigation system using data mining algorithm and Wireless sensors/circuits. The same methodology and idea can be implemented using Raspberry pi Integrated Circuit.

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