NIET Journal of Engineering & Technology (NIETJET)
Volume 13, Issue Winter / Summer 2025 ISSN: 2229-5828 (Print)

Sustainable Smart Pot Retrofitting System

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Abstract: *The demand for indoor plants is rising, and more individuals are purchasing indoor plants every day. However, growing indoor plants brings with itself many challenges for individuals since they are tough to care for and may die for unknown reasons. According to the Data Bridge Market Research the market value for indoor plants will see a CAGR (Compound Annual Growth Rate) of 4.87% during the forecast period of 2022-2029. This paper provides a retrofitting fitting technique for smart pots that may be fitted to regular earthen or plastic pots. By doing so, the plant would be able to post updates to its social media pages on things like soil moisture, temperature, and humidity. All of the information will also be mapped on Things Speak and accessible on a web-interface. Due to the fact that it is a retrofit, it may be reused and provides a sustainable solution to the problem of reusability.*

Keywords - Internet of Things (IOT), ThingSpeak, Retrofitting, Sustainable, Smart Pot, Sensor Array.

1. INTRODUCTION

With the advancement of science, researchers addressed the problems in the field of agriculture. Smart farming solutions were explored and research was conducted to integrate various technologies into the field of agriculture. [4] One such attempt was to integrate the newly explored IOT (Internet of Things) in the field of agriculture. From the agricultural perspective, IOT (Internet of Things) makes use of sensors, cameras, and various network connectivity and converts the elements and actions involved in farming, into data. [9] IOT devices are primarily based on a single chip board computer. These boards are powerful enough as to provide the required power, compact shape and a versatile functionality. Real time resource visibility, data driven decision making capacity and an improved user-end experience makes IOT the perfect tool to be used to solve agriculture related problems. [7] The most critical problem after the aggregation of agricultural data is storing the data and not just any data but a bulk of data. This is where technologies like Cloud Computing and Big Data comes at play. The Cloud Computing helps to store the data acquired from the farm over a server located in some faraway place while the Big Data helps to analyse, edit and manage the bulk of data stored. [8]

Apart from farming solutions, these technologies are also very useful for developing devices for gardening and indoor plants. While most of the researches are focusing on farming solutions there are very less studies in the field of smart gardening and indoor plants. This research focuses on how to make a Sustainable Smart Pot System for the indoor plants at a very nominal cost. It also helps to visualize the data acquired on the website and post a tweet based on the analog values that was received from the Sensor Array. The already available smart pot solutions are either very bulky or they are costly and not sustainable hence a problem arises to design a system that has a reduced cost and has a sleek design.

2. LITERATURE SURVEY

Vishaal Baruah researched on Smart Pot prototype soil monitoring system using IOT Technologies. In that paper a basic hardware approach was followed, to design a system using a Micro controller and Soil Moisture Sensor. 'AAA' size batteries were used to supply power. The data was stored on locally hosted ThingSpeak and the visualization of the data was done on the web interface. But what the device lacked was physical security and sustainability. Due to the poor physical design the device could get damaged and it is not a suitable solution for a long run. [3] Research papers in similar context were analyzed and enlisted in Table 1.

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Table 1 Literature survey of different smart agriculture systems

S. No.	STUDY	ADVANTAGES	LIMITATIONS
1.	Agriculture and Agricultural Science Procedia (Year- 2015) DOI: 10.1016/j.aaspro.2015.08.041	In this a system is proposed that allows the farmers to evaluate their potato crops and then make decisions accordingly.	This system focusses only on Potato crops rather than concentrating on a wider range of crops.
2.	Agris On-line Papers in Economics and Informatics VIII (Year- 2016) *DOI:10.7160/aol.2016.080108*	Here the research is based on a wider aspect of how IOT can be used in various agricultural aspects. It defines the types of protocols and networks that can be used to develop a IOT solution for agriculture.	The main concentration is on defining the various aspects of that are suitable for agriculture and does not talk about indoor gardening. IOT can help in the various
3.	Advances in Internet of Things, Vol.7 No.3 (Year- 2017) DOI: 10.4236/ait.2017.73005	In this the data related to the state of the soil is gathered using a 200SS soil Moisture sensor and transmitted to a web interface using radio and Wi-Fi communication.	The system gets costly and hence it is not a very effective solution to the problem.
4.	Proc. IEEE Conference on Emerging Devices and Smart Systems (Year 2017) DOI: 10.1109/ICEDSS.2017.8073690	It mainly focuses about how Big Data and Virtualized Information Database are important in Agriculture.	It talks about the development of IOT in the sector of Agriculture but only on theoretical basis.
5.	(Year- 2018) *DOI:10.5220/0007755801440152*	This IOLT Smart Pot system has an array of sensors placed both above the plant and in the pots to monitor the environment parameters.	Not suitable enough for indoor plants.
6.	International Research Journal of Engineering and Technology (IRJET), Volume: 06, (Year- 2019) e-ISSN: 2395-0056	Automating all the plant nourishment tasks can result in huge work and plant mortality reduction.	The system is bulky and costly.
7.	International Journal of Recent Technology and Engineering (IJRTE) Volume-8 Issue-2S6 (Year- 2019) ISSN:2277-3878,	The system uses the concept of coloured LEDs to show the state of a plant when the owner comes near the plant.	No solution for the existing earthen pots and the state of the soil.
8.	SSRN, International Conference on Innovative Computing & Communications (ICICC) (Year- 2020) DOI: 10.21.39/ssrn3562964	This smart pot takes us to the new era where plants are able to communicate to their owners with the help of sensors and a mobile application.	It is too costly.
9.	*IEEE 3rd International Conference on Computing for Sustainable Global Development* (Year- 2020) *(INDIACom) pp. 3247-3250.*	The system discussed in here provides a decision support capability using an array of sensors to acquire the information related to the farm.	The technology is discussed on theoretical basis and there is no practical project or prototype.
10.	International Research Journal of Modernization in Engineering Technology and Science Volume:04/Issue:04 (Year- 2022) e-ISSN: 2582-5208	With a user-friendly interface, the design of the system here is designed at a very low cost.	Poor design of the hardware system.

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3. PROBLEM STATEMENT

Most of the researches have been around the development of solutions for the agricultural problems and there are very few cases where the indoor plants and the gardening problems are addressed. Smart pots have been a major topic of research in the field of indoor plantation but there are no complete solutions. Some pots contain the problem of physical security; some are too costly while some are not sustainable and hence this gives arise to the need of a one solution for all the problem. A device that has some durability, is cheap and sustainable.

4. PROPOSED METHODOLOGY

To solve the problem of monitoring indoor plants, a system is developed making use of the 4 Layers of the IOT Architecture. In the first layer (Sensing Layer), data is acquired from the soil of the plant using various sensors like DHT11 (for temperature and humidity) and Soil Moisture Sensor. A programming board (in this case Node MCU) is used to program the device and control the working of the sensors. In the Networking layer the acquired data is transmitted using a Wi-Fi connection of 5GHz. The device automatically connects itself to the Wi-Fi when it is in the range and starts uploading the data that has been acquired. ThingSpeak is used as a locally hosted platform to store and analyse the information that was transmitted making up the Platform layer. The Application Layer includes mainly the visualization of the data on a web interface and on some social media platform (in this case Twitter). The web interface consists of the live status of the plant with all the statistics in the form of graph, chart or table and simultaneously some statements are generated based on the analog signals that were stored on the cloud.

This approach helps to keep the solution simple yet effective with many functionalities. Also, the casing of the hardware system is done in a 3D printed donut shaped plastic box which enables it to be directly placed under any pot and the system will start working. (Figure 01) shows the technology/platform used at each layer.

The security of the device is ensured on both physical and software levels. The sharing of the data from the sensors to the cloud is done on the basis of API Key and as every channel has a unique API Key hence it is ensured that the collected data goes to the correct channel, making the transfer of data safe. Also, the physical built of the system is unique providing it with durability and protecting the internal circuitry against any damages that can be done by water, heat or any other factor.

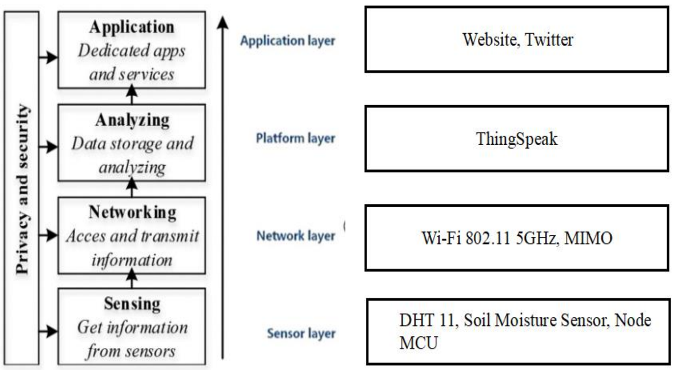

Fig. 1 Four Layer IOT Architecture [5]

4.1 DATA AQUASITION

The project uses two types of hardware, a programming board and a sensor array for Data Acquisition. It also uses a communication module to communicate the acquired data for Data Storage.

The Programming Board Node MCU, a microchip loaded with features like Wi-Fi capability, multiple analog and digital pins and serial communication protocols. The ESP8266 Wi-Fi chip helps it connect to the WIFI and communicate with the other components using the IFTTT server protocols. Here it is used as a

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programming board to update the current condition of the plant. The chip is programmed using Arduino IDE. (Figure 02) shows a Node MCU. [1]

The Sensor Array consists of two types of sensors (DHT11 and a Soil Moisture sensor) connected together to measure the physical parameters of the plant. DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. (Figure 03) shows a DHT11.

The soil moisture sensors are designed to estimate soil volumetric water content based on the dielectric constant (soil bulk permittivity) of the soil. The dielectric constant of soil increases as the water content of the soil increases. Because of the fact that dielectric constant of water is much larger than the other soil components, including air the sensor is able to produce these results. Thus, by measuring the dielectric constant gives a predictable estimation of water content in the soil. [3] (Figure 04) shows a Soil Moisture Sensor.

Fig. 2 Node MCU

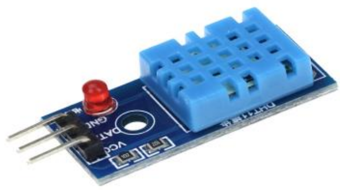

Fig. 3 DHT 11

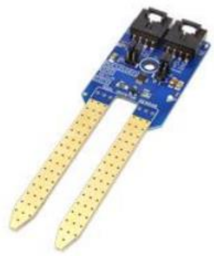

Fig. 4 Soil Moisture Sensor

4.2 DATA STORAGE

After the acquisition of the data from the sensor the data is then stored on the ThingSpeak cloud platform by the Node MCU using the API Key. As per the requirements and living conditions required for every individual houseplant. A dataset is created considering the various data points required in proper monitoring of the plant and maintaining the good health of the plant. The various data points that need to be considered for making the Smart Pot efficient include- soil moisture required, sunlight required per day, the optimum amount of temperature, and humidity. [6] All this data is uploaded to the Thing Speak Cloud where it is mapped and stored. On the ThingSpeak platform several channels can be created and each channel will have its own unique API Key. Each of the channel consists of data fields, location fields and status field and the data can be written, processed and viewed on the channel with the help of MATLAB code. The reaction to the data can with tweets, emails and various other alerts. The Node MCU makes use of these unique API Keys and uploads the data gathered from the sensor arrays to a specific channel on ThingSpeak. [10]

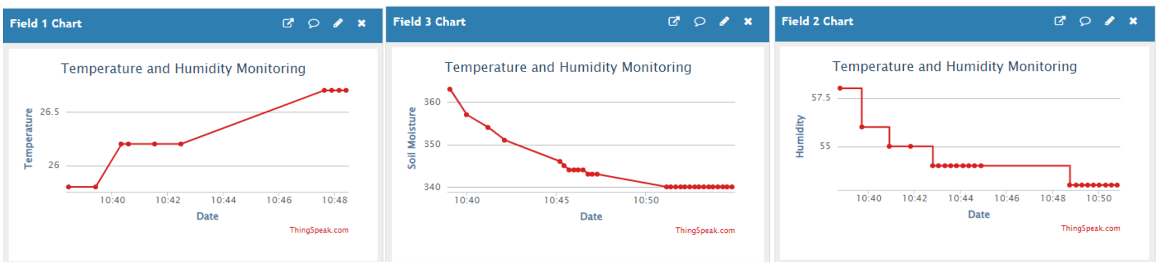

Fig. 5 Graph of Temperature, Humidity and Soil Moisture on ThingSpeak

4.3 DATA VISUALIZATION

A key aspect after the data is acquired, is being able to visualize the data in terms of Charts, Graphs or Tables. And in this system the acquired data will be converted into graphs as shown in (Figure 05) and then the

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graph will be projected on the web interface from there the cultivator can access the data. The data on the website will be updated on a regular basis on regular intervals to provide for a live monitoring system for the plant.

5. RESULT

When the device is placed under a pot and a power source is connected and when the system starts working, it gathers the data by the Sensors Array, and then using a programming board (Node MCU), it uploads it to the ThingSpeak cloud and their charts, graphs and tables are used to map the data.

A statement is prepared based on the analog values received from the sensors and the statement is then tweeted on the plant's Twitter account. Once the data is published on the website it allows for the visualisation of the Plant status and monitor the plant live. Figure 06 shows the physical design of the system and Figure 07 shows the twitter handle of the plant where it tweets the updates of its state.

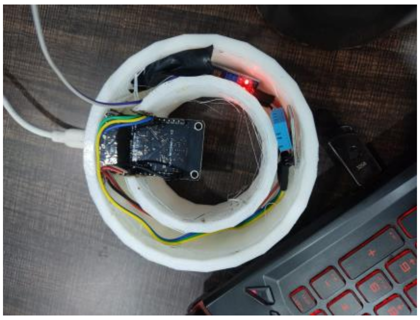

Fig. 6 Design of retrofitting system

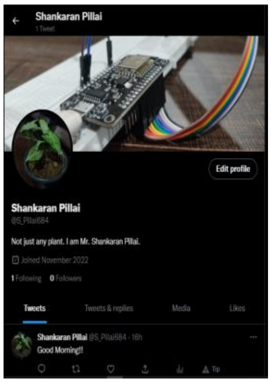

Fig. 7 Twitter handle of the plant.

6. CONCLUSION

The prototype was designed and tested successfully for various conditions of temperature and soil moisture. The device enables to successfully cut off 50% of the cost of existing Smart pot solutions with a sustainable approach of converting any normal earthen or plastic pot into a smart pot. The future scope of the research will be to integrate even more functionality in the system like powering using Solar Energy and develop an AI (Artificial Intelligence) that would update the statements using ML (Machine Learning). Also, a similar system can be designed and researched that would provide a better and sustainable alternative for the existing Hydroponic plants and Roof-top Agriculture.

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