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3D Printed Self Watering Plant Pot Using IoT

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Abstract : The user understands the proper use of a self-watering system, as plants that receive too little water die and insufficient water is also likely to kill the users plant. Monitor the water supply to put them exactly on plants so that large amount of water does not goes to waste. As a result, an automated system which will water the plant automatically and keep track over the moisture present in soil is necessary to promote the growth of this plant by giving it exact amount of water without any hassle in all climatic conditions. This paper presents an IOT system comprising of a NodeMCU microcontroller based plant watering system which irrigates the plant automatically without any human intervention and care required for the plants to be grown effectively. Sy stem which save water consumption and also it can be use as time saving.

Index Terms **- 3D Printing, Internet of Things, Self-watering, Soil Moisture, Indoor Plants.**

I. INTRODUCTION

In recent years, the use of indoor plants has become a really useful hobby craze that significantly improves our quality of life and allows us to have fun with nature. Unfortunately, keeping a plant alive requires watering it on time and how much is too little or too over can be confusing for people who are extremely busy professionally or rack up the frequent flier miles. For busy plant lovers, self-watering plant pots have become just the most perfect solution to this situation; a way to guarantee plants will receive their water without having to be manually watered all day everyday. In this paper, the automatic watering process is automated with using IoT Technology by design and production of an 3D printed plant pot. The microcontroller is programmed and attached to a soil moisture sensor, based on the signal sent from the soil moisture sensor, it triggers water irrigation from a water reservoir whenever necessary.

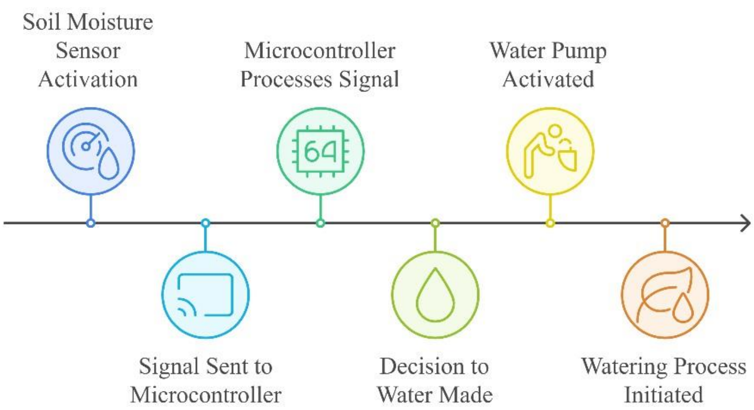

Fig. 1. IoT Enabled Selft-Watering Plant Pot

II. LITERATURE REVIEW

Reference [1] the implementation and the design of an IoT based system for plant irrigation by means of an ESP8266, in order to have sustainability, minimal human attention and the most appropriate water resources are described. Indoor environment platform using soil moisture sensors and temperature sensors is used to provided efficient control of the plant water supply in order to enhance plant health and reduce water consumption [2,3]. Cloud Based Smart Plant Watering System for PH Prediction [4]. Asha Mishra et al. Proposed an intelligent plant irrigation and water saving system based on IoT [5]. Sayali Chaudhari et al. Advances in the design of IoT and sensor modules for plant irrigation system automation to mitigate water loss and energy usage [6]. [7,8] described the design of and use of a Smart Flowerpot with Internet of Things (IoT) for automatic watering of a plant in case of low soil water level, for sending the owner a notification message using LINE Notify and for remote operation. Kritika Shah et al. The proposed system provides an end-to-end, IoT-powered, fully unattended plant water management system, along with real-time monitoring and remote operation with the aid of a mobile app [10].

Smart Irrigation System for agriculture, utilizing microcontrollers, GSM modules, humidity sensors, and soil moisture sensors to optimize water usage and crop growth [11,12]. Geetha S. et al. uses an Arduino board for plant health monitoring [13]. IoT Planting: Watering System Using Mobile Application for the Elderly [14]. Punitharaja et al. investigated automated water sprinkling and irrigation in urban residential areas, evaluating soil quality, exploring power sources, network technologies, and control devices [15]. Automating pet and plant nourishment tasks can reduce work and mortality, benefiting owners and protecting plants [16]. The Smart Plant Watering System utilizes IoT technology to conserve water and energy in urban areas, automatically watering household plants and providing fresh air and oxygen levels [17-20]. P4L is an IoT solution for automated houseplant care, contributing to sustainability and UN's SDG3, using TDDM4IoTS methodology and tool, and enhancing indoor pollution reduction [21]. Yee Shen Pang et al. proposed automated IoT-based drip irrigation and soil monitoring system [22]. Recently, Hana Mujid et al. presented a paper in which a remote automatic viewing system for home garden plants, using the Blynk platform and Ngrok camera [23]. Smart plant sprinklers enhance plant growth and development [24], comparing soil moisture to a threshold value, and alerting the owner via Blynk [25]. Very recently, the project uses technology to automate soil moisture monitoring, saving time and money for gardeners and the elderly, ensuring a predictable water distribution system [26]. GARNUS is a low-cost IoT platform that monitors soil moisture, water availability, and temperature in ornamental plants, reducing water misuse and promoting resource management [27,28].

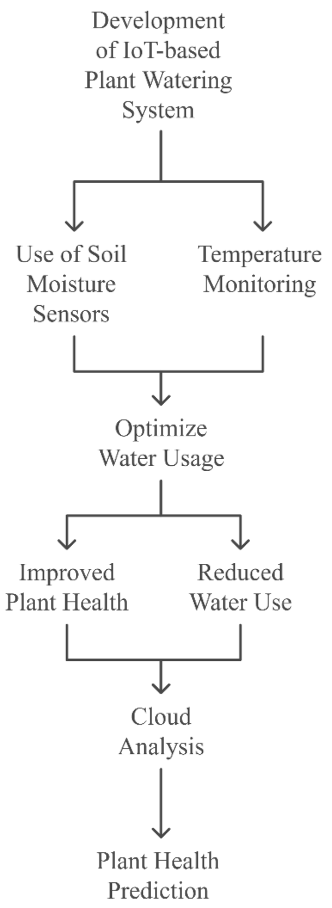

Fig. 2. Flowchart based on development of IoT-based Plant Watering System

III. SYSTEM DESIGN

3.1 Hardware Components

1) 3D printed plant pot with water reservior
2) Soil moisture senor
3) Microcontroller (e.g., Arduino, Raspberry Pi)
4) Water pump
5) Power Supply

3.2 Software Components

1) Microcontroller firmware for sensor data acquisition and watering control
2) IoT platform for data storage, analysis, and remote access

3) Web interface for monitoring and controlling the system

Fig. 3. 3D Printed Pot

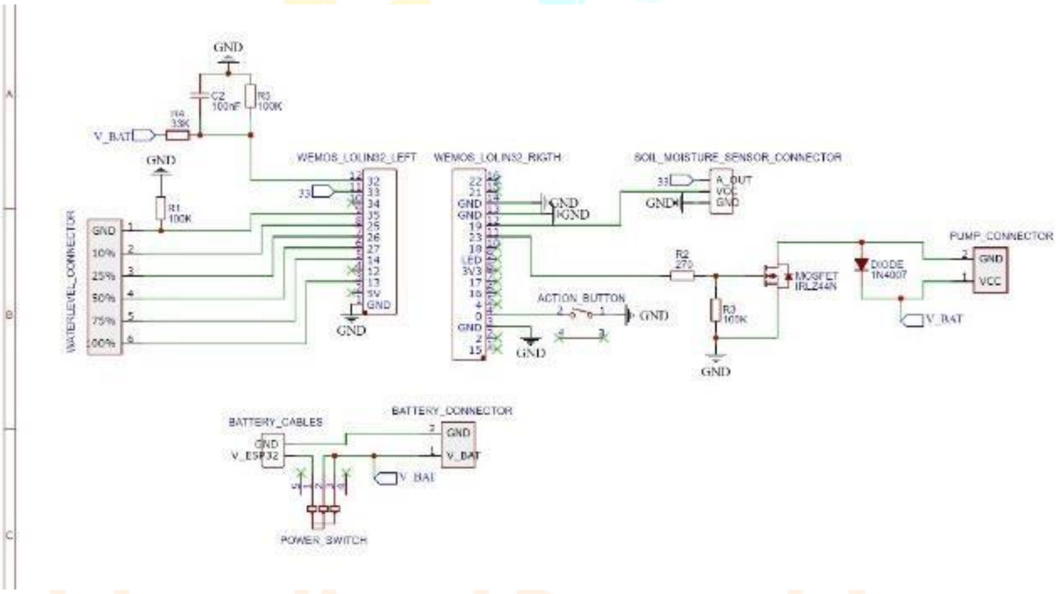

Fig. 4. Circuit Diagram

IV. IMPLEMENTATION

4.1 3D Printed Plant Pot

The plant pot is designed using 3D modelling software and printed using a 3D printer. The pot features a built-in water reservoir at the bottom, separated from the soil by a porous material that allows water to be absorbed by the plant's roots as needed. The reservoir is equipped with a water level sensor to monitor the water level and trigger the refilling process when necessary.

4.2 Soil Moisture

The soil moisture sensor is placed in the soil of the plant pot to continuously monitor the moisture level. The sensor sends data to the microcontroller, which processes the information and determines if watering is required.

4.3 Microcontroller and IoT Integration

The microcontroller is responsible for collecting data from the soil moisture sensor, controlling the water pump, and communicating with the IoT platform. It is programmed to maintain the optimal soil moisture level by activating the water pump when the soil becomes dry and deactivating it when the desired moisture level is reached.

The microcontroller is connected to the internet via Wi-Fi or Ethernet, allowing it to send sensor data to the IoT platform for storage and analysis. The IoT platform also provides a web interface for users to monitor the plant's water needs and adjust the watering schedule as needed.

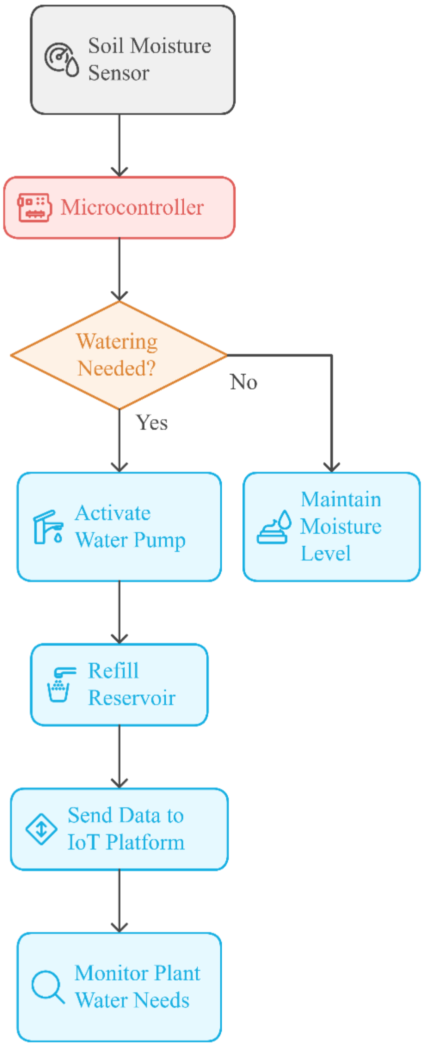

Fig. 5. Flowchart based on implementation and IoT integration

V. RESULTS AND DISCUSSIONS

The performance of the 3D printed self-watering plant pot with IoT integration was evaluated by monitoring the soil moisture level and plant growth over an extended period. The results showed that the system effectively maintained the optimal soil moisture level, reducing the need for manual watering and ensuring the plant's health and growth. The use of 3D printing technology allowed for the creation of customized plant pots that fit specific plant species and living spaces. The integration of IoT provided additional benefits, such as remote monitoring and control, historical data analysis, and the ability to receive notifications when the water reservoir needs refilling.

5.1 Performance Evaluation

A 3D-printed, self-watering potted plant container with an IoT interface demonstrated high monitoring performance in regards to obtaining the optimum soil moisture value. Commonly, the graphical view of the soil moisture sensor screen on the interface of the IoT dashboard interface always presented moisture information and triggered the irrigation function based on need. Over long period of time, this system guaranteed to maintain the soil in the interval of ideal moisture content, thus significantly reducing the need for manual irrigation. Stable moisture content promoted maximal plant growth and also manifested as increased plant leaf vigor, leaf color and leaf width.

5.2 Customization through 3D Printing

In the design of plant pots for a specific purpose, the importance of 3D printing technology cannot be overstated. The modular design of CAD imageable model structures made it straightforward to incorporate sensors and water reservoirs without sacrificing good appearance and utility. The amount of personalization that 3D printing could offer enabled the creation of pots appropriate for a range of plant species (including of different sizes) and living spaces. There are implications for use in residential and commercial settings of this nature.

5.3 IoT Integration and Benefits

IoT connectivity introduced useful fresh utility to remote monitoring and control capabilities. Specifically, in addition, a user will be able to see, in real time, the readings for soil moisture (the way the panel shows it) and get alerts in case the water tank needs to be refilled. Time series analysis of past data has been employed with a view to reprogram the irrigation plan and as a result to improve and therefore to reduce proportionally and more particularly the water wastage. When combined together, these characteristics improved user usability, specifically for those who are busy with a busy personal schedule or have many plants.

5.4 Sustainability and Resource Efficiency

Automatic irrigation incorporated in the system's implementation of the automatic irrigation procedure reduced water waste by supplying water only after the soil moisture reached a set threshold. This functionality is in line with sustainable drinking water management designs, and this system is ecologic. In addition, the 3D printing technology minimized the amount of material waste during production, and thus it helps to further enhance the sustainability of the whole project.

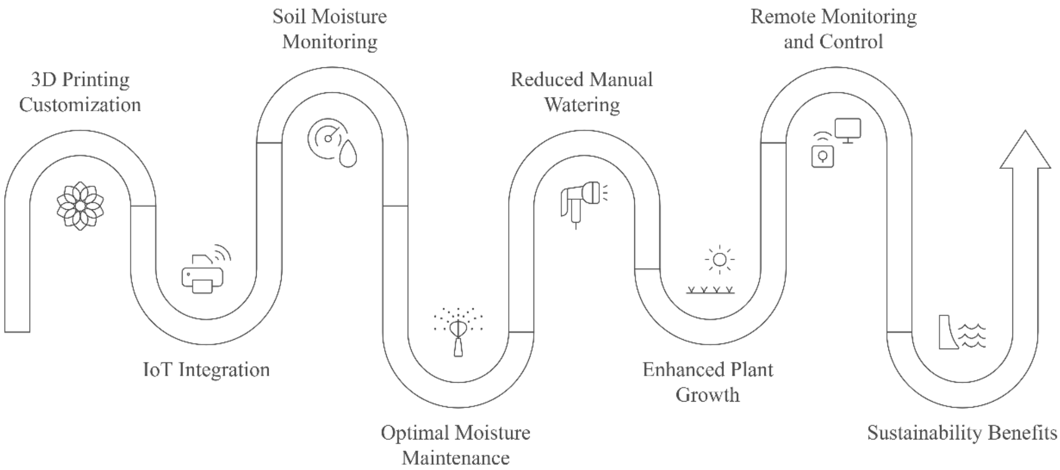

Fig. 6. Evaluation and Benefits for IoT-integration 3D Printed Plant Pot

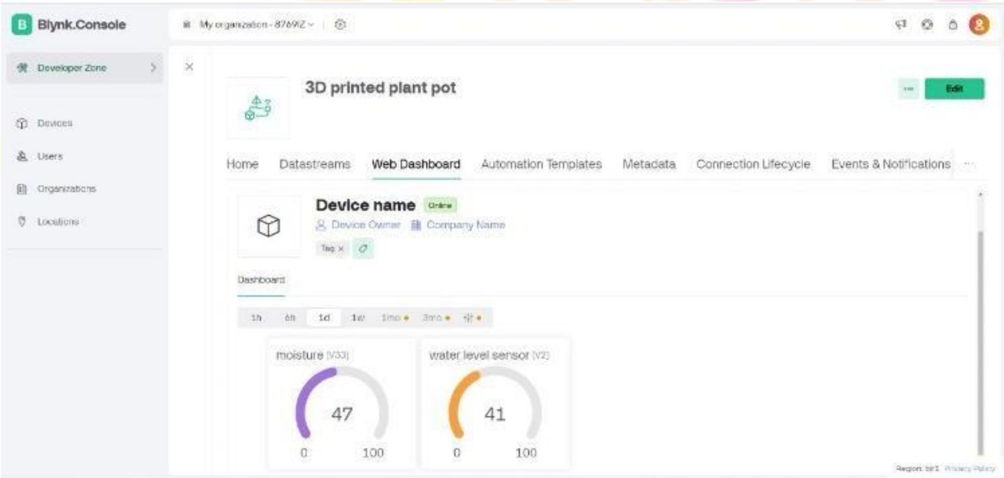

Fig. 7. Output of the project

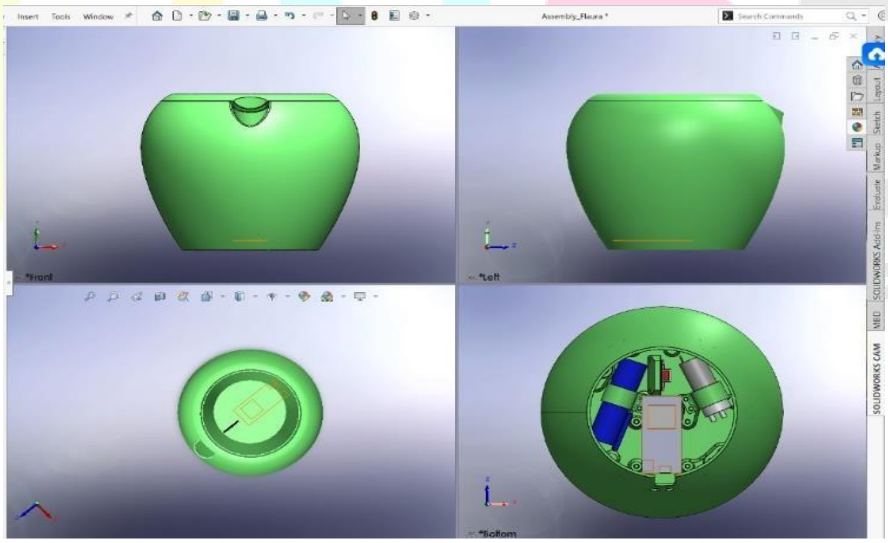

Fig. 8. 3D CAD Design of the Pot

Integration of 3D printing and Io Ts in plant self-watering pots is an important development towards smart horticulture. By efficient allocation of resources/users, and utility, this system has proved its effectiveness to the solution of current urban life scaling issues. Yet even more remarkable application and influence will eventually be realised, and even pushed further through developments in materials, power usage, and sensors.

VI. FUTURE SCOPE

The design and also the practical real-world implementation of the 3D printed IoT intelligent self-watering planter enable the setting out of a number of possible directions of future research and development work. These potential advances are in functions, sustainability, and system expansibility.

6.1 AI Integration

More recent developments in the type of the self-watering system are likely to pave the way for proceeding in using artificial intelligence (AI) for the control of all intelligent and autonomous aspects of the system.

1) Predictive Watering: These AI algorithms are also capable of estimating in real time, historical trend and meteorological prediction with help of which precise quantification of amount of water can be estimated.
2) Plant-Specific Adjustments: Flexible, AI models may be used to water plants in an adaptive manner based on plant species, plant growth stage and environmental conditions.
3) Dynamic Responses: Through continuous acquisition of environmental information in the form of feedback, the AI could be optimized towards water application, resulting in better plant health and resource conservation.

6.2 Solar Power Integration

In order to increase the system's energy independence and reduce the use of external energy, installing solar panels appears feasible:

1) Energy Independence: Solar-powered elements could now be employed in unattended/off-grid applications.
2) Sustainability: Renewable implementation and sustainability concepts with footprint reduction.
3) Scalability: Solar interconnection may enable the same system to be used in both rural and urban contexts where an electronic "baseline" is unavailable.

6.3 Larger Scale Applications

The system can further be adapted to modify farming practices, and the system can be scaled up from a single plant cups to other applications in agriculture:

1) Smart Farming: Systems, possibly based on IoT, could be established to manage the use of water on much bigger scales in the field and thus allow the evolution of precision agriculture.
2) Improved Crop Yields: Automatic irrigation and environmental regulation can be used to create the best growth conditions, which results in healthier vegetations, and as a consequence, greater yields.
3) Resource Management: Resistive technologies, comprising the measurement of large-scale soil moisture, soil temperature and soil humidity, provide the foundation for bettering water-efficient and low/no-input agriculture systems.

6.3 Advance Sensor Integration

The potential to build a system by the inclusion of a new sensor would, in turn, enable us a full description of the plant microenvironment:

1) Temperature Sensors: Cumulative soil and ambient temperature monitoring is used to create a suitable environment for plant establishment.
2) Humidity Sensors: Humidity monitoring would be of value in managing the water regime and in the practice of avoiding overwatering/drought stress.
3) Environmental Analytics: Fusion of sensor data can give us an improved view of the health conditions of the plant and allow us to take an active approach to the management of plant.

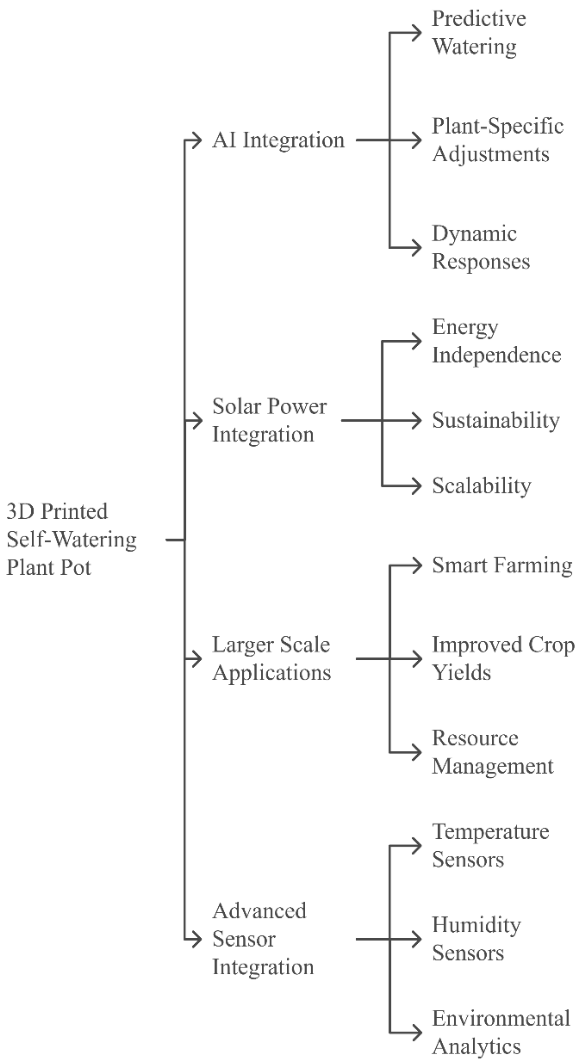

Fig. 9. Flowchart based on Future Research and Development

BROADER APPLICATIONS

Composite of 3D printing and IoT is able to bring much wider applications than what is currently in the market. Some promising avenues include:

A. Urban Farming Initiatives

1) Optimal management of the built environment is an essential first step towards urban food production (i.e., vertical green wall, rooftop agriculture).
2) IoT devices will offer the maximum possible conditions for crop growth in its corresponding geographic area and so represents a feasible solution for urban food production.

B. Smart Agriculture Systems

1) It has the potential to circumvent the need to repurpose fully the traditional machinery of commonplace agri-practices by "upgrading" the technology to multi-scale agricultural requirements.
2) Using automated irrigation and data driven irrigation control may enable the best use of water, the least number of labor hours, and the highest grain yield.

C. Customizable Home Gardening Solutions

1) 3D printing of pots of desired dimensions and specifications is a possibility that is attractive to those who grow their own plants.
2) Adaptive solutions for a variety of plant species as well as user acceptance may lead to the realization of the dream of gardening being available to everybody and pleasant for everybody.

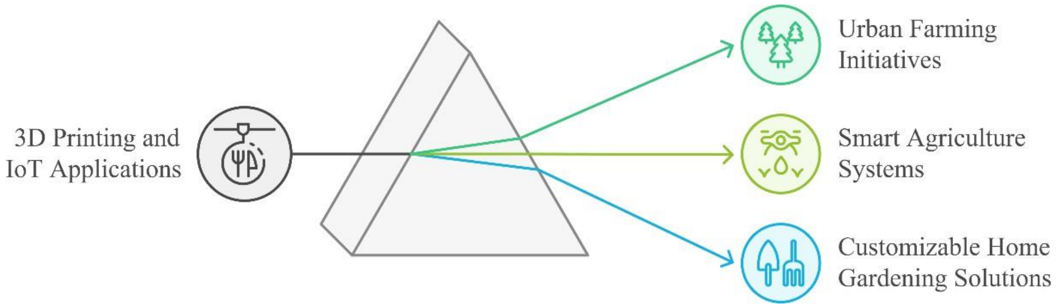

Fig. 10. Exploring the intersection of 3D Printing and IoT

VII. CONCLUSION

This paper describes the design and the implementation of a three-dimensional (3D) printed IoT-enabled, self-irrigated potted plant. The device consists of a 3D printed pot, a water reservoir, a soil moisture sensor and a remote-controlled Internet-enabled microcontroller. In terms of irrigation, the microcontroller monitors the water content in the soil and activates its irrigation system as needed, and thus provides a continuous irrigation of the vine. As an example, one of the functional benefits of the IoT is the possibility of remotely accessing and controlling the system, that is, providing a highly efficient solution for indoor plant monitoring. The additive manufacturing method of 3D printing offers immense capability for the realization of individualized, low-cost production of plant pots and for the integration of added value design in the plot through the use of IoT, real-time monitoring, historical data analysis and tele-control. Experimental results show that the system is able to maintain the soil at just the right degree of moisture and that plant growth in the system reaches a certain level. In a prospective agricultural effort a very intricate design, (for example, for the design and differentiation of plant, targeted purposes of adaptive irrigation to the variety of the species and the environmental context of their growth, and the integration of further sensors for the description of the plant status and growth) can be made use of.

VIII. ACKNOWLEDGMENT

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REFERENCES

[1] Dr. Sangeeta Kurundkar, Kapil Muchandani, Shubham Bannore, Pranita Mor, Akshay Aserkar, “PLAWATOS-An Automatic Plant Watering IOT Based System Using ESP8266”, International Journal for Science and Advance Research in Technology, vol.3, Issue 7, July 2017.

[2] Kotni Naga Siva, Raj Kumar G., Annasamy Bagubali and Kishore V. Krishnan, “Smart Watering of Plants”, International Conference on Vision Towards Emerging Trends in Communication and Networking, March 2019.

[3] Jacquline M. S. Waworundeng, Novian Chandra Suseno, Roberth Ricky Y Manaha, “Automatic Watering System for Plants with IoT Monitoring and Notification”, CogITo Smart Journal, 2018.

[4] Arathi Reghukumar, Vaidehi Vijayakumar, “Smart Plant Watering System with Cloud Analysis and Plant Health Prediction”, International Conference on Recent Trends in Advance Computing, 2019

[5] Asha Rani Mishra, Sanjeev Kumar Pippal, Bhavika Rajpal, Arshita Garg, Sushant Singh, “IOT based Self-Nourishing system for Plants”, Modern Electronics Devices and Communication Systems, 2023

[6] Sayali Chaudhari, Arati Sapkal, Mitali Solanki, Ananya Gawande, “Automatic Plant Watering System Using IoT”, IJNRD, vol.3, Issue 3, 2018

[7] Satien Janpla, Chaiwat Jewpanich, “The Architecture of the Smart Flowerpot by using the Internet of Things (IoT)”, IJEAT, vol.9, Issue 1, Ocyober 2019

[8] Satien Janpla, Chaiwat Jewpanich, Nisanart Tachpetpaiboon, Waraporn Prongsanthia, Butsirin Jewpanich, “The development of smart flowerpot based on internet of things and mobile and web application technology”, Indonesian Journal of Electrical Engineering and Computer Science, **vol.26**, 2022

[9] Sharan D., Sharon Jemimah Peace, Karan I., Stewart Kirubakaran, “Smart Pot Using Internet of Things for Plant Hydration”, ICECAA, 2023

[10] Kritika Shah, Saylee Pawar, Gaurav Prajapati, Shivam Upadhyay, “Proposed Automated Plant Watering System Using IoT”, SSRN Electronic Journal, 2019

[11] S. P. Vimal, N. Sathish Kumar, M. Kasiselvanathan and K. B. Gurumoorthy, “Smart Irrigation System in Agriculture”, Journal of Physics: Conference Series, 2021.

[12] Kush Rawal, Goldie Gabrani, “IoT based Computing to Monitor Indoor Plants by using Smart Pot”, 3rd International Conference on Innovative Computing and Communication

[13] Dr. Geetha S., Dr. Y. Asnath Phamila, P. Vaishnavi, Y. Lakshmi Sai Charitha, T. Jayasri, Manchikanti Bhumika, Nelakurthi Sudheer Kumar, “Automatic Watering System using Soil Moisture Sensor and RTC timer with Arduino”, International Journal of Advanced Research in Science, Communication and Technology, vol.2, Issue 1, February 2022.

[14] Krittin Lekjaroen, Rachatapon Ponganantayotin, Arnon Charoenrat, Suree Funilkul, Umaporn Supasitthimethee and Tuul Triyason, “IoT Planting: Watering System Using Mobile Application for the Elderly”, International Computer Science and Engineering Conference (ICSEC), December 2016

[15] Punitharaja, "Application of IoT in Plant watering system", Journal of Emerging Technology and Innovative Research, vol.6, Issue 2, February 2019.

[16] Bandari Theja1, P. Sathvik Prasad, A. Pavan Kalyan, N. Harshitha, P.Pooja, "Smart Pot Plant", International Research Journal of Engineering and Technology, vol.6, Issue 5, May 2019.

[17] Mani Bansal, Abhay Pandey, Mandvi Singh, Nilvesh Sharma, Ms Neha, "A Literature Review On Automatic Watering Of Plants", International Journal of Creative Research Thoughts (IJCRT), vol.10, Issue 5, May 2022.

[18] Nalband Sumaiyya, Kalbhor Supriya, Kshirsagar Shubham, Prof. Hirolikar D. S., "Smart Plant Watering System Using NodeMCU", International Journal of Creative Research Thoughts (IJCRT), vol.8, Issue 9, September 2020.

[19] Gopiya Naik S., Aishwarya R., Chaithra M. K., Pooja S., Jayanth K. Gowda, "Arduino Uno and IoT Based Smart Indoor Garden System", International Journal of Engineering Research & Technology (IJERT), vol.12, Issue 8, August 2023

[20] Rana Jyoti Chakma, Shaida Jannat, and Sayed Asaduzzaman, "An IoT based Energy Saving Automatic Watering System for Plants", International European Extended Enablement. in Science, Engineering & Management, vol.9, Issue 5, May 2021.

[21] Gleiston Guerrero-Ulloaa, Alejandra Méndez-García, Valeria Torres-Lindao, Vivian Zamora-Mecías, Carlos Rodríguez-Domínguez, and Miguel J. Hornos, "Internet of Things (IoT)-based indoor plant care system", Journal of Ambient Intelligence and Smart Environments, 2023

[22] Mohammad Wasim Haidhar Bin Mohamed Slime, Yee Shen Pang(B), and Chyi Shing Chua, "IoT Based Drip Irrigation and Soil Monitoring System", Proceedings of the Multimedia University Engineering Conference (MECON 2022), AER 214, pp. 213–228, 2023.

[23] Hana Mujlid, Haneen Daifallah Alghamdi, Hind Abdulaziz Alkharashi, Marah Awadh Alkhaldi, "IOT Intelligent Watering Sensor For Indoor Plant", International Journal of Computer Science and Network Security, vol.22, December 2022.

[24] Ridwan Siskandar, Muhammad A. Fadhil, Billi Rifa Kusumah, Irmansyah, Irzaman, "INTERNET OF THINGS: AUTOMATIC PLANT WATERING SYSTEM USING ANDROID", Jurnal Teknik Pertanian Lampung, vol.9, 2020.

[25] Ramya B. V., Lakshmi S. R., Rashmi B. T., "IOT SOLUTION FOR AUTOMATIC WATERING OF INDOOR PLANTS", International Journal of Engineering Applied Sciences and Technology, vol.5, Issue 3, 2020.

[26] B. Ramya, S. Swathi Varaha Sai, K. Pallavi, Dr. K. Srinivasa Naik, "Automatic Plant Watering System", Dogo Rangsang Research Journal, vol.12, Issue 5, May 2022.

[27] Mochammad Haldi Widianto, Annisa Istiqomah Arrahmah, Samuel Jason Santosa, Gregorio Kurniawan, "IOT BASED LOW-COST PLATFORM FOR SMART ORNAMENTAL PLANT MONITORING SYSTEM", Journal of Theoretical and Applied Information Technology, vol.99, December 2021.

[28] Swapnil Bhardwaj, Saru Dhir, Madhurima Hooda, "Automatic Plant Watering System using IoT" Second International Conference on Green Computing and Internet of Things (ICGCIoT).