IOT Based Smart Microgreen Sprouter

Chapter · October 2021

DOI: 10.1007/978-3-030-89906-6_22

6 authors, including:


Windhya Rankothge
Sri Lanka Institute of Information Technology


Praveen Kehelella
Sri Lanka Institute of Information Technology


Damitha Perera
Sri Lanka Institute of Information Technology


Bimsara Chandranath Kanchana
Sri Lanka Institute of Information Technology

IOT based Smart Microgreen Sprouter

W. H. Rankothge[1], Praveen Kehelella[2], Damitha Perera[3], Bimsara Kanchana[4], Kasun Madushan[5] and Rojith Peiris[6]

Faculty of Graduate Studies and Research, Sri Lanka Institute of Information Technology
Sri Lanka

[1]windhya.r@sliit.lk
[2]praveen.k@sliit.lk
[3]ms20902834@my.sliit.lk
[4]ms20910822@my.sliit.lk
[5]ms20906726@my.sliit.lk
[6]ms20909932@my.sliit.lk

Abstract. This research paper focuses on enhancing indoor farming technologies with an emerging technology: Internet of Things (IoT). The proposed approach creates a microgreen sprouter unit that automates the process of monitoring and providing optimum growing conditions with the minimum human supervision. This model can be used to achieve healthy growth of microgreen by providing ideal ventilation, moisture, humidity, light, and temperature levels, which prevents sprouts from ultraviolet radiation and pest attacks. Users can track the growth rate of sprouts and change the moisture, humidity, light and temperature levels. Our prototype implementation has been tested for mung-beans sprouts and validated for its accuracy and efficiency.

Keywords: IOT, Microgreen, Sprouter, Smart agriculture

1 Introduction

The world is facing a food insecurity situation due to the rapid population growth, lack of resources, limitations of cultivation lands and climate change. It is expected that in 2050 the world will reach its maximum carrying capacity [1]. To overcome these problems, scientists are exploring for alternative and innovative ideas, targeting secure food production and providing a solid food supply chain. Home gardening and in-house gardening are examples of innovative ideas. Furthermore, microgreens have become a popular in-house gardening trend due to its easy growing nature and content of healthy nutrients.

Furthermore, sustainable development, agriculture and farming have been always benefited from the use of information and communication technology developments [2-9]. Internet of Things (IOT) has become one of the popular emerging technologies, due to its ability to make life convenient. With the use of IOT technologies, plants growing can be closely monitored and required conditions for the healthy growing can be provided [10]. Therefore, IoT has created a trend not only among farmers, but also among public, for growing organic microgreens even within small spaces.

Due to the sensitivity to the climate, microgreens need regular watering to maintain the optimum growing conditions, and it requires continuous monitoring. This is a very time-consuming task and with the busy lifestyle of modern society, it is impossible for the public to spent time on such activities. Therefore, growing microgreens in-doors has become a challenging task.

To overcome the above problems, this paper introduces an IoT based smart microgreen sprouter. This IOT based Sprouter automates the control of climatic parameters and monitors microgreen remotely through a web dashboard. Generally, greenhouses are used to protect the plants from weather conditions and pests and also provide the optimum condition to grow healthy plants. Compared to a greenhouse, the proposed IoT based Sprouter model can provide edible microgreens and sprouts inside a portable device. However, unlike a greenhouse, sprouter is not capable of making a growing environment that enhances their growth. Therefore, this research work focuses on controlling the microgreen growing according to the required conditions.

2 Background

Young vegetable greens that are between 1-3 inches (2.5-7.5 cm) long are known as microgreens [11]. Microgreen is also known as a new form of super food. It is full of important minerals and vitamins. Microgreens are vegetables and seedlings, which have established roots, stems and first leaves called cotyledons, and even occasionally young true leaves [12]. Microgreens help to reduce the risks of human heart attacks, control diabetes, improve the human immune system, reduce the amount of cholesterol, reduce the constipation, improve, and maintain eyesight [13].

The most common varieties of microgreens are made from the seeds of the following plant families [11]:

- Brassicaceae family - broccoli, cauliflower, watercress, cabbage, arugula, and radish.
- Apiaceae family - carrot, dill, celery, and fennel.
- Asteraceae family - endive, lettuce, radicchio, and chicory.
- Amaranthaceae family - quinoa Swiss chard, amaranth, spinach, and beet.
- Amaryllidaceae family - onion, leek, and garlic.
- Cucurbitaceae family - squash, melon, and cucumber. Grains such as oats, rice, wheat, barley, and corn as well as legumes such as beans, lentils and chickpeas are sometimes grown into micro-greens.

For microgreens to be grown healthier, there are few factors to be considered, they are as follows [14]:

- Optimize environmental conditions: extreme humidity and temperature conditions hinder a healthy harvest. In general, for plants, a temperature range between 77 ° F / 25 ° C to 86 ° F / 30 ° C is optimal.
- Maintain and control moist soil: soil should be between wet or dry. If the soil feels dry when touching the leaves, and the plants seem less bright, then it needs water to grow. On the other hand, if the leaves are yellow, but not weak, then plants need additional water to grow.
- Sunshine: generally, plants require light to grow. But different varieties require different quantities to grow. For example, baby plants often need extra shading from the sun.

When consider the mung beans, they are fast growing seeds. At harvest time, mung bean grains can contain between 13% to 15% moisture, and the optimum temperatures are always about 28°C - 30°C and above 15°C. During autumn and summer, it can be sown. Also, it does not need a large amount of water. Mung beans grow on a wide variety of soils but prefer well-drained loams or sandy loams, with a pH of between 5 and 8. Mung beans consist of 0.72g non-protein nitrogen, 26.4g protein, 1.75g fat, 4.5g ash, 61.2g carbohydrates and 6.15 crude fiber [15].

2.1 Related Works

Sustainable development, agriculture and farming have been always benefited from the use of information and communication technology developments [2-9]. IoT has become one of the major topics in information and communication technologies and IoT is not -a novel idea in agriculture and farming. IOT contains a network of small physical devices that connect with network connection. McEven and Cassimally, defined IOT as "Physical Object + Controller, Sensors and Actuator + Internet" [16]. The main goal of the IOT is to increase the efficiency, reduce the process complexity and increase the quality of life [16].

In today's world, there are many IOT systems implemented to grow microgreens. Authors of [17] proposed an IOT based indoor farming system which contains a robotic appliance: AgroRobot, a food safe component and 3D printed microgreen growing trays. It also has an aeroponic system with vertically rotating spraying lance for watering plant roots with nutrient solution. The system is operated by an Arduino Nano that controls the water pump and artificial illumination of the system. Also, the AgroRobot is further monitored through a touch screen.

R. K. Kodali, S. K. et al. proposed an IoT based smart greenhouse system to avoid the intermediaries and their adversaries' effects on farmers and produce healthy organic food to consumers [18]. The system operates according to a predefined moisture level for soil, so that the optimal level of water is added to the plants. Ultrasonic sensors are used to measure current water level of the water tank and to ensure proper water management process. The appropriate wavelength light is also given to the plants through glowing lights during the night. Temperature and humidity sensor used to measure temperature and humidity level inside the greenhouse. A tube well is operated using the GSM module (missed SMS or Voice call). Bee-hive boxes are also used for pollination and boxes are tracked by ultrasonic sensors to calculate honey and automatically send e-mails to the buyers when they are packed.

The work in [19] proposed a smart greenhouse based on IoT for growing healthy plants with optimum environmental conditions. They have installed a smart device inside the greenhouse with sensors that measure air humidity and temperature. The measured data is transmitted to the cloud server by utilizing MQTT (Message Queuing Telemetry Transport) protocol.

3 Methodology

The proposed system is an IOT based Smart Microgreen Sprouter. The system facilitates public to grow their own microgreens easily under minimum environmental conditions, with less effort and cost effectively. As consuming healthy food have become an important aspect of our lifestyles, the Smart Micro green Sprouter System will be useful to public to grow their own microgreens. The architecture of proposed smart microgreen Sprouter is shown in Figure 1.

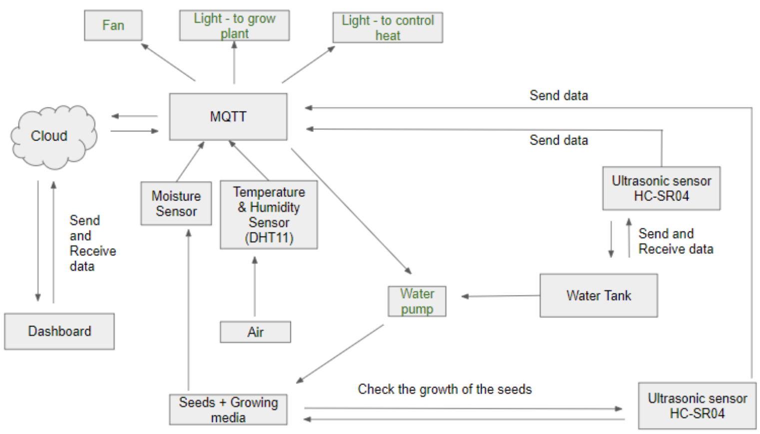

Fig. 1. Smart Microgreen Sprouter Architecture

We have implemented a prototype of the proposed system to grow "mung beans" (green gram), and the implemented prototype is shown in Figure 2. The system implements a centralized controller, that controls the set of sensors: moisture, temperature, humidity, ultrasonic. The most important feature of the proposed system is monitoring the growth of the mung bean, where user change temperature, humidity, and watering, and measure the mung bean growth rate. It also provides facilities to change the plant growth rates and to speed up the plant harvest timeline. Users can manually change the microgreen growth rates through the web dashboard by modifying the water level, moisture level, etc. The web dashboard visualizes the plant growth rate, temperature, water level and moisture.

As the initial step, the micro beans are inserted into the tray and put it into a container with a soil moisture sensor. Once the tray with mung beans is inserted into the container, a soil moisture sensor verifies whether the soil moisture level is enough to grow the mung beans. If it is not enough, the motor is automatically switched on and sprays water to the plant. Once the water level is sufficient, the motor is automatically switched off. The system uses two ultrasonic sensors (HC-SR04): (1) to measure the plant growth twice a day and (2) to measure the water level inside the water tank. Gathered data is displayed on the system dashboard.

Fig. 2. Implemented Sprouter prototype

A temperature and humidity sensor (DHT-11) checks the temperature inside the container, five times per day. If the temperature goes high, the light is automatically turned off and the exhaust fan is switched on, to reduce the temperature inside the container to maintain the required environmental conditions. If the temperature is decreasing, then the speed of the exhaust fan is automatically changed, and the brightness of the light is also adjusted. The same sensor (DHT-11) is used to measure the humidity as well and the fan can be used to adjust the humidity inside the container. Also, the glowing light is switched on every 14 to hours to provide an optimum light condition. The ultrasonic sensor is used to measure the plant growth every 12 hours.

Fuzzy inference engines are used to make decisions in temperature controlling and watering. In fuzzy logic, a rule base is used to control the output variables. A fuzzy rule is a simple “IF THEN” with the condition and action and Table 1 and Table 2 show Fuzzy rules used in the proposed system.

Table 1. Fuzzy Rules

Rule No	Fuzzy Rule
1	IF (temperature is cold) AND (target is normal) THEN turn on heating bulb.
2	IF (temperature is hot) AND (target is normal) THEN turn on cooling fan.
3	IF (temperature is normal) THEN turn off cooling fan and heating bulb.

Table 2. Fuzzy Metrics

Temperature/Target	Cold	Normal	Hot
Normal	Heat	No Change	Cool

4 Results and Discussion

The Microgreen Sprouter was tested for different samples of mung beans, under different environment conditions because the growing time of plants varies according to the climate.

First set of experiments were carried out to observe the effect of temperature and system was tested for different temperatures. By varying the temperature, we verified that the system could adjust conditions to maintain the optimal temperature inside of Sprouter. When the temperature is increased beyond the threshold level, the cooling fan was started and ran until temperature decreased. When the temperature decreased, the heating bulb was turned on to maintain the optimal temperature.

Second set of experiments were carried out to observe the effect of light and system was tested for different lighting conditions. The glowing light was turned on automatically as scheduled for a certain time of the day. It was observed that the short lighting periods decrease the plant growth. With high lighting conditions, plants grew rapidly.

Third set of experiments were carried out to observe the effect of water and system was tested for different water conditions. The water level of the tank was monitored using an ultrasonic sensor and if the water level decreased to a threshold level, a notification was sent to the user. Also, an alert message was displayed in the web dashboard in real-time. System scheduler activated the moisture sensor every hour and checked the soil moisture level. When the moisture level is less than the threshold, the water pump was turned on automatically and watered the plants.

The plant growth was monitored by ultrasonic sensors and height of the plants was recorded twice a day. When plant height is reached a predefined level, a message was displayed on the web dashboard. Furthermore, as shown in Figure 3, Figure 4 and Figure 5, the plant growth, temperature and humidity variations, real-time statistics for the environment conditions and plant height are displayed in the web dashboard as real-time statistics.

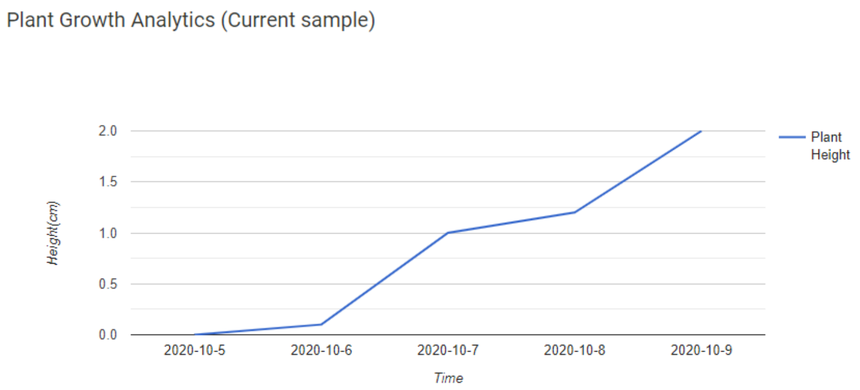

Fig. 3. Plant growth analysis

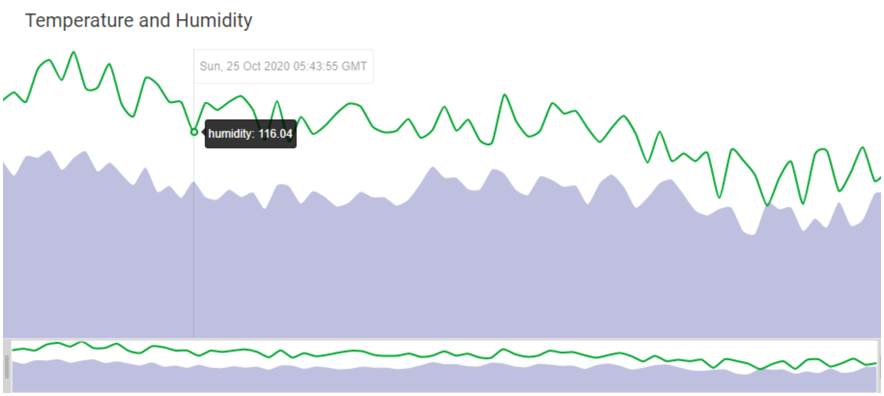

Fig. 4. Temperature and humidity inside the Sprouter

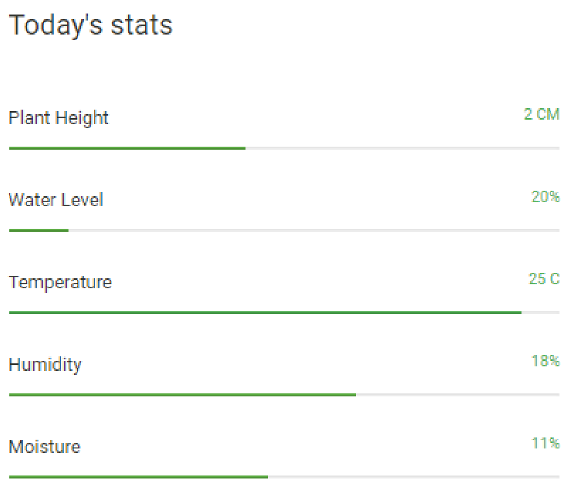

Fig. 5. Real-time status of the environment conditions and plant height.

Table 3 shows the growth of mung beans sprouts under different conditions. According to our observations, following are the optimum conditions for sprouts to grow healthy:

- Temperature: 24°C-26°C
- Lighting hours per day: 15
- Watering frequency per day: Every 4 hours

Table 3. Results of the experiment.

	Temperature	Lighting Hours per day	Watering Frequency per day	Plant Height	No. of Days	Sprouts Condition
1	24°C-26°C	15	Every 4 Hours	6-8cm	5	Healthy
2	24°C-26°C	-	Every 4 Hours	6-8cm	3	Turn to yellow
3	28°C-30°C	18	Every 6 Hours	6-8cm	4	Too much greenish
4	Less than 24°C	10	Every 2 Hours	6-8cm	7	Healthy

5 Conclusion

In this research, we have presented a portable IoT based microgreen Sprouter, and a prototype for mung beans, to accelerate and de-accelerate the growth by changing the environmental conditions such as light, moisture and temperature. We have identified the optimum conditions for the mung beans to grow and observed that other conditions such as darkness and high temperature reduce the quality of the microgreen.

As future work, we are planning to integrate an image processing model that can identify plant diseases using images taken from a camera. Also, we are planning to integrate an AI model to recognize plant species and configure system to offer an optimum environmental condition automatically.

6 References

1. S. K. De and I. Dey, "A simple way to study the global population growth," pp. 171-180, 2015.
2. M. R. S. Muthusinghe, Palliyaguru S. T., W. A. N. D. Weerakkody, A. M. Hashini Saranga, W. H. Rankothge, “Towards Smart Farming: Accurate Prediction of Paddy Harvest and Rice Demand”, R10-HTC 2018.
3. Dhanuka Perera, Chamod Rathnayaka, Sachin Dilan, Lasitha Siriweera, W. H. Rankothge, “Sustainable Tourism: Application of Optimization Algorithms to Schedule Tour Plans”, R10-HTC 2018.
4. M.C. Jayasuriya, K.T. Galappaththi, D. Sampath, N. Nipunika, W Rankothge, “Experimental Study on an Efficient Dengue Disease Management System: Planning and Optimizing Hospital Staff Allocation”, International Journal of Advanced Computer Science and Applications 2018
5. C Thiranjaya, R Rushan, P Udayanga, “Towards a Smart City: Application of Optimization for a Smart Transportation Management System” ICIAfS 2019
6. S Perera, S Dissanayake, D Fernando, “Supply and Demand Planning of Electricity Power: A Comprehensive Solution”, CICT 2019
7. WDI Fernando, W.H. Rankothge, “Optimization of Customer-Friendly Manual Load Shedding System, ICAC 2019
8. SMMM Senarath, MTK Perera, “Smart Platform for Film Shooting Management” CICT 2019
9. W.H Rankothge, S.V. Sendanayake, at el. “Technology assisted tool for learning skills development in early childhood” ICTER 2012
10. C. Gnauer, H. Pichler, C. Schmittner, M. Tauber, K. Christl, J. Knapitsch and M. Parapatits , "A recommendation for suitable technologies for an indoor farming framework," Elektrotech. Inftech, p. 370–374, 2020.
11. A. Petre, "Microgreens: All You Ever Wanted to Know," 6 March 2018. [Online]. Available: https://www.healthline.com/nutrition/microgreens. [Accessed 2020 October 2020].
12. "What are microgreens," 15 June 2020. [Online]. Available: https://plantui.com/what-are-microgreens/. [Accessed 25 October 2020].
13. M. Miller, "Is There Any Benefit To Microgreens Beyond Looking Adorbs?," 12 March 2019. [Online]. Available: https://www.womenshealthmag.com/food/g26784840/what-are-microgreens/. [Accessed 25 October 2020].
14. "Growing Microgreens," ChefSteps, [Online]. Available: https://www.chefsteps.com/activities/growing-microgreens#:~:text=Optimize%20the%20environment:%20Extreme%20temperatures,but%20rather%20somewhere%20in%20between. [Accessed 28 October 2020].

15. M. Karimi, K. Kheiralipour , A. Tabatabaeefar and G. M. Khoubakht , "Effect of Moisture Content on Physical Properties," International Journal of Engineering Research & Technology (IJERT), vol. 8, pp. 54-59, 2009.
16. S. Nizetic, P. Šolić, D. . L.-d.-I. González-de-Artaza and L. Patrono, "Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future," Journal of Cleaner Production, vol. 274, 2020.
17. A. Mody and R. Mathew, AgroFarming - An IoT Based Approach for Smart Hydroponic Farming, 2020.
18. R. K. Kodali, V. Jain and S. Karagwal, "IoT based Smart Greenhouse," in 2016 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), Agra, 2016.
19. A. Sofwan, S. Sumardi, A. I. Ahmada, I. Ibrahim, K. Budiraharjo and K. Karno, "Smart Greenhouse Based on Internet of Things for Environmental Engineering," in 2020 International Conference on Smart Technology and Applications (ICoSTA), 2020.