SIGMA: A Real-Time Soil and Environment Remote Monitoring for Indoor Garden Management

M. Izham Jaya[1,*], M. Arif Amir[1], Syifak Izhar Hisham[1], Azlee Zabidi[1], Mohd Faizal Ab Razak[1]

[1]Faculty of Computing, College of Computing and Applied Sciences,
Universiti Malaysia Pahang,
26600 Pekan, Pahang, Malaysia

*Corresponding author's email: izhamjaya@ump.edu.my

ABSTRACT: Each indoor plant requires a specific need to ensure its optimum growth including the right amount of water, precise lighting measurement, and accurate pH value. Some gardeners are unable to properly monitor and regularly perform maintenance tasks such as pH checking and plants watering. This paper aims to provide a solution by developing a Smart Indoor Garden Monitoring System (SIGMA) to assist gardeners in managing their indoor gardens remotely. A NodeMCU ESP32 microcontroller is used to collect soil and environmental data from the pH sensor, DHT11 sensor, FC-28 sensor, and light sensor. The collected data is then sent to the cloud database server using HTTP protocol. Additionally, actuator devices such as water pump and plants growth light are also connected to the microcontroller for automated irrigation and lighting systems. A mobile application is specifically developed to manage the indoor garden using real-time data and to control the actuator. The SIGMA prototype is successfully tested to verify its functionality. Indeed, SIGMA is capable to visualise real-time sensor data, allow users to control the actuator devices, provide automated irrigation and lighting systems as well as provide reports and notification to assist gardeners in their routine tasks.

Keywords: Keywords: *internet of things; indoor garden management; environment dynamic data monitoring; indoor farming, mobile application*

1. INTRODUCTION

Internet of Things (IoT) and digital agriculture allows gardeners to accurately monitor the plants' environment and soil conditions. This valuable information assists gardeners in deciding on their operations such as when and how much to water the plant, and when to change the soil [1]. Each indoor plant has its own specific needs including the right amount of water, precise lighting measurement, and accurate pH value [2]. Plants growth will be optimum if these elements are maintained properly. Unfortunately, constant monitoring on soil and environment conditions as well as performing maintenance tasks at the same time demand high labour cost and are time consuming [3]. On the other hand, indoor plants require a stable pleasant environment where factors such as temperature, humidity and lights are controlled according to the needs. As these factors are dynamic and easily change, supplementary management tasks and additional maintenance costs are inevitable as compared to the outdoor garden [4]. Additionally, it is difficult for the gardeners to detect early changes on the soil and environment condition and be aware of the necessary pre-emptive task they should take [3]. Inadequate knowledge on the changes of temperature, humidity, pH levels and lighting condition will also devastate the indoor plant's health condition and deteriorate its growth [5].

This paper aims to provide a user-friendly, automated, and scalable solution by developing a Smart Indoor Garden Monitoring System (SIGMA) to assist gardeners in managing their indoor gardens remotely. The proposed solution in this paper is motivated by the needs of low-cost, low-energy and low resource consumption in small scale indoor garden implementation.

2. METHODOLOGY

SIGMA's system architecture consists of two main parts which are the sensors/actuators and the monitoring system as depicted in Figure 1. The sensors/actuators part includes the NodeMCU ESP32 microcontroller where all the sensors including FC-28 Soil Moisture Sensor, light sensor, pH Sensor, DHT11 Air Temperature and Humidity Sensor, as well as the actuator devices such as water pump, growth light, and exhaust fan are connected. The ESP32 microcontroller is connected to the Wi-Fi network through an integrated Wi-Fi module that will give ESP32 access to the HTTP protocol. Each of the actuator devices is assembled with a relay that is attached between the actuator device and the microcontroller. The relay acts as a switch that changes high current to low current flow or vice versa. Real-time firebase is used as a cloud database server that will store all the collected data from the sensors. Due to this, the HTTP protocol is used to send data between the microcontroller and the smartphone. The mobile application development process strictly follows Rapid Application Development (RAD) methodology to ensure an efficient and structural application development process. SIGMA mobile application invokes sensors data from the real-time database and visualize the data to the users. At the same time, it allows users to control the actuator devices.

3. RESULTS AND DISCUSSION

An indoor hydroponic vertical garden is used to evaluate SIGMA functionality during the experiment.

The result shows that the hourly range of light sensor reading is between 0 to 2215 lux. The highest readings are during the day light from 12pm until 3pm.

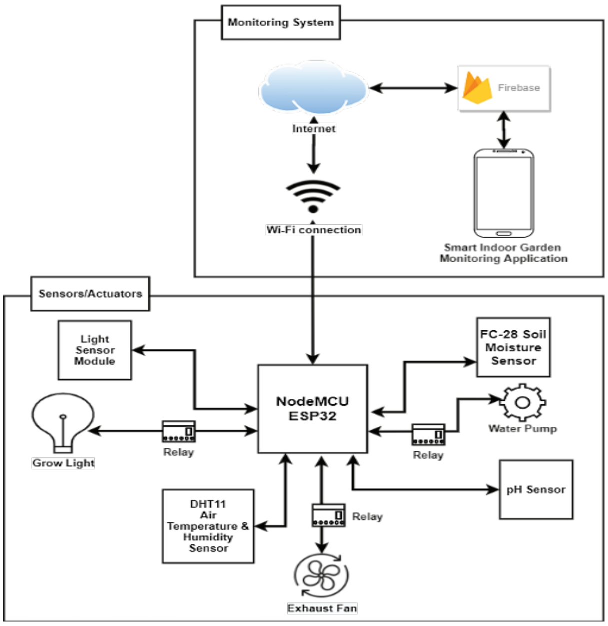

Figure 1 System architecture of SIGMA

Minimum sensor value for light intensity is set to 300 lux and in fact, the indoor plant is exposed to more than 300 lux natural sunlight for 9 hours daily. Light automation systems in SIGMA facilitates the gardeners to automatically control the usage of additional light sources when the minimum sensor value is not reached. Additionally, continuous usage of LED plant growth light can be reduced to save operational cost unless the plant requires high light intensity and long hours of exposure.

The hourly range of temperature sensor reading is between 28.5 degrees Celsius and 33.5 degrees Celsius. The minimum sensor value is set to 30 degrees Celsius as most of the indoor plant is tolerable to this temperature. The exhaust fan is automatically activated by SIGMA if the temperature value is above the allowable minimum value. Depending on the plant species and its temperature resistance, the exhaust fan operating hours can be reduced by setting a suitable minimum value.

The hourly range of soil moisture values is between 40% to 65%. The sensor reading is highly dependent on the time when the plant is watered and gradually decreased during time. The water pump is activated at 9 am daily and increases the soil moisture to 65%. Constant monitoring on soil moisture helps the gardeners to efficiently plan their irrigation routine and reduce their water consumption.

SIGMA mobile application is tested for its functionality and the results showed that all functional requirements were successfully met. Real-time sensor data from the Firebase real-time database is invoked and visualised in SIGMA mobile application as exhibited in Figure 2 (a) and Figure 2 (b).

4. CONCLUSION

This paper successfully implements SIGMA, an IoT solution which helps gardeners to monitor and control their indoor gardens' soil and environmental conditions remotely from anywhere and at any time.

(a) (b)

Figure 2 (a) Sensor's data visualisation (b) Time-series report of sensors value

SIGMA allows gardeners to monitor the light intensity that is suitable for each plant, soil moisture, soil pH, air temperature and humidity in real-time. Besides, gardeners can also control the actuator devices which consist of the water pump, growth light, and the exhaust fan remotely. The future plan for SIGMA is to integrate it with a camera device which allows users to do live video monitoring through the mobile phone application.

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REFERENCES

[1] A. Oliveira, C. Resende, A. Pereira, P. Madureira, J. Goncalves, R. Moutinho, F. Soares, and W. Moreira, "IoT sensing platform as a driver for digital farming in rural africa" Sensors, vol. 20, no. 12, pp. 1–25, 2020.

[2] A. Rizkiana, A. P. Nugroho, N. M. Salma, S. Afif, R. E. Masithoh, L. Sutiarso, and T. Okayasu, "Plant growth prediction model for lettuce (Lactuca sativa.) in plant factories using artificial neural network", IOP Conf. Ser.: Earth Environ. Sci. Vol. 733, 2021.

[3] K. Y. Kim, J.H. Huh, and H.J. Ko, "Research on Crop Growing Factory: Focusing on Lighting and Environmental Control with Technological Proposal", Energies, 14, 2624, 2021.

[4] M. E. H. Chowdhury, A. Khandakar, S. Ahmed. F. Al-Khuzaei, J. Hamdalla, F. Haque, M. B. I. Reaz, A. A. Shafei, and N. Al-Emadi, "Design, Construction and Testing of IoT Based Automated Indoor Vertical Hydroponics Farming Test-Bed in Qatar", Sensors, 20, 5637, 2020.

[5] S. Tagle, H. Benoza, R. Pena, and A. Oblea, "Development of an indoor hydroponic tower for urban farming", in Proceedings of the 6th DLSU International Conference on Innovation and Technology Fair, pp. 1–7, 2018.