Development of an IoT Hydroponic Production System for Urban Farming

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ABSTRACT – The hydroponic watering system with IoT is rising where plants can be grown without the need for soil and support urban farming, offering a solution to the people facing inflation and the COVID-19 impact. The emergence of IoT has allowed intelligent agriculture to cultivate where nutrient and soil humidity is controlled via smartphone and from afar. IoT adaptation in hydroponic is still lacking and motivates recent work. The paper aims to develop an IoT hydroponic system based on users' needs. The final design is created through concept screening and scoring matrices, and the physical prototype embedded with IoT is successfully constructed to validate the conceptual design.

1. INTRODUCTION

Planting vegetables for daily consumption has started to draw attention due to inflation and COVID-19. People living in apartments, for example, can now grow vegetables with the introduction of hydroponics called urban farming [1]. Hydroponics agriculture is a soilless cultivation method where the plant is grown with the help of nutrients and water alone and hence it provides a solution to the growing scarcity of agricultural land. In addition, a hydroponic system embedded with the Internet of Things (IoT) can monitor the plant's quality to sustain it when they are away via mobile app without intervening in their daily lives. To ensure proper growth of the plants and to achieve a maximum yield, the two essential parameters that need to be monitored regularly are moisture content and adequate nutrients intake [2]. IoT refers to the Internet of things, connecting people and things through the Internet and storing the data in the cloud for analysis. The emergence of IoT has allowed farmers to automate the hydroponic culture. Monitoring of water level, pH, temperature, flow, and light intensity can be done, and they can be regulated by the use of IoT [3]. This study aims to develop an IoT hydroponics system according to users' needs embedded with the nutrient and soil humidity monitoring system via the interface in mobile apps.

2. MATERIALS AND METHODS

Firstly, a survey method was used to obtain users' needs with 128 respondents involved. The House of Quality (HoQ) was created and used to map the needs with the technical specifications. The conceptual design has been generated from the technical specifications with the morphological chart and concept combination table assistance. Then, three conceptual designs are formed, and adapted decision matrices justify the selection process in concept screening and scoring tables. The 3D final design was developed in CAD and used to fabricate the physical prototype.

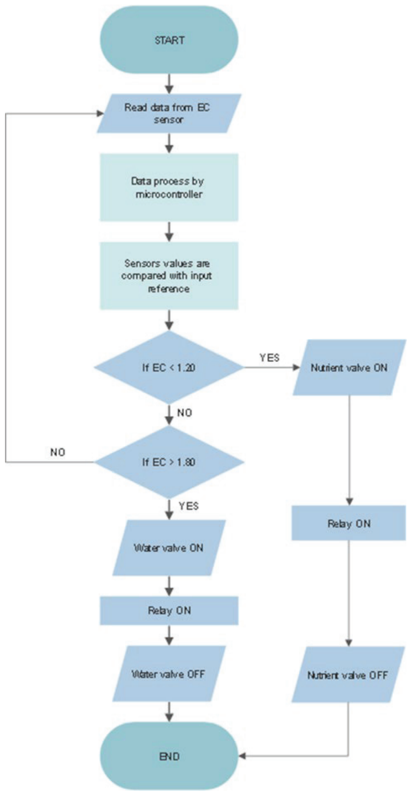
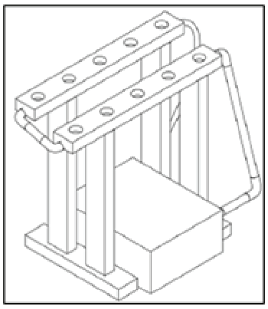


Figure 1 Real-time monitoring flow

Figure 1 shows the flow of the real-time data monitoring of this project. The real monitoring system is used to inform users when they need to add fertilizer and nutrients to the reservoir. It generally shows how the data acquisition flows from the input to the system's output. The system will begin to read data or measurements taken from the EC sensor. Next, all sensors' data or measurements will be transferred into web hosting and a database server. ESP32 microcontroller is initially connected to the internet by Wi-Fi communication, and all data is transferred from the microcontroller to the web hosting or server by Wi-Fi communication. The microcontroller will process a decision-making statement by comparing the current EC with the reference value. Respective solenoid valves will be actuated if the current values of EC less or exceed the reference value.

3. RESULTS AND DISCUSSION

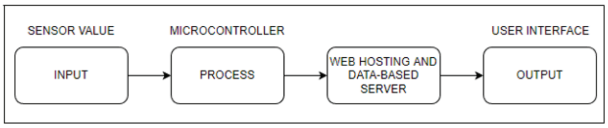
Among the users' requirements are energy saving, less maintenance, aesthetic, easy to set up, less space consumption, portable, less greenhouse effect, and a real-time monitoring system. The House of Quality was constructed based on the needs, mapped with the technical specification that must be embedded in the product. Figure 2 illustrates this project's 3D final design and physical prototype.



(a)

(b)

Figure 2 (a) Final 3D design, (b) Prototype



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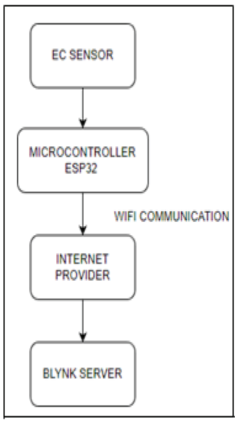

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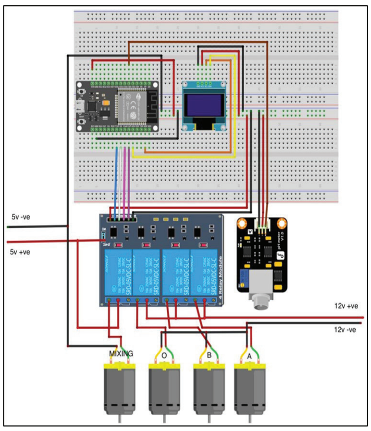

(c)

Figure 3 (a) Block diagram, (b) Data acquisition, (c) Wiring diagram

Figure 3 shows the design of the open loop block diagram to continuously deliver real-time measurements of all sensors. The values measured by the input sensors are primarily gathered and processed by the microcontroller. All required data was sent into web hosting and a database server via Wi-Fi. This type of continuous control system works in which the output has no influence or effect on the control action of the input signal. Regardless of the input, an open-loop system does not know the output condition. Hence finally, users can continuously monitor the current measurement of the sensors using a smartphone installed with an application as an interface without being able to control the output.

After wire connections have been made according to the wiring diagram, Arduino software is used for coding since IoT is a system of interrelated computing devices that are provided with unique identifiers and the ability to transfer data over a network. In addition, blynk applications are explored to monitor the EC value. Blynk provides native iOS and Android mobile apps that allow users to control and visualize data, as depicted in Figure 4.

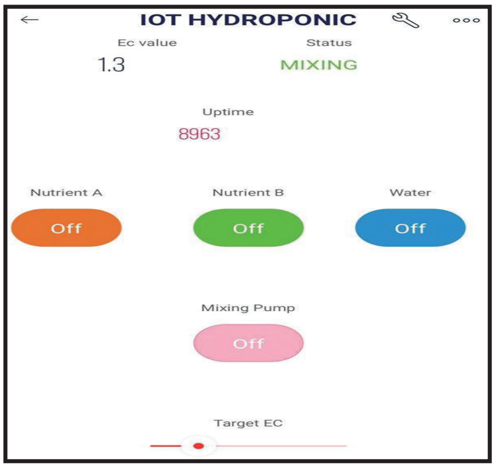

Figure 4 User interface of the mobile application

4. CONCLUSIONS

To conclude, the hydroponic watering system with IoT has been successfully developed.

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