Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Automated aquaponics maintenance system

To cite this article: Muhamad Farhan Mohd Pu'ad *et al* 2020 *J. Phys.: Conf. Ser.* **1502** 012021

Automated aquaponics maintenance system

Muhamad Farhan Mohd Pu'ad[1], Khairul Azami Sidek[1], Maizirwan Mel[2]

[1]Department of Electrical and Computer Engineering, Faculty of Engineering, International Islamic University Malaysia, Gombak, Malaysia.
[2]Department of Biotechnology Engineering, Faculty of Engineering, International Islamic University Malaysia, Gombak, Malaysia.

paan94my@gmail.com

Abstract. Nowadays, automation has become an essential feature in various applications. Agriculture is a crucial sector in which human being heavily depends on. Aquaponics is one of the efficient approaches in agriculture. Human resource allocated for aquaponics maintenance is very inefficient in terms of workload as compared to the time spent especially with the advanced technology we have today. It is necessary to include automation in aquaponics to reduce manpower involvement. However, a lack of attention has been given by local farmers to automate their aquaponics using technology. In this study, an automated aquaponics maintenance system was developed as a prototype to reduce human involvement in the activity. The system covers water level and light-emitting diode (LED) power switch maintenance. Furthermore, the automation system can be controlled via Telegram for user convenient. Moreover, it also measures the pH level of the water as an additional feature. Numerous tests were conducted on aquaponics to observe the reliability of the system at the Malaysian Institute of Sustainable Agriculture (MISA), a non-profit organization focusing on urban farming. Positive results were obtained from the tests which suggested that the system is self-dependent. Therefore, the system is suitable to be used in aquaponics.

1. Introduction

Nowadays, the advancement of technology has provided us with a new powerful tool which can control our traditional tools into working by itself; it is called automation. A trend today is replacing routine works conventionally done by a human with automated devices or machines moving towards the "Industry 4.0" [1]. This is to reallocate human resources to more challenging tasks which automation cannot perform. However, the adaptation of this technology in the agriculture sector is still slow compared to other sectors despite its importance to human being [2]. It is important to note that the increasing world population demands more food productions which call for a more efficient way to produce food [3]. In striving to achieve efficiency in food production should not leave the environment endangered. A system that suits that specification is aquaponics, a combination of plant and fish farming [4]. Using this approach, water is recycled for the use of plants and fishes harmoniously [5]. The integration of plants and fishes into a system comes with a variety of routine maintenance tasks which has the potential to be automated using the technology we have today. However, a lack of attention was given by local farmers to integrate aquaponics with automation to increase its efficiency. An automated aquaponics maintenance system is proposed in this study to reduce human dependent of the system in which covers water level maintaining and LED controlling tasks. The low water level may harm the fishes in the aquaponics if no immediate action is taken. The LED used to provide light even in the darkness of nightfall to increase the efficiency of plant growth. This study adopts a combination of design from [6] and [7] which uses Arduino with [8] which uses Raspberry Pi in agricultural automation. Besides, Telegram is integrated into the system for controlling the automation remotely.

2. Methodology

2.1. Hardware Design

Figure 1 shows an Arduino Nano microcontroller is used as a core of the automation with the aid of a Raspberry Pi 3 Model B+ microcomputer. Three analogue sensors are used in this study; ambient light sensor, pH sensor, and water level sensor. However, this study only covers automation on light-emitting diode (LED) for night time and maintaining the water level of the aquaponics. A liquid-crystal display (LCD) screen is used displaying real-time measurement on-site for monitoring purpose. A 12 V fluid pump is used for adding water to the aquaponics' water tank. Two relays are used each for controlling the pump and the LED. An additional power supply of 250 V 13 A is required for the LED and the pump. Also, a step-down transformer is required for the pump. All the sensors, LCD screen, and relays are connected to the Arduino. Power is supplied to the Arduino via the Raspberry Pi using a Universal Serial Bus (USB) cable. While data from the Raspberry Pi travels from its general-purpose input/output (GPIO) ports to digital ports of the Arduino. A portable Wi-Fi modem is used for Internet connectivity.

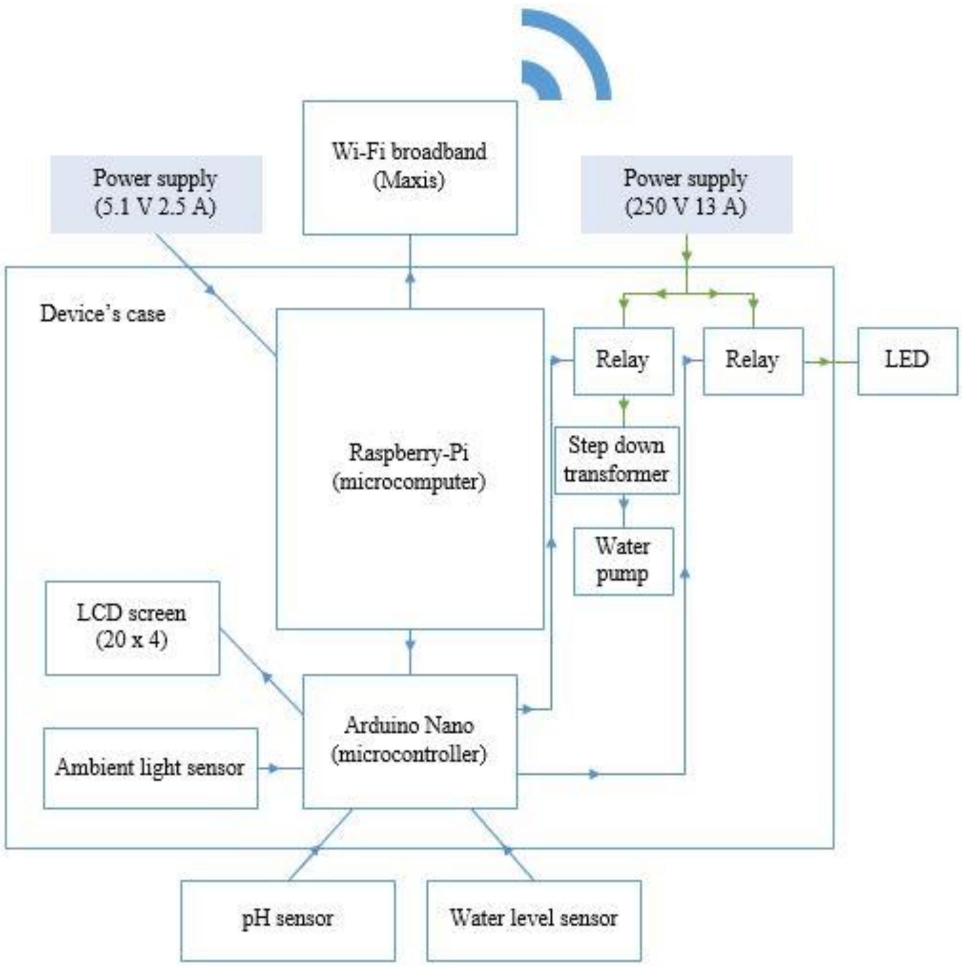

Figure 1. Block Diagram of the Hardware Components

2.2. Software Design

The main part of the automation is the Arduino code which handles the whole automation based on calibration values of all the sensors. The Arduino was programmed to retrieve measurements from the sensors and response to it accordingly such that if the water level drops, turn on the pump until the water level is back to its ideal level and if the ambient light level is low which indicates darkness, turn on the LED until the ambient light is back high. The pH measurement value is converted into pH value for display, while water level and ambient light measurement values are left in analogue-to-digital (ADC) values for easy programming of the system. The response value for both water level and ambient light must be defined in the code according to calibration values obtained. Meanwhile, the Raspberry Pi was installed with Raspbian, its official operating system which is the most compatible. It was also installed with Telepot, a Python framework for Telegram bot application programming interface (API). The highlighted feature of this study is the use of Telegram in controlling the automation remotely by the user using a personal computer or smartphone which requires Internet connectivity as shown in Figure 2. A unique bot was created with the name iWATER to communicate with user for controlling the automation which includes turning on or off the automation, LED, and pump.

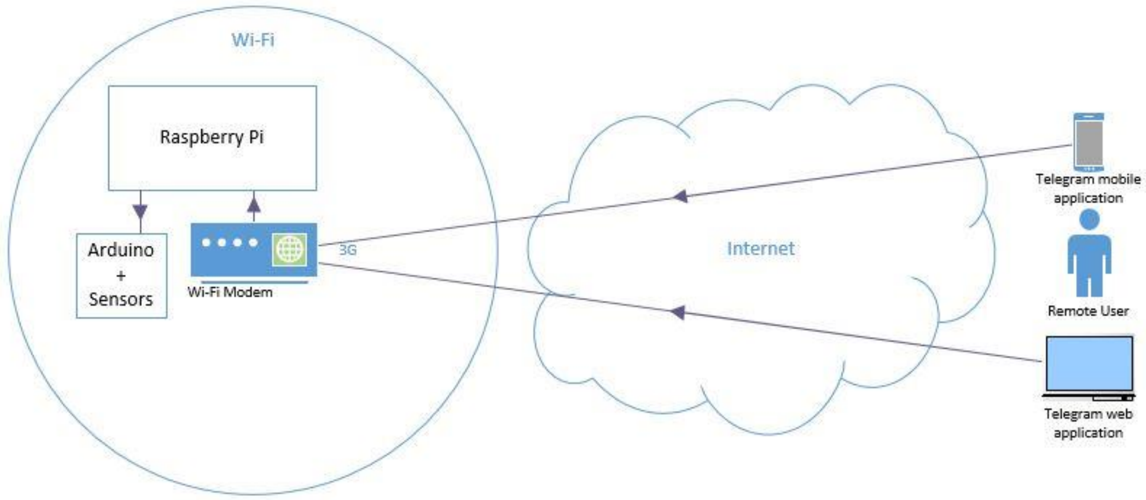

Figure 2. Block Diagram of the Telegram Connectivity

2.3. Experiment on the System

The experiment takes place at the Malaysian Institute of Sustainable Agriculture (MISA), a non-profit organization focusing on urban farming as shown in Figure 3. The pH sensor was calibrated with standard pH solution. Water level sensor was tested with different water level and observes output measurement value produced. The ambient light was tested in daylight and darkness to indicated output measurement value for both situations. A green bulb was used instead of a LED bulb for testing purpose only. The automation was also tested by controlling it via Telegram.

Figure 3. Testing of the Automation System

3. Results

Table 1 shows the measurement produced by the water level sensor based on water level drop. The ambient light sensor produces measurement value less than 100 in the dark and near 1000 in the brightness of daylight. Figure 4 shows a list of commands programmed to support the system including turning on and off for automation, light, and pump. Other than that, includes displaying date, time, and status of the system if necessary in the future. Besides, the system also includes a basic login and logout mechanism for minimum security since the telegram bot can be chatted with anyone around the world. The automation shows positive response towards measurement changes in water level and ambient light. Other than that, the automation was able to be controlled via Telegram as shown in Figure 4 from a smartphone. Thus, the automation system is reliable for use in aquaponics.

Table 1. Measurement of Water Level

Water Drop (cm)	ADC Value
0	290
1	275
2	260
3	235
4	200
Dry	0

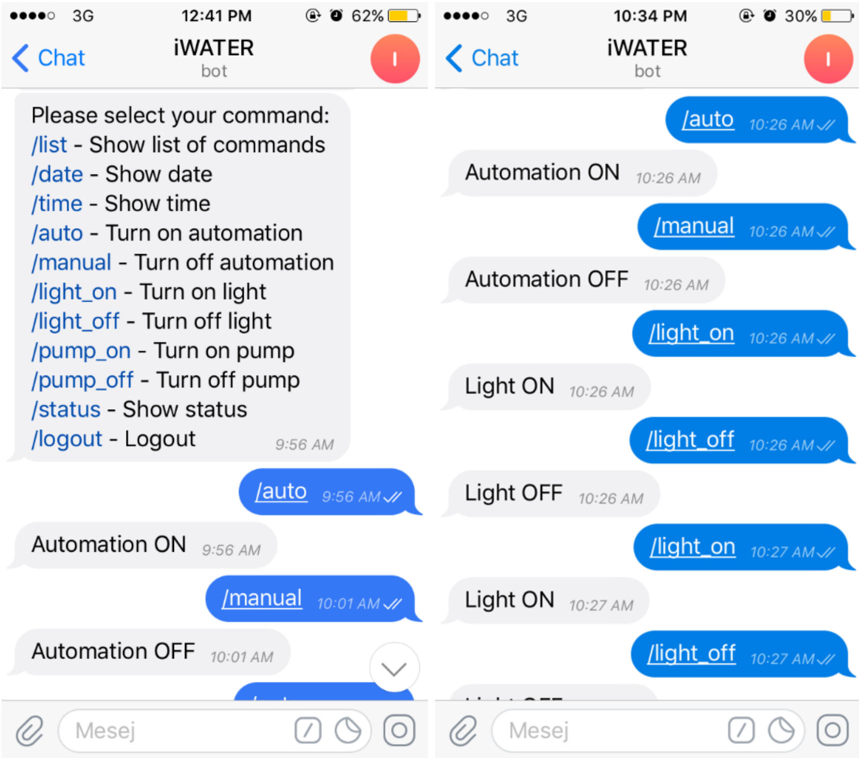

Figure 4. Telegram Chat

4. Conclusion

An automated aquaponics maintenance system prototype was successfully developed and tested in MISA. Using Telegram as a platform of the automation, it is convenient for common users among the MISA's staffs. Moreover, the system reduces the human dependency of the aquaponics in term of water level and LED power switch maintenance. However, there is always room for improvements such as including fish feeding and pH level controlling in the automation. Nonetheless, this is the little effort in modernising the local agriculture sector.

References

[1] Bahrin, M. A. K., Othman, M. F., Azli, N. N., & Talib, M. F. (2016). Industry 4.0: A review on industrial automation and robotic. *Jurnal Teknologi*, *78*(6-13), 137-143.

[2] Gondchawar, N., & Kawitkar, R. S. (2016). IoT based smart agriculture. *International Journal of advanced research in Computer and Communication Engineering*, *5*(6), 2278-1021.

[3] Pereira, L. S. (2017). Water, agriculture and food: challenges and issues. *Water Resources Management*, *31*(10), 2985-2999.

[4] Goddek, S., Delaide, B., Mankasingh, U., Ragnarsdottir, K., Jijakli, H., & Thorarinsdottir, R. (2015). Challenges of sustainable and commercial aquaponics. *Sustainability*, *7*(4), 4199-4224.

[5] Rakocy, J. E. (2012). Aquaponics: integrating fish and plant culture. *Aquaculture production systems*, *1*, 343-386.

[6] Budye, D., Dhanawade, P., Kirti, P., Mahesh, P., & Gupte, A. (2018). Automation in hydroponic system. *Int. Jounral Res. Eng. Appl. Manag*, *3*.

[7] Shirsath, D. O., Kamble, P., Mane, R., Kolap, A., & More, P. R. S. (2017). IoT based smart greenhouse automation using Arduino. *Int. J. Innov. Res. Comput. Sci. Technol*, *5*(2), 234-238.

[8] Krishna, K. L., Silver, O., Malende, W. F., & Anuradha, K. (2017, February). Internet of Things

application for implementation of smart agriculture system. In *2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC)* (pp. 54-59). IEEE.

Acknowledgements
This work was funded by the Publication – Research Initiative Grant Scheme (P-RIGS) 2018 (Project ID: P-RIGS19-013-0013) from the International Islamic University Malaysia. We would like to thank the Malaysian Institute of Sustainable Agriculture (MISA) for providing facilities for testing our system in this project.