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Automated Maintenance System For Freshwater Aquascape Based On The Internet Of Things (Iot)

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Abstract. Aquascaping is a hobby that has gained considerable popularity across different age groups, from young to old. Aquascaping itself is the art of arranging plants, water, rocks, coral, wood and other natural elements in glass or acrylic containers. One of the main obstacles in the world of aquascaping is consistency, which is often difficult to achieve when the owner has a busy schedule or limited time. Without the implementation of Internet of Things (IoT) technology and microcontrollers connected to mobile applications, this drawback is even more pronounced. The inability to maintain consistency in maintenance can lead to a decline in aquascape quality, both in terms of aesthetics and ecosystem health. Therefore, an innovative system using IoT is expected to provide a smart solution to overcome the major shortcomings of aquascape maintenance and enhance the experience of this hobby for its enthusiasts..

Keywords: Microcontroller, Monitoring, Internet of Things(IoT), Android

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1. Introduction

Aquascape is the art of organising aquatic plants, rocks, and wood with the aim of creating a look like gardening in water, enriched by the presence of fish as a companion to maintain the balance of the ecosystem.[1]. In Aquascape, the temperature factor must be a concern because it affects the balance of the ecosystem.[2]. With the development of the times, IoT or Internet of Things began to be integrated in terms of supervision and monitoring. [3]. IoT in its application can also function as a controller rather than just a supervisor [3].[4]. IoT is also popularly chosen because of the flexibility in the scale of its needs[5].

Android is also one of the results of the development of the times that has been widely used and developed[6]. The use of smartphones and android as a monitor device is increasingly popular[7]. Using a smartphone as a monitor device is also a practical choice in its use[8]. With the implementation of an IoT-based monitor system[9], aquascape ecosystem maintenance can be controlled easily and accurately without being hindered by distance or time and can be automated in its use.[10]The use of the IoT monitoring system in addition to maintaining the stability of the ecosystem, things such as replacement and detection of water quality can also be done automatically.[11]. Based on the advantages of the application of the IoT system in several fields including in the field of aquascape maintenance, this aquascape maintenance automation system was made. And based on some research that has been done before, here are the references used as a reference for this research:

a. In the research conducted by Moch Haidar Rafi and Bambang Santoso with the title "Design of Automatic Aquascape Liquid Fertiliser Giving Tool Using NodeMCU Based on Internet Of Things (IoT)". The results obtained are, the tool that has been designed has worked as expected and successfully integrated into the Blynk control application which allows the tool to be controlled and can be monitored parameters through the Blynk website or in the Blynk application.[12].
b. Another research conducted by Piter Wijaya and Theophilus Wellem with the title "Design and Implementation of Temperature and Water Level Monitoring Systems in IoT-based Ornamental Fish Aquariums", this research produces tools that can detect and manipulate temperature, water level, and can regulate light control that has been integrated via Telegram using Bot in the Telegram application.[13].
c. Another research conducted by Nurul Fahmi and Shellya Natalia with the title "Water Quality Monitoring System for Catfish Cultivation Using IoT Technology", this research successfully integrates water temperature and pH monitoring devices in catfish ponds with android-based applications using IoT telnology that can monitor and control tools through android applications.[14].
d. Research on the application of IoT in terms of Care and Monitoring conducted by Allieffa Salsabilla Pradisthi and Joko Aryanto entitled "Monitoring and Automation System for Bird Feeding and Drinking Based on Internet of Things Using ESP32", this study successfully implemented an IoT-based care and monitoring system in bird care and cages that are able to control the Interval of bird feed and drink monitored by the system using IoT.[15]

Based on the research references cited above, the use of IoT as an aquarium or aquascape maintenance system can improve the quality of the ecosystem being maintained [16]. However, the main drawback of aquascapes is the difficulty in achieving consistency of care, including consistent light and feed schedules. Without the help of IoT technology, aquascape owners may struggle to maintain ecosystem optimality, which could lead to a decline in ecosystem aesthetics and health.

This research demonstrates that maintenance tools have limitations in managing light and feed schedules, as well as regulating water levels in aquascapes. In this context, IoT system solutions are highly relevant and can overcome these weaknesses.

By implementing IoT tools, aquascape owners can easily set feeding intervals and lighting schedules automatically. This system facilitates maintenance without the physical presence of the owner and provides the flexibility of remote monitoring and control, improving maintenance efficiency without compromising the quality of the ecosystem.

Additional benefits of the system include remote monitoring via website or Android phone, automatic setting and monitoring of water levels, and scheduled automatic feeding. By automatically scheduling lights, the system creates an optimal environment for plant growth and fish health, while maintaining the beauty of the aquascape. The implementation of IoT in aquascape maintenance ensures the sustainability of the ecosystem and provides convenience and better control for the owner. This device will also be integrated with a website that uses Firebase as storage.[17]The device will also be integrated with a website that uses Firebase as its storage [17], using a website that can be easily opened on mobile and desktop devices[18]. The website used uses the PHP programming language as its basis[19] and uses Firebase type Realtime as a place to store data[20].

2. Methods

In this study, the research process is divided into several phases, including problem identification, literature review, system design, device assembly, testing, and conclusion.

2.1. Block System Diagram

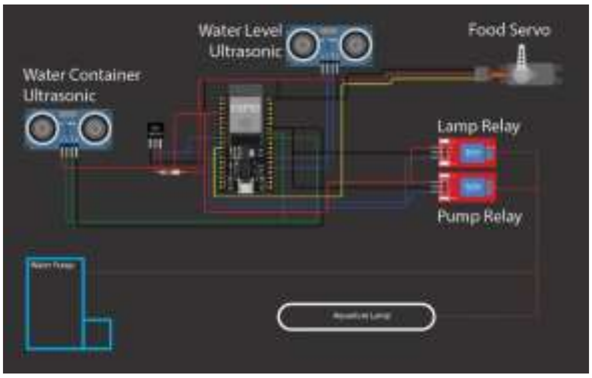

Figure 1 System Diagram

Based on Figure 1 above, ESP 32 which functions as the main control to process and process data taken from sensors and other modules which will later forward data to the Web. Water level sensor will detect the water level, then ESP 32 will process the data and if it has passed a certain limit, it will turn on the relay connected to the water pump to add water to the Aquascape. Water container Sensor on the other hand will detect the amount of water remaining in the water reservoir to fill the Aquarium, if less ESP will send the data to the Web. Food servo will open the food storage hatch every time that has been set by the web, while the Lamp Relay will turn on the lights according to the schedule hours that have been determined on the Web. The DS18B2 sensor will detect the water temperature which will be forwarded by the ESP to the Web.

2.2. Flowchart

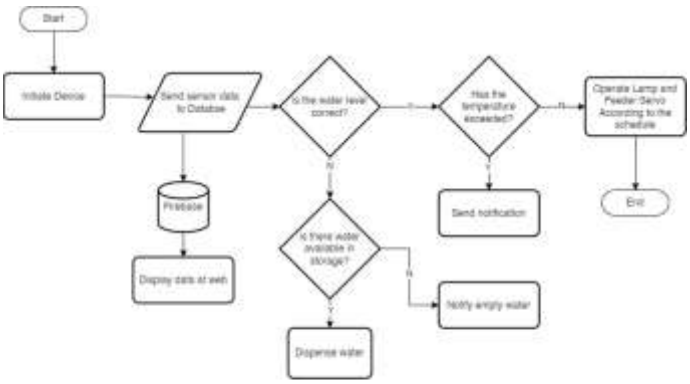

Figure 2 Device Flowchart

Based on Figure 2 above, it can be explained the workflow of the device starting from the initiation of the device followed by sending all the data detected by the sensor to the Database which will later be displayed on the Website. After that the device will process data from the water level detection sensor in the Aquascape then the reservoir sensor will detect whether water is still available in the reservoir or not, if there is still water in the reservoir, the pump relay will turn on the water pump in the water reservoir. If the water reservoir is empty, the device will send a notification. After that the device will detect the temperature in the Aquascape, if the temperature exceeds the limit then the device will send a notification. Finally, the device will turn on the lights and turn them off according to the hour, then the device also sets the servo to open the food storage hatch according to a predetermined schedule.

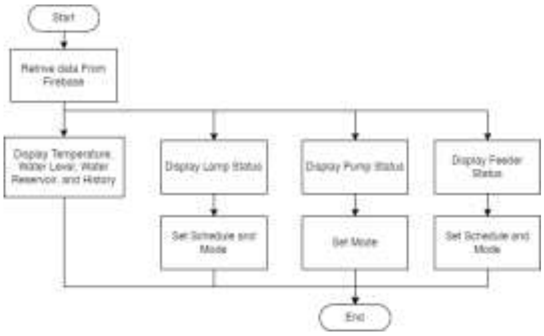

Figure 3 Website Flowchart

From the Flowchart Figure 3 above, the flow of the website can be explained as follows. First, the website will retrieve all data from Firebase to be displayed on the website, then through the website users can set schedules for lights and feed. Users can also set the mode used to manage pumps, feeders, and lights.

3. Results and Discussion

3.1. Result

The result of this system design is a tool that has been assembled and a website to monitor and control IoT tools for Aquascape. The tool can help maintain Aquascape Aquarium without the need for a lot of human intervention and with the help of a Website that can be opened through various devices, it is possible to control the tool without worrying about distance.


Figure 4 Device Set

Figure 4 above is the result of the application of the device that has been installed in an Aquarium with a size of 20cm x 15cm x 15cm. ESP 32 is used as a Microcontroller which will be connected to the Internet Network using WiFi so that it allows the device to be controlled remotely via a website.


Figure 5. Website

Figure 5 above is the result of the controller website to monitor, schedule, and view the status of sensors such as temperature, water level and water reservoir status.

3.2. Device Equipment Testing

The following is a table of device testing data that includes feeders, lights, and pumps and water levels. Testing is done to see if the device is successfully applied to real cases.

3.2.1 Feeder Testing

Table 1. Feeder Testing Result

No	Day	Time	Servo Status	Delay
1	Sunday	10.00 AM	ON	0s
2	Monday	10.00 AM	ON	0s
3	Tuesday	10.00 AM	ON	0s
4	Wednesday	10.00 AM	ON	0s
5	Thursday	10.00 AM	ON	0s
6	Friday	01.00 PM	ON	2s
7	Saturday	01.00 PM	ON	0s
8	Sunday	01.00 PM	ON	0s
9	Monday	01.00 PM	ON	0s
10	Tuesday	06.30 PM	ON	0s
11	Wednesday	06.30 PM	ON	0s
12	Thursday	06.30 PM	ON	1s
13	Friday	06.30 PM	ON	0s
14	Saturday	06.30 PM	ON	0s
15	Sunday	06.30 PM	ON	0s

During the first five days of the feeding trial, the ESP32 microcontroller functioned effectively and accepted the schedule settings at 10 am. However, when the setting time was changed, the feeding system continued to operate well despite slight delays caused by interruptions in the connection.

The ESP32 microcontroller can efficiently manage the feeding schedule under optimal conditions. However, it may experience a slight delay in situations where the connection is disrupted. Therefore, it is crucial to prioritize schedule management and maintain a stable connection to ensure optimal performance of the feeding system.

3.2.2 Lamp Testing

Table 2. Lamp Testing Result

No	Day	Time	Relay Stat	Delay	Time	Relay Stat	Delay
1	Sunday	08.00 AM	ON	1s	02.00 PM	OFF	3s
2	Monday	08.00 AM	ON	0s	02.00 PM	OFF	0s
3	Tuesday	08.00 AM	ON	0s	02.00 PM	OFF	0s
4	Wednesday	08.00 AM	ON	0s	02.00 PM	OFF	0s
5	Thursday	08.00 AM	ON	3s	02.00 PM	OFF	3s
6	Friday	08.00 AM	ON	0s	02.00 PM	OFF	0s
7	Saturday	08.00 AM	ON	0s	02.00 PM	OFF	0s
8	Sunday	08.00 AM	ON	0s	02.00 PM	OFF	0s
9	Monday	08.00 AM	ON	0s	02.00 PM	OFF	0s
10	Tuesday	08.00 AM	ON	2s	02.00 PM	OFF	0s
11	Wednesday	08.00 AM	ON	0s	02.00 PM	OFF	2s

12	Thursday	08.00 AM	ON	2s	02.00 PM	OFF	0s
13	Friday	08.00 AM	ON	0s	02.00 PM	OFF	1s
14	Saturday	08.00 AM	ON	0s	02.00 PM	OFF	1s
15	Sunday	08.00 AM	ON	0s	02.00 PM	OFF	0s

The test results indicate that the automatic light system was scheduled to turn on for 6 hours per day, in accordance with the specifications of the aquascape and its ecosystem. However, the recorded data shows delays in the relay function, which may have been caused by interruptions in the connection or potential interruptions in the Relay module used.

Overall, the testing of the lighting system went well, with no significant delays. The ESP32 microcontroller effectively received the light schedule, improving the system's operational reliability. Although some delays may have occurred, the automated lighting system's overall performance remained optimal, providing suitable lighting for the aquascape's needs.

3.2.3 Water pump and water level Testing

Table 3. Water level and container

No	Day	Interval	Delay	Capacity	Distance	Pump Relay Status
1	Sunday	1	1s	Available	1 cm	On
2	Monday	0	0s	Available	1 cm	Off
3	Tuesday	0	0s	Available	1 cm	Off
4	Wednesday	0	0s	Available	2 cm	Off
5	Thursday	0	0s	Available	2 cm	Off
6	Friday	0	1s	Available	3 cm	Off
7	Saturday	1	0s	Available	1 cm	On
8	Sunday	1	0s	Available	2 cm	On
9	Monday	1	0s	Empty	2 cm	On
10	Tuesday	0	0s	Available	1 cm	Off
11	Wednesday	0	0s	Available	1 cm	Off
12	Thursday	0	1s	Available	1 cm	Off
13	Friday	1	0s	Available	1 cm	On
14	Saturday	0	0s	Available	2 cm	Off
15	Sunday	1	0s	Available	1 cm	On

The data table attached records the results of testing the water level system on the Aquascape. The sensor was set at a distance of 1 cm from the water surface, resulting in satisfactory performance. The delays identified are believed to be due to connectivity constraints between the microcontroller and the server.

It is important to note that on the 9th day of testing, the water reservoir became empty. The system sent an automatic notification that the water reservoir was empty and required manual filling. After manual filling, the system activated the pump to replenish the water to a predetermined height.

Testing the water level system went smoothly overall, although filling the water reservoir still required manual intervention. However, this evaluation presents a favorable outlook on the system's ability to detect and respond to water levels, as well as its capacity to overcome connection constraints. Additional evaluation may be necessary to enhance the automation of water filling.

4. Conclusion

Based Previous research suggests that the success of the Aquascape system is largely dependent on the implementation of the Internet of Things (IoT) as a key infrastructure. The presence of the Website, ESP32 Microcontroller, WiFi connection, and Firebase as a Database in Aquascape maintenance highlights the shortcomings that IoT can overcome. Without IoT, Aquascape maintenance requires repetitive manual actions, such as manually setting lights. The major concerns are the risk of user forgetfulness and the potential for exceeding the recommended light limit for Aquascape. IoT offers solutions by enabling more efficient monitoring and management. For future development, focus should be on battery solutions as backup in the event of a power outage and system functionality under offline conditions. Improved connectivity is also a priority to overcome possible delays that may arise. Considering the drawbacks of Aquascape without IoT support, the development of this technology is expected to overcome these barriers and improve the overall effectiveness of the system.

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