Controllable LED by Using Smartphone Android for Aquascape Environmental Treatment

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Abstract. Aquascaping is a branch of art by arranging and creating a closed environment in an aquarium ecosystem. Aquascape uses living plants as the main element with fishes, shrimps, snails as the additional element. Plants need light to carry out photosynthesis. However, the light needed has certain parameters and quantities for each type of plants. If the light used is less than the needs of the plants, the plants will not grow up properly, however if the light given exceeds the ability of plants to absorb, algae will start to grow. In this study, an LED device that can emit the light needed by the plants will be developed. The light emitted by this device will be adjusted to the types of plants grown and the light around the aquarium environment. In this study, an application based on an android smartphone will also be developed. This will be used by users to choose the intensity of light that will be emitted by the device according to the type of plants grown in the aquarium. The device developed has been successful in maintaining the light emitted according to the light needed by the plants and the influence of light around the aquarium.

Keywords: Aquascape, Adaptive aquascape lighting, ESP32, Android Application

1. Introduction

Aquascaping is the art of creating a natural garden in an aquarium [1] and it focuses on the plants not the fish. Aquascaping has been known since Roman times and at that time people used stone or clay containers to carry out aquascaping activities whereas currently aquascaping uses aquarium. Aquascaping is a hobby that many people do because they like to see the beauty of the natural garden in the aquarium ecosystem. To maintain the beauty of the garden ecosystem, the aquascape must be maintained by considering several factors such as water quality, light, filtering, dissolved CO2, temperature and fauna choices [2].

The main focus of this research is to develop LED device that can provide the light needed by the plants. Based on interviews conducted with aquascape owners and activists, what needs to be considered in the light factor is the level of lumens and duration of exposure. The lumens level given will be different for each type of plant, where for the EASY type the lumen level is 10 - 20 lumens per liter of water, the MEDIUM type is 20 - 40 lumens per liter of water and ADVANCE type > 40
lumens per liter of water. Meanwhile, the duration of exposure is 5-12 hours per day with the provision that 6 hours are on and 3 hours off.

In this research, the LED device and its system will be developed based on Internet of Things (IoT) application. Currently, there many applications have been developed based on Internet of Things. The many uses of these IoT-based applications cannot be separated from the development of technology in the IoT environment such as the microcontroller used to control devices [3–5], android smartphone applications used for monitoring and adjustment [6–8], and communication technologies such as GSM [9–10], WiFi and the Internet [11] as well as wireless sensors [12] used to establish connections. The development of the LED device and its system will use ESP 32 as a microcontroller, HPL LED lamp as a light source, PT 4115 as a dimmable LED driver, lux BH1750 sensor to measure the output level emitted by the LED, and Blynk used to develop the mobile application.

2. Research Method
The first part is hardware development and the second part is software development. Hardware development will focus on developing the LED device while software development will focus on android application development and hardware programming.

![Figure 1. Block Diagram](image)

Process 1:
If the lux sensor reading is lower than the set LED output level, the system will wait for 50 loop cycle. If more than 50 cycles the lux sensor values remain less than the set LED output level, the ESP will slowly increase the PWM so that the value of the lux sensor reaches the desired output.

Process 2:
If the lux sensor reading is lower than the set LED output level, the system waits 50x the loop cycle. If in 50 cycles the lux sensor produces a fluctuating value (several times higher, and lower than the specified) it will be considered an error, and the calculation will be repeated from the beginning.

Process 3:
If the lux sensor reading is higher than the set LED output level, the system will wait for 50 loop cycle. If more than 50 cycles of the lux sensor values remain higher than the set LED output level, the ESP will slowly decrease the PWM value so that the value of the lux sensor reaches the desired output.
Process 4:
If the lux sensor reading is higher than the set LED output level, the system waits 50 times the loop cycle. If in 50 cycles the lux sensor produces a fluctuating value (several times higher, and lower than the specified) it will be considered an error, and the calculation will be repeated from the beginning.

Process 5:
If the PWM has been lowered to zero, and the lux sensor reads a higher value than the set number, the LED will turn off, and the ESP 32 assumes that the light from outside is sufficient for the plant to carry out photosynthesis.

Process 6:
If the PWM has reached the maximum number, but the lux sensor reading has not reached the desired lux, then the ESP will keep the LED lit with maximum PWM.

The process carried out on ESP 32 is part of hardware programming, while the design of smartphone applications and LED devices with its controller are the part of software and hardware development. In the smartphone application, as we can see in the Figure 2, there are options of LED output levels where for EASY plants the expected LED output level is 15 lumens/lt, while for MEDIUM and ADVANCED plants it is 30 and 45 lumens/lt respectively. The application also provides a slider that can be used by the user to adjust the LED output level according to user needs. In Figure 3, we can see the developed LED devices together with its controller.

3. Result and Analysis
In this research, a test has been conducted to measure the accuracy and the stability of the LED output level for every type of plant. The test is conducted for 3 days in 12 hours and the measurement is carried out every hour. The result of the test can be seen in the Table 1.
Table 1. A slightly more complex table with a narrow caption.

| Time | EASY (10 - 20 Lumen/lt) | Day 1 | Day 2 | Day 3 |
|------|------------------------|-------|-------|-------|
| 7    | 15                     | 15    | 15    |
| 8    | 15                     | 15    | 15    |
| 9    | 15                     | 16    | 15    |
| 10   | 17                     | 16    | 17    |
| 11   | 17                     | 19    | 17    |
| 12   | 19                     | 20    | 19    |
| 13   | 19                     | 20    | 20    |
| 14   | 18                     | 19    | 21    |
| 15   | 17                     | 18    | 19    |
| 16   | 15                     | 15    | 15    |
| 17   | 16                     | 14    | 15    |
| 18   | 15                     | 15    | 14    |
| 19   | 15                     | 14    | 15    |
|      | **Average**            | **16.38** | **16.62** | **16.69** |
|      | **Std. Dev**           | **1.56** | **2.26** | **2.32** |

From Table 1 it can be seen that the average LED output level for EASY plants per day is in the predetermined range, while the standard deviation shows a fairly good value even though at certain times the LED output level exceeds the specified range. This occurs because the light from the environment is bright enough so that the system cannot reduce the PWM to reach the specified LED output level. Based on the data in Table 1 it can be concluded that the device performance on EASY plants is good enough with a minimum accuracy of 92.3% and the output stability fluctuates with a maximum standard deviation of 2.32.

Table 2. The accuracy and stability test for MEDIUM plant

| Time | MEDIUM (20 – 40 Lumen/lt) | Day 1 | Day 2 | Day 3 |
|------|---------------------------|-------|-------|-------|
| 7    | 29                        | 30    | 30    |
| 8    | 29                        | 30    | 30    |
| 9    | 30                        | 30    | 30    |
| 10   | 30                        | 29    | 30    |
| 11   | 30                        | 30    | 30    |
| 12   | 30                        | 31    | 30    |
| 13   | 31                        | 31    | 30    |
| 14   | 31                        | 30    | 30    |
| 15   | 30                        | 30    | 29    |
| 16   | 29                        | 29    | 30    |
| 17   | 30                        | 29    | 30    |
| 18   | 30                        | 30    | 29    |
| 19   | 30                        | 30    | 30    |
|      | **Average**               | **29.92** | **29.85** | **29.77** |
|      | **Std. Dev**              | **0.64** | **0.55** | **0.44** |

Table 3. The accuracy and stability test for ADVANCE plant

| Time | ADVANCE (20 – 40 Lumen/lt) | Day 1 | Day 2 | Day 3 |
|------|---------------------------|-------|-------|-------|
| 7    | 45                        | 45    | 45    |
| 8    | 45                        | 45    | 45    |
| 9    | 45                        | 45    | 45    |
| 10   | 46                        | 45    | 46    |
| 11   | 46                        | 45    | 45    |
| 12   | 46                        | 46    | 46    |
| 13   | 45                        | 47    | 47    |
| 14   | 45                        | 47    | 47    |
| 15   | 44                        | 46    | 46    |
| 16   | 45                        | 46    | 47    |
| 17   | 45                        | 45    | 47    |
| 18   | 44                        | 45    | 46    |
| 19   | 44                        | 44    | 45    |
|      | **Average**               | **45.00** | **45.46** | **45.92** |
|      | **Std. Dev**              | **0.71** | **0.88** | **0.86** |

From Table 2 and 3 it can be seen that the average LED output level for MEDIUM and ADVANCE plants per day is in the predetermined range with minimum accuracy of
99.7% and 97.9% respectively while the output stability fluctuates with a maximum standard deviation of 0.64 and 0.88 respectively.

4. Conclusions

The controllable LED works better for the MEDIUM and ADVANCE plants which is indicated by the very good result in accuracy and stability with 97.9% minimum accuracy and 0.88 maximum standard deviation for the stability. For EASY plants the accuracy and stability of the controllable LED are quite good with 92.3% accuracy and 2.32 maximum standard deviation but there is an obstacle to lowering the LED output level when the light emitting from outside is very bright.

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