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# TANKMATE DESIGN FOR SETTINGS FILTER, TEMPERATURE, AND LIGHT ON AQUASCAPE

# 用于水族上的设置过滤器，温度和光线的修补设计

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**Abstract**
The success of aquascape maintenance lies in certain critical factors, including temperatures, lights and water filtration, which should be constantly monitored; but at some point, these keys are not well monitored, causing correctional action being taken too late and creating damage. Using an online control system as an IoT device can assist in control and automation functions, while an online feature provides monitoring, remote access, and remote override as other benefits that would help maintain an aquascape. This research's subject involves designing an IoT device as an online control system that would automatically control temperatures, lights and water filtration using an Arduino-compatible board based on an ATMega328/P microcontroller connected to web services and a web portal for a monitoring and management interface. This control system uses Wi-Fi as a communication line with the web service. API is a bridge from the control system and the web service, and the portal's front end and back end are custom-built using PHP and MySQL. The overall process was developed using a combination of the spiral model and prototyping paradigm modelling. The result is a fully working prototype of an online control system complete with a web interface, which helps aquascapers maintain their tank as human factors could be minimized by this device.

**Keywords:** Microcontroller, Aquascape, ATMega328P, Control System.

**摘要** 水族维持的成功与否取决于某些关键因素，包括温度，光线和水的过滤，这些因素应经常监测；但是在某些时候，这些按键没有得到很好的监控，从而导致采取纠正措施的时间太晚并造成了损坏。使用在线控制系统作为物联网设备可以辅助控制和自动化功能，而在线功能则可以提供监视，远程访问和远程覆盖等其他好处，有助于维护水族景观。该研究主题涉及将物联网设备设计为在线控制系统，该系统将使用阿杜伊诺兼容板（基于连接到网页服务的 ATMega328 / P 微控制器和用于监视和管理界面的网页门户）来自动控制温度，光线和水的过滤。 。该控制系统使用无线上网作为与网页服务的通信线路。应用程式介面是控制系统和网页服务之间的桥梁，门户的前端和后端是使用 PHP 和 MySQL 定制的。整个过程是使用螺旋模型和原型范

式模型的组合开发的。结果是带有网络界面的在线控制系统的完全正常工作的原型，它可以帮助水产养殖者维护其水箱，因为该设备可以最大程度地减少人为因素。

关键词: 微控制器，水景，ATMega328P，控制系统。

# I. INTRODUCTION

The potential for using information and communication technology (ICT) in various aspects of a good life is tremendous. The Internet of Things (IoT) is one manifestation of ICT implementation that has an extensive scope of essential qualities, such as communication, and nonessential nature, such as hobbies. The IoT's potential is in the form of a control system on things that require specific environmental conditions that are maintained and require extensive continuous monitoring. With IoT implementation in the use of a closed-loop control system, the consistency of environmental parameters can be maintained automatically, which is very helpful, especially in parameters that must be monitored continuously.

Aquascaping is a complex hobby that requires constant care and attention. Many enthusiasts have been attracted to the hobby due to the beauty of freshwater aquatic ecosystems. As a result, the hobby is associated with significant economic value. However, many aquascaping enthusiasts, due to the complexity and vulnerability of the ecosystems they create, as well as the need for continuous supervision for effective aquascape maintenance, do not want to install these systems in their home.

At present, most aquascape owners use manual methods to monitor and make changes to their ecosystems, especially in terms of lighting, water temperature, and filtration factors. At the same time, a limitation of aquascaping is that owners must operate the device directly, which requires being in the same physical location as the aquascape.

Therefore, the purpose of this study is to analyse a control system for addressing these problems. A prototype online control system, relying on a microcontroller, is designed for manipulating lighting device settings, as well as water temperature settings. The design utilises thermocouple and filtration elements to maximise the convenience associated with maintaining an aquascape.

# II. LITERATURE STUDY

## A. Previous Research

Available evidence indicates that microcontroller-based control systems can be effectively utilized to control other devices withing the IoT environment. In particular, a microcontroller in combination with Wi-Fi-based control and automation systems, is considered advantageous. Despite a delay of several seconds, control is more efficient and effective because it can be achieved remotely [9]. The use of Arduino with WiFi is also considered flexible, affordable and effective, as well as an energy-saving and cost-effective solution that can improve quality of life [5].

Household appliances can also be automated by controlling them through a website [6]. Electrical equipment monitoring through an Android application has also been successfully implemented, whereby control can be attained without having to approach the device. Additional use of fire logins and sensors and human sensors during development keeps the system safe, error-free and efficient. The system can also be modified, and additional equipment can be added [7].

The use of specific installations has also been studied and good results have been reported. Automation systems in hydroponic installations using Arduino Uno have also been proved beneficial. Similarly, a system for providing liquid fertilizer was demonstrated, using distance sensors. The water level within the pipe can be maintained as needed, and the sensor readings can be sent to Arduino as well as to an Android smartphone [8].

## B. Aquascape

Aquascape is an art to of creating artificial ecosystems in an aquarium, known in Japan as the nature aquarium or a natural park created in an aquarium [3]. Aquascape requires more than ensuring water and aquarium quality, such as careful control of temperature, light, media and food sources. Interviews with aquascape owners indicate that several essential factors are key to the success of aquascape maintenance, as outlined below.

*1) Light*

The illumination required for the aquascape is provided by lights that should be operational for 5−12 hours per day, following 6 h ON / 3 h OFF regimen. Light levels must be adjusted to the type of flora planted.

*2) Filtration*

In aquascape, filtration is carried out continuously so that the quality of water is maintained. This is essential, as if food remains or fish droppings are left to accumulate, water quality would deteriorate.

*3) Dissolved $CO_2$*

Besides being used by plants to photosynthesize and produce oxygen for existing fauna, $CO_2$ in aquascape is closely related to water acidity (pH) and carbonate hardness (KH). The ideal acidity level in aquascape is 6.8, beyond (below) which $CO_2$ levels needed to be reduced (increased).

*4) Temperature*

Aquatic plants usually cannot thrive at ambient temperatures below 25$^{o}$C or above 27$^{o}$C. To maintain the temperature in this narrow optimal range, a water cooler (commonly called a chiller) can be used, while ensuring that its capacity is adjusted to the volume of water in the aquarium. For a small aquarium, however, small fans can be used instead. At present, many cooler types are available, some of which are based on thermocouple components, such as Peltier devices that are often used in cold dispensers either with dye systems or with a water block.

*5) Fauna Choice*

Correct choice of fauna (e.g. fish, shrimp, and snails) will complement the beauty of the garden in the aquarium, and will give an artistic impression.

## C. Control System

The control system imposes and monitors the relationship among components forming a configuration to ensure that these provide the expected response or output [4]. The control system can give commands to individual units, or control other systems so that the desired system output is obtained. The primary function of the control system is to keep the actual output at the desired value continuously even though there is a disruption in the system.

In a closed control system, often referred to as a closed-loop, the results obtained from measuring the value of the system output are fed back into the system to enable a comparison with the entered input value. This means that the system output can exert a substantial effect on the input value. Consequently, the control system’s controller can be adjusted in such a way as to ensure the stability of the system output value.

## D. Microcontroller

The microcontroller is a microcomputer chip with the physical form of an IC (Integrated Circuit) [1]. Microcontrollers are widely used in everyday equipment such as digital televisions, microwave ovens, radios, remote controls and other systems that are small, inexpensive, and do not require the complex calculations required of more sophisticated equipment, such as computers.

Microcontrollers run on programs that have been designed for their specific uses. These programs are built directly into the microcontrollers, and are often used for reading external conditions (such as sensors) or controlling devices connected to them (such as actuator devices like switches, servo motors, stepper motors, and relay modules).

The various devices connected to microcontrollers, whether sensors or actuators, are connected to the microcontroller legs that function as IO ports with either input or output functionality. An input port serves as a pathway for entering data from outside into the microcontroller. An output port serves as a pathway for moving data or information out of the microcontroller. The input port is generally a digital path that only recognizes on or off. It may be used to detect the condition of a switch, for example, to determine whether it is open or closed.

Some microcontrollers have an ADC feature on some of the legs that is used to convert analog signals into digital values. This feature enables the processing of data from analog sensors as input. The ADC feature is used for such applications as voltage and temperature measurement from analog sensors.

The output path on a microcontroller can be used to control devices as outputs, including LEDs, motors, and relays in simple applications. This path can also be used to control informative devices, such as LCDs and seven-segments.

In general, microcontrollers work at a voltage of 5 volts, but some types of microcontrollers can be operated with a voltage of 3 volts.

## E. Arduino

Arduino is a prototyping platform using easy-to-use open source hardware and software [10]. This software and hardware combination makes it possible for anyone to carry out electronic projects easily and quickly [2]. Arduino hardware is comprised of a development board that contains a variety of possible AVR microcontrollers. The software on Arduino is an IDE (Integrated Development Environment) that is used to write program code and upload the program into the microcontroller.

## II. Research Methods

### A. Method of Data Collection

In this study, data collection was performed using the following methods:

1) Library with sources such as books and literature related to material and writing

2) Observation carried out by observing objects directly

3) Interviews to explore as much additional information as possible to complete the data with the object of interviewing Aquascape business owners and some random owners.

### B. System Development Method

The system development method used in this study is a combination of two systems-development methods, namely the spiral model and prototyping paradigm where the system is developed through a series of repeated prototype formation processes where each cycle is a development from the previous cycle until the prototype can meet the desired needs.

## III. Result and Discussion

In general, the design of the online control system named Tankmate is a system used to control water-cooling devices based on thermocouple devices, two filters, and three lights automatically. The initial reference value used in addition to using a predefined initial reference (default setpoint) can also be determined flexibly through a website that was created specifically as an interface for this purpose.

Tankmate was designed using a series of several hardware modules. The main components are an Arduino-compatible board Deek-Robot Pro Mini with ATMega328P as MCU chip, and waterproof temperature sensor as input feedback. Additional components to support functions are a logic level converter, relay module, DC Mini Stepdown, and 1602 LCD Display.

Some of the software used is Arduino C as a program for microcontroller units on hardware, PHP-MySQL as programs and databases used for web service, and APIs as translators between hardware and web-based and application interfaces used by users with web browser facilities. This system is divided into three parts, namely hardware, web service/API, and application interface.

In the application, the user can set the reference value, the frequency of sending and retrieving data, and save it into the database to be used later as new data when data synchronization is done on the hardware side.

On the hardware side, using a Wi-Fi module, the device will synchronize data with the web service. This is done periodically with the frequency of sending and retrieving data arranged by the user.

To bridge the hardware and application interface, a web service API is created that serves to translate data stored in the database so that it can be accessed by the application while storing data sent by hardware into the database so that it can be read by the user through the interface.

The overall overview of this system can be seen in the Figure 1.

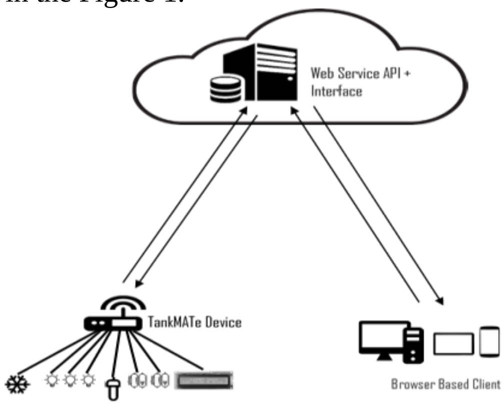


Figure 1. Overview of the tankmate system.

### A. Hardware Designing

The hardware in the proposed system is a controlling device (control system) with the main components of an Arduino-compatible Pro Mini board made by Deek-Robot based on AT Mega 328/P and ESP8266-01 as a link between the Arduino-compatible board that acts as the main controller with the network Wi-Fi available.

In addition to the two main components, there are several other components, one LCD Display 1602 unit as a medium for temperature and condition information, one logic level converter to change the data voltage from 5volt to 3.3 volts and vice versa, three relay modules as a switch, one temperature sensor and three Mini 360 DC Bucks Converter to convert 12 volt DC input to 3.3 volts for ESP8266-01 power, 5 volts for LCD Display power, temperature sensor and Pro Mini board, and 5 volts for three Relay Module power. The hardware circuit can be seen in the following figure 2.

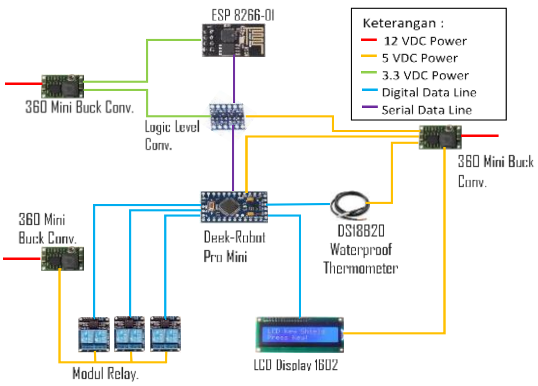


Figure 2. Hardware series.

## B. Designing a Web Interface

A web interface is an application that functions as an interface between the system as a whole and the user. In this application, all status data sent by the Tankmate hardware can be seen by the user. The user can also set the reference value to be applied.

The use of this application is limited to people who have Tankmate devices so that not everyone can use this application. Access to applications is limited by a username and password that can be registered on their own as long as they have an activation key that has been planted together with the device-ID on the hardware. The appearance of the web interface can be seen in figures 3 to 6.

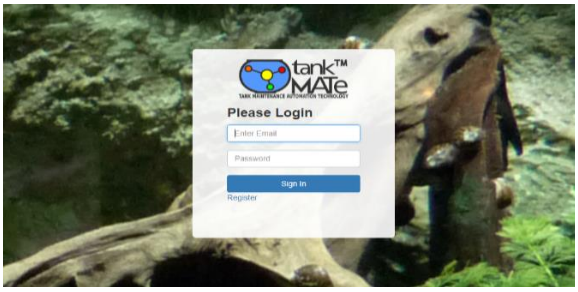


Figure 3. Display login.

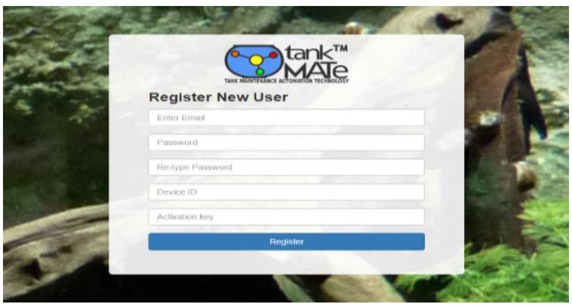


Figure 4. Display register.

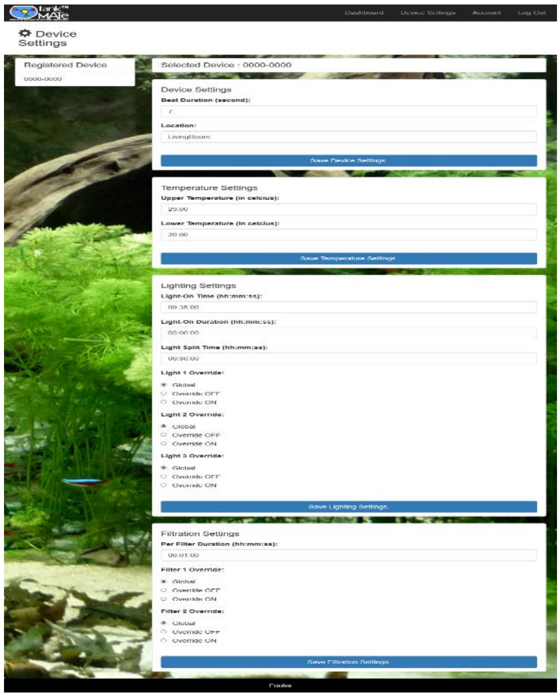


Figure 5. Display device setting.

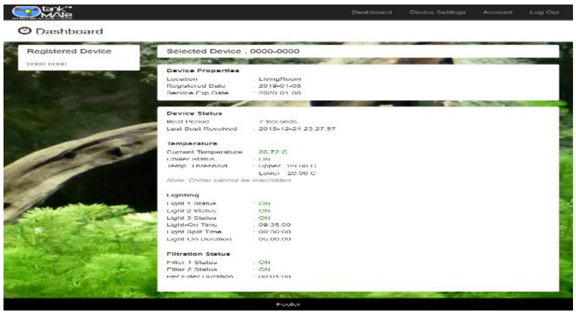


Figure 6. Display dashboard.

## C. Web Service Design

In this proposed system, a web service is used as a bridge between the application interface and the hardware. This web service has the task of processing data strands sent by the hardware and inserting them into available database systems, to then be processed by interfaces to produce information that can be seen by users.

In addition to this, when the hardware uploads data strands to the available web service, the web service will also provide feedback in the form of a set point data string that will be used as the basis for setting up the hardware.

The data strand at the time of the process is text data with a fixed length. In the process of returning data from a web service, the data strand is enclosed using a number sign (#) as the identifier of the location of the data from the data received by the Tankmate device. Data strand specifications can be seen in tables 1 and 2.

Table 1.
Strand of the web service

| Chr pos | Len | Information |
|---|---|---|

| | | |
|---|---|---|
| 1 | 5 | Server time (seconds) |
| 6 | 5 | Beat frequency (seconds) |
| 11 | 4 | Temperature upper limit (x 100) |
| 15 | 4 | Lower temperature limit (x 100) |
| 19 | 5 | First light on time |
| 24 | 5 | Second light on time |
| 29 | 5 | First light off time |
| 34 | 5 | Second light off time |
| 39 | 2 | Lamp 1 override setpoint |
| 41 | 2 | Lamp 2 override setpoint |
| 43 | 2 | Lamp 3 override setpoint |
| 45 | 5 | Filter start duration (in seconds) |
| 50 | 2 | Setpoint override filter 1 |
| 52 | 2 | Setpoint override filter 2 |

Table 2.
Strand towards web service

| Chr Pos | Len | Information |
|---|---|---|
| 1 | 1 | Lamp status 1 |
| 2 | 1 | Lamp status 2 |
| 3 | 1 | Lamp status 3 |
| 4 | 1 | Status *chiller* |
| 5 | 1 | Filter status 1 |
| 6 | 1 | Filter status 2 |
| 7 | 4 | Water temperature (x 100) |

### D. Implementation

The prototype design of the Tankmate device is carried out in stages following a system development cycle where each cycle is a development of the previous cycle. Development in each cycle can be in the form of design changes or the addition of new features to prototype devices. The cycle continues until the desired condition is reached.

After the desired features and capabilities are achieved, prototype devices enter the trial phase to work thoroughly and independently to find out how the prototype of the device performs. The results of the design and testing can be seen in table 3 below.

Table 3.
Design and trial stages

| Stage | Expectation | Results | Conclusion |
|---|---|---|---|
| 1 | Hardware:<br>-Can connect to SSID<br>-Can exchange data<br>Web Service & Interface:<br>-Can see the dashboard<br>-Can change SetPoint<br>-Can support the trans receiving process<br>-Can do add devices | Succeeded<br>Succeeded<br>Succeeded<br>Succeeded<br>Succeeded<br>Succeeded | Valid<br>Valid<br>Valid<br>Valid<br>Valid<br>Valid |
| 2 | Hardware:<br>-Can parse Set Point Data<br>-Can implement the New SetPoint Web Service & Interface:<br>- Can parse data from the device and save it to the database. | Succeeded<br>Succeeded<br>Succeeded | Valid<br>Valid<br>Valid |
| 3 | Hardware:<br>-Can save network data to EEPROM | Failed; 328P memory is not enough (remaining <700 Bytes) | Not Valid |
| 4 | Hardware:<br>-Moves the trans receiving routine to the ESP8266 chip to reduce memory load.<br>-Save network data to EEPROM | Succeeded<br>Succeeded | Valid<br>Valid |
| 5 | Hardware:<br>-Perform function tests and prototype resistance (complete test run) for 9 hours. | Succeeded; all features run as expected. | Valid |

## IV. Conclusion

From the discussion in section 4 above, conclusions can be drawn as follows: When using ICTs and Tankmate control systems, the owners no longer need to go to Aquascape to look at the water temperature or change the status of the device. The status of the device can be changed automatically, according to the input from the temperature sensor and set point configuration where set point can be implemented in near-real-time, depending on the frequency of data retrieval. The role of humans can be minimized in this way. The prototype can go as expected.

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