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An Unmanned Surface Vehicle (USV) for Water Quality Monitoring Platform

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Abstract: The goal of this project was to develop a low-cost unmanned surface vehicle (USV) water monitoring system. The project met its objectives since the overall cost was much cheaper than any other project available for the same purpose. The USV was also robust and controllable via Blynk apps, and the project was able to display some of the output data via the Blynk apps. The data is gathered under two distinct weather conditions. On a sunny day, the results show the temperature reading error rate is 1.88%, while on a rainy day, the error rate is 2%. This is considered to be fair. On a sunny day, the Ph reading error rate is 0%, whereas it is 6.4% on a rainy day. On a rainy day, this indicates that the sensor's accuracy is weakened. On a sunny day, the turbidity reading error rate is 99.35%, whereas on a rainy day, the error rate is -99.17%, which is extremely error. This may be from the damage of the turbidity sensor. This shows that only the Ph and temperature sensors can be relied on this testingThe job was performed in a systematic and precise manner. The design was built properly in AutoCAD software, and testing was carried out to collect data and confirm the results. In sum, the project's low cost makes it a realistic alternative for many organizations, and the USV's reliability and functionality make it a great instrument for water quality monitoring.

Keywords: USV, Monitoring, Blynk

1. Introduction

Monitoring water quality is an essential aspect of environmental monitoring. Accurate and timely information about water quality is crucial for protecting the water environment as a whole, controlling water pollution, and maintaining a healthy water environment. Presently, manual sampling and analysis are the primary methods used to monitor water quality. However, these methods have several shortcomings such as the limitations on the number of samples that can be taken, the time, money, and resources it takes, the safety risks it poses, and the added workload [1].

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To address these challenges, an autonomous surface vehicle (USV) will be developed. The USV will be equipped with the capability to take fixed-point samples of water quality using control by Blynk IOT. This project aims to provide a cost-effective and useful solution for monitoring the quality of water in rivers and ponds. This step is vital for us to get good water quality [2].

2. Methodology

The block diagram as shown in Figure 1 shows the flow of data of the full system of water quality monitoring system. It showed data transfer from the battery to a voltage sensor, which outputs from the battery. The motor controller is connected to the ESP32, which collects environmental data like pH, temperature, and turbidity. The microcontroller analyzes the data and sends commands to the motor driver, which executes the desired action.

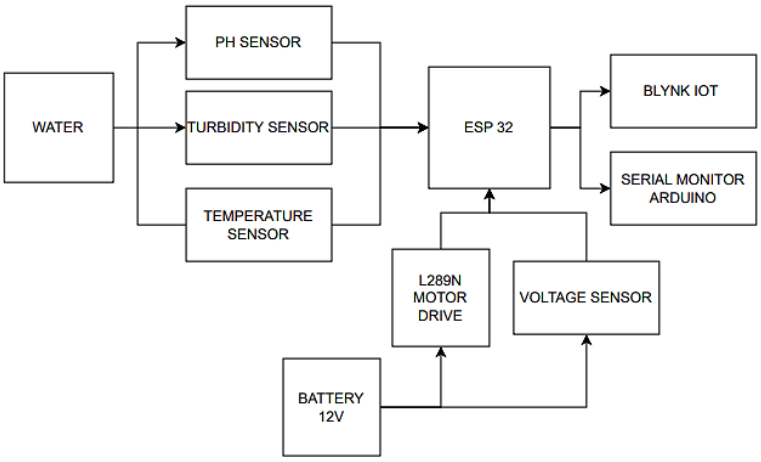

Figure 1: Block diagram for the proposed system

2.1 Hardware Design

This study aims to evaluate the performance of design monitoring systems using the software. The effectiveness of the implementation of this device was analyzed and proven using the Arduino IDE software and Blynk. The system receives the input and then transmits the data to the main processing unit. The obtained data is subsequently analyzed by the ESP32 and displayed on the Blynk platform. The Arduino IDE software is widely used in IoT applications. The applications were generally user-friendly, comprehensive, and open-source software. The researcher then displays the data using the Blynk program. Data may be monitored using both desktop and mobile apps.

Hence, an unmanned surface vehicle (USV) can be used to check the quality of water. The first step is the battery 12V needed to power the DC motor drive and ESP32. Next, the Blynk Internet of Things (IoT) software has to connect the ESP32 by Wi-Fi. Blynk lets USV can be remotely controlled to get to a certain place. Once the boat gets there, sensors find out how the reading the water is. If Blynk gets the info, it is displayed, and data collection is done. If Blynk doesn't get the data, ESP32 is reconnected to it, and the process is done again.

In general, the USV boat gathers its data by implementing the sensors of PH sensor, turbidity sensor, and temperature sensor to give data on the PH water reading, the clarity of water, and lastly the data of water temperature reading [3].

2.2 Software Design

The software is an integral part of the project's programming. In this investigation, the hardware was implemented using an Arduino IDE and Blynk application. Moreover, the Arduino IDE is widely used in Internet of Things applications. The software was user-friendly and open-source. Consequently, it is easier to create and submit code to the device. In addition, it is connected to hardware to upload and interact with programs [4].

Next, a Blynk application is an IoT platform that facilitates internet-based control on iOS and Android devices. The Blynk application can display all input parameters for the device. When a microcontroller is connected to a power source and Wi-Fi, it automatically establishes a connection with Blynk. The output can be accessed by serial monitor Arduino IDE display and Blynk IOT screen [5].

2.3 Integration of software and hardware.

USV water quality monitoring platform would merge software and hardware into an effective device. Initially, need to design coding using Arduino IDE. Then, set battery percentage, Ph water index, water clarity, and water temperature. Thus, the hardware part needs to check the functionality such as checking the continuity of each component and sensor calibration.

Furthermore, integrate the software and hardware. Then the process flow consists of many phases, including connecting to Wi-Fi on Blynk and the ESP32 microcontroller. Once the system connects to Wi-Fi following the activation of the device, the sensors begin working. Consequently, it would continue to read the value and show the data on the serial monitor in the Arduino IDE and the Blynk application on the web and smartphone.

In short, design the USV water quality monitoring system according to the desired criteria, such as PH sensing, temperature, water clarity, and battery percentage monitoring. The obtained data was then uploaded to the Blynk platform, where it was instantly stored and evaluated. Afterwards, the data were examined.

Figure 2 illustrates the development of a USV water quality monitoring system working process. It is separated into the software and hardware sections. The software design needs the use of the Arduino IDE. To achieve the requirement, configure the code for detecting PH reading, temperature, and water clarity. Regardless, the initial requirement for the system is to validate the WiFi connection between the device and the Arduino IDE. The second requirement is to detect the PH sensor for pH quality index, turbidity sensor for water clarity, and temperature sensor for water temperature reading. The last requirement is the ability to read data from the three sensors. Once a requirement was determined, software and hardware integration would begin. If no meeting occurs, the procedure must be repeated or returned to the setup step for troubleshooting. Thus, it would fulfill the requirement [6].

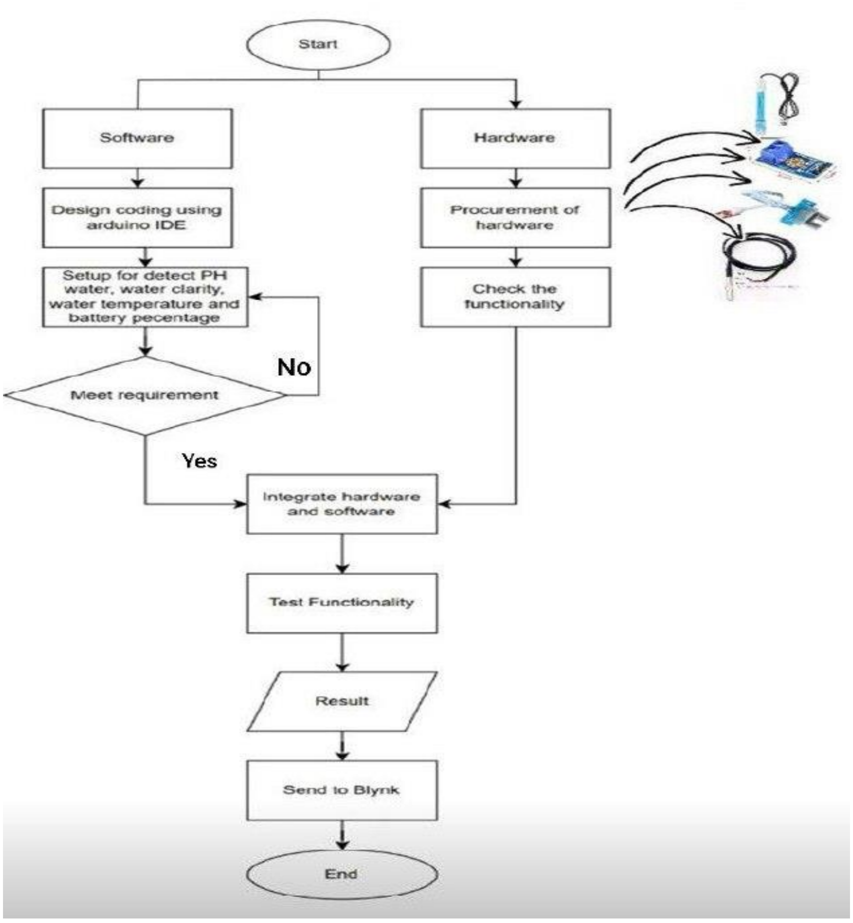

Figure 2: The development of a USV water quality monitoring system working process.

3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate.

3.1 Results

The data obtained by the USV water quality monitoring system is gathered under two conditions: sunny (Table 1) and rainy days (Table 2). The information would be tabulated in Excel and interpreted using a graph plot as shown in Figures 3 and 4.

3.2 The relationship between distance traveled and weather conditions.

It shows a sample of the data acquired for distance and weather between two distinct power supply circumstances.

a. Sunny day

Table 1: Data collection on a sunny day

Distance(meter)	Battery percentage (%)	Water Temperature(°c)	PH reading	Turbidity reading(ppm)
5	84	27	8	1655
7.5	84	27	8	1600
10	84	26	8	1500
12	83	26	8	1455

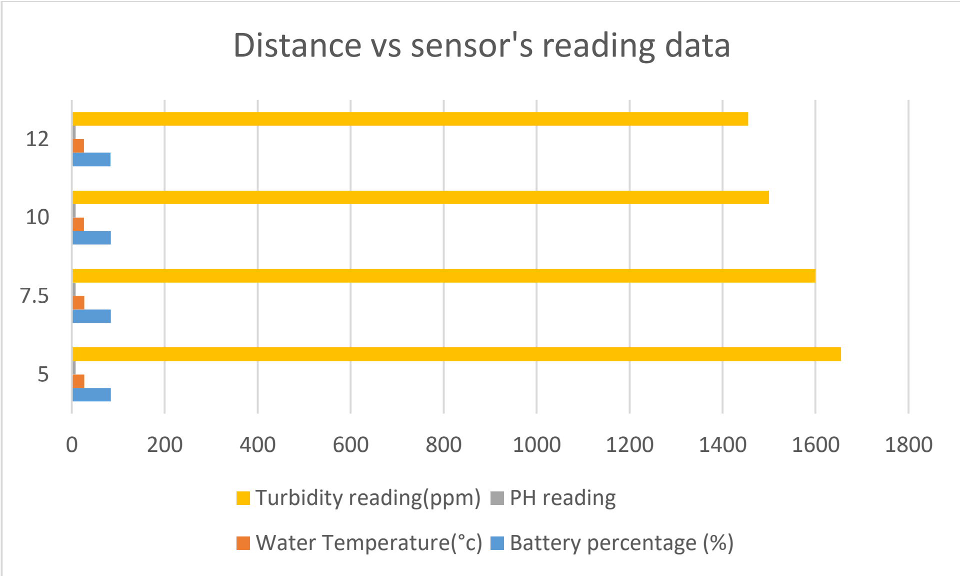

Figure 3: Value of distance vs. sensor's reading on a sunny day.

Figure 3 shows how the distance influences the reading of the sensors. For the temperature sensor, the deeper the lake, the colder the reading it gets. This is because sunlight does not penetrate very far into the water, so the deeper layers do not receive any heat from the sun. As for the Ph sensor, it stays on an 8-ph reading. Meanwhile, the turbidity sensor seems to be an error as the reading is too high. But for the note, on a sunny day, the clarity of the water should not be so dark.

b. Rainy Day

Table 2: Data collection on a rainy day

Distance(meter)	Battery percentage (%)	Water Temperature(°c)	PH reading	Turbidity reading(ppm)
5	100	25	6.5	1700
7.5	100	25	6.5	1750
10	100	26	6.3	1650
12	100	24	6.3	1600

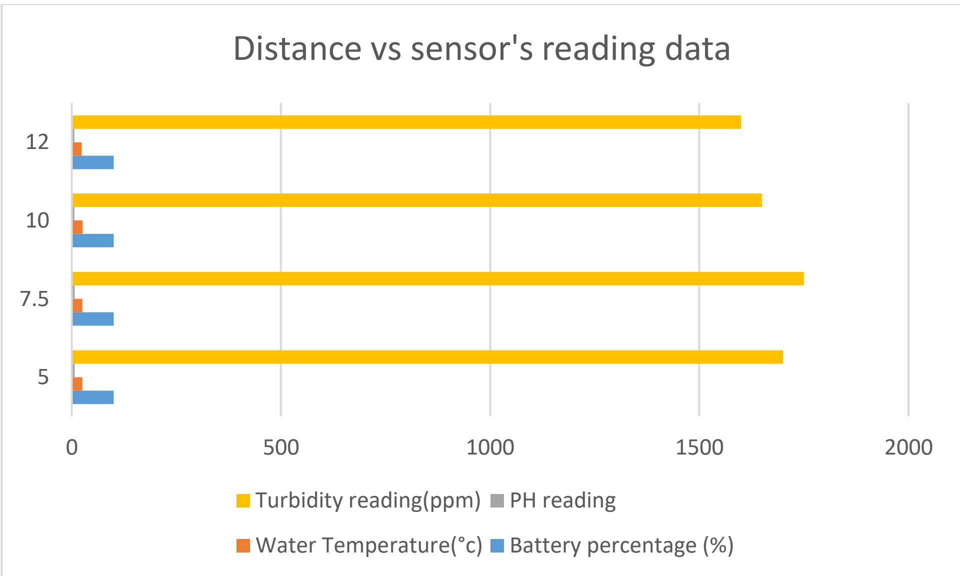

Figure 4: Value of distance vs. sensor's reading on rainy days.

Figure 4 shows how the distance influences the reading of the sensors on a rainy day. For the temperature sensor, the deeper the lake, the colder the reading it get. This is because sunlight does not penetrate very far into the water, so the deeper layers do not receive any heat from the sun. As for the Ph sensor, it goes in the range of 6.3-6.5 pH reading because it water is mixed well with the rainwater which is quite acidic. Meanwhile, the turbidity sensor seems to be an error as the reading is too high. But for the note, on rainy days, the clarity of the water is normally dark because of the mixing process of rainwater and lake water.

3.2 Discussions

The data is collected under two distinct weather and power supply conditions. The accuracy of the device's performance may be determined based on the tabulated error percentage reading:

Error rate = (measured value - expected value) / expected value * 100%

3.3 Tables

It displays the mean reading device parameter computation.

Table 3: Data of the Error Percentage

Weather	Temperature			PH reading			Turbidity reading		
	Expected value	Measured value (in avg)	%Error	Expected value	Measured value (in avg)	%Error	Expected value	Measured value (in avg)	%Error
Sunny	26	26.5	1.88	8	8	0	10	1552.5	-99.35
Rainy	25	24.5	-2	6.5	6.4	-1.54	13	1675	-99.17

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This computation illustrates the discrepancy between the actual and measured values. The calculation of the mean reading device is shown in Table 3. The error rate on a sunny day of temperature reading on a sunny day is 1.88% and on a rainy day is -2%. This is considered acceptable the error rate on a sunny day of Ph reading on a sunny day is 0% and on a rainy day is 6.4%. This shows that the sensor is not so accurate on rainy days. The error rate on a sunny day of turbidity reading on a sunny day is 99.35% and on a rainy day is -99.17% which is too much error [7].

4. Conclusion

In conclusion, the first objective of this project was to design and build a remotely unmanned surface vehicle (USV) water monitoring system. This objective was attained because the project was done remotely by IoT blank applications.

The second objective of this project was to create a stable boat shape to sail on water during the project testing. This objective was also attained because the final design of the USV was stable.

The last objective of this project was to do comparison testing on two different types of weather, which are sunny days and rainy days, and was successfully tested. This goal was completed in part because the finished and able to give output and the error percentage reading was done. The temperature reading error rate on a sunny day is 1.88%, while on a rainy day, it is 2%. The Ph reading error rate is 0% on a sunny day, while it is 6.4% on a rainy day. The turbidity reading error rate is 99.35% on a sunny day, while it is -99.17% on a rainy day, which is extremely error. This may be from the damage of the turbidity sensor. This shows that only the Ph and temperature sensors can be relied on in this testing process.

Overall, the project's objectives were met, and the final result was a USV water monitoring system that can be remotely controlled, and it is stable to sail. The initiative represents a significant contribution to the application of water monitoring, even though there is room for improvement in several areas.

Acknowledgement

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