Available online at:
Al-Fiziya: Journal of Materials Science, Geophysics, Instrumentation and Theoretical Physics
Website: http://journal.uinjkt.ac.id/index.php/al-fiziya
Vol.6 No. I 2023, 30-40

Design and Control Underwater Robot Based on Smartphone

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Submitted: May ; Revised: August ; Approved: August ; Available Online: September

Abstract. Underwater robot is a type of robot specially designed and configured to operate underwater, especially in seas, rivers, and lakes. The main purpose of underwater robots is to perform various tasks and missions underwater, which are often difficult or dangerous for humans to carry out. The method used to design the underwater robot is with a smartphone control system. The robot can move according to the user's commands by being connected through a internet network, allowing the robot and smartphone to be interconnected. This underwater robot is equipped with a camera and two lamps, and the images captured by the camera are displayed on a personal computer. Meanwhile, the lights are controlled by the user using a smartphone. The research results show that the underwater robot can be controlled to a depth of 0.5 meters with an average button press speed of 1 second in floating conditions and 2.9 seconds at a depth of 15 centimeters. The application of this robot can take photos, display good images, and monitor activities underwater. In addition, the captured image from underwater robot are also good and the image produced are clearly visible both on land and in the water.

Keywords: *Blynk, Smartphone, Underwater Robot, WiFi.*
DOI *: 10.15408/fiziya.v6i1.32368*

INTRODUCTION

Indonesia has a very wide water area that reaches more than 3000000 Km^2. The breadth of Indonesian waters certainly has abundant fishery potential such as various freshwater fish in lake waters. The large role of Indonesian waters certainly needs a monitoring system to be able to monitor the conditions and potential of underwater fisheries, one of which conditions and potential of underwater fisheries, on of which is by using an underwater robot equipped with camera. So that, every condition and potential of fisheries can always be monitored without having to dive into the water. Underwater robot is a robot that is intended specially for activities in the water. Where this robot is usually used to make observations or underwater surveys. Based on the working system, underwater robots consist of two types, namely AUV (Autonomous Underwater Vehicle)

and ROV (Remotely Operated Vehicle). Autonomous Underwater Vehicle (AUV) is an underwater robot that is autonomous based on the program that has been given to the robot chip [1]. This robot makes it easier for users to operate, which it can send data to users wirelessly [2]. Meanwhile, Remotely Operated Vehicle (ROV) is an unmanned underwater robot that can maneuver in water and it's controlled by an operator above the water surface [3]. The application of ROV can help humans in various research and engineering activities in the water [4]. In this research, an underwater robot based on ROV is designed which it's controlled using a smartphone connected to WiFi network.
Electronic communication underwater Robot [16],[21]. An underwater electronic communication robot, often referred to as an underwater communication system or underwater robot, is a specialized device designed to transmit and receive information in aquatic environments. These robots play a crucial role in various applications, including ocean exploration, environmental monitoring, underwater research, and industrial tasks. Technology continues to increase, ranging from means of communication to means of transportation. Technology can provide comfort and convenience for humans to carry out activities. Along with the rapid development of technology, a concept has emerged that can help human activities with the help of network commonly referred to as IoT [5]. Internet of Things (IoT) is a concept where objects can communicate with each other such as transferring data using the internet network in real time without involving human intervention [6][7]. One of the application of IoT can be done by using the blynk application on a smartphone. Where the blynk application can control various controllers such as Arduino, ESP32, ESP8266, Raspberry, etc. With blynk application, it is easier to control other devices using only a smartphone. So users can control anything remotely by staying connected to the internet. Blynk itself provides a limit of 2000 points for each new user in accessing the features in the application without having to pay (free) [8]. However, if we want to use it on a commercial scale and for a long period of time, we need to add limit points by buying an energy pack that is available on the blynk application.

RESEARCH METHODS

Underwater Robot System Requirements Design

Designing an underwater robot system requires careful consideration of various factors to ensure its functionality, reliability, and efficiency in the challenging underwater environment.

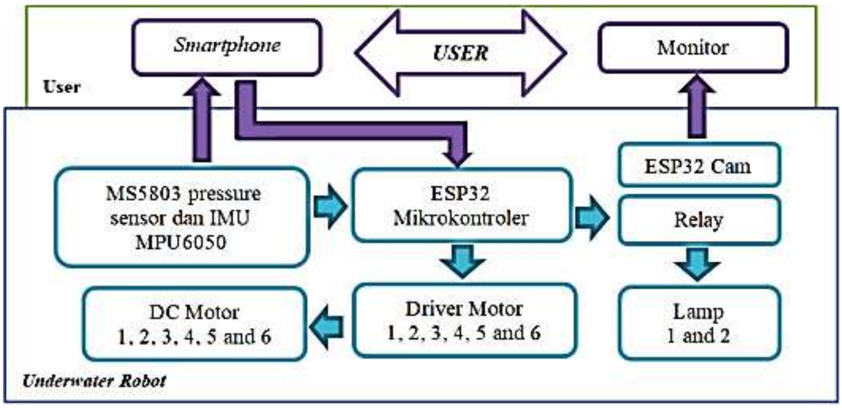

Figure. 1 Underwater Robot System Block Diagram

In this system consists of two parts of the function, where the first function is performed by the user and the second function is performed by the system.

1. Functions performed by user
   In this part of the function is carried out directly by user, where user control the system using a smartphone. In addition, the user can see and monitor data from pressure sensor in the form of depth position robot. Monitoring movement and stability of the of the robot by looking at roll and pitch data from IMU MPU6050 contained in blynk application display. Then user can also monitoring underwater conditions in the form of streaming video from those captured by ESP32 Cam.
2. Function performed by the system
   This function is carried out by the system such as reading commands from user via a smartphone, reading roll and pitch data values of IMU MPU6050 and reading data from pressure sensor which is the processed by DOIT ESP32 DEVKIT. Furthermore, the reading of data is poured in output of PWM value on the DC motor and the light condition.

Hardware Design

The following is a series of hardware on the underwater robot

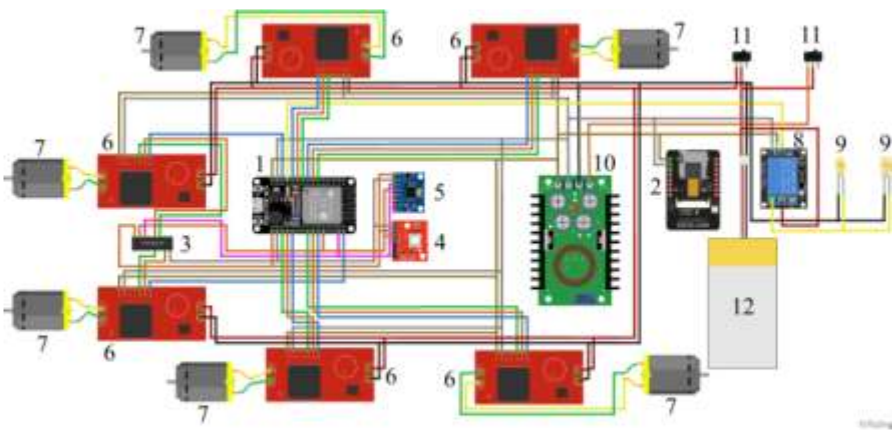

Figure. 2 The Overall Circuit of Underwater Robot Hardware

The explanation of the components contained in Fig. 3, including:

1. DOIT ESP32 DEVKIT is used as the main controller of the control system.
2. ESP32 Cam and OV2640 camera are used as image and video image data capture.
3. PCF8574 IO module is used as an additional GPIO pin.
4. MS5803 pressure sensor is used to measure depth position robot.
5. IMU MPU6050 sensor module is used to measure the tilt of robot and maintain the stability of robot.
6. VNH2SP30 driver motor is used as a DC driver motor.
7. 1100goh bilge pump DC motor is used to drive the robot.
8. Relay is used as a regulator of condition the lamp.
9. Lamps is used as a robot lighting.
10. Buck converter XL4015 is used to lower voltage from 11.1 Volt to 5 Volts.
11. On off switch is used to disconnect and connect electric current.
12. LiPo (Lithium Ion Polymer) battery is used as a voltage source for the robot.

The following is a flow diagram of the underwater robot as shown in Fig. 3.

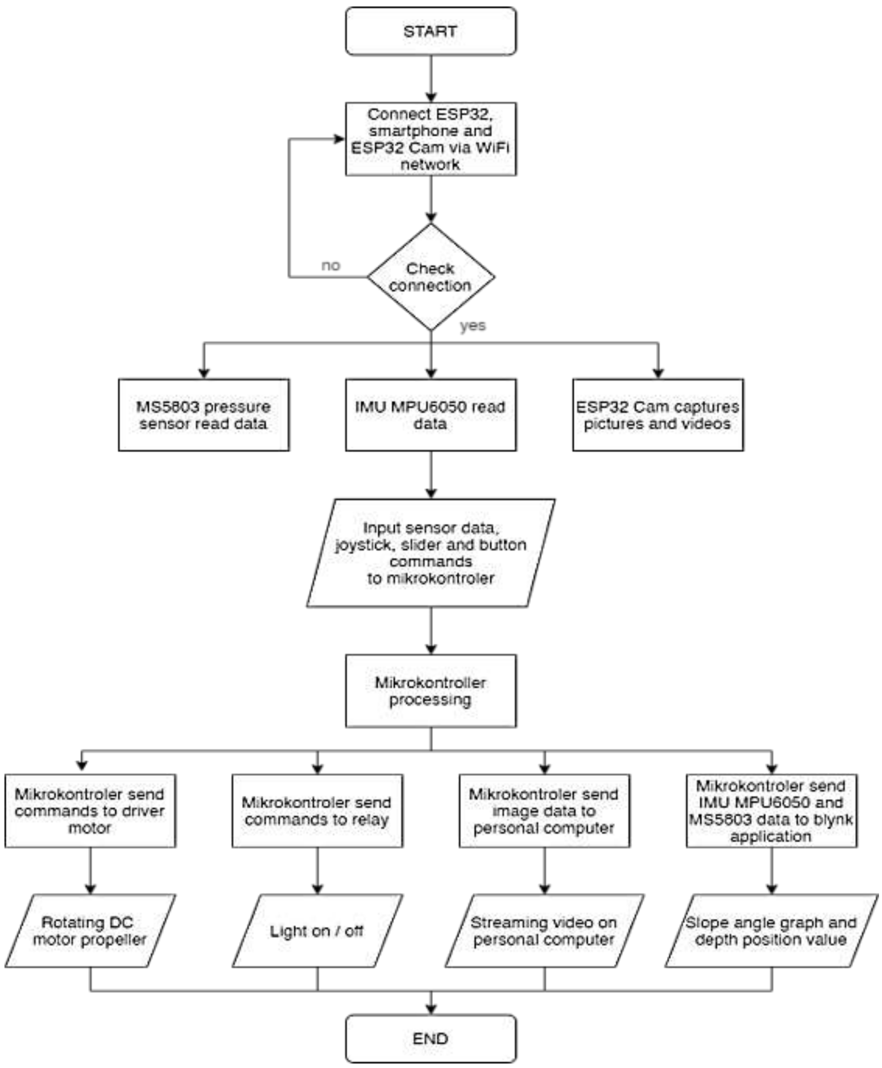

Figure. 3 Flowchart Design System Underwater Robot

Control System Design with Blynk Application

In addition, the control system design was also carried out using the blynk application which was previously installed on smartphone. After the inistallation is successful, it is continued by registering via email until it is finished according to the instructions in the application. After successful registraction, the next step is to create a new project by clicking the "New Project" button and then naming the project as desired, in this research it was named "Underwater Robot". Then, in the choose device section, select the type of device used namely "ESP Dev Board" and select the WiFi communication media, then click the "Create" button. So, blynk will send an auth token to the previously registered email address. The appearance of the new project can be seen in Fig. 4.

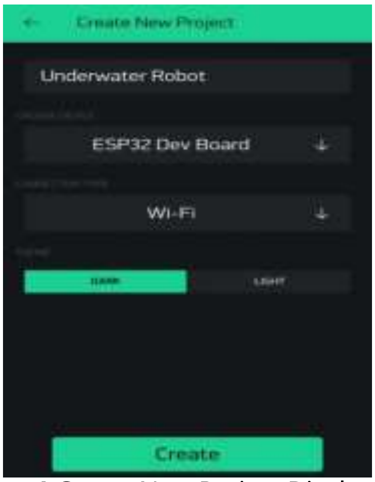

Figure. 4 Create New Project Display on Blynk

The next step is to create command buttons and display on blynk. In this research, a joystick widget is used to adjust the direction of the robot's movements such as forward, backward, and turn. In addition, using a slider widget to adjust the robot's up and down when in water, a button widget to adjust the robot's lighting, a value display widget to display the depth position robot and a superchart widget to display a graph of roll angle and pitch angle of the robot in water. So that, the robot stabilizer control system can always be monitored. The overall appearance of the widget on blynk used in this research can be seen in Fig. 5.

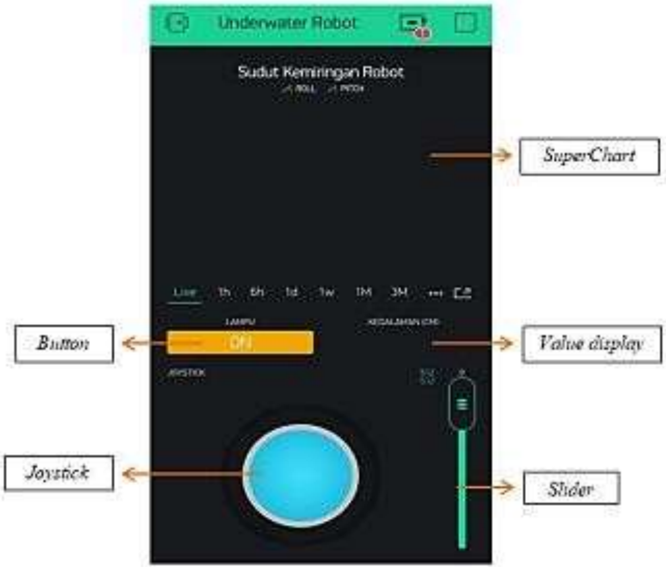

Figure. 5 Underwater Robot Control System Widget Display

After the design of control system on blynk is complete, next step is to configure the control system for blynk application to the personal computer. The steps for configuring blynk application control system to PC are as follows:

1. Copy the auth token sent to email.
2. Connect ESP32 to PC using a USB cable.
3. Enter the auth token, WiFi name and password according to the WiFi used on smartphone into program that we created on Arduino IDE, then upload it to completion.

RESEARCH METHODS

Underwater Robot Design Result

The design of an underwater robot can vary depending on its intended purpose and application. Below is the design of the underwater robot that has been created.

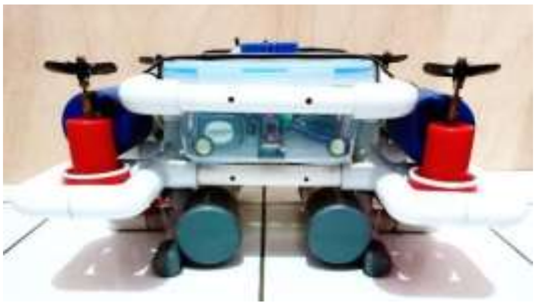

Figure. 6 Robot Design Result Front View

The specifications of the robot that has been made in this research can be seen in Table 1.

Table 1. Underwater Robot Specifications

Robot size	Title of second column
Robot size	45 cm x 38 cm x 24 cm
Input voltage	11.1 Volts
Number of motors	6
Number of lamps	2
Number of camera	1
Robot mass	8 Kg

Camera Test Results

The shooting test was carried out using an OV2640 cam mounted on the ESP32 cam. In shooting, image data is captured by the camera and processed by the ESP32 cam which is then sent and displayed on a personal computer using auth token with the help of WiFi network.

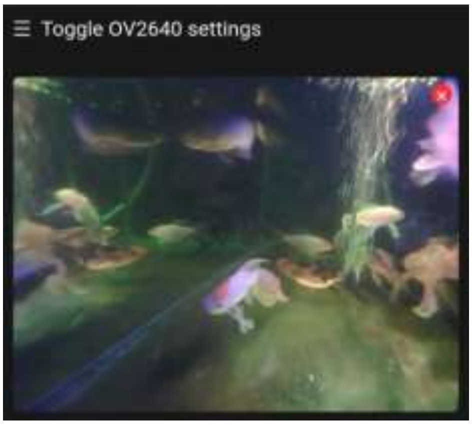

Figure. 7 Image Result of ESP32 Cam

Lighting Control Test Results

In the lighting control test, it is carried out to determine the response speed of pressing button on smartphone to the condition lights. In this research, two DC lamps are installed in series on relay with NO (Normally Open) mode. So, when relay is active, the lamps also be ON. Lighting system testing is done using button on smartphone application. When the button is pressed to ON then lights will turn ON and the button is pressed to OFF then the lights will go out. The data on the results of lighting testing on system can be seen in Table 2 and Table 3.

Table 2. Respon Speed Button Pressing to Light Conditions (Depth 0 cm or Floating)

No	Command	Button Press Time	Light Condition Time	Time Difference
1	ON	16.35.39	16.35.40	1 second
2	OFF	16.37.05	16.37.06	1 second
3	ON	16.39.32	16.39.33	1 second
4	OFF	16.40.10	16.40.11	1 second
5	ON	16.42.05	16.42.06	1 second
6	OFF	16.42.21	16.42.22	1 second
7	ON	16.44.13	16.44.14	1 second
8	OFF	16.45.28	16.45.29	1 second
9	ON	16.47.02	16.47.03	1 second
10	OFF	16.47.53	16.47.54	1 second
		Average Time		1 second

Table 3. Respon Speed Button Pressing to Light Conditions (Depth 15 cm)

No	Command	Button Press Time	Light Condition Time	Time Difference
1	ON	17.34.10	17.34.13	3 second
2	OFF	17.37.18	17.37.22	4 second
3	ON	17.49.21	17.49.25	4 second
4	OFF	17.52.19	17.52.22	3 second
5	ON	17.55.03	17.55.06	3 second
6	OFF	18.21.18	18.21.20	2 second
7	ON	18.23.06	18.23.08	2 second
8	OFF	18.24.17	18.24.20	3 second

9	ON	18.25.32	18.25.35	3 second
10	OFF	18.27.13	18.27.15	2 second
		Average Time		2.9 second

Based on Table 2 and Table 3, it can be seen that the response speed of pressing the button to the condition of lights when the system is at a water depth of 0 cm (floating) is faster than when the system is at a water depth of 15 cm. This happens because the molecular density in water is denser than in air, so it is making difficult for electromagnetic waves to penetrate when in water. Thus, the deeper diving robot, longer response speed of pressing the button to the condition of lights.

Control System View on Blynk Application

The display of experimental results on blynk application can be seen in Fig. 9.

Figure. 8 Overall Control System View on Blynk

In monitoring the stability of robot, superchart widget available in blynk application used. Which every time is a change in the stability of the slope and the change in depth position of robot, the graph will be formed according to magnitude of the slope and the depth position that occurs. In lighting control, a widget button is used, if the button pressed to ON then light condition will turn ON, while if the button is pressed to OFF then light condition will go out.Then in controlling the movement of robot, two widgets are used, namely joystick and slider widgets. Joystick widget is used to control horizontal movement of robot, like forward, backward and turn. While slider widget is used to control vertical movement of robot, like diving, hovering and floating. In the blynk application, a value display is also used which it is used to display the depth position of robot in cm.

CONCLUSION

Based on the results of testing and data analysis that has been carried out in this research, several conclusions can be obtained including the following: Based on experimental data, the underwater robot has an average button response speed of 1 second in floating conditions and 2.9 seconds at a depth of 15 cm. The blynk application can display a graph of stability and depth position robot in real time. In addition, the captured image from underwater robot are also good and the image produced are clearly visible both on land and in the water.

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