P.Issn : 2808-859X
E.Issn : 2809-0853

REMOTE CONTROLLED ROBOTS POWERED BY SOLAR CELLS AND ENVIRONMENTAL DETECTORS AFTER A MOUNTAINOUS ERUPTION

Muslim [1]*, Fachrid Wadly [2], Wirda Fitriani[3]
Universitas Pembangunan Panca Budi

Keywords:
Robot; IoT; Sinabung; Sensor

***Correspondence Address:**
muslim@dosen.pancabudi.ac.id

Abstract: Mount Sinabung is in Karo District, North Sumatra Province. Mount Sinabung's eruption has begun in 2019. Activity level has been Level III (Alarm) since May 20, 2019, and until now, the status of Mount Sinabung is still active. Through this technology, which is useful for safe environment detection, before officers are assigned to evacuation processes in the disaster area, robots will first detect the environment in the area around the site of the disaster, whether it is safe or not to be visited.Through the Internet of Things in the robot, this detection can be used at the disaster site, which can later help officers detect the environment before the evacuation of victims is done and is expected to reduce casualties. Hardware designs range from mechanical design to electronics. Software includes program design as well as the testing of the entire tool. The robot is expected to be used in a similar disaster, where it can later help officers detect the environment before evacuating the victims.

INTRODUCTION

The background of this research is because, geologically, Indonesia is located in the Ring of Fire, the volcanic belt that surrounds the Pacific Range. The road is marked by a series of volcanoes stretching from Sumatra to Java and Sulawesi. The reason why Indonesia is often hit by earthquakes is because Indonesia is home to three large tectonic plates, namely the Indo-Australian, Eurasian, and Pacific plates. As technology advances and is well used, it is hoped that this technology will help mankind solve the above-mentioned problems. With the technology being used for safe environment detection, before officers are assigned to evacuation processes in the disaster area, robots will first detect the environment in the area around the site of the disaster, whether it is safe or not. A variety of technological advances can be developed and used to create systems that help humans in their work. A technology that will be of great help, where using this technology can save energy and time. One of the uses of technology today is the Internet of Things (IoT). The Internet of Things serves as an integration between operating technology and information technology, or as a link between physical and digital(Budiarto & Hadi, 2020). The prototype of this automation system is designed using a microcontroller, where the microcontrollers act as the center of system-wide control (Wahyuni et al., 2021). Microcontroller is an IC commonly used for automatic and manual control of electronic equipment. Esp32-Cam is chosen because the microcontroller is directly available with the camera, which is used as a speed control medium for rotating, servo, and robotic cameras, and Nodemcu is used as a sensor data processing medium.

RESEARCH METHODS

The research site for the implementation of a remote control robot with a solar cell for the detection of the environment after the eruption of the Mount Sinabung disaster was carried out on the Universitas Pembangunan Panca Budi, exactly in the laboratory. The methods of research carried out can be seen in the picture below.

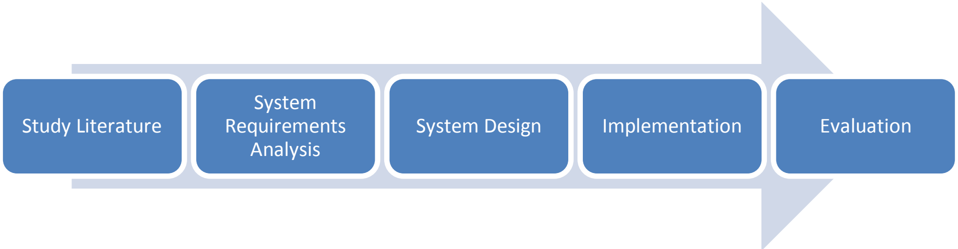


Figure 1. Research Methods

1. Study Literature : In this study of literature data is obtained not only from books, but the Internet also helps in finding information about how to work IoT along with a microcontroller (ESP32-Cam), servo, robot camera, Nodemcu, DHT11, and so on.
2. System Requirements Analysis : This need analysis is carried out as one of the processes to identify needs and provide accurate information to meet the needs of the manufacture of this robot.
3. System Design: This will describe everything it takes to build and design a remote control robot, ranging from the tools it needs, the materials it requires, and the software it uses to the set of ways the system works to stack all the parts into a robot that serves as a post-disaster environment detector.

   3.1. Design Planning

   Design As to the tools and materials needed at the time of the design of the remote control robot.

Table 1. Design Planning Tool

No.	Tools	Equipment
1	Laptop	ESP 32-CAM
2	Smartphone	NodeMcu
3	Data cable	Powerbank
4	Charger	Driver Motor L298N
5	ESP32 -CAM MB Uploader	Module Charger Multicell 3s 12v
6	Solder	Battery 18650 3s 12v
7	Solder Tin/Tenol	Sensor DHT 11
8	Clamp Shot	Sensor MQ-135
9	Scissor	Servo SG-90
10	Cable	Bracket Servo Y Axis
11	Screwdriver	Gain Antenna 3 Dbi
12	Multitester	PCB Dot Matrix
13	Acrylic	Tank Chasis
14		Switch
15		Battery Capacity

3.2. System Planning

Block diagrams are a sequential statement of relationships between one or more components that have one unity in which each block of components affects the other components. Each block is connected with one line indicating the direction of work of each block concerned. On the system block diagram, there are several blocks, namely the input block, the control block, and the output block.

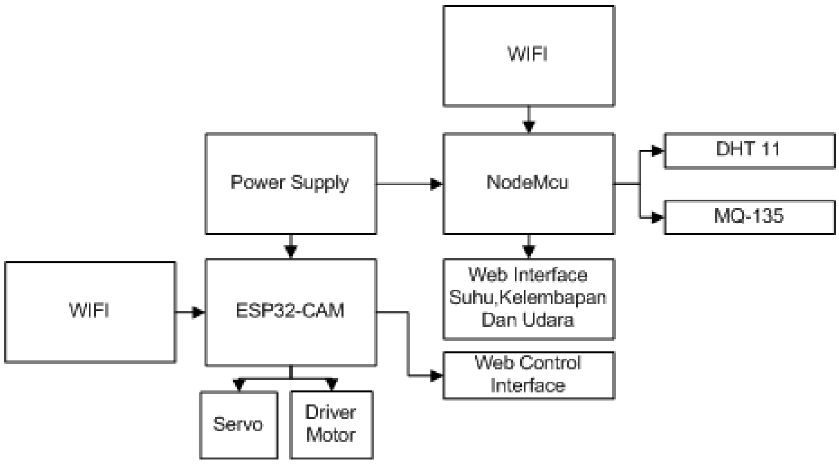


Figure 2. System Block Diagram

RESULTS AND DISCUSSION

a. Hardware and Software Specifications

The design is made up of two basic components, hardware and software, each of which requires the other to build and implement what is to be created.

Table 2. Hardware and Software Specifications

Hardware	Software
Lenovo IdeaPad 3 laptop with 8GB of RAM, Intel Core i5 Gen 11	Arduino IDE
Smartphone with 3 GB RAM and Android 11	Web Browser
ESP32-CAM	
NodeMCU	
Power Supply	
Driver Motor L298N	
Motor	
Sensor DHT11	
MQ-135	
Bracket Servo	
Servo	
Tank Chasis	

b. Testing Robots and Software

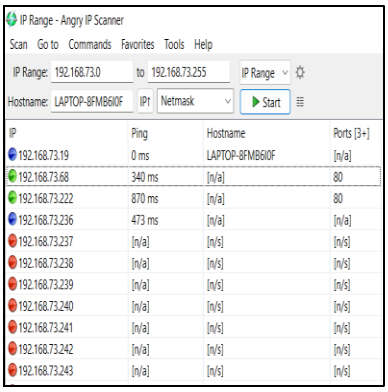
The purpose of the tool testing is to find out whether or not the designed system works properly. And after a thorough test, the result is that the designed tool works correctly.

Figure 3. Robot View

After testing the hardware, it is also necessary to test the software so that the entire robot system can be ensured to work properly. Software testing is done by checking whether the two microcontrollers can be connected to the controller device or access point.

Figure 4. Testing the connection to the smartphone

Enter the IP range that is in the network, as in the picture 192.168.73.0-192.168.73.255. After the scan, it will later be identified which IP robot (red using port 80), and blue is the controller elevation. The test is done as shown in the following picture.



IP	Ping	Hostname	Ports [3+]
192.168.73.19	0 ms	LAPTOP-8FMB6I0F	[n/a]
192.168.73.68	340 ms	[n/a]	80
192.168.73.222	870 ms	[n/a]	80
192.168.73.236	473 ms	[n/a]	[n/a]
192.168.73.237	[n/a]	[n/s]	[n/s]
192.168.73.238	[n/a]	[n/s]	[n/s]
192.168.73.239	[n/a]	[n/s]	[n/s]
192.168.73.240	[n/a]	[n/s]	[n/s]
192.168.73.241	[n/a]	[n/s]	[n/s]
192.168.73.242	[n/a]	[n/s]	[n/s]
192.168.73.243	[n/a]	[n/s]	[n/s]

Figure 5. Testing connections using a computer

c. Testing Web Interface

In order to perform the test, it is necessary to enter both microcontroller IPs that are already connected to the same wifi.

Figure 6. Web Control Interface Testing

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Testing the web control interface using the web browser Chrome on the smartphone resulted in all the drive buttons and cameras working properly.

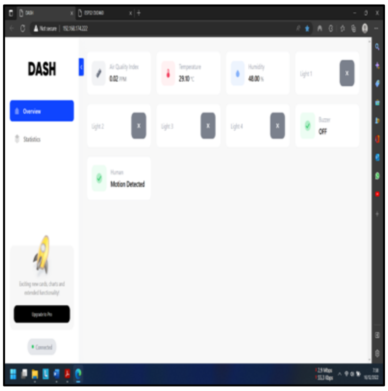


Figure 7. Web Sensor Interface Testing

Testing the web-page interface is carried out by accessing web-page pages on the tested devices and browsers, which is divided into two methods: testing the web-page interface on the computer and testing web-page interfaces on the smartphone.

d. Power Supply Testing

The power supply inside the robot includes several components, including the adapter charger, the solar panel, the charger module, and the battery. The main power supply of the device is obtained through batteries as a source of voltage for all the components installed on this robot. From the test results, the batteries obtain a voltage of 11.35 volts. Here is a display of the power supply test shown.

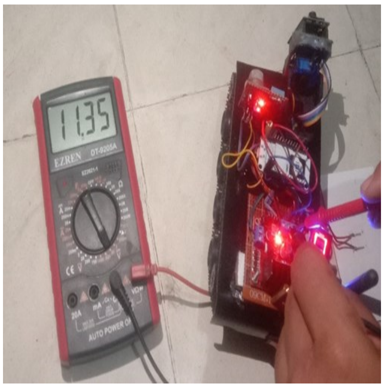


Figure 8. Testing Power Supply Main Robot

In the entire power supply chain, there are several components that are turned on at different voltages, like the microcontroller. For example, here both the microcontrollers ESP32-CAM and NodeMcu are powered at the same voltage of 4.90V.

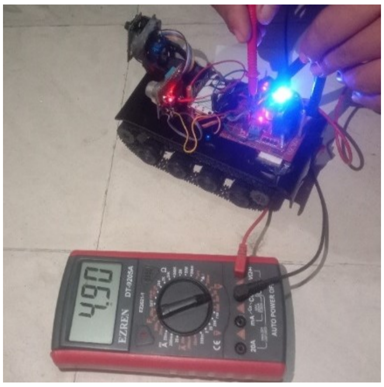


Figure 9. ESP-32CAM and NodeMcu voltage source testing

In using the robot, it is also necessary to carry out charging into the battery. That can be done with the charger adapter type C 5V and the adapter mini charger USB 5V, as well as the robot in the design to be charged using solar panels that are also tense about 5V, which will later be converted using the module BMS 3S 12V to battery.

e. Remote Control Testing

In the remote control tests that need to be taken into account, among them is the distance of data transmission received from the android web browser or computer to the access point, then to the robot, or from the web browser or android laptop directly to the robot. This test will be done by using the Android web browser to connect the robot directly, whether it is still connected or not. Here is the data obtained.

Table 3 Reading data transmission distance, web control interface, and web sensor interface

No	Distance	Web Control Interface (ESP-32CAM)		Web Sensor Interface (NodeMcu)	
		Controller	Camera	Sensor MQ-135	Sensor DHT11
1	2 m	Verry Good	Verry Good	Verry Good	Verry Good
2	4 m	Verry Good	Verry Good	Verry Good	Verry Good
3	6 m	Verry Good	Good	Verry Good	Verry Good
4	8 m	Verry Good	Good	Verry Good	Verry Good
5	10 m	Good	Less Good	Verry Good	Verry Good
6	12 m	Good	Bad	Verry Good	Verry Good
7	14 m	Good	Bad	Verry Good	Verry Good
8	16 m	Good	Bad	Verry Good	Verry Good
9	18 m	Less Good	Bad	Good	Good
10	20 m	Less Good	Bad	Good	Good

From the data obtained after testing, the results can be found in the table above with the following explanation:

1. Within 18 m above, the microcontroller began to experience delays in

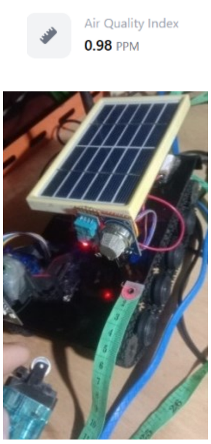
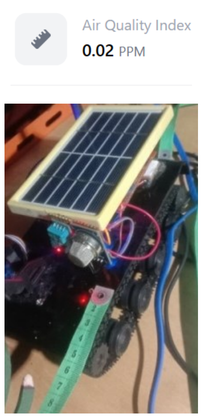
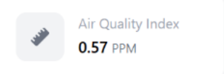
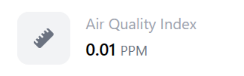
responding to the commands given through the controller.

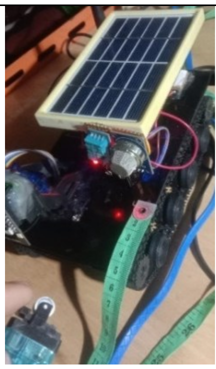
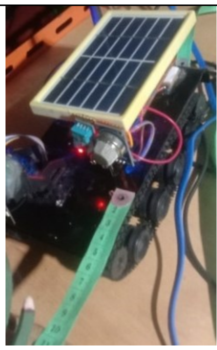
2. And on the part of the camera, it can only be up to 10 m away to obtain visual data, such as video streaming.
3. On the section of the sensor using the microcontrollers, NodeMCU achieved excellent results where the data sent could exceed the range of 20 m of the web sensor interface.

f. Sensor testing MQ-135

The tests were carried out with some simulations of air pollution with variable distances; the distances referred to are the distances of the sensor to the source. The data obtained was as follows:

Table 4 Tables of distance impact testing on the MQ-135 sensor

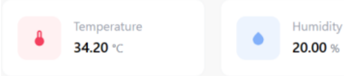
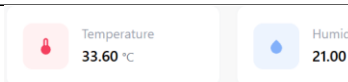
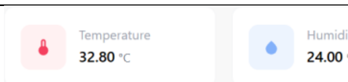
No	Distance	Air Pollution Simulation			
		Cork Gas / LPG	Description	Smoke	Description
1	6 cm		At a distance of 6 cm, the sensor detected a gas leak of 2.48 ppm.		At a distance of 6 cm , the sensor detected a gas leak 0.4 PPM
2	8 cm		At a distance of 10 cm , the sensor detected a gas leak of 0.98 PPM		At a distance of 8 cm , the sensor detected a gas leak of 0.2 PPM
3	10 cm		At a distance of		At a distance of

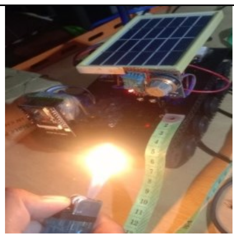
			10cm , the sensor detected a gas leak of 0.57 PPM Where the PPM level is low		10 cm , the sensor detected a gas leak of 0.1 PPM where is normal ppm

g. DHT11 Sensor Testing

The DHT11 sensor functions as a temperature and humidity detector in the robot area. The temperature testing is carried out using a gas cork with a variable distance of 2 cm to 10 cm.

Table 5 DHT 11 Sensor Testing

No	Distance	Temperature and humidity	Description
1	6 cm	 	From the data obtained in the 6cm test range, the temperature can still be detected at a value of 34.20 oC with a relatively stable humidity level of 20.00%.
2	8 cm	 	From the data obtained in the 8cm test range, the temperature detected at 33.60oC of course decreased drastically given the distance of the source of fire that is quite far away with the normal humidity rate of 21.00%
3	10 cm		From the data obtained in the 10cm test range the sensor no longer detects the temperature of the source of fire and also the humidity is very normal.

h. Explanation

From the overall testing and implementation of the remote control robot design, post-disaster environment detection has obtained satisfactory results where the processing and control devices using the ESP32-CAM microcontroller and Nodemcu can communicate well with the controller devices such as smartphones and computers. The web local server is used as a communication medium between the microcontroller and the control device because the data sent is large enough that the data is video that serves as the monitoring of the surrounding environment directly through the ESP32-CAM camera. The web control interface can also be well controlled overall, i.e., forward, backward, turn right, left, turn on the LED, as well as the movement of the servo up and down. The robot can be very well controlled by the controller without any errors at the time of testing, so that's why the web local server is chosen as the medium for displaying the image data or the operator.

CONCLUSION

The whole system of this robot tank can work well; wheel movements like forward, backward, twist, speed adjustment, moving the camera, activating the camera, and turning on or off the LED have worked according to the program and command given through the web controller. In the design of the entire system, several experiments have been performed using only one microcontroller, namely the ESP32-CAM as a control device and sensor data receiver, but the ESP32-CAM itself has limitations in the reading of analog sensors (MQ-135) as well as the limitations in the pins it possesses. The author then uses two microcontrollers of which the ESP-32CAM is the control processor, the camera, and NodeMcu as the sensor data processor. In the data transmission using a wireless wifi network where the robot works in client mode, the data is transmitted fairly well up to a distance of 20 m from both microcontrollers. Using wireless Wi-Fi network data controllers and sensors, data can be transmitted very well with a 100% success rate of the data obtained after testing, and sensor readings are quite accurate in detecting the data obtained after testing. The use of Web-Page on the robot as a media control interface and sensor interface is considered very appropriate, as it can be accessed by all devices that have a browser in them and is compatible with all the browsers being tested. As a post-earthquake and eruption environment detector, the design of a remote-controlled robot can provide many benefits. Using remote control technology, the robot can be operated from a sufficient distance so that it does not endanger the operator. In addition, the robot can also be used to explore areas affected by an earthquake or volcanic eruption, thus providing accurate information about the environmental conditions in the area.

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