

## DESIGN PROTOTYPE OF ROBOT EXPLORER TERRAIN NATURAL DISASTERS FOR MAINLAND FIELD

<sup>1</sup>GIVA ANDRIANA MUTIARA, <sup>2</sup>GITA INDAH HAPSARI

<sup>1,2</sup>Telkom University, Department of computer engineering, Telkom Appliance Science

E-mail: <sup>1</sup>[giva.andriana@tass.telkomuniversity.ac.id](mailto:giva.andriana@tass.telkomuniversity.ac.id), <sup>2</sup>[gitaindahhapsari@tass.telkomuniversity.ac.id](mailto:gitaindahhapsari@tass.telkomuniversity.ac.id)

### ABSTRACT

Nowadays, robots are used as alternatives tool to replace human activities in various fields. The case of the evacuation of disaster victims is one of good example where robots became one of the best choice because the heavy and dangerous terrain that mostly appear at disaster area was proved to be harmful and dangerous for humans operator. The idea of using robots is to become the instrument that can be controlled remotely, over difficult terrain and provide information for the evacuation team before taking further action. The robot used is wheeled robot designed and controlled *wirelessly* by *the joystick*. Cruising terrain information gathering is done using IP camera with wireless transmission media. Camera catches are then displayed in a web application on a personal computer (PC). Tests performed include testing the servo motor, servo motor control is wireless, wireless transmission range, IP camera, transmitting streaming video, and streaming video transmission range. The test results indicate that the functionality of the motor and the camera has been in accordance with the purpose only to be enhanced wireless coverage.

**Keywords:** *Robot explorer, field land, IP Camera, Wireless, Video Streaming*

### 1. INTRODUCTION

In many case of a natural disaster, rescue teams often have to trace the victims in the area with difficult terrain and inaccessible by humans. An earthquake disaster sometimes created this type of condition which requires a *Search and Rescue* (SAR) to find victims among rubble or rocks piles. In other cases sometimes SAR team need to find alternate ways for evacuation and need to gather more information regarding the state of the fields for minimum loss. So in this case, we need a tool that can assist or replace humans for exploring any possible harsh terrain and provide any needed information regarding circumstances and situation in the disaster area.

Robot design variation depends on its function and application. Embedded systems are used to control the robot as part of the control hardware and mechanics, which build by using microcontroller [1]. By using the embedded system, the design engineer can perform the optimization of the size and cost of the product, and may increase the capabilities and performance of the device. [2]

The purpose of this study was to design a prototype robot that could help a rescue team by its ability to explores, records and send terrain information remotely. The robot movement will be controlled by joystick using *wireless* system and the information will be recorded in a form of video

format that can be accessed using web application streaming.

### 2. SYSTEM DESIGN AND IMPLEMENTATION

There are few parameters that must be considered for designing robot for outdoor used. First most common aspect is the environment where the robot will take its operation. Another aspect is the appearance of noise or obstacle generated by the surrounding environment which could interfere with signal transmission. [3]

To achieve the basic need for all the parameters mentioned, the prototype of the robot will have a system that has the following specifications:

1. 4 wheeled robot with a 2 DC motors on the rear wheels controlled by joystick using wireless transmission. Microcontroller used to control motor movements is ATMEGA 8.
2. 1 piece robot with integrated camera mounted on the top of the robot and can be routed to the left or right by using the motor. Camera used is IP Camera IC-3005WN Wireless 802.1.1n dual mode and used motor is a servo motor.
3. Cruising terrain information in the form of streaming video captured by the camera

and transmitted wirelessly and released on a web-based application. The software used is XMPP Control Panel and Plug in. War shark software used to test the parameters of delay on streaming video.

4. For wireless control the Robot designed to have power supply from a 9 Volt batteries.

Figure 1 describes the design of the overall system prototype robot natural disasters which consists of 2 parts:

1. Mechanical and mechanical control module
2. Camera module and video streaming applications

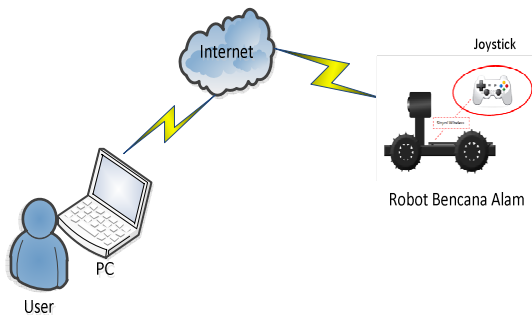


Figure 1: Design of Robot System Natural Disaster

Mechanical and control module is a module that handles all motors and mechanic movement of the robot using a joystick for its input. Camera module and video streaming application is a module that handles video capture on camera and display it in a web base application form.

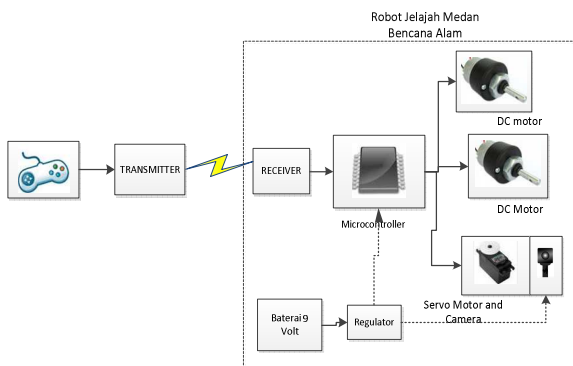


Figure 2: Module mechanics and mechanical control

In Figure 2, the keystrokes of a mechanical joystick on the control module generate an electrical signal that activates a specific channel and then forwarded to transmitter circuit. The transmitter circuit changes this signal to data signal and sends it using wireless media. After this data signal received by the receiver in the robot, it

convert to an electrical signal, and forwarded to the microcontroller. Transmitter and receiver have using the frequency of 27 MHz and 40MHz.

Microcontroller then process the data signal and convert it into a control signal for motor movement. Figure 3 describe the flowchart for this function. The output of the receiver connected to port C as input. Each different keystrokes will activate different channels so that data is transmitted and received by the receiver will produce a different movement.

The command set for robot movements consists of two groups of movements. Four body movements for the DC motor at the rear wheels which include forward motion, backward, right and left. Two servo motors movements for camera which include left and right rotation.

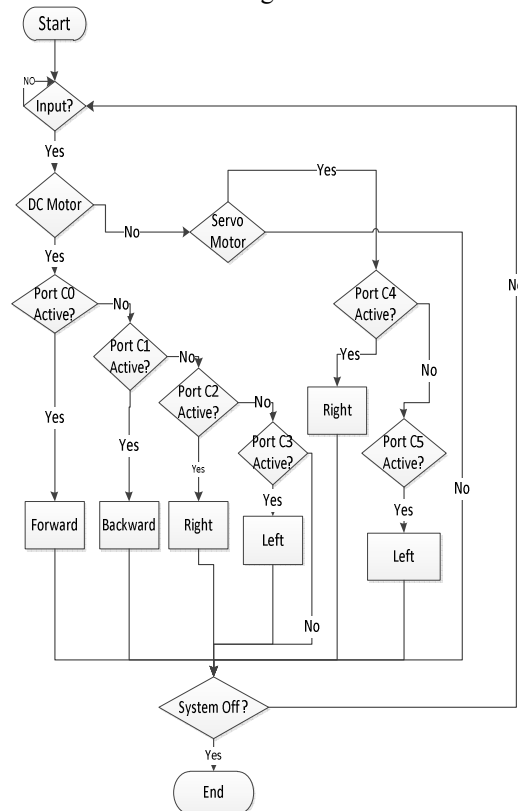


Figure 3: Flowchart for motor movements

The microcontroller used for processing the data in the receiver circuit is ATMEGA 8 from ATMEL co. The programming software is Code Vision AVR microcontroller (CV-AVR) and programmed by using the C programming language. Figure 4 shows the mechanical build of the robot.

As shown in Figure 5, the camera module is using IP camera to capture video. IP Camera or Net cam (Network Camera) is a latest capture and

recording device that has the ability to process audio as well as visual which could accessible to PCs directly, or through LAN, internet , and mobile phone networks. The camera module handles IP address configuration and streaming video data to be sent over the Internet



Figure 4 : The Prototype of Robot explorer Terrain [4]

The application for video streaming modules is built on laptop via a web browser using the IP address. Applications built using web-based program for more dynamic and portable use. Flowchart in Figure 6 shows the application consists of two parts: the client and admin.

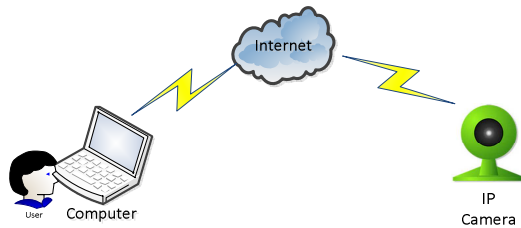
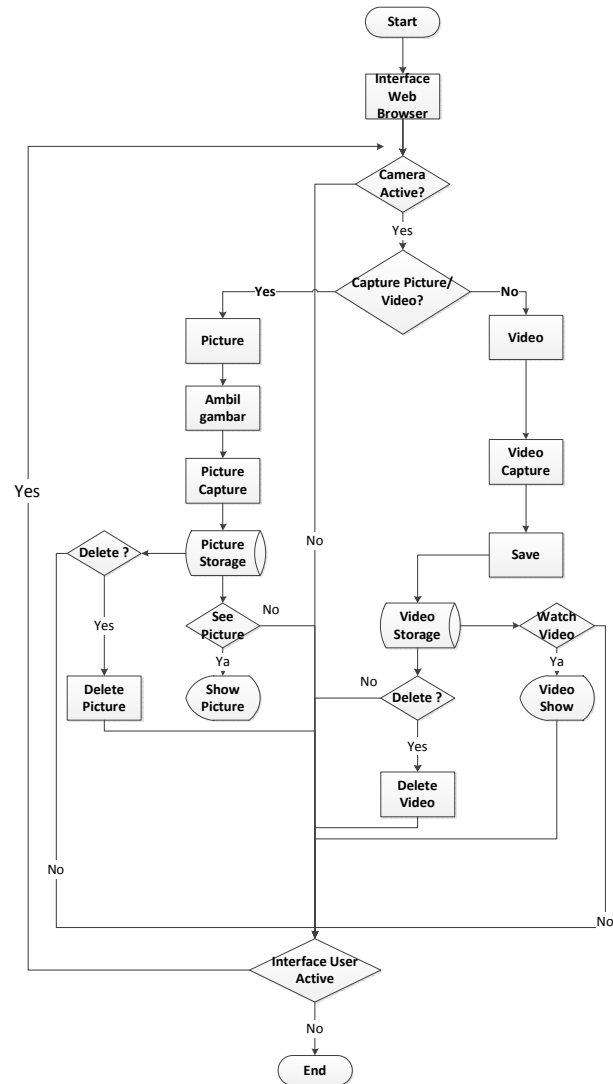


Figure 5 : Camera module and streaming camera

At user client interface in Figure 7, there are several tabs menu that could be accessed by user. The home menu leads to streaming video visualization of road / terrain that traversed by the robot. In the image menu, the user can view the captured images and video recordings that are controlled by the admin. In the user interface admin, admin can change the password, recording images and videos as well as view and delete the data record.



Gambar 6 : Flowchart for User Interface Application[5]



Figure 7: User Interface Application [5]

### 3. HARDWARE AND SOFTWARE DESCRIPTION

#### 3.1 Microcontroller AVR ATMEGA 8

AVR is a series of 8-bit CMOS microcontroller Atmel artificial, based on RISC architecture (Reduced Instruction Set Computer). The features of the AVR microcontroller ATmega8 are as follows [6]:

1. Maximum clock frequency at 16 MHz.
2. 32 ports I/O channels in 4 groups: port A, port B, port C, and port D.
3. 10 bits of Analogue to Digital Converter (ADC) with 8 *inputs*.
4. 3 Timer/counters.
5. 8 bit CPU with 32 registers.
6. Watchdog timer with internal oscillator.
7. SRAM internal: 1K byte.
8. 16K byte flash memory read while writes.
9. Interrupt internal & externals.
10. Communication Port SPI EEPROM (Electrically Erasable Programmable Read Only Memory) : 512 byte.
11. Analogue Comparator.
12. 2.5 Mbps Serial USART.

#### 3.2 IP Camera

IP Camera is a technology was developed to maintaining security and monitoring a room or space. IP camera is a CCTV (Closed-Circuit television) cameras use Internet Protocol to transmit image data and control signals over Fast Ethernet links.. A number of IP cameras are usually placed together with a Digital Video Recorder (DVR) or Network Video Recorder (NVR) to a video surveillance system.

#### 3.3 DC Motor and Servo Motor

Servo motors are DC motors which have high quality, already equipped with control systems in it. Servo motor applications are often used as a closed-loop control to handle the change in position precisely and accurately and also have speed and acceleration settings. Servo motor cabling system consists of three parts, namely Vcc, Gnd, and Control (PWM). The use of PWM at servo motor is different with the use at DC motors. In the case of servo motor, giving values to the PWM will make the servo motor moves in a certain position and then stopped (control position). Settings can be performed by using *delay* on any displacement of the starting position into the end position.

There are two type of Servo motors: *continuous servo motors* and *un continues servo motors*.

Continuous servo motor can rotate a full 360 degree allowing it to perform rotational motion.

#### 3.4 Programming Language

Code Vision AVR is a software C-cross compiler, using C language for writing its program codes. Code Vision AVR has complete IDE (Integrated Development Environment), where programming, compiling, manufacturing of machine code (assembler) and downloading the program into the AVR chip can be performed on Code Vision. It has terminal facility to perform serial communication with programmed microcontroller.

### 4. TESTING AND ANALYSIS

Whole system testing performed on two phases, module test and integrated test. Module test is done by testing the functionality of each module while the integrated testing done by integrating both the module and test the performance and functionality of a system prototype robotic rover field of natural disasters.

#### 4.1 Module Test

The test of mechanical modules consists of motor movement test and wireless coverage test. The motor movement test is done by connecting all the devices on the mechanical module and mechanical control and observes the synchronization between motor movements and key stroke on the joystick. Test result in Table 1 show that the control module could function well.

Table 1: Motor Control Movement Test Result

No	Push Button	Movement
1	Forward	Move Forward (rotates clockwise on both DC motor)
2	Backward	Move Backward (rotates counter clockwise on both DC motor)
3	Turn Left	Move Forward (rotates clockwise on right DC motor)
4	Turn Right	Move Forward (rotates clockwise on left DC motor)
5	Camera Look Right	Rotate Right (rotates clockwise servo motor)
6	Camera Look Left	Rotate Left (rotates counterclockwise servo motor)

Wireless coverage test performed by measuring the signal range in the absence of obstruction and hindrance. Media hitch used are wood and walls. Based on the test results in Table 2, range obtained in the absence of obstruction reaches 8 meters. As for the wireless range with timber hitch is 3 m and to crimp the wall is 2m. This shows that it takes a

signal amplification to increase the coverage of the wireless signal.

Table 2: Video Quality Test Result

Obstacles	Distance	Video quality	Wireless function to distance
Tidak Ada Halangan	1m	High	Moves as controlled
	2m	High	Moves as controlled
	3m	High	Moves as controlled
	4m	High	Moves as controlled
	5m	High	Moves as controlled
	6m	High	Moves as controlled
	7m	High	Moves as controlled
	8m	High	Moves as controlled
	9m	High	Not smooth
Halangan Media Kayu	1m	High	Moves as controlled
	2m	High	Moves as controlled
	3m	Good	Moves as controlled
	4m	Good	Moves as controlled
	5m	Good	Not smooth
	6m	Good	No movement
	7m	Good	No movement
Halangan Media Tembok	1m	Good	Moves as controlled
	2m	Good	Moves as controlled
	3m	Good	Not smooth
	4m	Good	No Movement
	5m	Good	No Movement
	6m	Good	No Movement
	7m	Good	No Movement

Camera module test performed by testing the quality and streaming range of the video based on delay and throughput parameters. Tests range of streaming delivery is done by measuring the quality of the resulting video on the application based on distance and obstacles.

Video streaming application module test performed by checking the compatibility of the application programs with various web browsers and also test its functionality. In addition it also conducted the testing range on the streaming delivery of video quality based on the distance the prototype robot with the user.

Test results in Table 2 shows that video quality does affected by distance and obstructions. The farther the distance between the user laptop and the camera will lower the quality of the video. The data also shows that video quality also affected by the obstacles that appear between user laptop and the camera.

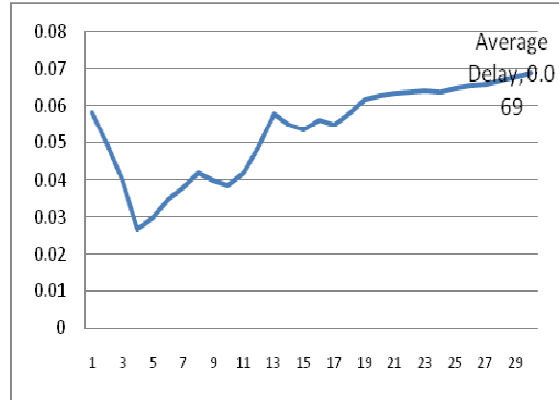


Figure 8: Delay IP camera test to the distance (m)

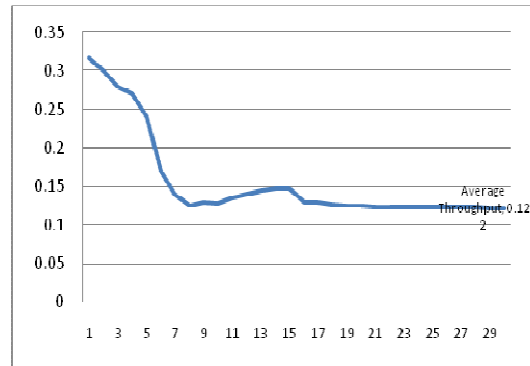


Figure 9 : IP camera throughput test to the distance (m)

Video quality testing performed on delay and throughput parameters using the software Wireshark. From the test results in Figure 8 and 9 demonstrated that the greater the distance the delay will be longer and bandwidth that occurs will be smaller.

#### 4.2 Integrated Testing

Integrated testing is done by integrating the module then performs field tests using a field that simulated to a field created by natural disasters. Table 4 shows the simulated robot on a variety of terrain simulating a disaster. Prototype robot runs well on disaster field puddle and sandy soils but less going well for rocky terrain and bumpy ground. This is caused by the limitation of using only two motors on the rear wheels.



Tabel 4 : Movement test on a variety of terrain [4]

No	Terrain	Movement	Notes
1	Sandy Soil Mainland	Smooth	Succeed
2	Gravel land	Not smooth	Skid Tires
3	Bumpy Ground	Not Smooth	Hiccough
4	Slick surface	Not Smooth	Skid Tires
5	Pool of Water (3cm)	Smooth	Succeed

The quality of video test provides the similar outcome as the camera module test which means that video quality would be lower for at farther distance. The test limited to the distance of 9 meters due to the limit of controlling signal for control module and show that the video quality still displayed properly on the web application within this distance.

## 5. CONCLUSION

Prototype Robot cruising terrain natural disasters that are designed and implemented have the functionality to suit the purpose that it can take the difficult terrain roaming and can provide information in the form of streaming video over the internet. Mechanical module can function properly in accordance with the given control via a joystick. Only upon passing cruise uneven terrain, the robot runs less smoothly. This can be done by adding the motors on the front wheels. Part transmitter and receiver work well in handling wireless delivery. Only wireless coverage achieved is less good so the need for signal amplification in order to reach its maximum coverage area. The control module is functioning at its best when there are no obstacles between the robot and the control joystick. IP Camera functions properly and can provide images with good enough quality in the range of wireless coverage.

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