IMPLEMENTATION OF FUZZY LOGIC ALGORITHM IN AUTONOMOUS MOBILE ROBOT FOR CASE DETECTION OBSTACLE

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ABSTRACT

Autonomous mobile robot is a robot that can navigate independently without any human assistance with embed specific algorithms as a regulator of robot motion. Robots of this type can do a good job because it has intelligence that resembles human intelligence as to avoid obstacles that are in front, obstruction conditions of potholes and obstacles that resemble high tunnel. Artificial intelligence is embedded in autonomous mobile robot will help the robot to take decisions and adapt to his lane to avoid any obstacle.
The purpose of this research is to build autonomous mobile robot obstacle avoidance algorithms and fuzzy logic to embed the mobile robot as a regulator of mobile robot by utilizing motion detection ultrasonic sensor so that the mobile robot can evade any obstacle is detected. Sensor detection results are processed in the microcontroller that has been implanted in advance with fuzzy logic and produce an output in the form of motion that will be mobile robot. From the test results showed that the mobile robot obstacle avoidance has been built in accordance with the berfugsi well crafted design with a 98.8% success rate.

Keywords: autonomous mobile robot, obstacle avoidance, ultrasonic sensor, microcontroller, fuzzy logic.

1 INTRODUCTION

Robotics is a multidisciplinary field of study of the manufacture of machinery to alleviate human tasks. Some of the disciplines involved in the manufacture of robots include mechanical science that studies the construction of the robot, science robot electronics for electronic systems, and artificial intelligence as the brain of the robot. The term robot comes from the word "robota" meaning unskilled or waitress. Awalanya robot is only used in industrial applications or robot manipulator, the robot has a construction similar to a human arm. But with the changing times and then there is the term mobile robot, humanoid, animaloid and others. Its function also changes that had been for industrial purposes now also for the field of medicine, entertainment and even for the military. Clarification robot is divided into three parts, namely, autonomous robots, robot teleoperated and semi-autonomous robots. Autonomous robot is a robot that can walk / move automatically without the help of humans continuously, teleoperated robot is a robot whose operation is controlled by a human from a distance and semi-autonomous robot is a robot that a human can be controlled from a distance and can be moved automatically.

Mobile robotic technology used is no longer used for industrial purposes, but can be used in various fields. For example Sojourner robot used for a mission to Mars that serves to avoid obstacles. Robot freeway is sebuh robot by intelligence in order to choose the safe path in performing the movement. In the process of movement, the robot must be able to detect any possible obstacles and avoid the obstacle.

Mobile robot obstacle avoidance can be applied to various fields, other anatra in the military for navigation purposes, spy / surveillance and the robot is able Exploring areas difficult to reach by humans.

According to previous studies conducted Eagles Derdian Marindani [5], mobile robots are designed only to detect and avoid obstacles in front, right side and left side as well as the robot which is designed to detect the presence of obstacles that height is lower than the position of the ultrasonic sensor. Mobile robot relies on a microcontroller and a DC motor. The microcontroller is used as a regulator of movement or rotation of DC motor. DC motor is used as the main driver of overall mobile robot body. But in studies previously said that the mobile robot several deficiencies in the control system of the mobile robot. From the results of these studies are written mobile robot can be added sensors for obstacle detection in addition to detection of obstruction front, right side and left side and barriers whose height is lower than the ultrasonic sensor.

In this case the required sensors that can detect the obstacle and need a program to regulate the rotation of the DC motor by using an algorithm that

can govern the motion of rotation of a DC motor assisted by a sensor located on the robot to detect the distance that are in front, right and left side as well can detect the presence of obstacles that height lower than the height and the mobile robot can detect the condition of the ground (road) is not good. It is intended that the mobile robot can avoid multiple obstacle detected by the sensor. One of the methods that can be used to combine these abilities is a fuzzy logic. Where the use of fuzzy logic method is now growing rapidly and expanding in various fields, fuzzy logic has become a basic material for the design of mobile robot technology.

Based on the above, in the application of mobile robot control that makes the mobile robot scout / spy autonomous are using a program that has been defined in advance to avoid multiple obstacle.

1.1 The Limit Of The System

Restrictions problems in making a wheeled mobile robot control system are:

1. The main part of the control of wheeled mobile robot using a pc / laptop.
2. Designing software for the programming process using arduino IDE compiler with programming language C language
3. Fuzzy logic is used to regulate the movement of the robot.
4. Rule Robot :
   a. Trails are used for no more than 6x6 meters.
   b. Tracks used a dry track (no water pooled).
   c. Tracks used track does not rocky.
   d. Hitch is used for the detection distance of the front, right side and left side of the form fields resemble perpendicular walls.
   e. Hitch is used for the detection of road conditions such as potholes.
   f. Hitch is used for the detection of high resemble tunnels.
   g. Detection of the obstacles in the front, right side and left side can only detect the distance obstacle at an angle of 180 °.
5. The Physical Limitations Of Robot :
   a. Using three ultrasonic sensors to detect obstacle front, right side and left side as well as to detect the height as well as to detect the road conditions.
   b. The microcontroller used arduino romeo.
   c. Batteries used a 12 Volt battery.
   d. Using 2 pieces of DC motor.
   e. Use 1 piece of servo motor.
   f. Using a 6 wheels.
   g. Robot designed to resemble the shape of the tank.
   h. Basic ingredients of the body of the robot using acrylics.
   i. The robot canot walk backwards.
   j. The robot can turn right and left with an a angle of 90°.
   k. The robot is autonomous robots.

1.2 Mobile Robot

Mobile robot is a robot construction which typically are having an actuator to move the whole body of the robot, so the robot can make the shift position from one point to another. In general, mobile robots are divided into two wheeled robot and legged robots [2].

a. Wheeled Robot
   Wheeled robot is very popular for people who started studying the robot. This is because it makes this robot does not require heavy physical labor. Wheels are often chosen, because it provides good traction, easy to obtain and use, and also easy to install on the robot. To be able to make a minimum wheeled robot requires knowledge of microcontrollers and electronic sensors. Base wheeled robots can be easily made by using plywood or plywood, acrylic and metal use. This robot can be made to be followers of the line (line follower), or followers of the wall (wall follower) or a follower of light. In figure below is a wheeled robot [11].



Figure 1 Wheeled Robot

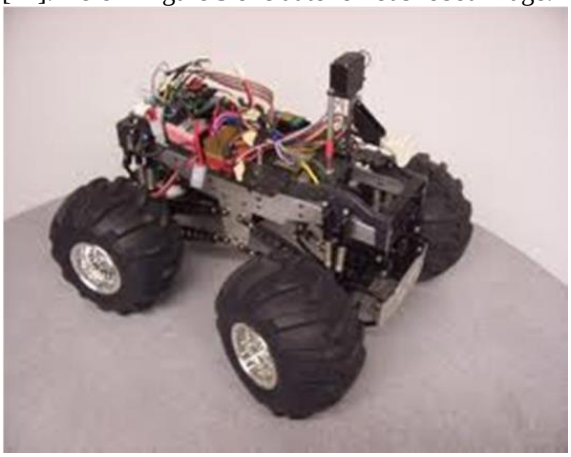
b. Legged Robot
   To pass the uncertain terrain, excellent legged robots used for legged robots are more adaptable than using a wheel like to climb the stairs. Shape-legged robot being adopted from living things or human form. Figure 2 below is a legged robot, a robotic insect species [11].



Figure 2 Legged Robot

1.2.1 Autonomous Robot

Autonomous robot is a robot that can perform the desired tasks in unstructured environments without continuous human guidance. Many types of robots have some degree of autonomy. Level of autonomy is needed in areas such as space exploration, clean the floors, mow the lawn, and waste water treatment [11]. Here in figure 3 one autonomous robot image.



Picture 3 Autonomous Robot

1.3 Artificial Intelligence

Artificial intelligence is derived from the English "Artificial Intelligence" or abbreviated AI, that intelligence is an adjective that means intelligent, whereas artificial artificial means. Intelligence is meant here meranjuk on a machine that is able to think, to weigh the actions taken, and were able to take such a decision made by humans.

According to Alan Turing, a British mathematician who dubbed the father of modern computer and password breaker Nazis in World War II in 1950, establishes the definition of Artificial Intelligence. "If the computer can not be distinguished by humans while talking through a computer terminal, it can be said that computer savvy, have intelligence".

According to John Carty from stanford define intelligence as "the ability to achieve success in solving a problem". According to Herbert Alexander Simon (June 15, 1916-February 9, 2001) ":" Artificial intelligence (Artificial Intelligence) is an area of research, application, and instructions related to programming the computer to do something in the man's outlook is bright. " According to Rich and Knight (1991): "Artificial Intelligence (AI) is cope with a study of how to make computers do things at this time can be done better by humans". The main scope of artificial intelligence include :

1. Expert System.
2. Natural Language Processing.
3. Speech Recognition.
4. Robotic and Sensor System.
5. Computer Vision.
6. Intelligence Computer aid Intruction.

1.4 Fuzzy Logic

In real conditions, some aspects of the real world always or usually located outside of mathematical models and vague. The concept of uncertainty that is the basic concept of the emergence of the concept of fuzzy logic. The originator of the idea of fuzzy logic is L.A. Zadeh (1965) from California University.

Fuzzy logic is one right way to map an input space into an output space. Fuzzy logic is different from the digital logic usual, where digital logic ordinary knows only two circumstances, namely: "yes" and "no" or "on" and "off" or "high" and "low" or "1" and "0". While fuzzy logic mimic human thinking by using the concept of the nature of vagueness value. With fuzzy set, an object can be a member of many subsets with different degree of membership in each set [12].

Fuzzy system has several advantages when compared with traditional systems, misaljan on the number of rules that are used. Initial processing tremendous amount of value becomes a value of the degree of membership in the fuzzy system reduces the amount of value that should be used to make a decision controller. Another advantage is that the system has the ability fuzzy reasoning similar to human reasoning capabilities. This is because the fuzzy system has the ability to respond according to Opera- qualitative, inaccurate and ambiguous.

2 THE CONTENT OF RESEARCH

2.1 Analysis Of The Problem

Robot car obstacle avoidance can be applied to various fields, including in the military field for navigation purposes, spy / surveillance and the robot is able Exploring areas difficult to reach by humans.

According to previous studies conducted Eagles Derdian Marindani [5], a mobile robot that is designed only to detect and avoid obstacles in front, right side and left side. mobile robot is based on a microcontroller and a DC motor. The microcontroller is used as a regulator of movement or rotation of DC motor. DC motor is used as the

main driver of overall mobile robot body. But in studies previously said that the mobile robot several deficiencies in the control system of the mobile robot. From the results of these studies are written mobile robot can be added sensors for obstacle detection in addition to detection of obstruction front, right side and left side only. Based on the above, this research will make an autonomous mobile robot using fuzzy logic method using ultrasonic sensors, infrared and arduino romeo and use three (3) parameters of the first parameter within the front, right side, left side. The second parameter is the parameter of road conditions and the third parameter is the high parameter. The first parameter uses ultrasonic sensors used to detect the obstacle front, right side and left side by a distance of 0-200 cm obstacle is in the form of a wall or object that resembles a wall.

The second parameter uses ultrasonic sensors that road condition parameters which aims to detect the road conditions can be passed at a distance of 0-10 cm robot obstacle is in the form of a track or roads are missing. The third parameter uses ultrasonic sensors that height parameters which aims to detect the height of obstacle height less than the height at a distance of 0-10 cm robot obstacle is in the form of obstacles that resemble tunnels. From the results of the third detection sensor that is used as a detector or a sense of the robot will be processed by the fuzzy logic to as determining the movement of the robot.

2.1.1 The Obstacle Around

An overview of the obstacle around is the obstacle detected by the robot to stop was in front, right side and left side of the robot at a distance of 0-20 cm is classified as an impediment to snag close and at a distance of 18-200 cm away categorized as an obstacle. Hitch is in the form of impediment bebentuk resembles a plane perpendicular to the wall or walls. The following figure 4 of obstruction around.

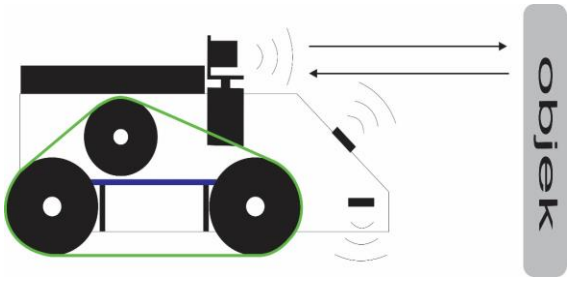


Figure 4 Obstacle The Around

2.1.2 The Snag Road Condition

An overview of the obstacle the road condition is detected by the obstacle that hinders robot in the form of road conditions is perforated with a distance of 0-5 categorized as an obstacle close and 4-10 cm away categorized as an obstacle. The following figure 5 of obstruction of road conditions.

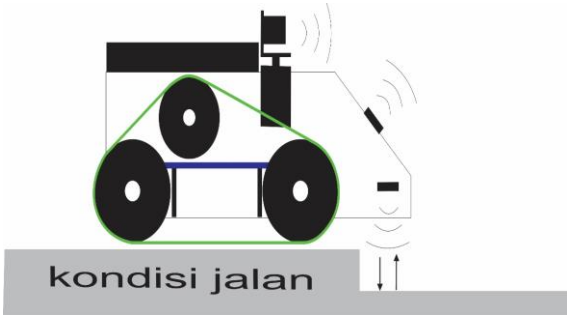


Figure 5 The Snag Road Condition

2.1.3 The Obstacle Height

A description of the high obstacle is detected by the obstacle that hinders robot resembling a tunnel with a distance of 0-5 cm is classified as an obstacle close and 4-10 cm away categorized as an obstacle. Here's a picture of a high obstacle.



Figure 6 The Obstacle Height

2.2 Analysis Of The Solution

Analysis of the solution is focused on understanding the needs of the information, functions, performasnsi dam system. Process analysis solution is also a procedure that is performed for examination and preparation of alternative problem-solving problems that arise and make the system specifications that will be forwarded. The general description of a mobile robot system to be built can be seen from Figure 7 below :

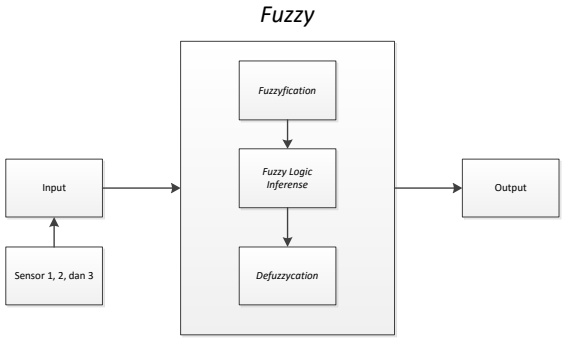


Figure 7 An Overview Of The System

1. Input is taken from the detection sensor 1, 2, and 3 how the detection distance to the obstacle. 1 obstacle detection sensor for the front, right side and left side. 2 sensors for detecting road conditions. 3 sensors for obstacle detection is high. The result of the detection of obstruction of the three sensors is sent into fuzzy.
2. The result of the detection of three sensors is processed by fuzzy into stage fuzzification is the process of changing the value of firm / real submitted three sensors into the membership function then berlajut into the formation stage Anturan that the process of establishing rules menggukana IF and Then later berlajut into stage inference engine that processes Applying the function of the implications of using MIN function to get the value of each Anturan then berlajut into defuzzyfication stage is the process of mapping the fuzzy set firmly into the set.
3. The output is taken from the fuzzy logic be any type of robot movement is slow or fast command.

2.3 Analisis Of The Input

Here is a table of input and output variables in this research.

Table 1 Variable

Fungsi	Variabel	Keterangan	Range
Input	The Distance Around	Retrieved from detection of the sensor against the obstruction is detected	[0-200 CM]
	The Road Condition	Obtained from the detection of the sensor against the road is not good	[0-10 CM)
	High	Retrieved from peneteksian sensor against the hitch height is less than the height of the robot.	[0-10 CM]
Output	Speed	Obtained from the process of *fuzzy*	[0-250 PWM]

Of the variables that have been raised, then structured fuzzy set domain. Based on that domain, then determined the membership function of each variable. Can be seen in Table 2 below.

Table 2 Set Variable

Fungsi	Nama Variabel	Himpunan	Domain
Input	The Distance Around	Near	[0-20 CM]
		Far	[18-200 CM]
	The Road Condition	Near	[0-5 CM]
		Far	[4-10 CM]
	High	Near	[0-5 CM]
		Far	[4-10 CM]
Output	High	Slow	[0-50 PWM]
		Fast	[50-250 PWM]

According to the table above fuzzy set, then the input-output mapping in this study are as follows :

1. Variable Distance Surroundings
   Variables within the front, right side and left side is a variable that can be of detection sensor 1 (one). In this variable was formed two fuzzy set, ie near and far. To represent the variables within the front, right side and left side of the triangle shaped curve for curve fuzzy set near and far triangles for fuzzy set. For more details can be seen in Figure 8 below.

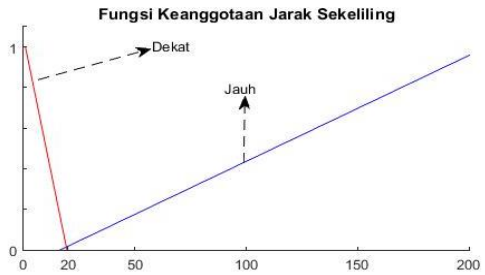


Figure 8 The Membership Function OF The Distance

With a membership function as follows:

$$\mu Dekat(x) = \begin{cases} 1; & x \leq 0 \\ \dfrac{20 - x}{20 - 0}; & 0 < x \leq 20 \\ 0; & x \geq 20 \end{cases}$$

$$\mu Jauh(x) = \begin{cases} 0; & x \leq 18 \\ \dfrac{x - 18}{200 - 18}; & 18 < x \leq 200 \\ 1; & x \geq 200 \end{cases}$$

2. Variable road conditions
   The variable road conditions obtained from the detection sensor 2 (two). In this variebel formed two fuzzy set, ie near and far. To represent the condition variable triangular shaped curve for curve fuzzy set near and far triangles for fuzzy set. For more details can be seen in Figure 9 below.

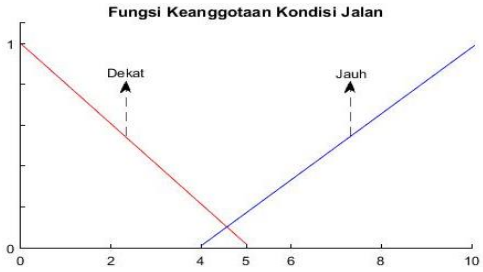


Figure 9 Membership Function Road Condition

With a membership function as follows:

$$\mu Dekat(x) = \begin{cases} 1; x \leq 0 \\ \dfrac{5-x}{5-0}; 0 < x \leq 5 \\ 0; \quad x \geq 5 \end{cases}$$

$$\mu Jauh(x) = \begin{cases} 0; x \leq 4 \\ \dfrac{x-4}{10-4}; 4 < x \leq 10 \\ 1; \quad x \geq 10 \end{cases}$$

3. Variabel Tinggi
   Variable height detection sensor is obtained from 3 (three). In this variable was formed two fuzzy set, ie near and far. To represent the variable road conditions for the triangular shaped curve near the fuzzy sets and fuzzy curve triangle to set far. For more details can be seen in the image below.

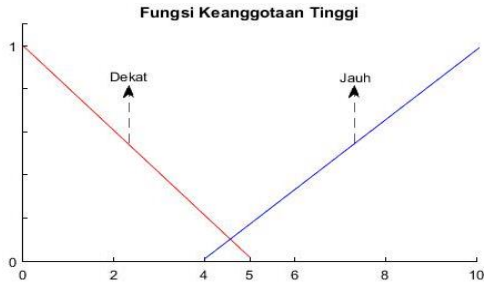


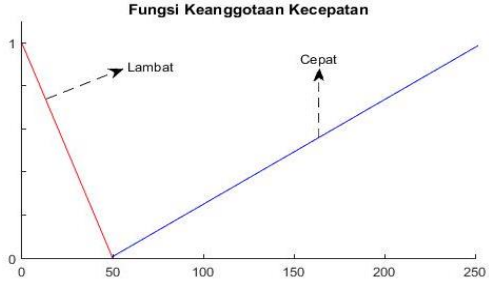
Figure 10 A High Membership Function

With membership function as follows:

$$\mu Dekat(x) = \begin{cases} 1; x \leq 0 \\ \dfrac{5-x}{5-0}; 0 < x \leq 5 \\ 0; \quad x \geq 5 \end{cases}$$

$$\mu Jauh(x) = \begin{cases} 0; x \leq 4 \\ \dfrac{x-4}{10-4}; 4 < x \leq 10 \\ 1; \quad x \geq 10 \end{cases}$$

4. Variable Speed
   Variable output speed is variable, the variable speed established two fuzzy sets, namely slow and fast. To represent variable speed triangular shaped curve for curve fuzzy set slow and fuzzy triangle to set quickly. For more details can be seen in Figure 11 below.



Gambar 11 Function Of Membership By Paid Subscription Speed

$$\mu Dekat(x) = \begin{cases} 1; x \leq 0 \\ \dfrac{50-x}{50-0}; 0 < x \leq 50 \\ 1; \quad x \geq 50 \end{cases}$$

$$\mu Cepat(x) = \begin{cases} 0; x \leq 45 \\ \dfrac{x-50}{250-50}; 45 < x \leq 250 \\ 1; \quad x \geq 250 \end{cases}$$

As for the fuzzy rule obtained by measuring and conducting experiments on this control system. Rule on autonomous control system is as much as 8 rule.

Table 3 The Formation Rule

NO	IF	Jarak Depan, samping kanan dan samping kiri	AND	Kondisi jalan	AND	Tinggi	THEN	Kecepatan
1	IF	Dekat	AND	Dekat	AND	Dekat	THEN	Lambat
2	IF	Dekat	AND	Dekat	AND	Jauh	THEN	Lambat
3	IF	Dekat	AND	Jauh	AND	Dekat	THEN	Lambat
4	IF	Dekat	AND	Jauh	AND	Jauh	THEN	Lambat
5	IF	Jauh	AND	Dekat	AND	Dekat	THEN	Lambat
6	IF	Jauh	AND	Dekat	AND	Jauh	THEN	Cepat
7	IF	Jauh	AND	Jauh	AND	Dekat	THEN	Lambat
8	IF	Jauh	AND	Jauh	AND	Jauh	THEN	Lambat

2.4 Analysis Of The Fuzzy Logic Algorithm

The process of the fuzzy logic algorithm used first performed wheeled mobile robot is a start which will be input to the mobile robot. Mobile robots will execute orders according to user input control system. For autonomous control, this control using fuzzy logic. Fuzzy logic is used to give orders

to a DC motor to do the rounds in accordance with tedeteksi in antanya impediment to the movement to each respective DC motors for forward, reverse and silent.

2.5 The Design Of robots

The following stages of manufacture of autonomous robots in figure 11 below.

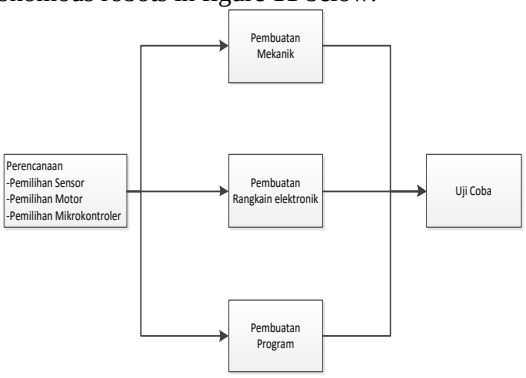


Figure 11 Stages Of The Design Of Robots

There are three stages in the design of robots, which are :

1. Planning Stages
   In this stage of planning robot that will be made and there are some things that must be determined in this stage. Diataranya dimensions, sktruktur materials, sensors are used, a method of controlling.
2. Stages Of Manufacture
   In this phase includes the manufacture of mechanical robots, electronic component selection and programming.
3. Testing Phase
   At this stage of electronic devices that have been prepared and have been programmed to be carried out tests on the robots that have been built.

2.5.1 The Design Of The Mechanical Robot

Model robot designed to have 3 pieces of ultrasonic sensors, two DC motors, 1 Arduino microcontroller Romeo, six wheels and the support wheels Belt As mobile robot. 1 sensor for detecting hitch front, right side and left side are placed almost the middle of the above servo robot body because in order to get a detection angle of 180 ° to the front, left and right. 3 sensors placed at the front of the robot body aims to detect the obstruction of road conditions so that the robot can mennghindar before passing through potholes. Sensor 2 is placed in the middle is used as a high obstacle detection. DC motor 1 is placed on the right rear wheel mobile robot. 2 DC motors placed on the left rear wheel mobile robot. Arduino placed at the center of the mobile robot body.

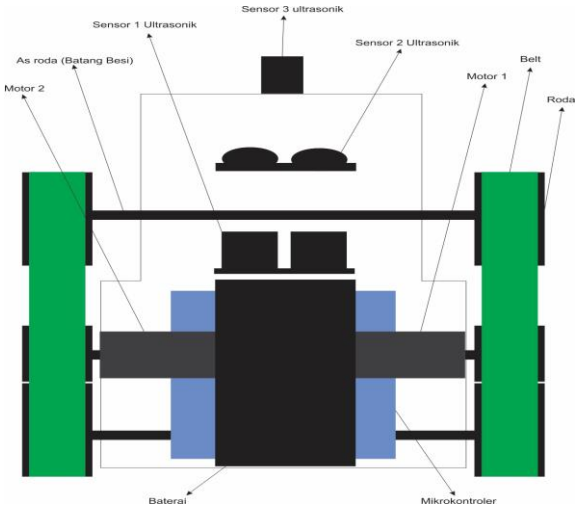


Figure 12 The Design Of Mechanical Looks Over

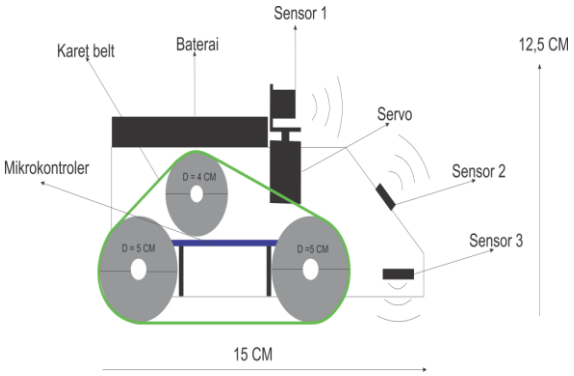


Figure 13 Mechanical Design Seem Right

2.6 Flowchart Of The Robots

Flowchart mobile robot control system are charts that illustrate the steps to resolve the problem. Here in the figure below 14 is a flowchart to work the system to be built.

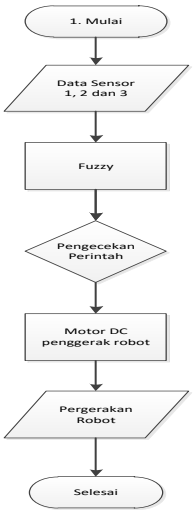


Figure 14 Flowchart Robot

2.7 Testing

Testing conducted to determine the success rate of the robot obstacle detection results. Below in table 4 test results from February 13 until February 18, 2016.

Table 4 Result Of Experiments Of Robot

No	Date	The Total Number Of Experiment	The Total Number Of Succesfully	The Total Number Of Failed
1	13/02/2016	100	98	2
2	14/02/2016	100	100	0
3	15/02/2016	100	100	0
4	16/02/2016	100	100	0
5	17/02/2016	100	96	4
Average			$\frac{494}{500}\ x\ 100\% = 98{,}8\%$	

The average success already achieved a success rate of 98.89% as shown in Table 4. The failure occurred due to the level of the battery capacity is not optimal (exhausted).

3 CLOSING

3.1 Conclusion

Based on the research that has been done can be concluded as follows:

1. The mobile robot is built to detect any obstruction of the third variable (distance around, the road conditions and high).
2. The mobile robot is built to function properly against any obstacle detected by the rules that have been created.
3. Experiment robot has done robot can detect any obstruction premises tinggkat success of 98.8%.

3.2 Advice

The results of this research is still far from perfection, it is necessary to conduct further research in the design process to produce a robot obstacle avoidance. Here are some suggestions that can be used as consideration for continued research robot obstacle avoidance, including:

1. Using the sensors more sensors so that the robot can be more responsive to each obstacle ancountered.
2. Combining two microcontroller (parallel). One microcontroller to control a DC motor and a microcontroller to control the sensors so that the robot can be more responsive to every movement.
3. Using a robotic framework material that is lighter, stronger and water resistant than the materials that I use in order for the robot can be used in the region or track containing water.
4. Election of the motor robot with greater torque so that the motor robot makes maneuvering easier.
5. Mobile robot can be extended by adding mobile robot gripper that can avoid the obstacle like a tree with the hitch mengakat without having to evade obstacle.

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