MOTION CONTROL SYSTEM DESIGN ON ROBOMAGELLAN (JELAJAH-V18)

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ABSTRACT

Robomagellan (Jelajah V-18) is a prototype of an autonomous car where the robot can navigate automatically for both long-distance navigation and close-up navigation. The remote navigation process involves the use of GPS (Global Positioning System) as a reference for navigating later for close-range navigation using a proximity sensor, where the proximity sensor used is an ultrasonic sensor. In addition to navigating the robot has a system that can search and recognize an object in the form of traffic cone orange. The recognition of object patterns performed using image processing is intended for robots to process each inserted image and distinguish it between the object being searched with other objects. The main purpose of robomagellan is being able to navigate safely and reliably and can reach the final destination point marked by a traffic cone where the robot must be able to touch it

Keyword : robot, prototype, navigation, gps, proximity sensor.

1. INTRODUCTION

Autonomous vehicles are vehicles that can operate safely and effectively without the need to be controlled by humans [1]. This vehicle consists of a collection of systems that are coordinated with each other to allow the vehicle to cross its environment. Autonomous vehicles are able to feel the surrounding environment and navigate alone, where humans themselves choose goals but are not required to carry out vehicle mechanical operations. A control system that can identify the right navigation path, as well as the obstacles that exist through sensory input.

The autonomous vehicle itself has a long history. The first prototype that could function properly was created in 1980. By using the camera as a sensor the prototype managed to travel 100 km of empty road without being driven by humans. With this success, many projects emerged in the 80s and 90s using a similar system used to drive through highways [2] .

In the development of autonomous cars, a problem arises, namely about safety when driving. Researchers are aware that they want to solve the driving safety problem. Therefore, it encourages robot researchers to conduct a challenge which makes a prototype to discuss in this field named Robomagellan in the Robogames category.

RoboMagellan is one of the competition branches in the Autonomous Autos category on RoboGames. RoboMagellan is a robotics competition whose main goal is to emphasize autonomous navigation where robots can navigate automatically to coordinate points outside the room. The intended coordinate point is marked by an orange (orange) cone placed outside the open space around the building and so on, the robot must be able to overcome obstacles such as disturbances of natural conditions and find a cone which is its main purpose using GPS points (Global Positioning System) as the route of travel [3].

2. LITERATURE REVIEW

2.1 Mobile Robot Steering System

There are several types of mobile robot steering systems. Here are some mobile robot steering systems [4]

1. Differential Steering
   Differential Steering is a steering method where two wheels can move in opposite directions so that the turn radius is smaller. This improves the ability to maneuver robots better. The disadvantage of this type of steering is that it produces friction on the right and left wheels when turning. So it will be problematic when the robot moves on a rough or uneven surface.

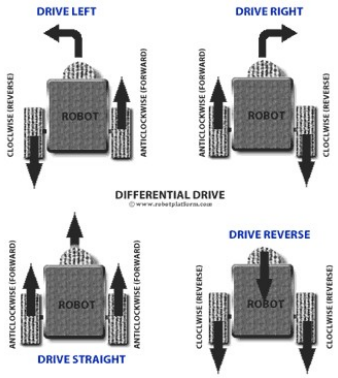


Figure 1. Differential Steering system

2. Skid Steering
   Basically this steering system is the same as differential steering. This steering system uses a wheel chain or arrangement of wheels with a fixed position. The disadvantage is the friction on the wheel when turning is greater than a differential steering system.

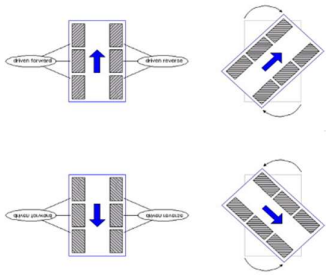


Figure 2. Skid Steering system

3. Car-Like Steering
   This steering system is a configuration where two wheels are used to change the direction of the robot. Usually the front wheel that is used even though it does not rule out the possibility to use the rear wheel as the steering wheel. This steering system is divided into two, namely Parallel Steering and Ackermann Steering.

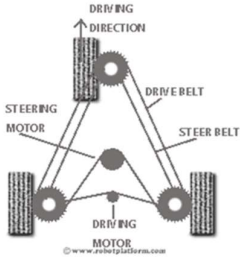


Figure 3. Parallel steering system

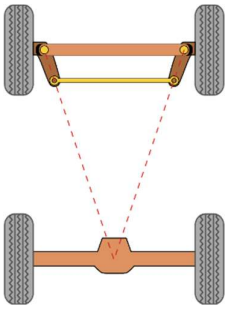


Figure 4. Ackermann steering system

4. Multi Independent Steering
   Multi independent steering system is a steering system where each wheel can move freely. With this steering system, the robot can move freely in all directions and is a type of holomonic motion. A robot that has holomonic motion capability can do all types of turn without having to change the position of the robot body.



Figure 5. Multi Independent Steering system

2.2 Aktuator

1. Motor DC

A DC motor is a device that converts electric pulses into motion, has the same basic principle as a stepper motor but its motion is continuous or continuous. DC motors are divided into 2 types, there are two basic parts of DC motors [5] :

a. A fixed / stationary part called a stator. The stator produces a magnetic field, either generated from a coil (electro magnet) or permanent magnet.
b. The rotating part is called the rotor. This rotor is a coil where electric current flows. The following examples of dc motors can be seen in Figure 6.

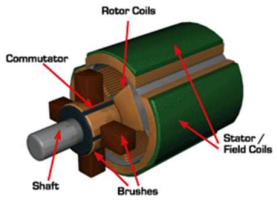


Figure 6. DC Motor

1. Servo Motor

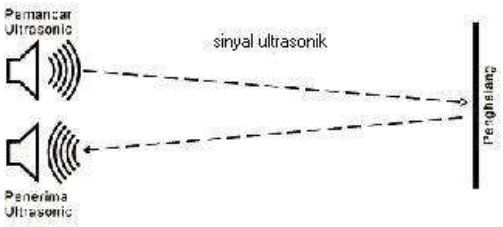
A servo motor is a DC motor that has a control circuit with a closed feeback system integrated in the motor. In the servo motor the rotational position

on the axis (axis) of the motor will be informed back to the control circuit that is in the servo motor [6].

2.3 Proximity Sensor

Within the scope of sensor robotics it provides the same function as the senses in humans. The proximity sensor is used to detect objects without physical contact, for example the proximity sensor is an ultrasonic sensor. Ultrasonic sensor is a sensor that works based on the principle of sound wave reflection and is used to detect the presence of a particular object in front of it, its working frequency is in the area above the sound wave yairu from 20KHz - 40KHz.

Basically the ultrasonic sensor consists of two parts, namely the transmitter and receiver. The transmitter sends ultrasonic waves and the receiver waits for echoes from the ultrasonic waves that have been sent before. The working principle of ultrasonic sensors can be seen in Figure 7.



Gambar 7. Working principle of ultraonic sensor

To measure the distance between objects detected using an ultrasonic sensor can use the following formula:

$$S = (tIN \times V)/2$$

Where:

S = The distance between the ultrasonic sensor and the object detected

V = Fast ultrasonic wave propagation in the air (344 m / s)

tIN = Difference in transmission time and reception of wave reflection

3. METHOD AND DISCUSSION

3.1 System Design

The system block diagram explains that there are 3 main parts, namely input, process, and output where each part has its own functions that are integrated with each other. At the input there are several supporting components, namely Sensors, Android smartphones, and remote where these components are as input media. Then in the part of the process there is the main microcontroller and Mini PC where these two components play a role in processing the system, and the last part is the output part of several components, namely DC Motor, Servo Steering, Buzzer and Led indicator where all the components will work according to the command from a microcontroller.

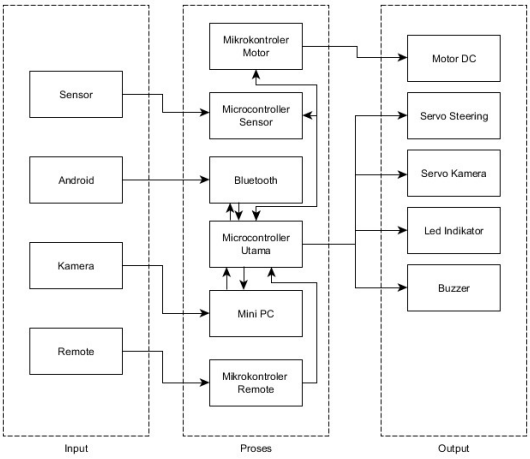


Figure 8. Block system diagram

3.2 Design of Navigation Steering System

1. Navigation Motion Steering System

The navigation motion steering system is a system for regulating the direction of movement of the robot. The robotic navigation motion steering system uses a car-type steering system (car-like steering) where the two front wheels are used to change the direction of the robot. This system uses input media from android in the form of GPS point coordinates. The following concepts of robot steering wheel are shown in Figure 7 and Figure 8.

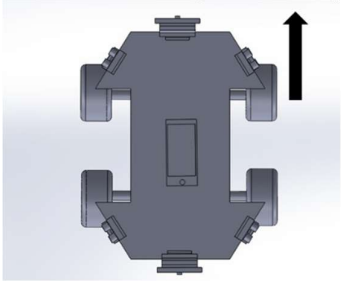


Figure 9. Robot steering system

In its design, the steering system is supported by several supporting components such as proximity sensor, led indicator and buzzer as a marker of the program. Then two main processing equipment and other supporting components are placed in the robot body with the aim to protect against any possible interference that can interfere with the performance of the device

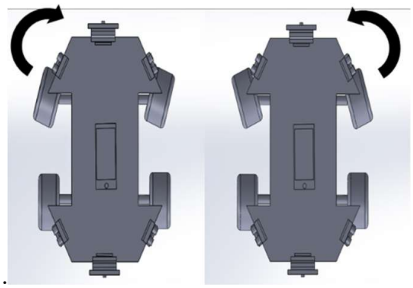


Figure 10. Robot Steering

The design of robomagellan navigation motion system can be seen in Figure 11.

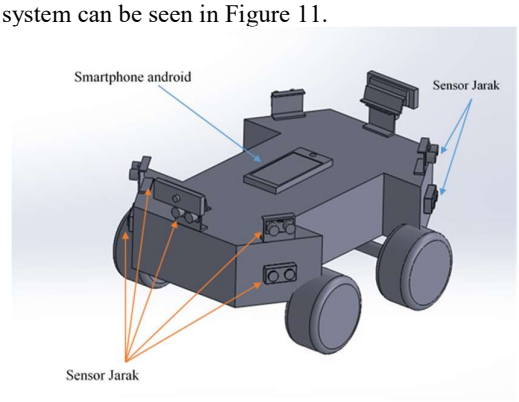


Figure 11. Motion control system on robomagellan (JELAJAH v-18)

3.3 Basic Motion Algorithms Design

Straight forward motion is used when the robot will move forward or backward.

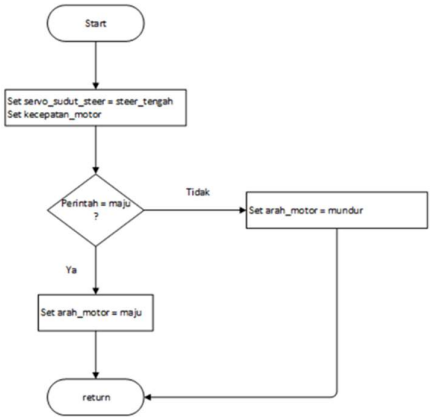


Figure 12. Straight motion flow chart

Forward motion turns to use when the robot will navigate turn right or left when the motion conditions are straight and the motor is in advanced condition. This movement is divided into 2 directions, namely: go right turn and go left turn. Turning forward motion is also needed when there are obstacles on the left or right and if the robot has to move right or left while continuing to move.

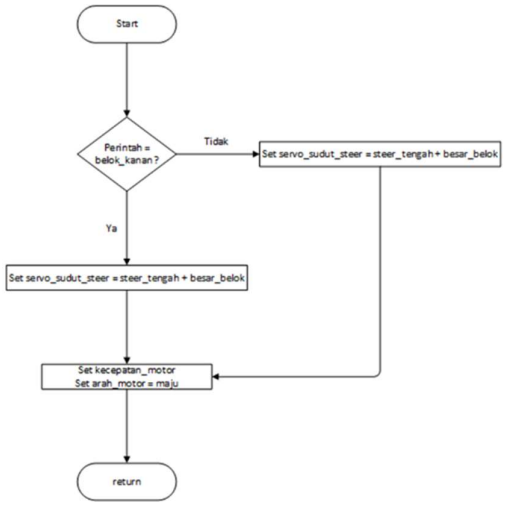


Figure 13. Forward and turn flow chart

Algorithms are objects that are used for existing robots, so that robots do not experience collisions with objects or obstructions in front of them.

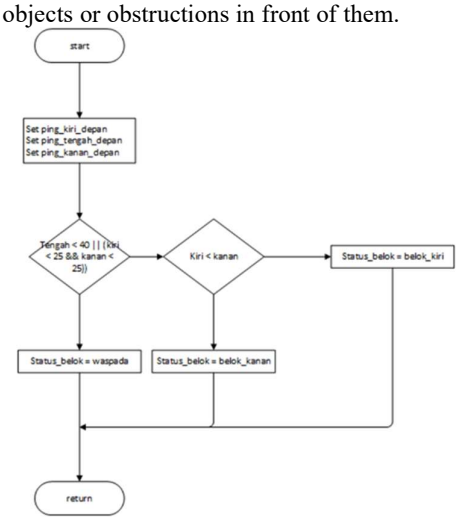
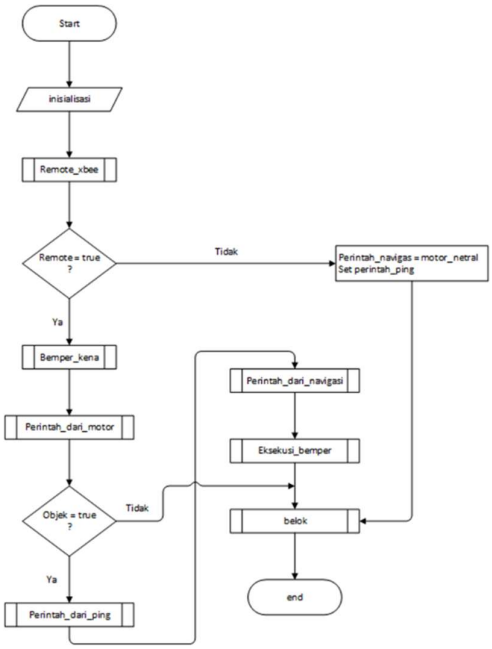


Figure 14. Avoid object flow chart

The main algorithm is the whole robot algorithm to complete the tasks that must be done by robomagellan in its mission. In general, the main algorithm flow is shown in Figure 13



Gambar 15. Man algorithm flow chart

4. RESULT

4.1 Proximity Sensor Testing

The test carried out on the SRF05 ultrasonic sensor is intended to get the comparison value between the actual distance value and the distance value received by the microcontroller. Testing is done by placing objects or walls in front of the ultrasonic sensor. The test results for the ultrasonic sensor can be seen in Table 1. Ultrasonic Sensot Testing Results.

Based on the results of the test, the error value of the ultrasonic distance sensor tested was very small indicating that there was a difference between the actual value and the value of the sensor readings. So it is quite accurate to be used as a reference for robots to navigate.

Tablel 1. Proximity sensor result testing

Jarak yang ditentukan (cm)	Waktu yang ditempuh (µs)	Hasil perhitungan (cm)	*Error* (cm)
10	572	10.21	0.21
20	1153	20.3	0.3
30	1733	30	0
40	2315	40.6	0.6
50	2894	50.21	0.21
60	3476	60.72	0.72
70	4056	70.51	0.51
80	4637	80.54	0.54
90	5217	90.1	0.1
100	5799	100.02	0.02
110	6378	110.1	0.1
120	6960	120	0
130	7540	130.2	0.2
140	8123	140.24	0.24
150	8701	150.3	0.3
160	9234	160.16	0.16
170	9863	170.2	0.2
180	10444	180.1	0.1
190	11024	190	0
200	11606	200	0
Rata-rata error			0.225

4.2 Navigation Motion Control System Testing

Control system testing is a testing phase of the navigation motion control application that has been built. Figure 16 and Figure 17 are the results of field testing of the navigation motion control system.

It can be seen that the position shown by the GPS coordinates are marked by red and yellow markers. The red marker shows the waypoint that must be passed and the yellow marker like a cone is the final destination.

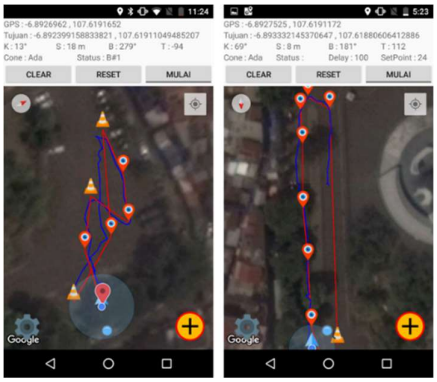


Figure 16. Result testing

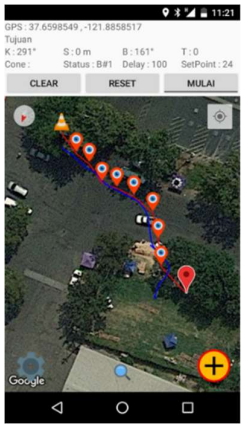


Figure 17. Test resulr in the race area

The red line that connects the marker is the path that should be passed by the robot, then the blue line adjacent to the red line is the actual route that is passed by the robot. From the results of these tests it

appears that the robot is able to reach the final destination in accordance with the specified route.

4.3 Agorithm Testing

Trials conducted in the open field, overall system testing carried out in March to April 2018 can be seen in Table 2.

When viewed from Figure 18 the overall success rate of the overall system is above 87%. Failure occurs due to changes in weather conditions that cause navigation motion control conditions not working optimally, because the navigation motion control system uses GPS which is very dependent on the weather conditions at the time of testing.

Table 2. Test result all robot

No	Tanggal	Keadaan Cuaca	Jumlah Cone	Keberhasilan Menemukan Cone	Error	Keterangan
1	19 Maret 2018	Berawan	2	2	-	Berhasil
2	19 Maret 2018	Berawan	2	2	-	Pengiriman Data Lambat
3	19 Maret 2018	Berawan	2	2	-	Pengiriman Data Lambat
4	19 Maret 2018	Berawan	2	2	-	Pengiriman Data Lambat
5	22 Maret 2018	Berawan	3	2	Berhenti	Cone Terakhir Tidak Terdeteksi
6	22 Maret 2018	Berawan	3	3	-	Berhasil
7	22 Maret 2018	Berawan	3	3	-	Berhasil
8	22 Maret 2018	Berawan	3	3	-	Berhasil
9	22 Maret 2018	Berawan	3	3	-	Pengiriman Data Lambat
10	22 Maret 2018	Berawan	3	3	-	Berhasil
11	22 Maret 2018	Berawan	3	3	-	Pengiriman Data Lambat
12	22 Maret 2018	Berawan	3	3	-	Berhasil
13	22 Maret 2018	Berawan	3	3	-	Pengiriman Data Lambat
14	22 Maret 2018	Berawan	3	0	-	Berhasil
15	2 April 2018	Cerah	3	0	Tidak Terdeteksi	Terjadi Perubahan Kalibrasi Warna
16	2 April 2018	Cerah	3	3	-	Berhasil
17	2 April 2018	Cerah	3	3	-	Berhasil
18	2 April 2018	Cerah	3	3	-	Berhasil
19	2 April 2018	Cerah	3	2	Tidak Terdeteksi	Robot Berhenti Jauh Dari Cone
20	2 April 2018	Cerah	3	3	-	Berhasil
21	2 April 2018	Cerah	3	3	-	Berhasil
22	2 April 2018	Cerah	3	0	-	Berhasil
23	6 April 2018	Cerah	3	3	-	Berhasil
24	6 April 2018	Cerah	3	3	-	Berhasil

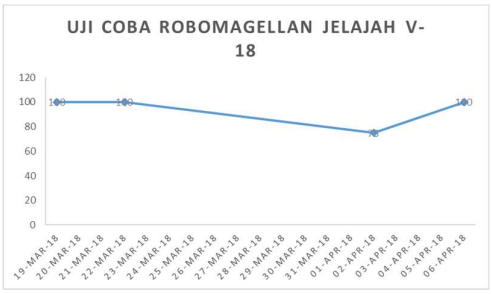


Figure 18. Success chart

5. CONCLUSIONS

5.1 Conclusion

Based on the description discussed, the following conclusions can be drawn:

1. Robot robomagellan Jelajah V-18 can move to navigate according to the GPS coordinates specified in the test (race).
2. Robot robomagellan Jelajah V-18 can find the last destination in accordance with the coordinates entered..
3. Robot robomagellan Jelajah V-18 can navigate at the same time through obstacles on the way to the last destination..
4. Navigation motion control system uses GPS which is very dependent on weather conditions, for example when the weather is cloudy, the accuracy of the reading will decrease.

5.2 Suggestion

For the sake of improving and developing further research the authors propose several suggestions, namely, Adding the GPS system used, so as not to stick to a GPS reading; Soften the object avoiding algorithm; Replacing the current ultrasonic proximity sensor with another proximity sensor for example Lidar.

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