# Obstacle Avoidance system on the Wheeled KRSBI Robot Barelang 63

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**Abstract**

Wheeled robot (KRSBI) is a robot designed to be able to play football like a human in general, as for the main driving mechanism in the form of wheels. Wheeled football robots are distinguished into two, namely attacking robots that have the task of scoring goals against opponents and goalkeeper robots tasked with keeping the goal from happening into the goal. In the era of industrial revolution such as today many robots are increasing in terms of artificial intelligence, in this proposal the author lists several systems that were appointed as the writing of final task proposals among others is, a system used to avoid an obstacle that exists in the field. In order for the robot to be able to continue its ultimate goal is to score a goal.

This was raised in the writing of this final task intends to develop the system on robots to have more capable abilities at the time of competition. In this study the system developed using ZED Camera and TINY YOLO V3 deep learning, the performance produced by using a laptop acer aspire v 15 nitro with specifications that have a graphics card NVIDIA GTX 860m is 40 - 60 FPS. After conducting experiments to perform obstacle avoidance movements the robot has an accuracy rate of 94,00% with an mAP value. Then the system will perform the process of avoiding obstacles by taking distance data ranging from 0-2 meters and 45° angles on the right side of the robot and -45° on the left side of the robot.

**Keywords : Mobile robot, fuzzy logic, obstacle avoider.**

## 1. Introduction

Currently the Barelang 63 robot has three robots, namely two attack robots and one goalkeeping robot. For the attacking robot, the main task is to score as many goals as possible, and the goalkeeping robot has the task of keeping the goal from being conceded.

The goalkeeping robot must have the ability to block the ball into the net from the opponent's attack (ball interception), and always be in the goal area. Another thing that the striker robot must have is to kick the ball using a solenoid (coil wire). In terms of kicking a ball, the robot must also have the ability to determine the target for the execution of kicking the ball or passing the ball.

pad when going to kick the ball will allow the robot to find obstacles, therefore the wheeled soccer robot must have the ability to avoid obstacles, the process of avoiding obstacles begins with detecting the obstacle, the robot must be able to know the presence of an obstacle detected on the right or left side robot, then proceed with making directional decisions with dodging movements in the safest direction to achieve the goal by continuing to maintain the ball being carried.

From the various basic abilities that the wheeled soccer robot that has been described previously. The most basic of all intelligence capabilities, namely the wheeled soccer robot must be able to detect and distinguish objects. In Barelang 63 wheeled soccer robot, the object detection system used is TINY YOLO V3 YOLO (You Only Look Once). Followed by the development of intelligence that this wheeled soccer robot must have is to be able to measure the distance from the detected object and measure its velocity (velocity). This is a development of the object detection system owned by YOLO (You Only Look Once), which aims to increase the intelligence of the robot.

## 2. General Instructions

In the football robot on wheels on the Barelang 63 team, the robot is being attempted to be able to play soccer like a human, except that the robot uses a dc motor as the actuator. Among them, the robot can avoid obstacles that exist when competing, according to methods that can support the process of making robots and making the final project, described as follows.

### 2.1 Avoidance System

#### 2.1.1 Fuzzy logic

Fuzzy logic was first introduced in 1965 by Prof. Lutfi A. Zadeh, a researcher at the University of California at Barkley Professor Zadeh thought that logic 1 and 0 could not represent every human thought, which was then raised and developed fuzzy logic that could implement various kinds or represents human thought. The difference between fuzzy logic and thinking lies in the number of membership elements in a set. Fuzzy logic is an alternative to various existing systems in decision making because fuzzy logic has the following advantages:

a. Fuzzy logic has a very simple concept that is easy to understand.
b. Fuzzy logic is very flexible, meaning that it is able to adapt to changes and uncertainties.
c. Fuzzy logic has a tolerance for imprecise data.

#### 2.1.2 Decisive Set

An emphatic set is a set of objects that have been clearly defined. Which means that the object has clearly determined its existence. The objects in the set are called elements or members of the set. In general, sets are symbolized by a small alphabet. The notation "a ∈ A" is read as a member of the set and the notation "a ∉ A" is not a member of the set. (Sukirman, 2006: 116).

#### 2.1.3 Fuzzy set

Fuzzy set is a description of a strict set. The strict set is that the membership value of the element has only two possible degrees of membership, namely:

$$\mu A(x) = \{\frac{1\,; jika\ x\ \in A}{0\,; jika\ x\ \notin A}$$

It is defined that μA is a characteristic function of the set A. whereas in the fuzzy set the degree of membership for each element lies in the interval [0,1].

a. Curve Representation

A simple representation of the membership function uses a linear representation which is drawn on a straight line. The linear representation is divided into two, first the set has increased from one degree of membership to the right to a higher degree of membership (maximum). As illustrated in the image below

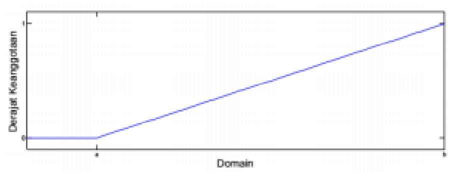



Figure 1. Representation of Upward Linear Curve.

Ascending linear membership function:

$$\mu(x) = \quad 0, x \le b$$

$$\frac{x-a}{b-a}, a \le x \le b$$

$$1, x = b$$

Where:

**a** = smallest domain value when the degree of membership is small.

**b** = the degree of membership that has the greatest value in the domain.

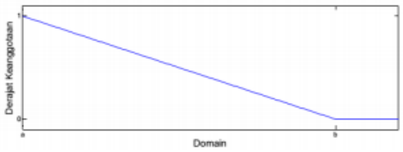



Figure 2. Representation of Downward Linear Curves.

A descending linear curve membership function

$$\mu(x) = \frac{b-x}{b-a}, a \leq x \leq b$$

$$0, x \geq b$$

Where:

**a** = smallest domain value when the degree of membership is small.

**b** = the degree of membership that has the greatest value in the domain.

b. Triangle Curve Representation.

Mapping on a triangle curve is a combination of a linear upward representation and a downward linear representation, as shown below.

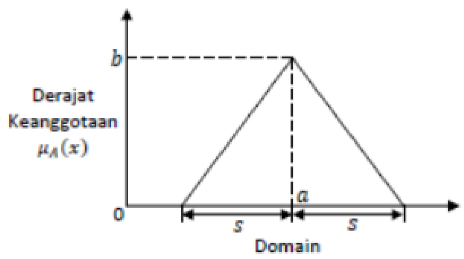



Figure 3. Representation of Triangular Curves.

The membership function of the triangle curve representation is:

$$\mu(x) = 0,\ x \leq a \ atau\ x \geq c$$

$$\frac{x-a}{b-a}, a \leq x \leq b$$

$$\frac{c-x}{c-b}, b \leq x \leq c$$

Where:

**a** = smallest domain value when the degree of membership is small.

**b** = the degree of membership that has the greatest value in the domain.

**c** = domain value when the smallest degree of membership

c. Trapezoid Curve Representation.

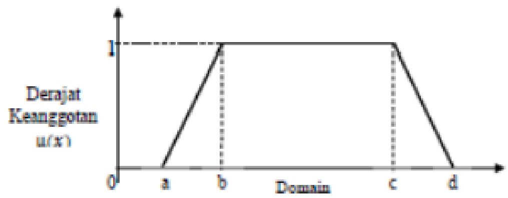



Figure 4. Representation Trapezoid Curve

The membership function of the trapezoidal curve representation is:

$$\mu(x) = 0,\ x \leq a \ atau\ x \geq d$$

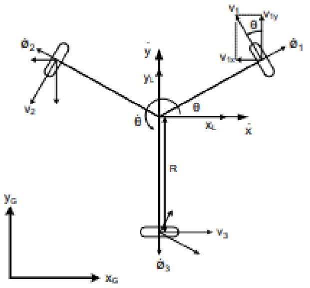
$$\frac{x-a}{b-a}, a \leq x \leq b$$

$$1, b \leq x \leq c$$

$$\frac{d-x}{d-c}, c \leq x \leq$$

### 2.1.4 Kiwi Drive Movement Kinematics Omni Wheels Robots

The inverse kinematics equation informs the relationship between the local velocity of the robot and the angular velocity of the wheel axle. Kiwi drive inverse kinematics diagram is shown in Figure below:



$$\dot{\emptyset}_1 = (-\sin(\theta+\alpha_1)\cos(\theta)\,\dot{x}_L + \cos(\theta+\alpha_1)\cos(\theta)\,\dot{y}_L + R\dot{\theta})/r$$

$$\dot{\emptyset}_2 = (-\sin(\theta+\alpha_2)\cos(\theta)\,\dot{x}_L + \cos(\theta+\alpha_2)\cos(\theta)\,\dot{y}_L + R\dot{\theta})/r$$

$$\dot{\emptyset}_3 = (-\sin(\theta+\alpha_3)\cos(\theta)\,\dot{x}_L + \cos(\theta+\alpha_3)\cos(\theta)\,\dot{y}_L + R\dot{\theta})/r$$

Figure 5. Kiwi Drive Kinematics Diagram.

Where:

θ: Robot orientation (degrees)

α: Wheel angle from XL axis (degrees)

R: Wheel distance to the center of mass of the robot (meters)

r: Wheel radius (meter)

### 2.1.5 Object Distance Measurements

To determine the distance of the object, the camera used is a stereo Zed camera, this camera has a distance detection range of objects ranging from 30 centimeters to 25 meters and this camera also has a maximum field of view (Field of View) of 90 ° (H) x 60 ° (V) x 100 ° (D). So that it allows the robot to detect the distance from objects more widely and accurately, this camera is also integrated with Linux Ubuntu, OpenCV, and YOLO through the SDK that has been published by Stereolabs. Therefore, the method used to measure the distance of the detected object is to use the method of comparing the three-dimensional X, Y, and Z coordinate values obtained at the time of object detection. In Figure 1, you can see the optical axis of the polar epi geometry on the stereo camera to find the value on the Z-axis, where there are two center points between the left camera and the right camera. With the congruence of Δ PCLCR and Δ PLPR triangles.

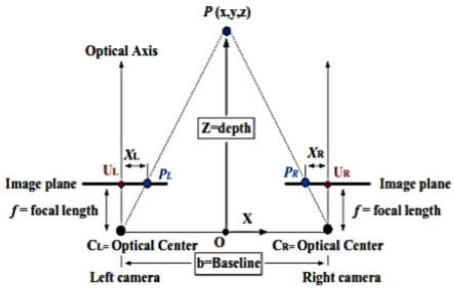



Figure 6. Geometry of Epi Polar Optical Axis

$$\frac{b}{z} = \frac{(b + xr) - xl}{z - f}$$

$$z = \frac{b * f}{xl - xr} = \frac{b * f}{d}$$

Where d is the disparity value, xl is the x coordinate on the left camera, xr is the x coordinate on the right camera, b is the length between the center points of the two cameras and f is the focal length on the two cameras. The greater the disparity value, the closer the object will be to the camera baseline [5]. After obtaining the three coordinates desired, to find the distance between the robot and its object, the following equation can be obtained:

$$d = \sqrt{(x * x) + (y * y) + (z * z)}$$

The distance obtained is in meters, because the values of the X, Y, and Z axes are already in centimeters.

## 3. Test Results and Discussion

### 3.1 Avoidance System

In this section, we will discuss the test results of the obstacle avoidance system in the field, the data obtained using a stereo camera, namely a ZED Camera and a computer or laptop that uses an Intel Core i7 processor, NVIDIA GTX 860M graphics card. With these specifications the resulting frame rate is around 40 - 50 fps (Frames Per Second) with a capture resolution of 1344 x 376.

### 3.2 Appearance of fuzzy calculation results by calculation

In the obstacle avoidance system, the method used is the fuzzy method in which the method will calculate the results that the motor will use to move the robot so that it can avoid obstacles in the field, here is a graph of the input values that will be used to calculate the direction of movement to avoid obstacles using the method. fuzzy logic.

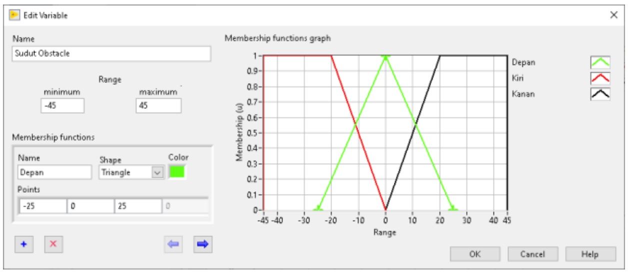



Figure 7. Angle Input Graphical Image (Front)

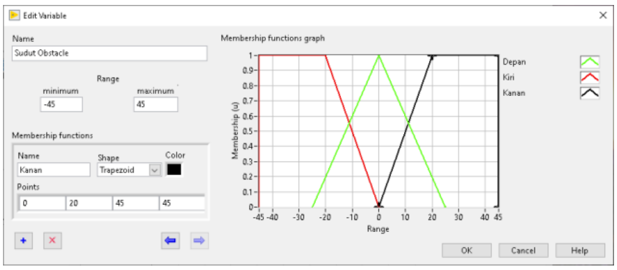



Figure 8. Angle Input Graphical Image (Right)

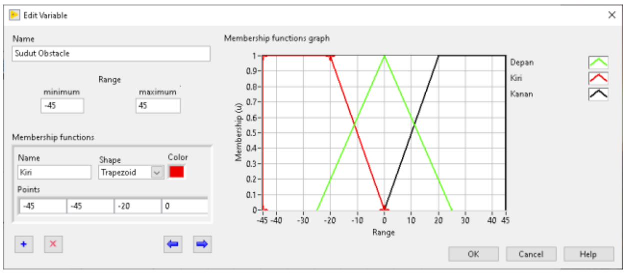



Figure 9. Angle Input Graphical Image (Left)

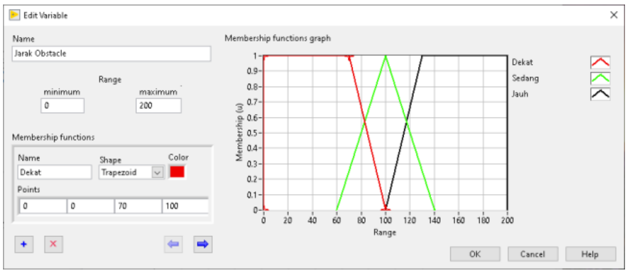



Figure 10. Distance Input Graph Image (Near)

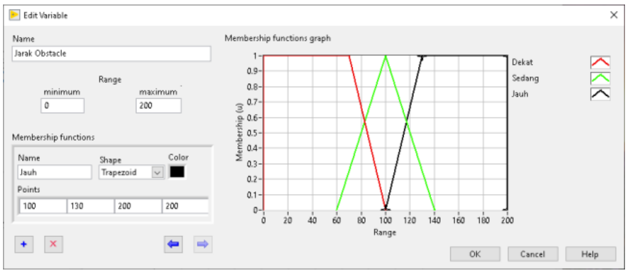



Figure 11. Distance Input Graph Image (Far)

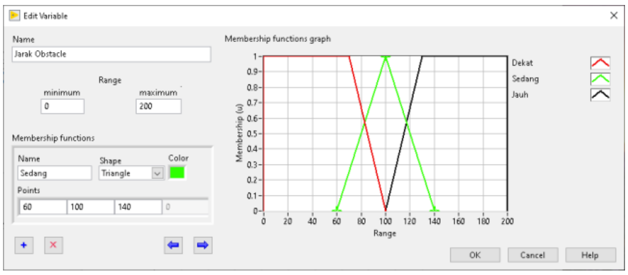



Figure 12. Distance Input Graph Image (Moderate)

In the obstacle avoidance system, the method used is the fuzzy method in which the method will calculate the results that the motor will use to move the robot so that it can avoid obstacles in the field, here is a graph of the input values that will be used to calculate the direction of movement to avoid obstacles using the method. fuzzy logic. From the three graphs above (angle input) is taken from the object detection system and takes the resulting angle value, and from that angle reading is made logic again in producing the angle value of the detected object where if the object is to the left of the robot then the angle value will result in negative , and vice versa if the object is detected on the right will produce a positive value. After the angle value is used as the input value, the next fuzzy logic input is the distance from the detected obstacle, here the obstacle is divided into 3 parts, namely the short distance that ranges from 0 - 100 cm, and the medium distance is 60 - 140 cm, the last. is a long distance that ranges from 100 - 200 cm, here are some results from the calculation of fuzzy logic to avoid obstacles that result in moving to the right or to the left.

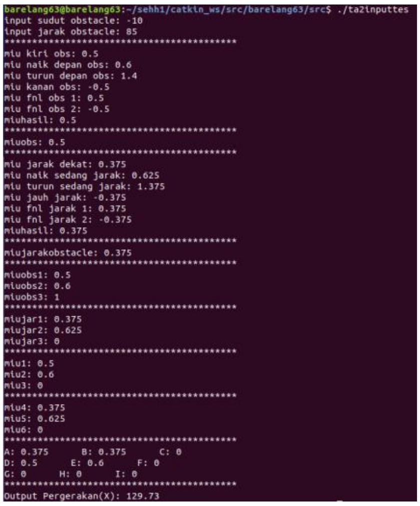



Figure 13. Image of Fuzzy Logic Calculation Results (Move Right)

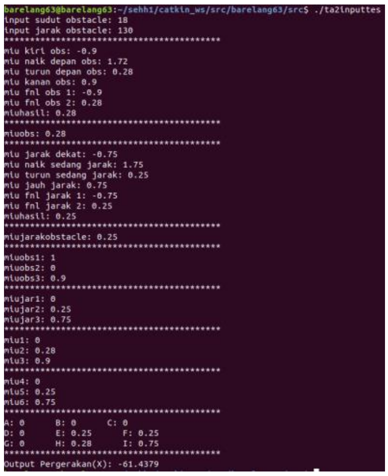



Figure 14. Image of Fuzzy Logic Calculation Results (Move Left)

### 3.3 Movement results appearance and dodging success

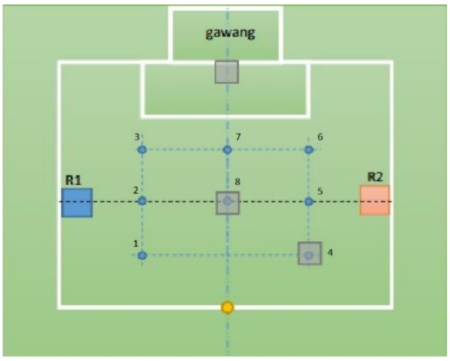



Figure 15. The Race Field in 2020

In the obstacle avoidance system, the object detected as an obstacle is a cardboard box according to the rules of the KRI 2020 Wheeled KRSBI division. After obtaining data from evasive movements, the data will be forwarded to the microcontroller as a data processor that is generated to move the robot, be it evasive movements. The presentation of the success rate of the robot in avoiding obstacles. The data comparison seen is the comparison between the results of the calculation of the fuzzy system calculation output with the data from the success rate of the robot in avoiding obstacles in the field. The percentage of Mean Average Precision (MAP) can be seen in the table as follows.

| Obs 1 | Obs 2 | goal position (ball) | goal position (ball) | number of trials | succeeded | failed |
|---|---|---|---|---|---|---|
| Position 3 | Position 8 | Right | Left | 20 | 18 | 2 |
| Position 2 | Position 7 | Right | Left | 20 | 20 | - |
| Position 7 | Position 5 | Right | Left | 20 | 17 | 3 |
| Position 1 | Position 5 | Right | Left | 20 | 19 | 1 |
| Position 8 | Position 4 | Right | Left | 20 | 20 | - |

Table 1. Table of Fuzzy Logic calculation results

Table 1 shows that there are several percentages of the level of precision that each object has. The percentage that each object has is as follows.

| Trial | Obs 1 | Obs 2 | goal position (ball) | goal position (ball) | Average Precision |
|---|---|---|---|---|---|
| 1 | Position 3 | Position 8 | Right | Left | 90% |
| 2 | Position 2 | Position 7 | Right | Left | 100% |
| 3 | Position 7 | Position 5 | Right | Left | 85% |
| 4 | Position 1 | Position 5 | Right | Left | 95% |
| 5 | Position 8 | Position 4 | Right | Left | 100% |

Table 2.Fuzzy Logic Percentage Result Table

From the data that has been displayed above and has been tested, the robot can be concluded that the barrier system can be used when the robot is operated in accordance with the field described in the figure 15.

## 4. Conclusions

Based on the tests that have been carried out in the previous chapter, the obstacle avoidance system that has been set by the author, is able to make movement to avoid obstacles in the field at least 17 out of 20 trials. The obstacle avoidance system has a mAP percentage of 94.00% for 5 different types of obstacle laying totaling 2 pieces. While the trial was conducted 20 times in each type of obstacle laying.

The percentage of errors in the obstacle avoidance system in this trial is 6%. Furthermore, the obstacle avoidance system is carried out by placing the robot at the starting point (box on the left side of the field) and then running the robot will automatically go to the ball position, and if on the way it detects an obstacle, the robot will activate the logic of avoidance using logic. fuzzy and after dodging, the robot will return to the strategy to walk towards the ball position.

## References

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