Ball Interception for Goal Keeper Barelang 63

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Abstract

The KRSBI wheeled robot is a robot designed to be able to play soccer just like humans in general, while someone who has the main driving force is a wheel. The football robot with wheels is divided into two, namely the attacking robot that has the task of scoring goals against the goal and the goalkeeping robot that keeps the management goal at bay. In the era of the industrial revolution, like today, many robots have increased artificial intelligence. In this proposal, one of the systems raised as a final project proposal is, among other things, a ball interception system used to keep the goal rather than being conceded.

This was founded in this final project based on a system on the robot to have more competent abilities when competing. In this study, the system developed using ZED Camera and TINY YOLO V3 deep learning, the performance produced using the MSI GF65 laptop with specifications that have an NVIDIA GTX 1660Ti graphics card is 90-100 FPS. Experimental system experiments have been carried out with methods for estimating velocity with motion blur within an image frame and intercepting a moving object. By using this method, the robot is expected to be able to predict the direction of movement.

Keywords: Ball Interception, Mobile Robot

1. Introduction

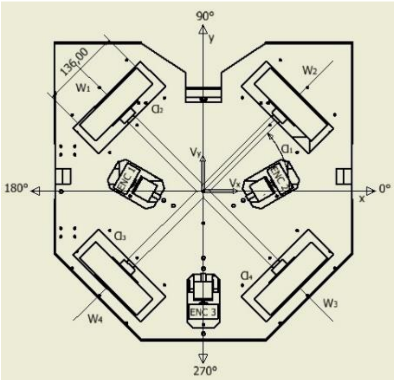
Currently the Barelang 63 robot has three robots, namely two attack robots and one goalkeeping robot. For the attacking robot, the main task is to score as many goals as possible, and the goalkeeping robot has a duty to keep the goal from being conceded.
The goalkeeping robot must have the ability to block the ball into the opponent's goal (ball interception), the intercept ball process begins with the ball's response, ball distance, and ball vector. The goalkeeper will take decisions in the form of the distance and direction of the ball. From the various basic abilities of the wheeled soccer robot that have been stated earlier. The basis of all the intelligent abilities of the robot that wheeled football must be able and distinguish objects. In Barelang 63 wheeled soccer robot, the object detection system used is TINY YOLO V3 YOLO (You Only Look Once). Following the development of intelligence that this wheeled soccer robot must have, it is able to measure the distance from the detected object and measure its speed (speed). This is the development of YOLO's (You Only Look Once) object detection system 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 measure objects, the robot can dribble, kick the ball, avoid opponents, and the goalkeeping robot is able to block the ball that leads to the goal area. Therefore we need methods that can support the process of making robots and making the final project, the methods are as follows:

2.1Inverse Kinematic

The method used to move the goalkeeping robot is Inverse kinematic, this method is used because it determines the combined parameters to provide the desired position for each of the goalkeeping robot's end effectors[1]. The specification of the movement of the robot so that the end-effector reaches the desired point is known as the planning motion. In a goalkeeping robot, the kinematics equation defines some part of the goalkeeping robot's motion which is the velocity v_x, v_y, and ω to the angular velocity for each wheel. Figure 2.13 design and sketch of an omni-wheeled robot with an X frame consisting of four wheels so that the angle formed on each wheel is $\alpha 1$ = 45 °, $\alpha 2$ = 135 °, $\alpha 3$ = 225 °, $\alpha 4$ = 315 ° on the X axis.



Wheel and Movement vector configuration

From the parameter value and the angle formed between each wheel and the X-axis, each wheel has an additional velocity component towards the X and Y axes as a consequence of the rotational speed ω. The translation speed for each wheel can be written in the equation:

$$Vi = \sin(\alpha i)\, Vx + \cos(\alpha i)\, Vy + R\theta$$

$$Vi = \omega i R \quad (1)$$

From the inverse kinematic equation for each wheel can be presented in the equation:

$$\begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} \frac{1}{R} \begin{bmatrix} \sin(\alpha_1) & \cos(\alpha_1) & R \\ \sin(\alpha_2) & \cos(\alpha_2) & R \\ \sin(\alpha_3) & \cos(\alpha_3) & R \\ \sin(\alpha_4) & \cos(\alpha_4) & R \end{bmatrix} \begin{bmatrix} V_x \\ V_y \\ \theta \end{bmatrix} \quad (2)$$

2.2 Moving Target Prediction Pose

The method used for the prediction step aims to make the interception more efficient and more accurate. When an object is detected that will get the object pixel value (u, v) with an image size of 672x376 to determine the pixel depth

$$z_N = v * 672 + u \quad (3)$$

Where z_N is the pixel depth. By performing the calibration, it will get a value (f_x,f_y) as the value of the focal length and the principal point (c_x,c_y)

From the equation R is the radius of the omni wheel and θ is the angle formed when the robot orientation or robot heading is changed. Furthermore, using the equation and calculating the inverse kinematics of the equation, the angular velocity for each motor can be derived to the equation

$$F\ [280 \quad 280]$$

$$CC[333{,}9893 \quad 185{,}7518] \quad (4)$$

The value obtained will be in 2D-3D as follows

$$x_i = \frac{u - c_x}{f_x} \quad (5)$$

$$y_i = \frac{v - c_y}{f_y} \quad (6)$$

The actual position of the sphere's center will be determined in the coordinate system as

$$x_c = x_i * z_N \quad (7)$$

$$y_c = y_i * z_N \quad (8)$$

Where x_c and y_c are the Cartesian coordinates of the object center.

$$x = Vxt + Xc$$

$$y = Vyt + Yc \quad (10)$$

The predicted position (X, Y) can be obtained from the approximate target position after t[2]

2.3 Position Recognition Using Odometry

This method is used for goalkeeping robots to help the goalkeeping robot stay in the goal area. The encoder sensor is installed on the base of the robot, to obtain information on the position of the robot in the field. Determines the position of the robot based on

$$\begin{bmatrix} x_i \\ y_i \end{bmatrix} = \begin{bmatrix} x_0 \\ y_0 \end{bmatrix} + \begin{bmatrix} \cos(c_x) & \sin(c_x) \\ -\sin(c_x) & \cos(c_x) \end{bmatrix} x \begin{bmatrix} d_x \\ d_y \end{bmatrix} \quad (11)$$

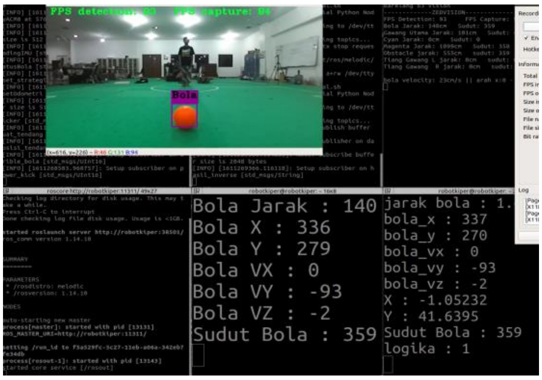
Where (x_i,y_i) are the global coordinates of the current robot, (x_0, y_0) are the global coordinates of the last robot

Moment, c_x is the angle of rotation of the robot clockwise. Global coordinates are obtained by accumulating previous displacements.[3]

3. Test Results and Discussion

3.1 Prediction accuracy testing

In testing the accuracy of this prediction by looking at the predictive value formed when the ball object starts moving in a certain direction. The success of this prediction process is influenced by other processes as well, such as the detection process must be good. Here are some examples of correct prediction results and errors during the prediction process.



Prediction Process

Table 1. Test Data of Prediction Success Rate To the right

DISTANCE	TRIAL									
	1	2	3	4	5	6	7	8	9	10
1.5 m	Y	Y	N	N	Y	Y	Y	Y	Y	Y
2.5 m	Y	Y	Y	N	Y	Y	Y	Y	Y	N
3.5 m	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
4.5 m	Y	Y	Y	Y	Y	Y	N	Y	Y	Y

Information:
Y = succeed
N= failed

Table 2. Percentage of Success Predictions to the Right

Distance (m)	Percentage of Success	Number of Tries
1,5	70%	10
2,5	80%	10
3,5	90%	10
4,5	90%	10
Average	82,5%	

From the above presentation, the average score reached 82.5%

Table 3. Test Data of Prediction Success Rate to the Left

DISTANCE	TRIAL									
	1	2	3	4	5	6	7	8	9	10
1.5 m	Y	N	Y	Y	N	N	Y	N	Y	N
2.5 m	Y	Y	N	Y	N	N	Y	Y	Y	Y
3.5 m	Y	Y	Y	Y	Y	Y	N	Y	N	Y
4.5 m	Y	Y	N	Y	Y	Y	Y	Y	N	Y

Information:
Y = succeed
N= failed

Table 4. Test Data of Prediction Success Rate To the Right

Distance (m)	Percentage of Success	Number of Tries
1,5	50%	10
2,5	70%	10
3,5	80%	10
4,5	80%	10
Average	70,0%	

From the above presentation, the average score reached 70%

3.2 Testing of robot odometry results

In this odometric test, by looking at the value formed when the encoder rotates, which produces a pulse. Odometry output is the distance that will be compared to the actual distance. Here are some examples of odometric results.

Table 5. Right Odometry Result Testing Data

Data Input (cm)	Data Odometry (cm)	Actual Value (cm)	Error
20	20,7	20,5	0,2
40	39,8	38,9	0,9
60	60,2	59,5	0,7
80	80,1	78,2	1,9

Table 6. Left Odometry Result Testing Data

Data Input (cm)	Data Odometry (cm)	Actual Value (cm)	Error
-20	-20	-19,8	0,2
-40	-39,2	-38,5	0,7
-60	-59,5	-59,9	0,4
-80	-81,2	-81,6	0,4

Based on the results above, this odometry is already good to use for the purpose of robot movement with motion restrictions to the right and left. Where the biggest error is only 1.9 cm from the actual distance.

3.3Testing the robot's response to the speed and direction of the ball

This goalkeeper robot determines its movement using the X coordinate where if the ball object is on the left side of the robot caught by the camera the X coordinate value will be negative and if the ball is right the X coordinate value will be positive. The X coordinate value is then continued in the PID computation process. The greater the X value, the higher the speed of the robot moving. And vice versa, if the value of X approaches the setpoint and tolerance value of 0, the robot stops moving. In this test the robot is tested with a ball that is moved from different distances and different angles. With a distance of 1m, 2m, 3m, and 4m and with an angle of -10 to +10 degrees

Table 7. Robot response at a distance of 1.5m

Ball velocity (m/s)	ANGLE		
	-10	0	10
3,88 m/s	G	S	G
2,75 m/s	G	S	G
2,06 m/s	G	S	G

The experimental results in table 4.5 show that the robot is still being conceded at a distance of 1 meter with a speed of 3.88 m / s and 2.75 m / s and 2.06 m / s. This happens because the distance of the ball is too close to the robot and the ball speed is high. From the experimental results above, it can be concluded that the success rate reaches 33.3%.

Table 8. Robot response at a distance of 2.5m

Ball velocity (m/s)	ANGLE		
	-10	0	10
3,88 m/s	G	S	G
2,75 m/s	G	S	G
2,06 m/s	G	S	S

The experimental results in table 4.6 show that the robot is still being conceded at a distance of 2.5 meters. From the experimental results above, it can be concluded that the success rate reaches 44.4%.

Table 9. Robot response at a distance of 3.5m

Ball velocity (m/s)	ANGLE		
	-10	0	10
3,88 m/s	G	S	G
2,75 m/s	S	S	S
2,06 m/s	S	S	S

The experimental results in table 4.7 show that the robot is able to keep the goal well. This is because the distance is not too close and the robot is still able to catch the ball object. From the experimental results above, the success rate increased to 77.7%.

Table 9. Robot response at a distance of 4.5m

Ball velocity (m/s)	ANGLE		
	-10	0	10
3,88 m/s	S	S	S
2,75 m/s	S	S	S
2,06 m/s	S	S	S

The experimental results in table 4.8 show that there is no error because the distance between the ball and the robot is still far away so that the robot is able to make correct decisions based on its predictions, and the speed of the robot can still balance the ball speed. From the experimental results above, the success rate is increased to 100%.

4. Conclusions

Based on the tests that have been done, the prediction system for the direction of movement of the ball of the Barelang 63 goalkeeper robot uses the 3D moving object interception method. Judging from the experiments that have been carried out, it has resulted in a success of 63.8% of the total experiments.

If seen from the level of success, it can be said that it is good, although in some conditions the robot is still being broken, there are several factors that influence it as follows.

1. Limited vision of the robot.
2. The process of moving has not been able to catch up with the prediction results

5. Suggestions

Based on the results of the research, discussion and conclusions above, the authors provide suggestions aimed at further improvements and systems, as follows:

1. Using additional mechanics to help block the ball
2. Updating the drive actor to help block the ball.

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