Barelang63 Team Description 2023

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Abstract. This paper describes the Barelang63 Middle Size robot soccer team for qualification to RoboCup 2023. During the last year, improvements have been made in a significant number of components of the robots. The most important changes include improvements to the kicking system, vision system, local, communication between robots, and game strategy.

1. Introduction

Barelang63 is the RoboCup middle-size league (MSL) football team from the Batam State Polytechnic, Indonesia. The project involved students, staff, and former members of the Barelang63 team for the development of all mechanical components, from hardware to software. The Barelang63 squad was founded in 2016 to carry out developments in the field of robotics, especially in the Middle Size League branch. Barelang63 has participated in several national and international competitions, including the Indonesian robot contest, the RoboCup world championship (5th place in 2022), and the Asia Pacific RoboCup (2nd place in cooperation challenges). This paper describes the robot platform, the technology used in the robot, and the development of the robot from the previous year. Part 2 introduces the Barelang63 soccer robot. Then, section 3 describes the improvement of the robot kick system. Part 4 describes the vision system of the robot platform. Section 5 shows the communication of our robots. Part 6 describes the strategy play of the robots. The last section is the conclusion of this paper.

2. Robot Platform

Barelang 63 used the robot last year. In this section, we will treat the Barelang 63 robots. Section 2.1 will introduce the hardware for this platform, while section 2.2 will describe the software.

2.1 Hardware

The robot mechanic system is built with three omnidirectional wheels, allowing it to move forward, backward, or surprisingly diagonally. The robot measures 51 x 51 x 75 cm. The whole robot body is built of aluminum and PLA+ filament. Barelang63 robots use three Maxon RE 40 Ø40 mm Graphite Brushes 150 Watt motors as the robot movement, two high-speed DC motors with a diameter of 28 mm for the ball grip, and a solenoid as the ball kicker. We also use three external encoders on the bottom of the robot to determine the robot's position. The Barelang63 striker robot uses three omnidirectional wheels with a configuration like in figure 1(a). This configuration allows the Barelang63 robot to move in all directions to control the movement system then the kinematic equations are used at the local coordinates and global coordinates.

a b c

Fig. 1 .(a) Inverse kinematic diagram (b) Barelang63 Robot Striker Design (c) Application of design to Robots

The goalkeeper robot is built to use four omnidirectional wheels with a configuration like in figure 3, allowing it to move left and right quickly. This configuration allows the robot to move in all directions to control the movement system, then the kinematic equations are used at the local coordinates and global coordinates. We use 3 PG-28 Motors as the propulsion of the keeper extends mechanism actuators. We also used three external encoders on the bottom of the robot to determine the robot's position in figure 2(a)[1].

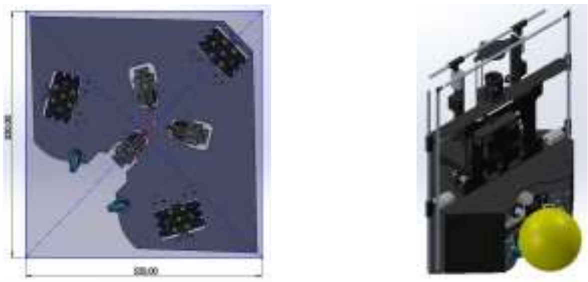

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Fig. 2.(a) Base design on the robot keeper Barelang63 (b) Barelang63 Robot Goalkeeper Design for RoboCup.

In the block diagram of Figure 3, there are three main parts used in the robot such as input devices, processing devices, and output devices. The input device is responsible for collecting data on the area around the robot. The 360° Omni camera and Zed stereo camera are also used to detect objects, while the ZOTAC ZBOX Magnus EN52060 mini PC is used to automatically distinguish objects such as balls, field lines, goal posts, and enemy robots on the field. Arduino Mega 2560 is applied to control the reset button, angle sensor, proximity sensor, kicking system, and dribbling system. STM32F407 is used to control the Maxon motor and data of the rotary encoder. The system is connected via ROS communication.

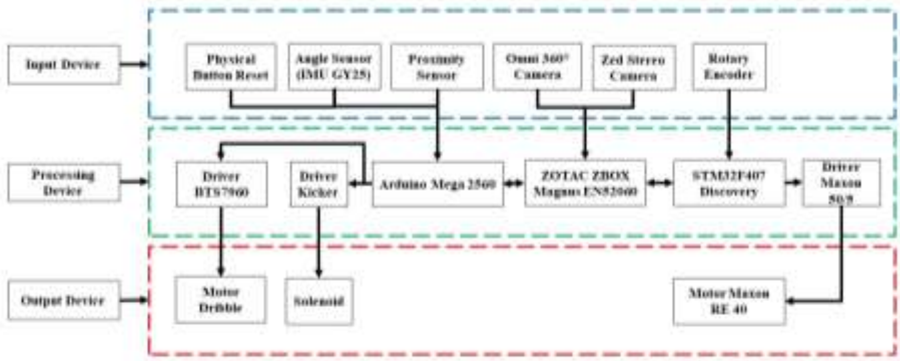

Fig. 3. Barelang63 Robot Hardware System.

2.2 Software

Figure 4 describes the Barelang63 software section. The software part consists of the vision system, strategy, base station, and kinematics. Color segmentation has been used as vision systems programmed in Python. The data obtained from the vision will be used as input for the localization system and robot algorithm strategy, not only from the vision system but also from robot kinematics, team coordination, and data from the base station. Robot strategy processing will produce a robot trajectory planning system to act as a kinematic system according to the soccer strategy.

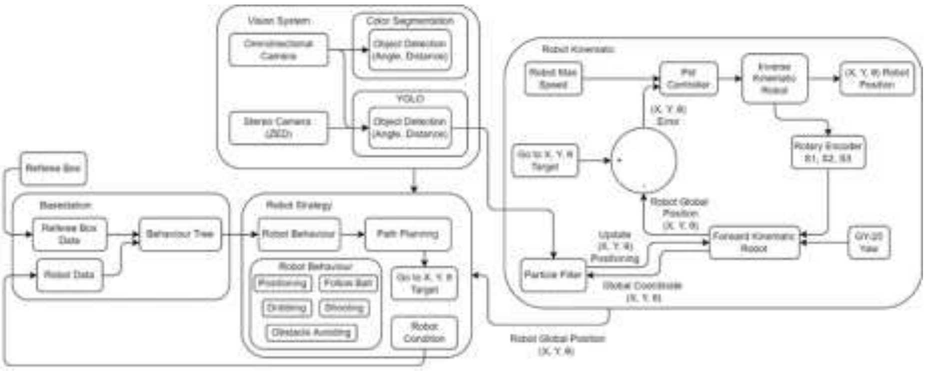

Fig. 4. Barelang63 Robot Software System.

3. Improve Kicking System

a b c

Fig. 5.(a) Solenoid (b) Robotic kicker mechanical design (c) Application of design to robots

The solenoid mechanism is used as a kicking system for robots controlled by the Arduino Mega 2560. The kick strength of this system depends on how wide the pulse is input as the trigger gate on the IGBT. The kicking leg on our robot is not fixed and it can be set for flat kicks and lobs. For the kicking leg mechanism last year we adopted the CAMBADA team kick system, where there are two kicking feet for flat kicks and lobs[2]. This kick system has many drawbacks, including weak kicks, monotone kick modes, flat kicks only, and lob kicks. To cover the shortcomings of this system, we adopted the kick system used by the Tech United team which only uses one kicking leg to make it more flexible in its kicking mode[3]. In this kicking leg system, we can adjust the kick so that it is not too high, the lob kick is so high to get past the obstacles in front of the robot when it is about to pass, and the kick is flat. We developed a kick system aimed at getting a greater variety of kicks and increasing the power of the robot's kicks. We also recalculate the manufacture of solenoids which function to reduce the load generated from the kicking system and increase the robot's kick power.

Coil

Number of turn : 1125
Length coil : 105 mm
Inner radius coil : 13,5 mm
Outer radius coil : 35 mm
Wire radius : 1,4
Layers : 20

Shield

Material : 1020 Steel
Radial thickness :`10 mm
Axial thickness : 50 mm

Plunger

Length : 160 mm
Radius : 13 mm
Material : 1020

4. Vision

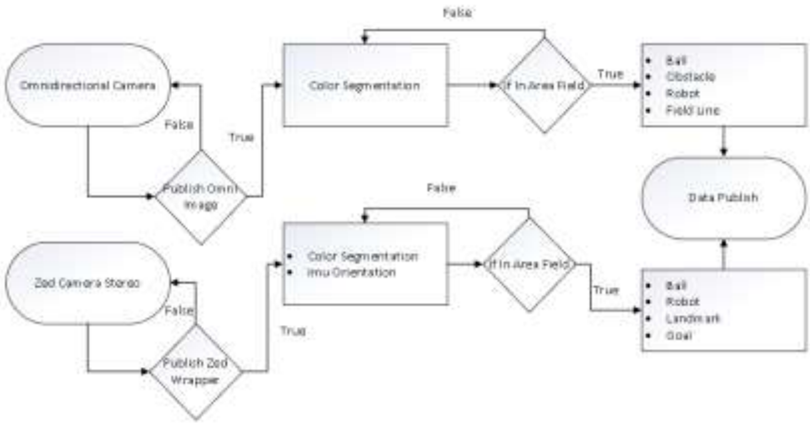

Fig. 6. Diagram of object detection system using omnidirectional camera and zed camera.

The 360-degree viewing angle of the omnidirectional camera function allows it to locate objects. The ROS-based image technique publish is used to publish camera captures. Subscribe to the color segmentation area for the camera publication yield. In order to maximize the number of detected objects in the form of balls, fields, robots, and obstacles, the Morphology Transformation Method, RGB Convert Image, Kalman Filter, Gaussian Image, Thresholding, Angle Detection, and Distance Detection are used in color segmentation. The data is then sent using ROS publish messages.

Fig. 7. The left side is the original view on the omnidirectional camera and the right side is the field contour

4.1 Goal Detection

On the current goal detection system we have development. To detect the goal we use the color segmentation method, using filtering with open, erode and dilate morphology methods. This detection will later assist in the goalpost detection process, where the goalposts will be detected in the goal area.

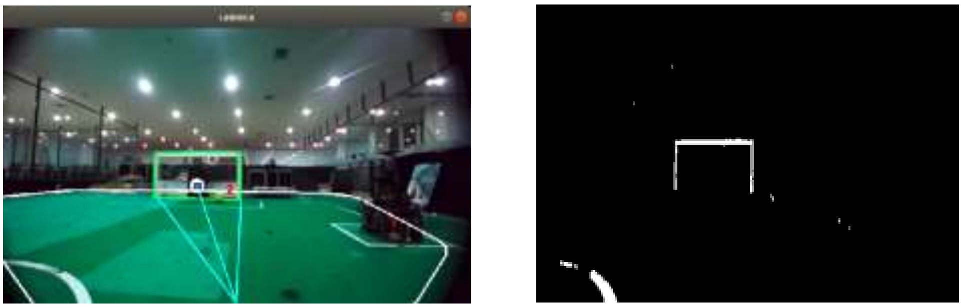

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Fig. 8. (a) Original display (b) Goal Contours

4.2 Landmark Detection

The vision system here is also experiencing development. Previously, to detect landmarks such as goalposts, we used a deep learning method using the Yolo v3 algorithm. This deep learning system consumes a large amount of computation so that the battery that supplies the PC runs out quickly and also requires data retrieval for learning which takes quite a long time. To overcome this problem we use the segmentation method to read the goalposts. This color segmentation detection system is applied to a stereo zed camera where it will read white pixels that are vertically positioned.

To avoid the whites that are outside the field being detected by the camera, we create area boundaries around the goal, so only the whites that are in the vertical position of the goal area will be detected by the camera, the whites that are outside the area will not be detected.

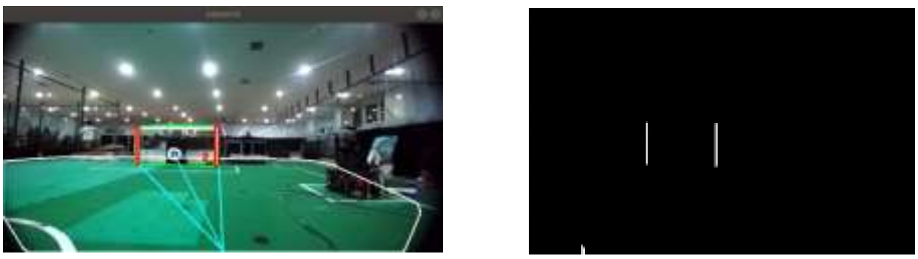

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Fig. 9. (a) Original display (b) Landmark Contours

4.3 Imu Orientation

In the orientation system here, we are upgrading it using the orientation Imu sensor that is on the Zed stereo camera. The imu sensor on the zed camera has a smaller error value compared to the imu gy25 sensor. The IMU sensor from the zed stereo camera will certainly be useful to assist movement and reduce errors from the odometry robot.

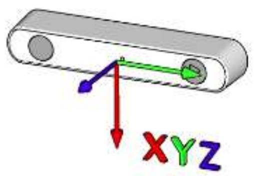

Fig. 10. Three axis imu zed camera

5. Robot Communication

The communication system between robots that we use is RTDB which was developed by the CAMBADA team and the Falcon team. The RTDB communication system functions as middleware, namely for communication between programs in the local agent and communication with other agents[4]. RTDB is easier and more flexible to communicate between robots than using the UDP communication protocol because the data sent is in the form of a serialized structure making it easier to process the data. Meanwhile, for microcontroller programming communication with a PC, we use ROS communication where the microcontroller can act as a sender and receiver as well as communication on a PC.

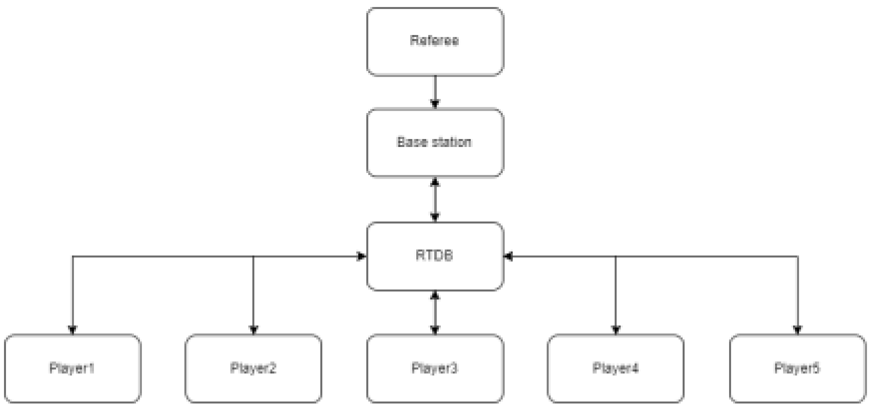

Fig. 11. Flowchart Robot communication system using RTDB.

6. Robot Strategy

The Barelang63 robot strategy uses basic strategies such as passing, ball handling, shooting at goal, avoiding obstacles, determining defenders, and determining attackers. Decision-making is done with the behavior tree algorithm, the behavior tree algorithm starts by executing each node sequentially, known as the control flow node, determined by the parent and child relationships. The signal to start execution is given to the root node, with a specified frequency as necessary. After execution, the node returns the running value. If the execution successfully reaches its destination, it returns a success value; otherwise, it fails. The behavior tree uses two control flow nodes, sequence, and fallback, followed by two execution nodes, action, and condition. Sequence nodes are marked with "->" and start by executing child nodes from left to right. Execution continues with a failure or a running value depending on the step taken and succeeds if all child nodes return a success value, similar to the AND logic gate

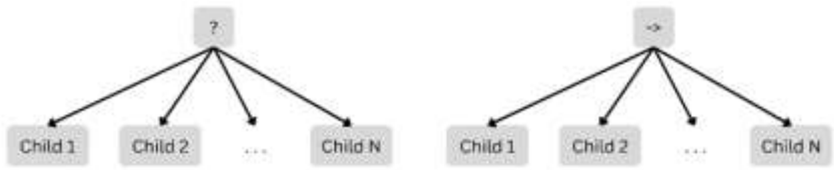

Fig. 12 Fallback (left) and sequence (right) node graphical representation.

The figure on the right depicts the sequence node. The action node is on the left, indicated by a "?" mark. Like the sequence node, the action node begins by executing its child nodes from left to right. If a running value is returned, execution continues. If a failure value is returned, the next child node is attempted until one returns a success value, allowing the node to finish. It operates like an OR logic gate.

Fig. 13 Action and Condition node graphical representation

The figure depicts the two types of child nodes in use. The action node executes commands and returns success, running, or failure values. The condition node checks conditions and returns either true or false. Both child nodes work together to create a condition check that can be executed in an open or closed loop.

7. Conclusion

This paper describes current research on the development of capabilities and systems used in the Barelang63 soccer robot from a mechanical, electrical, and software perspective. Some of the improvements that have been and are ongoing out include the first section, the goalkeeper robot building changes to the mechanical design and adding a kicking mechanism so that the goalkeeper robot can build up attacks. The second change is the robot's kick system, where last year the Barelang63 soccer robot used a system of lob resistance and flat kick by moving the kicker's leg to the side, now the Barelang63 soccer robot uses an up-and-down system where this system is more flexible in kick selection. The third is an improvement in the detection of vision robots, and now Barelang63 has changed the system for detecting objects in the field using color segmentation. The previous detection method that our robot uses is the YOLO method, where the YOLO method requires heavy computation, so object detection requires a lot of power and processing. The third is an improvement in the robot communication system, previously the Barelang63 soccer robot used the UDP communication protocol and has now switched to using the RTDB communication system where RTDB communication is easier and more flexible to communicate between robots than using the UDP communication protocol because the data sent is in a serial structure so that easier to process data.

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