Barelang FC Software Description Humanoid Kid Size League of RoboCup 2020

Susanto, Hendawan Soebhakti, Eko Rudiawan Jamzuri, Andrey Karona Sitepu, Febry Alwan Putra, Jony Arif Ricardo, Junito Suroto, Eko Priono.

Department of Electrical Engineering
Politeknik Negeri Batam
Jl. Ahmad Yani, Batam Centre, Batam, 29461 Kepulauan Riau, Indonesia
Email : susanto@polibatam.ac.id, hendawan@polibatam.ac.id, ekorudiawan@polibatam.ac.id
Website : barelangfc.polibatam.ac.id

1 Introduction

In 2017 was the first time we participated in the Robocup competition in Nagoya, Japan. And we managed to get 4th place. In 2018 is the participation of the two Barelang-FC teams in the Robocup competition in Montreal, Canada. And with better performance we got 3rd place. In 2019 was the third time the Barelang-FC team participated in the Robocup competition in Sydney, Australia. In the 2019 Robocup competition we discovered many new problems when our robots competed with other teams. The problem starts with the landmark distance measurement system for robotic localization which is still inaccurate. Another problem arises where the center of mass the robot's does not match so the robot is not stable when walking. Therefore, this year we are focusing on vision, increasing the accuracy of landmark distance measurements for particle filter inputs, and improving the robot's mechanical design.

2 Robot Architecture

In the block diagram in **Fig. 1**, there are three main parts such as input devices, processing devices, and output devices. Input device denote to parts that responsible to collect environmental data surrounding the robot. The WebCam Logitech C930 is still used to detect the object while additional Jetson TX1 proceed the image data from WebCam to distinguish ball, goalpost, robot, and white line in the field independently. sub controller 2 is applied to the strategy button and sub controller 1 is CM730 connected via serial communication. To stabilize the robot when walking in the field, we use an accelerometer, and a gyroscope. Both of these sensors are connected to the main processing device via sub controller 1 using the ARM Cortex-M3 microcontroller.

In **Fig. 2** the software part of Barelang-FC is explained. The software part consists of vision system, strategy and kinematic. YOLO v3 has been used as a vision system programmed in C. Data derived from vision will be used as an input of localization system and robot algorithm strategy, not only from the vision system but also from sub controller 2, team coordination and game controller. The processing of robot strategy will produce path planning system for robot to acts as kinematic system according to the soccer strategy.

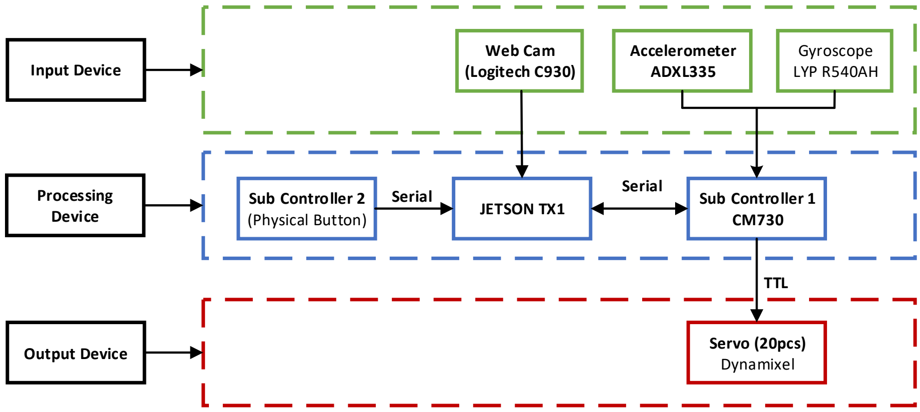

Fig. 1. Block diagram of the hardware system.

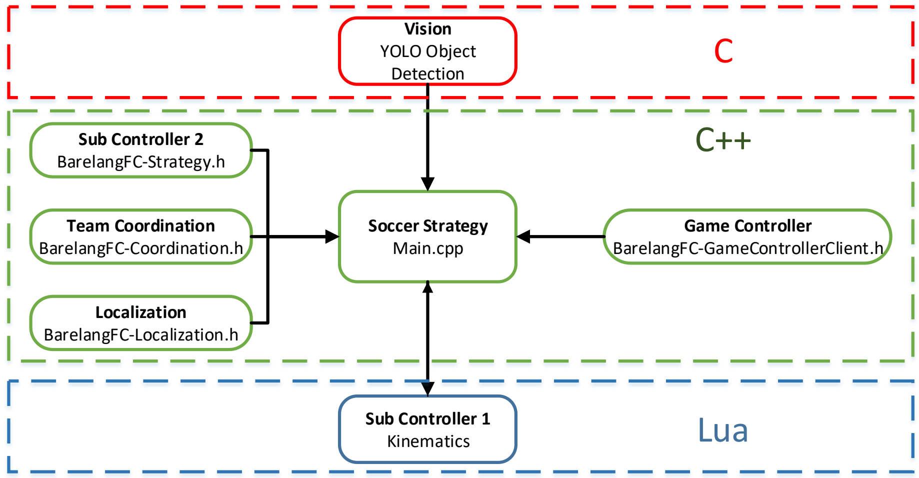

Fig. 2. Block diagram of the software system.

3 Walking

In the walking system algorithm we adapted from the Darwin team. We use the kinematic system algorithm from RoboCup Released code Upennalizers in 2012 [7]. The part that must be modified is in walk parameters and kick parameters, this modification makes the robot work optimally. And by making a few additions to the sending and receiving of data using socket programming. The walking system of Barelang-FC described in **Fig. 3.**

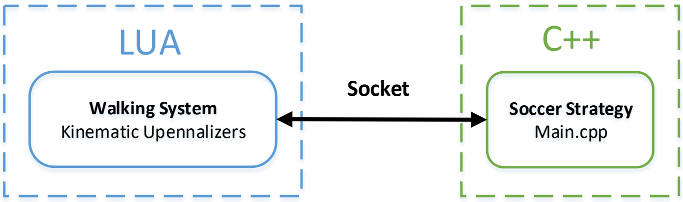

Fig. 3. Block Diagram of the walking system.

4 Vision System

In the vision system, we developed by using deep learning as YOLO v3 generated in Jetson TX1 [4]. Barelang-FC already implemented the YOLO for vision system, YOLO system is tended to unify the separate components of object detection becomes a single neural network. It makes bounding box of entire image feature shouldbe considered [5].

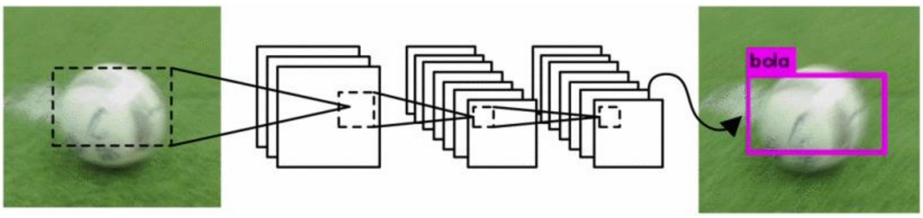

Fig. 4. YOLO recognition system.

Fig. 5 illustrates the block diagram for a vision system. In general, WebCam gets images of environmental data around the robot. The image will be processed by the CNN algorithm. The resulting CNN can reliably differentiate between categories, provide bounding boxes and class probabilities. And the coordinate of objects that are detected based on their class, such as: ball, goalpost, and robot.

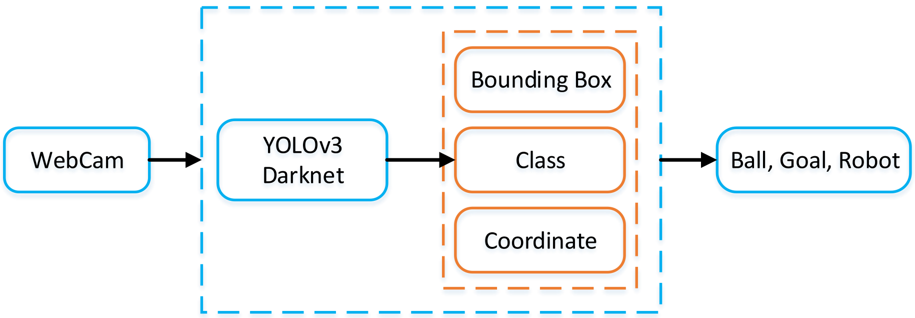

Fig. 5. Block diagram of the vision system.

This method already implemented in robot and gave the result which can be seen in **Fig. 6.** When robot detected the ball inside the white line and outside the white line, vision remains detect the ball whenever it has some other disturbance precisely. Another experiment is illustrated in **Fig. 7** to detect the goal with a different angle. **Fig. 7 (a)** we conducted an experiment to detect the goal with a straight view of the robot. When the robot is moved with a different angle as shown in **Fig. 7 (b)**, vision remains detect the goal accurately.

(a) (b)

Fig. 6. Vision detecting ball in the field (a) outside the white line (b) inside the white line.

(a) (b)

Fig. 7. Vision detecting goal (a) in straight viewpoint (b) from several angle.

5 Localization

Localization system uses vision data and Odometry data. In our vision data system, we calculate the distance of the ball and goalposts. The distance is calculated using the angle of the head (camera) and the vertical position of the object in the image (from the camera) and the height of the robot (the height of the camera from the ground). Whereas in the Odometry data system we use angular data of each servo at the robot leg and IMU data as the robot heading, the data is to estimate the distance of the robot's movement from its initial position. Our localization module uses 300 particles scattered in the field.

Fig. 8 Illustrating the block diagram for a localization system, there are 2 inputs used, namely Odometry and Landmark. The input will be processed in the MCL algorithm and the results are in the form of particles selected based on their weights, the particles are duplicated according to the weight and finally low weighted particles are likely to be wasted, whereas those with high weight are likely to be replicated repeatedly . Particles that have been duplicated based on their weight are then averaged and their value is used as an estimate of the position of the robot in the field. In **Fig. 9** is the General User Interface (GUI) on each robot to visualize the results of the estimated position of the robot.

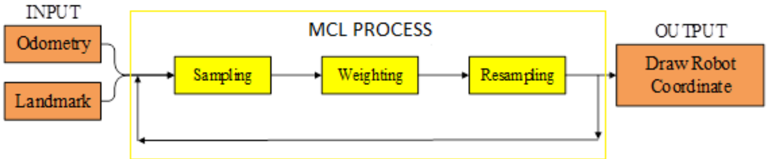

Fig. 8. Block diagram of the localization system.

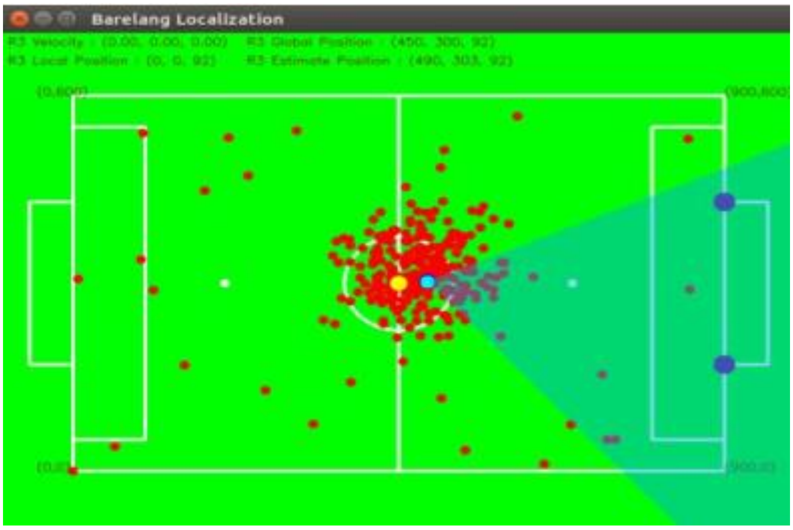

Fig. 9. Position estimation from particle filters.

To facilitate the process of monitoring the position of all our robots in the field, each robot sends its position data using the User Datagram Protocol (UDP) as its communication protocol. Data transmission is directed at the IP used by the monitoring computer. **Fig. 10** is a GUI that is used to monitor all of our robot positions, GUIs are created using the C # programming language.

Fig. 10. GUI Localization

6 Team Communication

In our system, we use the User Datagram Protocol (UDP) as our data travel communication protocol to send and receive data between robots. Computer applications can send messages, in this case referred to as datagrams, to other hosts on an Internet Protocol (IP) network. In **Fig. 11** described the communication system between the Barelang-FC robots. Each robot sends and receives data on each port and IP that has been fixed.

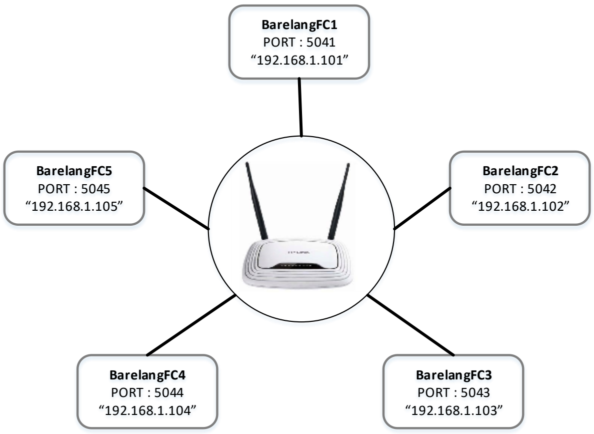

Fig. 11. Block diagram of the robot communication architecture.

Illustration of data flow diagram can be seen in **Fig.12**. Robots send their status to all robots and receive the status of other robots as well. After that, each robot that has received the state of another robot, will process the situation and send the results of the process to other robots and so on.

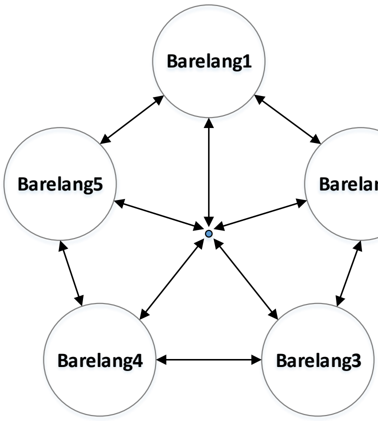

Fig. 12. Flow diagram of Barelang-FC Communication.

7 Behavior

Our robot can play as a goalkeeper, attacking or defender player. Based on their respective roles, the behavior of robots will be different. The goalkeeper robot stays on the goal when the ball is far away, when the ball approaches the keeper area the goalkeeper robot will prepare to make a save. Attacking robot will walk towards the ball and kick the ball towards the opponent's goal. For the defending robot will defend in front of the goalkeeper's robot and help the attacking robot. Information to conduct behavior is received from vision and communication between robots in the team through the UDP communication protocol.

8 Publications

The deep learning development for real-time ball and goal detection of barelang-FC

This paper presents integrated real-time object detection for humanoid robot soccer. To improve vision for detecting balls and goalposts, the You Only Look Once (YOLO) method is used as a method for detecting deep learning objects [5].

Introduction to Modest Object Detection Method of Barelang-FC Soccer Robot

In this paper explains the detection of white ball systems in the field using a simple algorithm by combining the CVblobs and Hough circle (CBHM) methods. To improve vision to detect white objects, the YUV color space has been selected which is transformed from the RGB color space [8].

Trigonometry Algorithm for Ball Heading Prediction of Barelang-FC Goal Keeper

In this paper introduces another algorithm to predict the ball coming from the attacker. We use trigonometric algorithms to predict the ball directly to the current guard position. This algorithm is used to estimate the distance between a robot and a ball when it is on a line in a horizontal position [9].

9 Conclusion

This year we focus on improving robot vision, localization systems, and improving the mechanical design of robots. From this effort, the robot can not only detect objects but can also measure the distance of objects to the robot. Other work, we apply odometry and particle filters to localization systems with better results for understanding the position of the robot itself. In other side, we are improving the design of our robot so that it can better competed with other teams. By making these improvements Barelang-FC is confident to compete with other teams at RoboCup 2020 Bordeaux France.

References

1. Susanto, Hendawan Soebhakti, Eko Rudiawan, Barelang FC Team Description Paper Humanoid Kid Size League of RoboCup 2017.
2. Susanto, Hendawan Soebhakti, Eko Rudiawan, Barelang FC Team Description Paper Humanoid Kid Size League of RoboCup 2018.
3. Susanto, Hendawan Soebhakti, Eko Rudiawan, Barelang FC Team Description Paper Humanoid Kid Size League of RoboCup 2019.
4. Redmon, Joseph & Farhadi, Ali. (2018). YOLOv3: An Incremental Improvement.
5. Susanto, E. Rudiawan, R. Analia, P. Daniel Sutopo and H. Soebakti, "The deep learning development for real-time ball and goal detection of barelang-FC," *2017 International Electronics Symposium on Engineering Technology and Applications (IES-ETA)*, Surabaya, 2017, pp. 146-151.
6. W. Adiprawita, A. S. Ahmad, J. Sembiring and B. R. Trilaksono, "New resampling algorithm for particle filter localization for mobile robot with 3 ultrasonic sonar sensor," *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics*, Bandung, 2011, pp. 1-6.
7. UPenn-RoboCup/UPennalizers; Code available online : https://github.com/UPenn-RoboCup/UPennalizers ; last accessed April 2013.
8. Susanto, G. B. A. Dewasakti, R. Analia, "Introduction to Modest Object Detection Method of Barelang-FC Soccer Robot," *2018 International Conference on Applied Engineering* (ICAE), Batam, 2018, pp. 200-205.
9. Susanto, F. Azmi, R. Analia, "Trigonometry Algorithm for Ball Heading Prediction of Barelang-FC Goal Keeper," *2018 International Conference on Applied Engineering* (ICAE), Batam, 2018, pp. 206-211.