Team Description Paper: IRIS Team 2022

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Abstract. IRIS is a team of robots competing in the soccer robot league. The Team has founded in mid-2016 with the ambitious goal of competing in international robotics competitions with continuous technological developments. This paper presents the middle league information of the IRIS team including team information, hardware information, and software information for RoboCup 2021. In this paper, we will introduce the mechanical system, electrical system, and software of our robot.

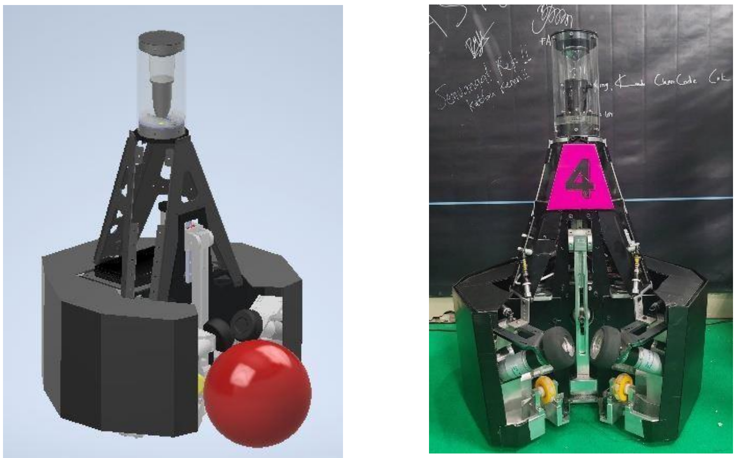
1 Introduction

IRIS (acronym for ITS Robots with Intelligence System) is a robotic team that competesin the soccer robotic competition, focusing on the Middle-Size League. The team members are students of Institut Teknologi Sepuluh Nopember Surabaya, which consistof 28 undergraduate students and a Doctoral Student. The team was formed in mid-2016 with the ambitious goal of competing in the international robotics competition. IRIS annually competes in the middle-size soccer robot competition which is held by the Ministry of Research Technology and Higher Education of the Republic of Indonesia. This first competition was held in 2017 and our team has won various awards. In 2017,we won 3rd place and best design in Regional and won best innovation, best design in National competition. In 2018, we won 1st place, best strategy in the Regional and 2nd place in the National competition. We also participated in the FIRA RoboWorld Cup 2018 and won 1st Place Passing Challenge, 3rd Place Obstacle Avoidance Challenge, 3rd Place Localization Challenge. In 2019, we won1st place in the Regional and National while also participating in ROBOCUP 2019 Sydney. The team also won 2 silver medals in FIRA 2019 Korea. Our research focuses on mechatronics, computer vision, and software architecture and engineering. Recently in 2020, we won 1st place in Regional and Best Strategy. We also won 1st place in the National League and Best Design. In 2021, we got 2nd Place in the Regional and 2nd Place in the National League and Best Design. In addition, at RoboCup Asia Pacific 2021, we won 2nd place in the Video Challenge.

2 Mechatronic

IRIS decided to create its own robotics platform at the start of the research. MSL is a soccer-playing autonomous robot. Meanwhile, football is a sport in which players have a lot of direct contact with one another. Robots are designed and built with wheels as a driver and are programmed to employ attack and defense strategies similar to those used in football games. That is why we designed the robot to be capable of both high speed and flexibility, as well as robustness. We have now completed the construction of our forty-generation robot and are doing research on goalie robots.

2.1 Mechanical System



(a) **(b)**

Fig. 1. (a) Forty-Gen. Design of the Robots (b) Robot Photograph

The mechanical system of the robot was built around three omni wheels, allowing it to move forward, backward, and even diagonally. The rectangular-cut edge is also represented in the base design, which measures 51cm x 47cm. The entire body of the robot is made of alumunium plates. We use three High-torque DC motors for robot movement, two High-speed DC motors for ball handling, and a Solenoid System for kicking. We also use two external encoders mounted at the bottom of the body robot to map the field and determine the robots' coordinates.

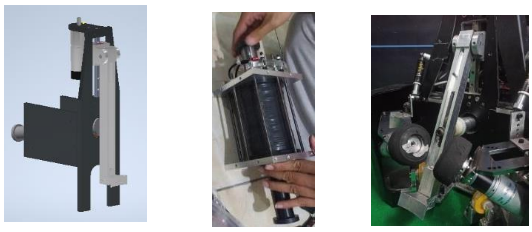
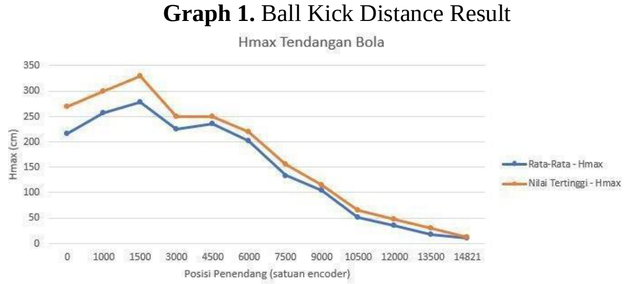


Fig. 2. Kicking Mechanism

A Solenoid is used in the kicking mechanism, which is controlled by a microcontroller (STM32F4 Discovery). Because our robot's kicking mechanism is notfixed, it can move up and down. The mechanism is powered by a high-torque DC motor that is also controlled by a microcontroller. This system enables the robot to adjust theheight of the kicker (low pass and lob pass) and the speed of the kick based on the target's distance from the robot's position. Testing the kicking system is done by combining 10 variations of the kick trigger signal pulse width with 12 variations of the kicker's height position. This aims to determine the relationship between the pulse width used and the height of the kicker's position on the results of his kick. The result of the kick recorded is the point where the ball first fell as the kick distance and the maximum height of the ball when it bounced as the kick height. Based on the results of 120 tests, it was found that the pulse width did not affect the kick results because from 10 variations of the pulse width, the kick results were quite similar to one another. Thus, the 10 data only took the highest value and the average value as a reference and then compared with 12 variations of the kicker's position. The test results can be seen in the following image.

Graph 1. Ball Kick Distance Result



Graph 2. Maximum Kick Height Result

The two graphs show a fairly stable value because the highest value curve and the average value curve have a similar shape.

2.2 Electrical System

The electrical system used in our three-wheeled robot uses three lithium-ion batteries, the electrical system is devided into four main parts, consist of sensors, actuators, power management, and controller. The actuators used in this robot are brushed DC motors, AC servo motors, and electromagnetic solenoid for kicking system. The outer sensors which is installed in this robot are line sensors, GP sensors, and Camera. The inner sensors are rotary encoders, MPU gyroscope and accelerometers sensor, and SRF sensors on goalkeeper robot. We create power management board to supply PC, actuators, and sensors. This board can switch input from batteries to charger adapter. This switch system is used when change some empty batteries with full new batteries without turning off the PC. This robot used numbers of low level microcontroller, such a STM32F407VG, STM32F103C8T6, and Arduino Nano. Not only that, a high level controller also used, there is Mini PC. These controllers communicate each other by serial communication by UART and ethernet. We also use an HMI to monitor several numbers of important variable. For general input-output, we install several of button to make debugging easier. Below is the display of HMI which show several variables.

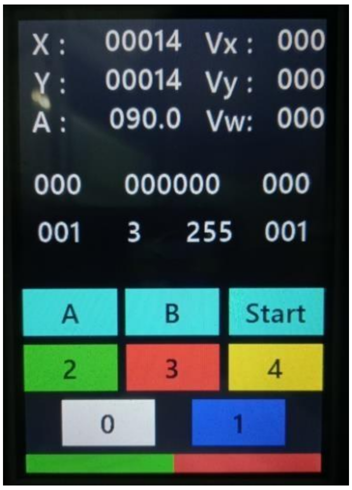


Fig. 3. HMI Display System of the Three-Wheeled Robot

Below is our robot electrical system design.

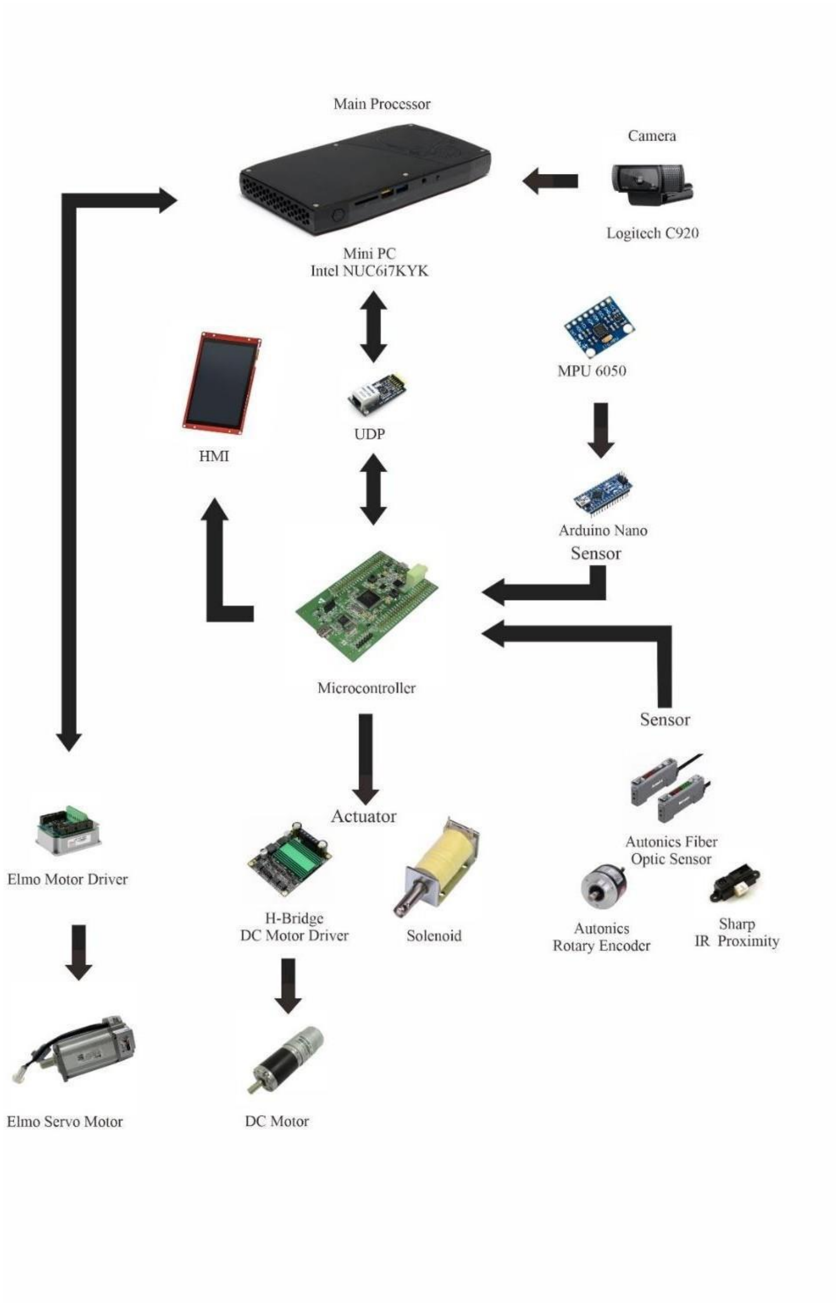


Fig. 5. Electrical System of the Robot

3 Software

This section will explain the 3 main algorithms of IRIS' robot, and their role in forming the robot's in-game behavior. These 3 algorithms are image processing, communication as well as strategy planning. Each of these algorithms will be explained in subsection 3.1, 3.2, and 3.3 accordingly.

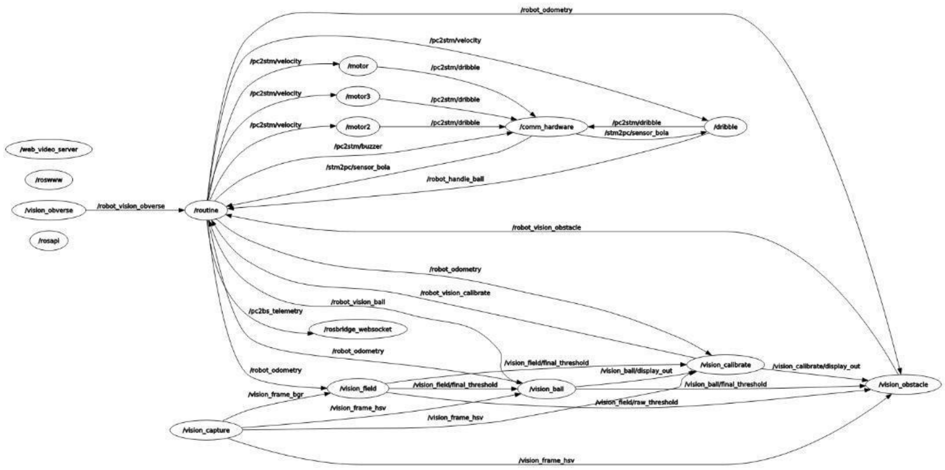
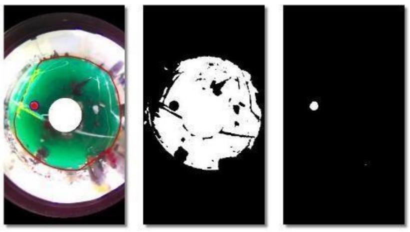


Fig. 5. Program Architecture

Our program architecture is shown on the fig 4, where the circle part describes the ROSnode (a single process that run simultaneously with each other), and the arrow part describes the information that were given from one node to the other. Each of these nodes are handling different algorithms. For vision_capture, vision_field, vision_ball, and vision_obstacle handle the image processing algorithm, basestation and udp_serial handle the communication algorithm, and for strategy planning algorithm is handled by routine. It also had motor dribble node run for hardware controll prpose. As for rosbridge_websocket, web_video_server, and vision_capture was only there for supproting purpose.

3.1 Image Processing

The RoboCup Middle Size League environment is currently color-coded, so we focus to design vision systems to recognize color-coded objects in the RoboCup environment. At the early version of our robot, the proven concept of omnidirectional vision is implemented. The omnidirectional vision system consists of a hyperbolic mirror and awebcam camera (Logitech Webcam Camera). Because of the wide angle of view in omnidirectional vision, the robot does not need to look around using moving parts (cameras or mirrors) or turning the moving parts.



(a) **(b)** **(c)**

Fig. 6. (a) Original Display (b) Field Contours (c) Ball Contours

The method that we use to recognize the environment is by thresholding using HSV colorspace. HSV (hue, saturation, value) colorspace is a model to represent the colorspace similar to the RGB color model. Since the hue channel models the color type, it is very useful in image processing tasks that need to segment objects based on its color. The orange color will be the ball, green will be the field, and the other colorswill be recognized as an obstacle. By the end of this process, the robot will obtain the position of the ball as well as the obstacle that may accompany it. In recent years, we also used front camera to improve the passing accuracy between robots. Assuming thekicking method is ideal, Assuming the ideal kicking method, the robot will know whichside the ball is coming from and estimate the friend's angle to the ball coming from. this has proven to be effective in the game of kick ball to a friend.

3.2 Communication

Communication based nodes have the role to communicate each robot to base station, as well as sharing information between PCs (as the main system) to the microcontrolleras the controller of the whole actuator. All communication is handled with UDP protocol.

3.3 Strategy Planning

The basic strategy of IRIS' robot consists of ball handling, passing, and shooting. All of these algorithms have been set on robot's in-game behavior. To enhance the robot in-game behavior and decision making, the robot needs to have the ability to position itself accurately on given position, as well as determining its current position. The technology used for this purpose is rotary encoder. Rotary encoder is a device that can

measure how far the robot has moved. With this technology, the robot can etermine its current position based on the initial position and the distance they have moved.

Although this technology is enough to roughly estimate the robot's current position, it is still far from perfect. Rotary encoders tend to have an increasing error of estimation the longer the robot moves. Therefore, we constantly use a calibration method to re- calibrate the error to minimum. We use field line, and line sensor to do this calibration.Every time the calibration function is called, the robot will move to a specific location and look for the field line. This way, the robot can estimate the current location based on the line they detect.

The ball handling and shooting algorithm is enhanced with an obstacle avoidance algorithm. This algorithm will instruct the robot to evade enemy robots and look for clear shooting sight. By doing this, we will have higher chance on scoring goal

4 Conclusion

Based on the achievements of our team in National Leagues and the experience in participating in 2019 RoboCup, IRIS will have a strong commitment in joining the RoboCup 2022 proven by the development of the robot in the software platform and electronic system.

The major improvements that were made for this past year are mostly about software platform. We used to have Open Framework runs on Microsoft Visual Studio as a platform to run the whole program. Although there was no significant error from this platform, we decide to improve our processing capabilities by using ROS (robot operating system) as the main platform. The communication is also being improved inUDP to get faster data streaming. By doing this, we have gained a system that run smoother, easier to modified and easier to debug. We still use UDP for communication and have not changed it to RTDB because UDP is fast enough to transfer data.

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