Ichiro KidSize Team Description Paper
For RoboCup 2024 Eindhoven

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Abstract. This paper presents a brief overview of the mechatronic and software design of Ichiro KidSize robots from the Institut Teknologi Sepuluh Nopember Surabaya, Indonesia; to fulfill the prerequisites for participation in RoboCup 2024 Eindhoven which will be held in Eindhoven, Netherland. In the RoboCup 2024 competition, we will combine our KidSize and AdultSize (84 cm heights) robots. Currently, we are conducting various matches to find problems that arise and to solve those problems.

1. Introduction

The spirit of the RoboCup as a competition with the goal using sports as benchmark problems for state of the art research in robotics and other related areas was very interesting for us to do research in the humanoid robot field. This enthusiasm is also interesting for us to actively participate in various humanoid robot competitions at the national and international level.

Team Ichiro is a robot team from the Institut Teknologi Sepuluh Nopember Surabaya, Indonesia. We specifically conducted research in developing humanoid robots and participated in various humanoid robot competitions. We began to actively participate in humanoid robot competitions since 2014. In 2023, we were unable to participate in RoboCup 2023 due to various constraints and internal decisions. In 2024, we are determined to return to the RoboCup Humanoid League competition in the KidSize category by using our robot.

In developing our robot, we emphasize the development of reliable mechanical design, our vision algorithm that can recognize balls and field features. Thanks to our vision algorithm, the robots can localize themselves in the field by relying on our vision and odometry system. In this paper, we will briefly explain our robot in terms of software and hardware that we will use to enter the competition in

RoboCup 2024 Eindhoven. We will also explain the development of our robot compared to the Darwin-OP robot that we have used in previous years.

2. Electrical Hardware Overview

We divide the Ichiro robot hardware into three main components, first there is an input device as feedback for processing data on the processing device. Second processing device whose role is to process data, make decisions and provide robot instructions. And the last is the output device as a recipient of instructions from the processing device.

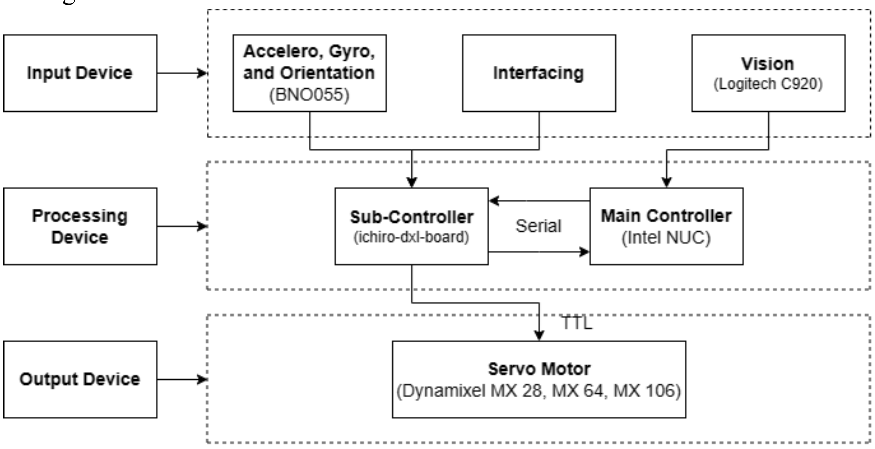

Fig. 1. Block diagram Hardware system of Ichiro Robot

There are several input devices such as BNO055 to get orientation data, accelerometer, gyroscope. Then there is a Logitech C920 webcam to capture images, and a robot interface to run the program. The data generated by this input device will be combined so that the robot can detect the ball, field, goal and determine the direction of the robot. The processing device is divided into two types, namely the main controller and sub-controller. The main controller uses Intel NUC, for the Sub-Controller used is a custom Sub-Controller developed by the Ichiro team. And the output device is a servo motor that will drive the robot mechanics. The servo motor consists of a combination of Dynamixel MX-28, Dynamixel MX-64, Dynamixel MX-106. The block diagram of the Hardware system shown in **Fig. 1**.

3. Mechanical Design

Ichiro ITS team still employs the same robot design with various modifications gathered over the years from previous RoboCup competitions. We use two types of robots, including:

3.1 Hiro and Tomo

Hiro and Tomo (see **Fig. 2**) is our second-generation KidSize robot which is the result of our mechanical research. We use aluminum type 6 with a thickness of 2 mm as the robot's material and Stainless Steel SS304 with 3 mm thickness. The material is getting cut with laser cutting. The height of the robot is 58 cm, and the weight is 5 kg. The robot used two types of Dynamixel MX Series. We use MX-64 for the lower body and MX28 for the upper body. For the power of the robot, we used LiPo 4 cell 3300 mAh battery.

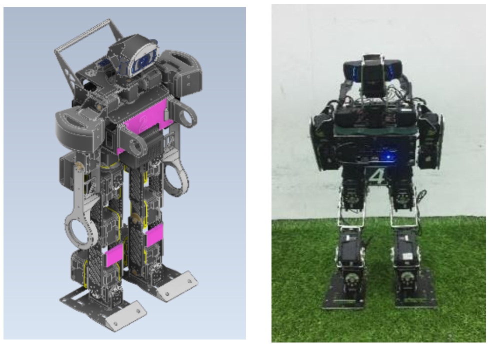

Fig. 2. The CAD design and a picture of robot: Hiro and Tomo

3.2 Ithaaro and Miru

Ithaaro and Miru are humanoid robots with a height of 85 cm, reinforced with a series 5 aluminum structure with thickness variations of 2mm and 3mm, along with a 3mm thick Carbon fiber plate for the robot's body to achieve a lighter weight. Various PLA+ and PETG filaments are used for specific components, and TPU is employed as impact protection for the robot. This robot features 20 degrees of freedom using a variety of Dynamixel servos, including MX-28, MX-64, and MX-106

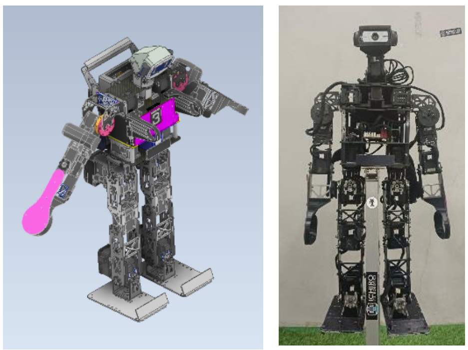

Fig. 3. The CAD design and a picture of robot Ithaaro and Miru

4. Software Overview

4.1 Walking

A sinusoidal trajectory is incorporated into the walking pattern of the robot. This motion does not involve dynamic modeling of the robot, rendering the walking system open-loop and not reliant on the ZMP criterion. Based on the provided trajectory points, all joints are currently calculated using the inverse kinematics of the robot's legs. Due to the inherent imperfections in the actual dynamics of the robot, certain parameters in the walking engine are being manually fine-tuned through trial and error.

Additionally, the Proportional-Derivative controller (PD) control strategy is currently applied to both the arms and hips of the robot to maintain its pitch at the desired angle, preventing potential falls. Compensation for hip pitch and foot height is also being introduced based on the amplitude value of the x-axis movement to achieve a more stabilizing walking gait.

4.2 Vision

The YOLOv4 tiny model is used in our object detection program. The objects that are detected include balls, goalposts, and field features such as x-intersection, t-junction, l-junction, and plus-sign where the ball is placed in the initial game state. The detected objects are retrieved as bounding boxes with labels of the object type and confidence level. The detected objects are filtered based on their confidence level with a threshold value to reduce noise.

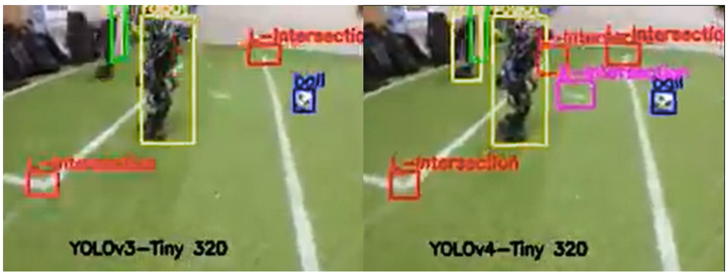

Fig. 4. The robot’s vision display

4.3 Localization

The robot's position on the field is determined by its initial placement alongside the field. By utilizing the estimated distance between the robot and the goalpost and employing the trilateration calculation method, along with predefined initial positions, the robot's starting point can be ascertained.

The ongoing estimation of the robot's position at each step considers its speed based on anterior step parameters and its direction. To mitigate errors in position estimation, the robot initiates a re-estimation of its initial position when the game state is reset, typically occurring after a goal or during a drop ball. Additionally, the robot undergoes a re-estimation of its initial position upon entering the field following being picked up.

4.4 Team Communication

The robots employ the Mixed Team Communication Protocol (mitecom) for communication, operating over a UDP network. The data is broadcast and received in real-time without employing a handshake or acknowledgment mechanism. Each robot broadcasts crucial information, such as its current role, position, and active status. Simultaneously, each robot receives data from other robots, utilizing this information to make decisions, such as determining which robot should chase the ball or specifying the state in which a robot should operate.

4.5 Behavior

The robot behaviors are structured using a finite state machine, and the transitions within it vary based on the current game state, the states of teammates, as well as location and orientation information from the localization module. The team comprises two main roles: the robot defender and the robot striker. The defender becomes active when the striker is on the field, with each role having its predetermined position. The defender's role involves approaching the ball when it is in proximity. On the other hand, the striker actively searches for the ball based on specified coordinates, including our own field, the center of the field, and the opponent's field.

Previously, we developed our program within a C++ monolith framework, consolidating all programming projects into a single container and utilizing object-oriented programming principles. Currently, we are in the process of transitioning to ROS 2 while retaining object-oriented programming for enhanced scalability, streamlined development, and more convenient research. The original program has been deconstructed into smaller packages, where each package functions as a microservice aligned with its specific scope or program topic, such as vision, action, walking, etc.

References

1. Inyong Ha, Yusuke Tamura and Hajime Asama, “SHORT PAPER Development of open

platform humanoid robot DARwIn-OP”, in: Advanced Robotics, Volume 27, 2013 - Issue 3, Pages 223-232 (2013)
2. Macenski, S., Foote, T., Gerkey, B., Lalancette, C., & Woodall, W. (2022). Robot Operating System 2: Design, architecture, and uses in the wild. *Science Robotics*. https://doi.org/abm6074
3. Tuohy, Shane & O Cualain, Diarmaid & Jones, Edward & Glavin, Martin. (2010). Distance determination for an automobile environment using Inverse Perspective Mapping in OpenCV. 2010. 100 - 105. 10.1049/cp.2010.0495.
4. Ficht, Grzegorz & Pavlichenko, Dmytro & Allgeuer, Philipp & Farazi, Hafez & Rodriguez, Diego & Brandenburger, André & Kürsch, Johannes & Schreiber, Michael & Behnke, Sven. Grown-up NimbRo Robots Winning RoboCup 2017 Humanoid AdultSize Soccer Competi-tions. RoboCup 2017: Robot World Cup XXI, pages 448-460, Lecture Notes in Computer Science. Springer, Berlin, Heidelberg (2017).
5. J. M. Ibarra Zannatha, R. Cisneros Limón, A. D. Gómez Sánchez, E. Hernández Castillo, L. E. Figueroa Medina and F. J. K. Lara Leyva, "Monocular visual self-localization for human-oid soccer robots," CONIELECOMP 2011, 21st International Conference on Electrical Communications and Computers, San Andres Cholula, pp. 100-107 (2011)