Ichiro Team Description Paper
For RoboCup 2026 Incheon

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Abstract. ICHIRO ITS (ITS Champion in RoboCup) is a humanoid robotics team from Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia, participating in the Humanoid Soccer League. This Team Description Paper presents the latest development of the ICHIRO humanoid robots for RoboCup 2026 in Incheon, South Korea. Building on strong achievements in 2025, including multiple championship titles in national and international competitions, the team focuses on improving system reliability, mechanical robustness, and motion accuracy. Hardware enhancements include redesigned mechanical structures with reduced backlash, improved electronic architecture, and the integration of multiple sensors for perception and balance control. On the software side, a modular and distributed framework based on ROS 2 is implemented, incorporating walking pattern generation, inverse kinematics, vision-based object detection, localization, team communication, and behavior control using finite state machines. These developments aim to enhance stability, autonomy, and overall performance of the humanoid robots in dynamic soccer environments.

1. Introduction

ICHIRO ITS (ITS Champion in RoboCup) is a humanoid robotics team representing the Institut Teknologi Sepuluh Nopember (ITS) Surabaya, Indonesia, specializing in the Humanoid Soccer League. This Team Description Paper presents our latest research and development progress as part of the qualification process for the RoboCup 2026 competition in Incheon, South Korea. The team was established with the ambitious goal of advancing the field of autonomous robotics through continuous participation in international-level competitions.

In 2025, ICHIRO ITS achieved outstanding results, securing 13 championship titles at FIRA and winning 1st place in the National KRI (Indonesian Robotics Contest). This success serves as the foundation for our 2026 development, where the team's primary focus is on enhancing system reliability and precision. Learning from technical challenges during RoboCup 2024, we have redesigned our electrical architecture with a more robust main board to prevent power failures and implemented an anti-backlash body design to minimize mechanical play in the servo movements.

The technical innovations proposed for the Incheon competition include the integration of a sophisticated localization system for accurate relative positioning on the field, the use of load cell sensors to monitor foot pressure distribution in real-time, and the application of a new walking algorithm for more dynamic maneuver stability. Through this participation, ICHIRO ITS is committed not only to maintaining its competitive dominance but also to providing significant research contributions to the global humanoid robotics community.

2. Electrical Hardware Overview

The Ichiro robot hardware is divide of three main components. First, the input devices provide feedback for data processing on the processing device. Second, the processing device for process data, makes decisions, and generates instructions for the robot. Third, the output devices execute the commands received from the processing device.

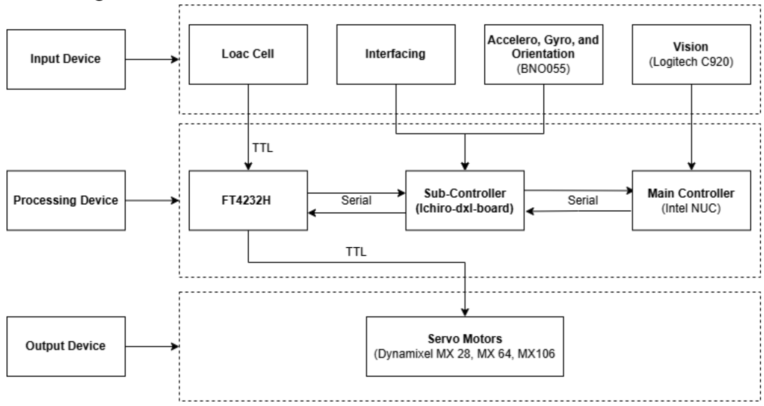

Fig. 1. Block diagram of the hardware system of Ichiro Robot

There are many input devices, including a gyroscope, accelerometer, and BNO055 to obtain orientation data. Then, an interface device is used to run the program, and a Logitech C920 webcam is used to capture an image. The robot will be able to detect the ball, field, and goal as well as estimate its direction by combining the data produced by this input device. Otherwise, we will use a load cell on the foot robot. The load cell is for measuring the center of mass of the robot Ichiro as a balancing system that will be integrated with the program. The main controller, sub-controller, and FT4232H are the three categories of the processing device. The main controller is an Intel NUC, while the sub-controller and FT4232H is custom by the Ichiro team. We made our own board to be more flexible in changing the communication protocol firmware requirements and the power supplied. Additionally, the robot mechanics will be driven by servo motors, which are the output devices. A combination of Dynamixel-MX28, Dynamixel MX-64, and Dynamixel MX-106 makes up the servo motors. The block diagram of the Hardware system is 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.

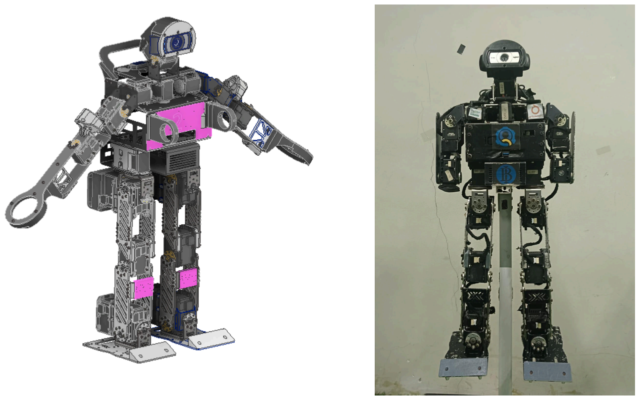

Fig. 2. The CAD design and a picture of robot: Hiro and Tomo

3.2 Siber and Miru

Siber 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.

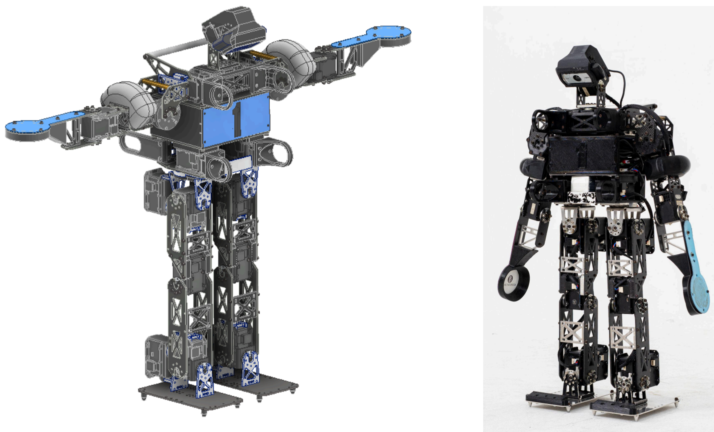

Fig. 3. The CAD design and a picture of robot Ithaaro and Miru

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 YOLOv8-small model is used in our object detection program. The detected objects include balls, goalposts, robots, and field features such as X-intersections, T-intersections, and L-intersections.

The detection results are represented as bounding boxes with object class labels and confidence scores. These detections are filtered using a confidence threshold to reduce noise. In addition, we use field contour detection based on the HSV color space to define the region of interest (ROI).

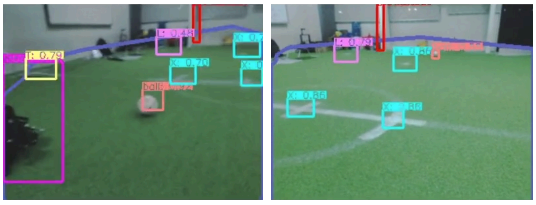

Fig. 4. The robot's vision display

4.3 Localization

The robot's position on the field is estimated using a Monte Carlo Localization (MCL) approach. The localization process starts from a predefined initial placement based on the game state and field configuration. A set of particles is initialized to represent possible robot poses on the field.

Sensor updates are performed using observations of predefined field landmarks, including goalposts and field features such as X-intersections, T-intersections, and L-intersections detected by the YOLO-based vision system. The relative distances between the robot and these landmarks are computed using Inverse Perspective Mapping (IPM), while the robot's orientation is obtained from the IMU. These measurements are used to update the particle weights through a sensor model.

Motion updates are applied using odometry estimated from the robot's walking steps, which provide displacement and heading changes between time steps. This motion model propagates the particles according to the robot's estimated movement. To handle localization drift and large uncertainties, the system performs re-initialization of the particle distribution when the game state is reset, such as after a goal, during a drop ball, or when the robot re-enters the field after 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.

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