PMEC Humanoid Soccer Robot Team

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Abstract. This document presents the team's history, and the challenges faced during the development of a fully autonomous humanoid robot, as well as the objectives achieved and what's still in development too.

Keywords. Humanoid robot, ROS, signal conversion

1 Introduction

The Pequi Mecânico Humanoid team started its journey in 2016, with only 2 members, to compete in the Latin-American Robotics Competition (LARC) in the IEEE Humanoid Robot Racing Child Size. Since then, the team has grown significantly and, in 2018, expanded its research fields to compete in the RoboCup Humanoid Soccer.

In 2022, the need to build a new humanoid robot arose, and led the team to start the Marta project, currently used in competitions. In 2024, the implementation of its simulation model made the tests in the real robot easier, which accelerated the tasks' progress and made the project accessible to the entire team. The robot's development from scratch provided deep learning, technical knowledge evolution, and scientific articles' production [2][3]. Furthermore, the challenges faced throughout the process resulted in the team's acknowledgement, that won 3rd place in the CBR/LARC Humanoid Soccer for two consecutive years, 2024 and 2025 [4][5].

Currently, the Pequi Mecânico Humanoid team remains focused on the robot's hardware and software improvements, with the goal of optimizing its performances and strengthen both team's qualifications and its contributions through the Marta project.

2 Hardware History and Improvements

Marta's current structure began to be designed in 2023, where the "chest" was practically fully re-designed because it was too big, the electronics used, based on printed circuit boards, could not fulfill the development's needs.

The old structure was fully reviewed and only the "limbs" were kept. The biggest challenge was accommodating the components in the "chest", as the NUC and the batteries took up most of the space. In 2024 the focus was on reducing the structure's weight and readjusting the internal space to accommodate the components better. Therefore, the project based on laser cutting and 1.00 mm thick steel sheet bending was rethought, and the material was changed to 1.00 mm aluminum sheet. The NUC and the batteries' holders were also replaced with ribbed plastic bases, produced through 3D printing, lighter than the previous ones.

The team is currently working on resizing the "limbs" to facilitate the movements.

As for the electrical sector, the current PCB has 2 voltage regulator modules (stepdown) Lm2596, 1 Teensy 4.0, 4 logic level converters, 4 buffers SN74LS241N, 4 ceramic capacitors, 4 pull-ups resistors (10 kΩ), 4 resistors in series with data, 12+ servos MX28T, 2 IMU BNO0086. This board works as an interface for the communication between the actuators and Teensy 4.0, through the half duplex TTL serial communication protocol: the servos were connected in 4 data buses, one for each "leg", one for both

arms, one for the head; the circuits convert serial UART full duplex to Half-Duplex Data Transmission. To carry out this conversion, integrated circuits were used, each one has 8 buffers, with 3 outputs and 3 inputs: the logic levels 0 and 1, and a third state where the impedance is not high (0), neither low (1), known as high impedance state. SN74LS241 was used to control the data's income and outgoing traffic without adding a new signal path. This project has significant similarities to the one used in CBR 2024, with the only relevant difference being the fact that the voltage regulators are built into the board.

3 Software

Perception is made with YOLOv5n6 for detection, Lucas-Kanade optical flow for tracking and visual odometry with IMU for navigation, with calibration via OpenCV for better precision. Control algorithms are being developed, like the model that aims to improve walking, kicking, fall's detection and the ability to get up on its own, adapting the robot to the game's challenges. The communication between Perception, Behavior, Control and Hardware is made through ROS Noetic Ninjemys, ensuring efficient transmission of essential information for the desired behavior. Therefore, these technologies not only optimize the robot's performance. but also guarantees its adaptability and constant evolution.

4 Further Researches

The team is interested in improving control algorithms using Reinforcement Learning (RL), as well as developing the robot's localization using sensors fusions like camera and IMU and developing robust behavior algorithms for the game, also switch the Logitech camera to a realsense d435i in order to improve the robot's navigation, as well as the ball tracking's accuracy.

References

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