UTRA - Humanoid KidSize Team Description Paper for RoboCup 2025

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Abstract. This paper discusses lessons team UTRA has learned from previous competitions and details information about their robots and current research developments. Moreover, major robot design changes are discussed and the current state of the implementations. Hereby UTRA apply for participation at the RoboCup 2025 for **Team Competition** in Salvador, Brazil[1].

1 Introduction

Team UTRA is from Toronto, ON, Canada and is supported by the Department of Applied Sciences and Engineering at the University of Toronto. We are an interdisciplinary group of Undergrads, Bachelor's and Master's students from various disciplines such as Computer Science, Engineering Science, Mechanical Engineering and Electrical Engineering. We believe in innovation and have our code shared in a public repository on our GitHub [1]. In this paper, we will provide an overview of our challenges in RoboCup and how we are trying to overcome them as we intend to participate at the RoboCup 2025 for Humanoid League, KidSize.

2 Lessons Learned and Problems

RoboCup 2024 was a major step back from our performance from the previous year. Our main robot's redesign wasn't thoroughly tested resulting in major problems where it couldn't qualify until our last match. After extensive analysis of the design, we realized that we selected motors based on torque analysis of the robot walking, but we should have used the torque when it was getting up. This oversight caused the hips and arms to be underpowered. Another factor was that we were trying to build two robots on an unverified design, spreading the team too thin. In the future, we will increase our time spent on testing to ensure smooth performance when it comes to the functionality of our new designs.

3 Major Changes and Status of Implementation

We present recent advancements in robot locomotion, navigation, and system architecture enabled by transitioning to Placo, Rhoban's new planning and control library[2]. Placo leverages the robot's URDF for zero-moment point selection based on a linear inverted pendulum model, resulting in significantly improved walking stability and reduced simulation-to-reality iteration cycles. The dynamic footstep adjustment capability further enhances reactive navigation. Stability optimization through PID, adaptive tuning, and LQR methods is currently under investigation, alongside the development of a pure pursuit-based navigation algorithm.

To enhance modularity and testing efficiency, the codebase has been refactored to reduce dependency on ROS. The switch from PyBullet to MuJoCo provides superior physical fidelity and computational performance, facilitating GPU-accelerated reinforcement learning via MJX. Ongoing efforts include porting agents from Isaac Gym and leveraging real-world motion capture data to train new skills such as walking, kicking, and defense. A renewed focus on infrastructure and Sim2Real implementation aims to bridge the gap between simulation and real-world deployment.

Computer vision capabilities have been upgraded to YOLOv8 for improved object detection and segmentation in dynamic environments. Integration with CUDA-accelerated libraries, ROS2, and Foxglove Studio is underway for enhanced debugging and performance monitoring. Further enhancements include behavior trees for robust strategy execution, improved localization to mitigate the kidnapped robot problem, and increased automation in camera calibration.

Hardware developments involve testing SMT components for space-efficient PCB design and implementing current and voltage sensing for real-time operational data. The integration of the BMI088 sensor has improved motion accuracy, although yaw drift issues are being addressed. Firmware optimizations using synchronous read and write operations have improved processing efficiency. The team is also evaluating the use of C++, Rust, and FreeRTOS for embedded code development.

Significant mechanical redesigns have been implemented to ensure stronger hip and arm segments for enhanced structural integrity during dynamic tasks. A newly designed torso offers better weight distribution and stability, further improving walking efficiency. Future developments include the potential integration of foot pressure sensors to provide real-time ground interaction feedback, which would contribute to more adaptive and stable locomotion strategies.

Finally, we report the successful repurposing of hobby servos to mimic the performance of Dynamixel MX108 servos at a significantly lower cost. Although these modified servos have enabled the construction of a walking humanoid robot, challenges related to their reliability and maintenance require further investigation for sustained use.

References

1. *UTRA Extended Abstract Robocup 2020.* Available online at https://submission.robocuphumanoid.com/uploads//UTRA_Robosoccer-tdp-5e533ac29ed6f.pdf
2. *GitHub. 2025. rhoban/placo.* [online] Available at: https://github.com/rhoban/placo [Accessed 30 Jan. 2025].