Extended Abstract for RoboCup 2025 Humanoid Kid-size League: Team KURA

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Abstract. This abstract outlines Team KURA's innovations for the RoboCup 2025 Humanoid Kid-size League. Building on past experiences, we address challenges in humanoid robotics, emphasizing stability, vision upgrades, and lightweight design. Key innovations include advanced model predictive control for balance, improving stereo vision systems for object detection, and modular, energy-efficient robots. Early results show notable improvements in stability, precision, and efficiency, with full integration and testing planned before RoboCup 2025.

Keywords: Humanoid Robotics · RoboCup · Locomotion Stability

1 Lessons Learned from Previous RoboCup Competitions

Team KURA's participation in past RoboCup events provided valuable insights into robotic design and strategy. A major lesson was the need for robust locomotion in dynamic environments. In 2024, stability issues during movement and kicking hindered gameplay efficiency

2 Major Problems Addressed for RoboCup 2025

For the RoboCup 2025 competition, Team KURA is focusing on solving two major problems:

- **Enhanced Stability and Locomotion:** Improving robot stability during rapid movements and uneven terrains by refining walking algorithms with model predictive control and dynamic balancing techniques. Additionally, enhancing the accuracy and stability of ball-kicking actions.
- **Advanced Perception and Decision-Making:** Upgrading vision systems with stereo vision-based object detection to better identify the ball, teammates, and opponents.

3 Planned Changes for RoboCup 2025

3.1 Hardware Enhancements

Team KURA is designing a new generation of humanoid robots with lightweight yet durable materials, improved joint actuators for smoother motion, and mod-

ular components for easier maintenance. The new robot design is significantly lighter, improving agility and energy efficiency.

3.2 Software Upgrades

The software stack will be upgraded to include:

- Advanced control algorithms for dynamic locomotion and stability.
- Reinforcement learning (RL) algorithms for optimizing kicking, standing, and recovery actions.
- Integration of stereo vision-based object detection and tracking, enabling robust perception of balls, teammates and opponents for effective decision-making in dynamic environments.

3.3 Simulation and Testing

A custom simulation environment, based on ROS and Mujoco, will be developed to test algorithms extensively before deploying them on physical robots, enabling the early identification of potential issues.

4 Current Implementation Status

As of submission, Team KURA has made significant progress in the following areas:

- **Locomotion and Stability:** The initial prototype of a new walking algorithm has demonstrated improved stability in simulated tests. Physical trials are underway, focusing on optimizing kicking actions for precision and power.
- **Vision System:** Preliminary integration of stereo vision systems has shown accurate object detection for balls and field elements in controlled environments.
- **Hardware Prototyping:** A lightweight robot prototype has been fabricated and passed durability tests, with positive results for energy efficiency and ease of maintenance.

5 Future Plans and Goals

By RoboCup 2025, Team KURA aims to:

- Fully integrate and validate all planned hardware and software upgrades.
- Conduct extensive gameplay simulations to optimize team coordination and strategies.
- Publish detailed results and findings to contribute to the broader robotics research community.

We are confident that the planned developments will significantly enhance our robots' capabilities and competitiveness in RoboCup 2025.