Extended Abstract
CIT Brains for RoboCup2023

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Abstract. CIT Brains has been participating in the RoboCup Humanoid League since 2007, and won the RoboCup2022 Thailand, Bangkok for the third time in the regular tournament for KidSize (4 vs. 4). This paper describes the hardware and software development for RoboCup2023 at CIT Brains. First, we present lessons learned from RoboCup2022. Next, we introduce the open platform humanoid robot SUSTAINA-OP used in RoboCup2022. Then, we introduce the new hardware development and software approach we plan to take in the future.

Keywords: Open Hardware Platform, Multi-Agent Reinforcement Learning.

1 Lessons Learned from Past RoboCup

We have been participating in the RoboCup Humanoid League KidSize since RoboCup 2007 and have developed six generations of major robots and many minor versions. Our robots are designed to be rigid and durable. We believe that the process of winning a game is to have four robots keep working on the field for the duration of the game and to have them cooperate in soccer. In RoboCup2022, we developed and manufactured six "SUSTAINA-OP" robots, including a reserved robot, with the same specifications and configuration, differing only in player numbering. However, all of them were able to get up immediately and continue the competition. The robot remained on the field for most of the game time without leaving the field due to hardware failure, switched roles between FW and DF immediately depending on the game situation, and prevented goals by following up with other teammates' robots. This led to the victory with 55 goals and 1 goal. However, the robot fell about 50 times during the game, and its coordinated movements were simpler than those of a human soccer player. Therefore, we believe that it is necessary to develop a robot to realize gait control using ZMP that can discriminate stability and complex cooperative movements as humans do.

2 Open Hardware Platform “SUSTAINA-OP”

We have released 3D models of SUSTAINA-OP and other information through GitHub [1]. The concept of the robot is to further improve on the durability of the previous generation robot, while at the same time making it easy to manufacture and maintain and sustainable enough to be used for a long period. To ensure software processing time, the computer board has been shifted to an NVIDIA Jetson Xavier NX 16GB. In addition, to reduce the CPU load, a camera with MIPI CSI-2 connection was adopted instead of a USB connection, and specifications were changed to facilitate software development, such as the implementation of a 4-parallel communication circuit control circuit for 19 servo motors.

3 Development of Additional Sensor Modules

We are planning to develop two additional sensor modules for our robots; the first is a sensor module for measuring foot pressure. The second is an audio module with one speaker and two microphones. RoboCup2023 is scheduled for a major rule change, and although the GameController will continue to be used, game signals will be preceded by a whistle blown by the referee. Therefore, a microphone for voice recognition is required. In addition, we anticipate that the GameController will be discontinued in the future, and we believe that a speaker will be necessary to enable the robot to vocalize information from itself and share information with other robots in the team.

4 Reinforcement Learning-based Planning and Coordination

Robotic soccer is a dynamic and complex multi-agent system, and robots are required to keep selecting appropriate actions for team coordination. Currently, our team is building a rule-based action decision program [2], but it is difficult to handcraft optimal actions. Therefore, in order to appropriately handle these problems, we aim to acquire cooperative behavior of autonomous distributed robots using multi-agent reinforcement learning and implement it in a real environment. There are several obstacles to applying multi-agent reinforcement learning to RoboCup Soccer. Since not all information is available to each robot, the assumption of a Markov decision process does not hold. Also, the number of robots may change dynamically due to malfunctions. We are developing algorithms that can be applied under these conditions.

References

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