NimbRo AdultSize Extended Abstract 2024

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Abstract. As qualification material for the RoboCup Adult-Size Humanoid Soccer competition 2024 held in Eindhoven, Netherlands, team NimbRo AdultSize of the Rheinische Friedrich-Wilhelms-Universitat Bonn, Germany presents problems encountered during the previous competition in Bourdeaux, France, and improvements to further push the boundaries of our system. The complete design and development with regards to software and hardware of the robots were done in-house by members of the NimbRo team over the years of participating in the Adult-Size Humanoid Soccer league. In the following, we will first present the lessons we have learned over the past years and continue with specific problems encountered during the last competition. Lastly, we state potential improvements we aim to achieve for the upcoming competition.

1 Observations from past Competitions

The major lesson from our previous RoboCup experience is that our combination of modular hardware and software is quite effective and robust for competing in a tournament, where little time is given for configuration and preparation between games. Focusing on the dynamic walking capabilities over the past years to improve our walking speed, push recovery and maneuverability, led to robots maximizing their potential hardware-wise. Incorporating this with our reliable ball and field detection, ball handling, team play and localization, our system showed impressive results throughout the last years' competitions.

Having the fundamentals laid down properly, we can now focus on refining and improving our existing system to close the gap to the human-level. During the previous RoboCup, we identified multiple problems, presented in the next section, that are required to be resolved. Besides resolving theses issues, we plan on improving the existing software to be prepared for the upcoming competitions and potential rule changes.

2 Problems

In specific occasions, such as a free kick, our localization module sometimes mismatched detected lines due to field ambiguities leading to an immense shift

in the robot's believed position leading to our robot kicking the ball not towards the goal but outside of the field. This resulted in a repetitive behavior of the robot kicking the ball out-of-bounds which is crucial to be solved before the next competition.

With deep learning models of increasing size becoming the go-to method as perception backends, it becomes vital to optimize their memory and computational resource utilization. We encountered bottlenecks hardware- and software-wise in the utilization of the GPU for our deep learning models. A key to deploying larger networks with larger resolutions to improve our detection pipeline is optimizing the deep learning model at inference time for the GPU architecture and the scheduling between the different modules running on the robot.

3 Improvements

In last year's technical challenges, we presented a novel centroidal state estimator for dynamic walking that showed impressive performance in push recovery exceeding not only our last year's performance but also the performance of the other teams. Implementing this into our system is crucial, as the opponent robots become heavier and stronger. This improvement intends to further increase robustness against pushes from other robots and decrease time required to recover into a stable walking state.

Moreover, we plan the continuation of the improvement of our teamplay behaviors. Currently, the communications between the robots are based on an asynchronous request-and-response system, which may lead to some extensive latencies in certain cases. Reducing these latencies could further make our system more efficient with regards to the speed of teamplay-related decision making.

With the rule changes pushing towards larger fields, it is evident that the vision system has to adapt to this. Our current system is able to perceive the ball and robots across half the field, while the accuracy decreases at larger distances. As the game becomes faster and the kicks stronger, it becomes vital to reliably and accurately detect the ball over large distances to implement predictive behavior of the ball state, essential for downstream tasks such as path planning.

4 Conclusions

With a focus on the next years and potential future rule changes, we want to further improve our system as described above. We are confident that we will be able to tackle the described problems and further improve our system to potentially reach the human-level in 2050. We are looking forward to participating in RoboCup 2024 in Eindhoven.