RoMeLa Extended Abstract for RoboCup 2022 Humanoid League

Min Sung Ahn[1], Taoyuanmin Zhu[1], and Dennis Hong[1]

University of California, Los Angeles, Los Angeles CA 90066, USA
{aminsung,tymzhu,dennishong}ucla.edu
http://www.romela.org

1 Introduction

RoMeLa (Robotics and Mechanisms Laboratory) at the University of California, Los Angeles is a robotics research lab with diverse experience in humanoid robots, starting from the design stages to high-level control. RoMeLa has conducted humanoid research in a variety of different applications which also includes fire suppression and disaster response using in-house built humanoids such as SAFFiR (Shipboard Autonomous Fire-Fighting Robot), THOR (Tactical Hazardous Operations Robot), and THOR-RD (Tactical Hazardous Operations Robot-Rapid Deployment).

Team RoMeLa hopes to participate in RoboCup 2022 with two humanoid robots that are vastly different in its core principle to demonstrate that despite the differences, these robots complement each other well and can cooperate in a tournament setup. The two robots that will take part are THOR-RD and ARTEMIS (Advanced Robotic Technology for Enhanced Mobility and Improved Stability). With the new breed of humanoids equipped with quasi direct drive (QDD) actuators[1][2], we hope to demonstrate much more dynamic motions relevant to soccer through Robocup 2022.

2 Lessons from Previous RoboCups

RoboCup 2022 is the third time that THOR-RD will be taking part in the competition after two successive championship runs in 2014 and 2015, while for the team, it will be its 6th participation. This will be the first time the team takes part in the tournament since 2015. Our two primary lessons learned from previous RoboCups is always having the capability to have hardware support and also having a robust vision algorithm. Because the hardware is brought out of the

[1] Taoyuanmin Zhu, Min Sung Ahn, and Dennis Hong. "Design and Experimental Study of BLDC Motor Immersion Cooling for Legged Robots". In: *2021 20th International Conference on Advanced Robotics (ICAR)*. IEEE. 2021, pp. 1137–1143.

[2] Taoyuanmin Zhu, Joshua Hooks, and Dennis Hong. "Design, modeling, and analysis of a liquid cooled proprioceptive actuator for legged robots". In: *2019 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)*. IEEE. 2019, pp. 36–43.

lab and has to travel to a remote location, there are many unforeseeable events that can damage or make the hardware function erroneously. As a mechanical engineering lab, we build and repair the robots ourselves. Having sufficient equipment, tools, and manpower to repair as needed on-site has been key, as minimizing downtime and saves valuable time which can be re-allocated to testing the robot on the field. Furthermore, because visually the field (i.e. lightings on it) and its surroundings are unknown, having a vision algorithm that can properly adapt to the different time of the day (in the case that outside lighting affects the venue's brightness) as well as overcome the outliers from the dynamic environment around the field (i.e. spectators) seem to be areas of improvement from our previous outing.

3 Problems to Solve and Plans

Team RoMeLa strives to push the limits of humanoid robot soccer and RoboCup's state-of-the-art technology in general. Therefore, rather than relying on traditional position controlled humanoids, we are approaching the robotic soccer game using a torque-controlled humanoid built with QDD actuators. We break down this problem into three pillars that we specifically aim to address and solve. First, an on-board torque controlled motion generation and soccer playing capability needs to be developed. Second, because force control can be unsafe, a well thought out safety logic around the controllers need to be developed such that when the robot does loose balance or malfunctions, its limbs do not uncontrollably swing, potentially damaging the robot or people near it. Lastly, a capable hardware that can support such a control approach needs to be developed and manufactured from the ground up. Ideally, such design principles would be adoptable by other teams in the future or research/commercial groups wishing to build torque-controlled humanoids.

Our immediate plans are to test the locomotion and motion controllers on the lower body of ARTEMIS as the upper body assembly is completed. The upper body went through a recent modification, which has pushed back the assembly schedule. We do not expect additional major changes to occur to the hardware, aside from interior modifications on the body for mass re-distribution and potentially changes in the camera model and computing units.

4 Conclusion

We are excited at competing in Bangkok and taking part in pushing the limits of humanoid soccer from both a hardware and a software level. We are particularly interested in pushing ARTEMIS to be a part of this competition, alongside the more conventional humanoid THOR-RD, to demonstrate and assess torque controlled robots for such dynamic games. We believe our experience in implementing this actuation technology in humanoid soccer will open another set of doors in both hardware and software design for the next breed of humanoids that the community can collectively further research.