

RoboCup 2024 Humanoid Soccer Competition

Bold Hearts Extended Abstract

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Abstract. Bold Hearts is a UK-based team from the University of Hertfordshire (UK) which was founded in 2002. The team firstly moved from 2D to 3D simulation, to the Humanoid Kid Size League in 2013. We believe our team to be the longest active UK team and only current UK Humanoid League team. In this abstract we summarise the challenges faced in 2023, and efforts and actions undertaken to address these challenges.

1 Lessons Learned from RoboCup 2023

Framework A few years ago we switched our to ROS2¹. In the previous competition we faced several issues due to the DDS layer and networking with multiple agents, including issues disconnecting from robots. We also have unsolved issues for deployment and are actively exploring simplification of our framework.

Controller We previously faced issues with a legacy CM730 driver² and decided to address this by wrapping the Robotis dynamixel library³ as a ROS2 node. We experienced ~30ms latency for reported motor positions. Additionally our initialisation was too fast for the motor voltage to stabilise.

Motion Our scripts were previously based on the assumption that the actuators would reach the target angle, and would use the current position to interpolate to the next goal position. This is not always correct and would cause our scripts to run unpredictably.

Walking With the fixes in place for the *controller* and *motion*, we found that the walking parameters were tuned based on incorrect control assumptions. This greatly affected our ability to compete as other competition setup was delayed until these issues were resolved.

Behaviour Our implementation imposed little abstraction and was error prone. We are currently improving the generalisation of our behavioural tree.

¹ Marcus M. Scheunemann and Sander G. van Dijk, “ROS 2 for RoboCup,” in *Lecture Notes in Computer Science* (Springer International Publishing, 2019), 429–38, https://doi.org/10.1007/978-3-030-35699-6_34.

² Bold Hearts CM730: https://gitlab.com/boldhearts/ros2_cm730

³ Robotis Dynamixel SDK: <https://github.com/ROBOTIS-GIT/DynamixelSDK>

Vision We use an adapted XNOR CNN named xYOLO⁴, which is used to detect the ball, goals, lines and robots. We had some issue processing the larger network due to compute limitations.

Organisation In 2022-2023 we were not able to successfully recruit many new members, and unfortunately two members were not able to join the competition immediately prior to the 2023 World Cup.

Although we tested exhaustively in simulation, it is clear that more physical testing was required to ensure correct behaviour. We actively investigate several hardware upgrades and have had a larger recruitment for 2024.

2 Challenges & Planned Updates for RoboCup 2024

Web-based debug Since last year, we are continuing to develop a debug utility to replace *RoundTable*, and intend to use it for RoboCup 2024.

Localisation Our previously proposed approach of rtabmap was too computationally expensive for our current compute. We have since experimented with a custom implementation and look towards a particle filter approach. The symmetry problem remains an issue. We have an initial simulation environment for automatically testing localisation implementations.

Behaviour & Cooperation The behaviour tree abstraction is implemented and we look to bring back more advanced behaviours, including basic team play (dribbling, back-off).

Motion The USB issues have been largely addressed and we have achieved reliable script motions and walking on several robots. We look to upgrade several key motors as these were demonstrated to be underpowered for our platform's size and weight.

Electronics We currently investigate a new modular control board to replace the ageing CM730, which would provide a platform and upgrade path for several years. We intend to open source these works when a prototype is working.

Academic Our robotics module ran for the first time in 2023 at the University of Hertfordshire, where students have learned basic principles and interacted with some systems we used within RoboCup. We look to improve the content and experience to engage with more students.

Research: Several team members explore the use of intrinsic motivation through *empowerment*⁵ as an approach to remove the need for motion scripts. This is currently explored with 2D humanoids.

⁴ Daniel Barry et al., “xYOLO: A Model For Real-Time Object Detection In Humanoid Soccer On Low-End Hardware,” in *IVCNZ* (IEEE, 2019).

⁵ A. S. Klyubin, D. Polani, and C. L. Nehaniv, “Empowerment: A Universal Agent-Centric Measure of Control,” in *2005 IEEE Congress on Evolutionary Computation*, vol. 1, 2005, 128–135 Vol.1, <https://doi.org/10.1109/CEC.2005.1554676>.