RoboCup 2025 Humanoid Soccer Competition Bold Hearts Extended Abstract

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Abstract. Bold Hearts is believed to be the oldest active UK-based team founded in 2002, operating from the University of Hertfordshire (UK). The team originated in 2D simulation, transitioned to 3D simulation, and then to the Humanoid Kid Size League in 2013. In this abstract we summarise the challenges faced in 2024, and efforts and actions undertaken to address these challenges.

1 Lessons Learned from RoboCup 2024

Computational limits: Since switching from our original bespoke binary codebase[1] to ROS2[2], we have been implementing further advanced features. During the competition whilst operating the full stack with realistic data, we have reached the limit of processor speed and RAM on the Odroid XU4[3].

Controller: After fixing the communication issues with the CM730 in 2024 by creating a ROS2 wrapper node for the Robotis Dynamixel SDK and hardware timing issues, a large number of our CM730s have now died. As we have increased the size of our motors the EOL CM730 has been under increased load.

Motion: Fixing fundamental issues due to assumption of reaching target angles required the creation of new scripts which are now more reliable. We still have issues with transitions between scripts and engines (e.g. walk & kick), allowing the robots to become unstable.

Behaviour: We currently use a fall-through behaviour tree to perform actions and perform state transitions. As the behaviour grows, we have found it increasingly difficult to maintain and make assertions that states do end and transition.

Localisation: We have for some years successfully used xYOLO[4] on the CPU. We have found it difficult to reliably perform inverse kinematics to estimate the

[1] Open sourced bold-humanoid: https://gitlab.com/boldhearts/bold-humanoid
[2] 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.
[3] Odroid XU4: https://www.odroid.co.uk/hardkernel-odroid-xu4/odroid-xu4
[4] Daniel Barry et al., "xYOLO: A Model For Real-Time Object Detection In Humanoid Soccer On Low-End Hardware," in *IVCNZ* (IEEE, 2019).

pose of the camera. Issues have included inconsistencies in the hardware, bad IMU data, latency issues between the pose estimation and the detected objects.

Organisation: Due to availability and visa issues, we had a small team in 2024 for operating the robots.

2 Challenges & Planned Updates for RoboCup 2024

Localisation: We develop an approach to calculate camera pose estimation independent of IMU and inverse kinematics estimations. Previously we search for (X, Y, Θ) for a given camera pose (Z, R, P, Y) by converting from camera frame, to agent frame, to world frame. We develop an approach to course search for $(X, Y, Z, \Theta, R, P, Y)$ candidates in the camera frame, followed by a refined search, allowing us to integrate data directly into the world frame. This approach is less accurate, but removes errors introduced by latency and inconsistencies in the hardware.

Behaviour: After exploring several options we look to integrate the ROS2 node YASMIN[5], with support for stack FSMs, debug output and forced state transitions.

Motion: Previously we had a series of engines, namely walk $W(p)$, kick $K(p)$ and script $S(p)$ engines, each requiring carefully tuned parameters. To transition from $W(p) \rightarrow K(p)$ it is required to bring the robot to a known stable kinematic pose $\mathbf{P}$, i.e. $W(p) \rightarrow \mathbf{P} \rightarrow K(p)$. By combining these models, we should no longer require the intermediate stable state to perform actions.

Electronics: We upgrade our remaining MX28 leg motors, and replace the aged CM730 with either an OpenCR1.0 or an internally developed control board.

Hardware: A large factor for unreliable motion has been the inconsistencies caused by 3D printed parts interfacing to motor horns. We have redesigned critical parts and designed a new horn interface designed to reduce stress. Additionally we explore cable routing through limbs.

Academia: We continue to run a RoboCup focussed robotics module for students and have begun to develop an intermediate humanoid robotics competition to onboard members with reduced complexity. We completed the transition to our new RoboCup lab which includes a full sized field.

Research: With the upcoming requirement for whistle detection, we have an active research project for whistle detection and location estimation, using two microphone only in the agent's head.

[5] YASMIN: https://github.com/uleroboticsgroup/yasmin