

# RoboCup 2023 Humanoid Soccer Competition

## Bold Hearts Extended Abstract

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### 1 Introduction & History

Bold Hearts is the RoboCup (RC) team from the University of Hertfordshire (UK). The team was founded in 2002, and moved from the 2D and 3D RoboCup Simulation Leagues to the Humanoid League (HL - Kid size) in 2013. To the best of our knowledge, we are the longest continuously active RoboCup team in the United Kingdom, and currently still the only British team in HL.

### 2 Lessons Learned & Problems Overcome

**Hardware** During the last competition, we noticed that the movements of our new designed robots' head did not allow for full rotation. For this reason, we work towards a revision that allows the robot's head to move with a higher degree of freedom of movement.

**Vision** Prior to 2020, we employed semantic segmentation object classification for the detection of balls and goals <sup>1</sup>. We then integrated xYOLO into ROS2 using the Darknet framework, making use of the XNOR hybrid CNN developed by the *Electric Sheep*. This traded some accuracy for faster detections and a larger number of detection objects <sup>2</sup>. We have since begun work towards the next iteration of this approach, further increasing speed and accuracy.

**Behaviours** In the 2022 competition in Bangkok we were severely hampered by a software incompatibility stemming from the differences between running motion scripts and the walking engine, due to some bugs in ROS2. This has now been resolved in our code base and we are developing a new behavioural decision tree.

**The 3D simulation environment** As with many other teams, we have found difficulty in bringing undergraduates into our relatively complex development process. For this reason, we decided to start developing our software and

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<sup>1</sup> van Dijk, S.G. and Scheunemann, M.M., 2018, June. Deep learning for semantic segmentation on minimal hardware. In Robot World Cup (pp. 349-361). Springer, Cham.

<sup>2</sup> D. Barry, M. Shah, M. Keijsers, H. Khan and B. Hopman, "xYOLO: A Model For Real-Time Object Detection In Humanoid Soccer On Low-End Hardware," 2019 International Conference on Image and Vision Computing New Zealand (IVCNZ), 2019, (pp 1-6).

robot model for Webots, which it will also allow us to compete in the RC-HLVS. Our intention is to give new members the opportunity to work on isolated components with realistic world constraints, the thrill of a competition, but further minimising the barrier to entry.

**Web-based debugging tool** During the last year competition, we realised how much we needed again a web-based debug tool providing us with live information from all robots on our team. For this reason, we are currently developing it and we named it “Round Table” as our past one.

### 3 Planned Major Updates for RoboCup 2023

**Localization** We are working to implement an appearance based mapping technique for localization <sup>3</sup>. Our initial plan is to include the ROS RTAB-Map package<sup>4</sup> into our environment using only camera and IMU data to build a map by incorporating closures of visual features as constraints on a graph representation of the environment.

**Walking & hardware** Furthermore we continue actively research towards a dynamic balance engine. Last year, the Hamburg Bit-Bots <sup>5</sup> presented a new walking algorithm which performs well on a variety of models. This inspired us, and it is not only a step towards a more dynamic walking but also simplifies the collaboration with other teams in the future. Additionally, we are actively working on the development of a new foot model with a moveable and deformable sole. The human foot generally has both longitudinal and transversal arches elevating the middle of the sole and creating three main points of contact to the ground which can move relatively to each other allowing the foot to adapt to irregularities of the ground. Furthermore, while walking these arches can give way elastically greatly dampening the impact of the body weight. Our current plan for the model contains the three points of contact and an elevated main block to connect everything together and to the robots leg. In the next step, we plan to add elastic material to create the low tension of the arches and allow for the foot to cushion the robot’s steps.

### 4 Academic & Scientific Activities

To recruit new team members and form new roboticists, we have been working towards designing a robotic module at the University of Hertfordshire (UH) that uses RoboCup as an use-case for robotic applications. We also yearly incentivize and engage the students by offering a cross-displine RC hackathon over several weeks. Winners and well executed projects also have their prototypes/artefacts implemented and tested on our physical robots.

<sup>3</sup> M. Labbé and F. Michaud, “Appearance-Based Loop Closure Detection for Online Large-Scale and Long-Term Operation,” in IEEE Transactions on Robotics, vol. 29, no. 3, pp. 734-745, June 2013

<sup>4</sup> [http://wiki.ros.org/rtabmap\\_ros](http://wiki.ros.org/rtabmap_ros)

<sup>5</sup> Bestmann, Marc and Zhang, Jianwei. Bipedal Walking on Humanoid Robots through Parameter Optimization.