

# RoboCup 2026 Humanoid Soccer Competition

## Bold Hearts Team Description Paper

### Small & Middle Leagues

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**Abstract.** In this paper we describe the Bold Hearts team of the University of Hertfordshire from the United Kingdom. We introduce two new humanoid platforms, *BoldKnight* and *BoldRbot*, to address several key challenges, including computation, chassis, motors and motor controller. We provide an update on our current progress and several key areas for further development, including motion, localisation and behaviour. Lastly, we discuss the impact and contributions that the team have made to both the RoboCup community and wider.

## 1 Introduction

The UK-based Bold Hearts team is based at the University of Hertfordshire, and was founded in 2002. The team previously successfully competed in the 2D simulation league, then the 3D simulation league, then transitioned to the Humanoid Kid Size League in 2013. As of league’s restructuring in 2026, the Bold Hearts now aims to compete in the small and middle sized leagues of the RoboCup Humanoid Soccer League as part of a long-term strategy towards 2050.

## 2 Previous Participation

Previously, the team has competed with the BoldBot platform in 2025, which itself evolved from the original Darwin-OP platform. In 2026, the Bold Hearts intends to compete with two different platforms: the BoldKnight in the small league and the BoldRbot in the middle league. Whilst having two different humanoid platforms involves different sensors, firmware and integrations into ROS2, the high-level software and strategy is shared amongst both platforms. Any meaningful differences are noted in the relevant sections.

With the new platforms, we look to improve in several key areas:

- *Computation* - We previously used the Odroid XU4 with 8 low-power Big-Little cores, 2GB of DDR3 RAM. We have been unable to run our full stack at the previous competition due to resource constraints, where upgrading the compute board required significant changes to the chassis to accommodate.

- *Chassis* - As well as accommodating larger internal components, we also discovered the rigidity of 3D printed parts has been causing significant issues when maintaining multiple robots in the older platform. Parts can wear quickly and unexpectedly, making testing and deploying a difficult task. We have begun to replace 3D printed parts with aluminium parts, fabricated with both sheet metal and SLM processes.
- *Motors* - The motors have been significantly upgraded in both new platforms, increasing the size of the platforms and the theoretical upper walking speed limit. Both platforms draw significantly more power and have required custom solutions for their motor controllers.
- *Motor controller* - The previously used Robotis CM730 was already unable to handle the power requirements from the upgrades made over previous years, but additional upgrades mean that it is now impossible to continue using these boards. The new controller firmware has allowed for improvements, and we have been able to experiment with offloading further computation to the controller board and reduce bandwidth bottlenecks.

For both the BoldKnight and BoldRbot platforms we work to keep both software stacks as similar as possible, to allow for a seamless upgrade between the platforms and to deploy both platforms for as long as possible. The only current difference in the software stacks is the motor controller API. With increased computation resources, we will be able to deploy our heavier ROS2-based stack.

### 3 Progress & Development

The BoldKnight platform is a significant iteration on the previous BoldBot platform. We actively develop and debug the new motor controller and port our software stack to the new compute board. The BoldKnight platform kinematic structure is not yet locked in for a full fabrication for all robots.

For the BoldRbot platform, we believe that the first prototype will be completed by April. Depending on changes required, we expect to be able to deploy a complete platform for the competition. The software stack is currently only tested in simulation.

The vision system is being ported to the Luxonis Oak D Lite, where it is expected that the onboard computation can again be significantly reduced. We intend to test deploy our custom xYOLO network [1] with reduced computation requirement.

### 4 Intended Further Development

**Motion** – It has been a long-term goal for our team to move away from motion scripts and an open-loop walk engine [2], and towards a more general realisation of motion. Currently we experiment within a MuJoCo environment to develop

and test new approaches. We expect to be able to demonstrate reinforcement learning (RL) based approaches at the next competition.

**Localisation** – For many years our robots have operated with a limited global understanding of state, instead operating with local state. As such, players could only communicate local information such as their distance to ball, limiting the complexity of team-based behaviour.

**Behaviour** – Our previous implementation was based on a custom C++ behaviour tree, which had several drawbacks, including needing to be recompiled for each change. Our new behaviour tree is written in Python and provides a web-based debug console, where states can be manually transitioned.

## 5 Impact & Contributions

A large success of the Bold Hearts team was the creation of an undergraduate *Robotics* module that primarily teaches concepts related to RoboCup. The module has been running several years and students are able to benefit from active Bold Hearts members.

Additionally, we have developed the *STRIDE* group, with the purpose of educating students at any level of study on humanoid robotics. Students actively work with ROS2 and the Robotis Darwin OP 3 platform to develop and test ideas.

The long-term objective of the group is to increase the profile of humanoid robotics and RoboCup specifically within the UK. In the first instance we held a Booster workshop at the University of Hertfordshire with a second workshop planned that can take advantage of the permanent field within our facilities. In a longer time horizon, we are working towards organizing further workshops, more specifically for the Humanoid Soccer League with the intention of small local competitions.

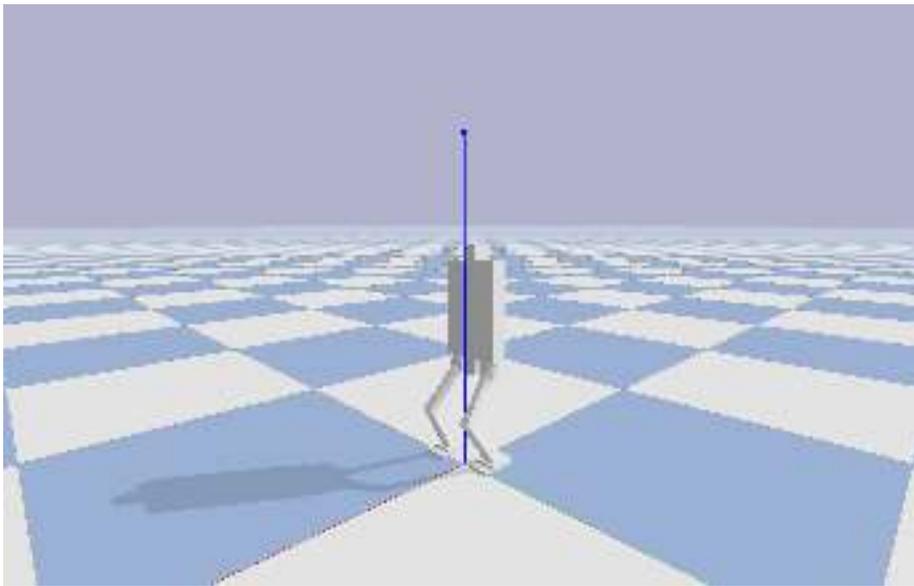
Our current main objective is the upgrade of the previous BoldBot to the BoldKnight. This involves a complete overhaul over the electronics with a modular design that allows for an upgrade path for existing legacy platforms. Once completed and tested, the source files will be available for the benefit of the community.

The Bold Hearts team is currently exploring multiple directions to add further human like mechanical capabilities to the robot platforms. Unlike the simple upgrade, the BoldRbot features an upgrade to the kinematic chain with additional joints, with the intention of unlocking movements of greater complexity. The team is entering uncharted territory with this addition and will contribute to future research.

In the long-term, the team aims to include further experimental upgrades especially around passive control, leaning on recent developments in the soft robotics community. One such contribution is a foot design including a compliant arch.

We previously developed two independent approaches to vision, one based on semantic segmentation [3] and another approach based on a CNN [1]. We eventually chose the CNN approach based on the Darknet framework for performance and deployment convenience.

Historically we deployed our system based on a custom framework<sup>1</sup>, which had occurred a large amount of technical debt and was resistive to sharing and integrating contributions. Other teams previously attempted to use ROS1 which itself had several issues. After reviewing several frameworks, we had success in developing with ROS2 [4], which we continue to use.



**Fig. 1.** Intrinsically motivated footstep planning in PyBullet [5].

In-line with our long-term research objective for intrinsically motivated autonomous agents, we investigated the feasibility of an intrinsically motivated footstep planner [5]. This work has shown promise for an approach that combines ZMP and empowerment.

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<sup>1</sup> Bold Humanoid framework (2017): <https://gitlab.com/boldhearts/bold-humanoid>

## 6 References

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