

# RoboEireann Team Description Paper for RoboCup 2026

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## 1 Lessons Learned from Previous RoboCup Competitions

RoboEireann has been an active team in RoboCup since 2009 and has extensive experience of robot soccer in the Standard Platform League (SPL) using the Nao robot. We have advanced from very simple walk-to-the-ball-and-shoot strategies in 3 vs 3 games to fully fledged formation and selective passing strategies for 7 vs 7 games. We have seen the issues that arise from manual calibration procedures and algorithmic/heuristic approaches to perception, and have gradually moved away from such approaches.

From 2009 to 2021, the RoboEireann team developed and used its own architecture and code base. In recent years, our relatively small team size made it challenging to develop new features, keep up with rule changes and fix defects in the core architecture. Therefore, since early 2022, we adopted the 2021 B-Human code release [5] as the base software for our development. This allowed us to focus on our unique contributions and higher order problems that benefit the progress of RoboCup overall, rather than replicating low level infrastructure features. Consequently, we plan to use [1] as our base framework for RoboCup 2026.

## 2 Challenges for 2026

**Porting to New Framework:** Transitioning from our 2021 base [5] to the 2025 release [1] requires substantial porting of our own non-hardware-dependent components due to architectural changes.

**Perception Challenges:** Existing robot and whistle detection systems are fitted to Nao-specific datasets (Nao morphology, camera system, microphone and audio characteristics). These must be retrained for the diverse robot types of the Humanoid Soccer League (HSL) and the Booster K1 robot hardware. Similarly, ball detection must be generalized to accommodate various sizes and patterns, moving beyond the fixed SPL standard.

**Motion:** As the current codebase is hardware-specific, all locomotor and specialized behaviours—including walking, kicking, and goalkeeping—must be entirely redeveloped for the new platform.

### 3 Planned Changes and Status

**Behaviour and Infrastructure Components:** We are porting and enhancing our stackless coroutine based behaviour architecture and infrastructure components, such as fast text logging, for our new base framework. We will adapt our behaviour formations and strategy to 3 vs 3 and 5 vs 5 games. (The latter was already used in SPL competition but may need further customisation to match the capabilities of the Booster K1 robots.)

*Status: This is in progress and the initial work will be completed shortly. Strategy refinement will continue right up to RoboCup itself.*

**Robot and Jersey Detection:** We aim to extend our existing Nao robot dataset with examples of other HSL robots. We are also investigating the use of a foundation model to generate pseudo-ground truth labels for in-the-wild robot images and the inclusion of other techniques for domain generalisation (to cope with previously unseen robots) based on the work of one of our PhD students. Our existing robot detector was based on a modified Tiny YOLOv3 model with a modified head for robot detection and jersey colour detection. With the increased computational power of the Booster K1, we plan to use a more modern YOLO variant (likely YOLOv11) and integrate depth information from the camera post inference.

*Status: This work is in the initial research and development stage.*

**Any Ball Detection:** We currently plan to perform basic ball detection with a YOLO based model (likely YOLOv11). We will explore the input image size required to detect the ball at distance while maintaining good real time performance (e.g. 640×640 or 416×416) and the ability to share computation with the model used for robot detection. We anticipate modifying the detection head for more precise ball location.

*Status: This work is in the initial research and development stage.*

**Whistle Detection:** We plan to use acoustic domain adaptation so that our current dataset may be used to retrain the whistle detector for the Booster K1. We plan to use spectral equalisation (using the stable noise profiles of each robot) and augment the data with K1 noise where appropriate. We also anticipate collecting some new clean whistle samples on the K1. Finally we plan to modify the model used for inference which was previously just a small custom CNN applied to the recent spectrogram of the sound.

*Status: Planned.*

**Motion:** We will train walking and kicking motions at least using Curriculum Reinforcement Learning via Proximal Policy Optimization within the IsaacLab framework. Tasks are formulated as a Partially Observable Markov Decision Process. We utilize an asymmetric actor-critic architecture to provide the critic with privileged simulation data during training. Our curriculum strategy involves incrementally increasing proprioceptive noise and domain randomization of ground plane properties (e.g., friction and surface height) to ensure robust balancing and sim-to-real transfer.

*Status: This work has started, with the tasks trained and tested in IsaacSim. Current work focuses on integrating the model runner into our codebase with the proper tuning mechanism for addressing the sim-to-real gap.*

## 4 Own Contributions

Our most recent published research contributions to SPL were the development and evaluation of a fast and small object detection architecture suitable for the Nao and similar platforms [8] and the release of a data set and evaluation of deep learning architectures for ball detection [2]. The former publication also contributed a dataset for object detection and both data sets are listed on the datasets page of the SPL website.

Our complete code is published on GitHub<sup>1</sup>. Since 2021, our most significant contributions within the soccer software itself are the behaviour module (which now provides support for a stackless coroutine based behaviour architecture), a mechanism to specify behaviour formations and tactics more easily, a machine-learned whistle detector module, a machine learned referee gesture detector, and certain architectural features, such as a fast text-based logging mechanism.

For 2026, the research and development described in Section 3 is being developed and each of the perception and motion pieces identified are potentially research publishable.

## 5 Impact

RoboEireann has been an active team within RoboCup since 2009 and our members have been active in the organization of the standard platform league and latterly in the RoboCup Federation itself.

Our published contributions to the SPL include a fast object detection architecture and accompanying dataset [8]; a dataset and evaluation of deep learning architectures for ball detection [2] with related works [3] and [4]; and a robust example of “localisation without goals” [6,7] (when coloured goals were still an important landmark).

Within Maynooth University, RoboEireann provides students with experiential challenge based learning and exposes them to the practical and cutting-edge

<sup>1</sup> <https://github.com/roboeireann/RoboEireannCodeRelease>

aspects of robotic software development. Each year undergraduate and taught postgraduate students complete RoboEireann related projects and several students have gone on to complete Research Masters and PhDs in robotics in our labs as a consequence.

Maynooth University launched a new B.Sc. programme in Robotics and Intelligent Devices in 2016 and an M.Sc. programme in Robotics and Embedded AI in 2024 which build on the wide array of research and postgraduate level activities in robotics including our participation within RoboCup.

Our involvement in RoboCup has played a key role in attracting research and public engagement funding from Science Foundation Ireland (now Taighde Éireann – Research Ireland), including the funding of 30 summer internships over a 3-year period and outreach activities for robot soccer demonstrations seen by thousands of children, families, and the wider public. Our participation in RoboCup is highly motivating for students and helps ensure the ongoing impact of RoboCup’s mission in diverse geographical areas.

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