# RoboEireann Team Description Paper for RoboCup 2025

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## 1 Team Information

*RoboEireann* is a RoboCup team from Maynooth University, and is Ireland's only RoboCup Standard Platform League team and indeed the only European team not based on the continental mainland.

***Team name:*** RoboEireann
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The team working towards RoboCup 2025 comprises the following members:

***Staff:*** Rudi Villing and Ralf Bierig.
***Undergraduates:*** Meda Griniute, Eoin Keatley, Nathan Ewnetu, Markel Draper, Mariia Solianyk, and Jack Guilfoyle.
***Postgraduates:*** Aidan Colgan and Shauna Recto.
***Graduates:*** Conal Hughes.

## 2 Code Usage

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 in accordance with rule changes and technical challenges while also fixing defects in the core architecture. Therefore, since early 2022, we have adopted the 2021 B-Human code release [5] as the base software for our development. We plan to use this same base software for RoboCup 2025.

In 2024, we also adapted the BadgerBots 2023 AbstractSim release for our use. We used the RL training environment as a base to build our own contributions, and to develop, train, and export our own RL policies. We utilised the

tools provided in the BadgetBots 2023 code release to load and infer the trained RL policies in the context of our own behaviour architecture.

Between 2019 and 2021, while using our own architecture and code base, the most significant direct uses of code from other SPL teams were as follows: from B-Human we used the B-Human 2010 walking engine [6], the libbhuman process (though significantly modified), shared memory communication code, Unscented Kalman Filter, some utility classes related to math and poses, and significant parts of the self-locator module after RoboCup 2019. We also integrated the Walk2014Generator from the 2016 code release of UNSW Sydney, the FieldColorProvider from the NaoDevils 2018 code release (though mostly switched off for RoboCup 2019). Finally, we used an adapted version of the RegionScanner and some whistle detection code from Nao Team HTWK.

We also adopted ideas without direct code reuse for a RANSAC line fit and certain aspects of gradient line detection from Nao Team HTWK, some aspects of the field boundary detection approach from B-Human, and a ball circle fitting technique from code released by UChile.

## 3 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 [9] 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[1]. Since 2021, our most significant contributions to the soccer software itself are the behaviour module (which now provides support for a co-routine 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 2025, the following research and development highlights are in progress:

- We are working to improve the current robot and teammate detection system by integrating object detection and jersey colour classification into a single, efficient deep-learning model. The existing system, as implemented in [5], detects robots and their jersey colours (to classify as teammate or opponent) using two separate detectors. Robots are detected using greyscale images to determine their position. Then, the robot bounding boxes are used to estimate a jersey area and a grid-based examination of pixel intensity, hue, and the field colour is performed. Notably, this method is not designed to work particularly well (if at all) with the RoboEireann team colours, green and white. When faced with a green team colour, every colour except green has a recall of less than 10%, making accurate teammate identification extremely

[1] https://github.com/roboeireann/RoboEireannCodeRelease

difficult. Additionally, the system often fails to detect fallen robots, limiting its overall effectiveness. We are currently examining YOLO-based architectures to simultaneously predict robot locations and jersey colours. The main challenges are choosing an appropriate model size and complexity (to minimize latency and maintain real-time performance), training for colours that rarely or never appeared in real games, and distinguishing between similar colours.
- We are developing the ability to kick a rolling ball in line with this year's challenge rules. Typically, kicking a ball involves detecting the (stopped) ball, then walking up to a kick pose whose position relative to the ball is determined by the kick that will be used and the target direction. With a rolling ball, in contrast, there is limited scope to alter the kick pose and the best kick pose is largely determined by the point of closest approach to one of the robot's feet. We have integrated a basic predictive model to anticipate the time at which a ball will pass within kicking range, and are currently investigating the ability to reliably initiate a kick so that it will connect with the ball as it arrives at the robot's foot, making modifications and enhancements where necessary. We also hope to integrate the feature into normal game play if time permits.
- For RoboCup 2022 we developed a standalone visual referee signal detector and this was significantly modified and integrated into the game code for RoboCup 2024. To meet the increased visual referee challenge for 2025 we are redesigning and improving our synthetic image generation tool based on Unreal Engine 5. Enhancements include configurable generation of valid robot viewpoints (location and rotations) that likely occur during gameplay and that are not pre-determined. This directly supports the Set Play visual referee signal but can also be applied for future referee signals or other more general gameplay situations. Image generation will utilise an updated set of highly realistic EPIC SuperHuman models without red-gloves and a new referee animation data set for all simulated situations to support increased realism and greater flexibility in movements. Configurable automation of backdrops/backgrounds will also serve to provide a wider range of ML training situations for more robust signal detection. The inference approach used in 2024 is also being reassessed and will be modified as necessary.
- We continue to extend/enhance the mechanism to specify formations and tactics to provide richer specifications and to provide support for teams with larger and more variable numbers of players. We also hope to adapt the functionality to support sub-groups of co-operating players for set plays and coordinated dynamic moves.

## 4 Unpublished results

All RoboEireann results since 2020 are published on the SPL website and are not included here as a consequence. Our best performances to date were at RoboCup 2023, where we achieved first in the Challenge Shield competition, and RoboCup 2024 where we placed third in the Champions Cup competition.

We do not anticipate participating in any open events this year.

## 5 Impact

RoboEireann has been an active team within RoboCup since 2008 and we have made a number of technical contributions and been active in the organization of the standard platform league. Our team leader, Rudi Villing, has been chair of the Organising Committee in 2014 and 2015, a member of the Technical Committee in 2016 and 2017, and a member of the Executive Committee from 2018 to 2024. Other team members have also contributed to the Organising Committee in 2020, 2023, and 2024, and to the Technical Committee in 2025. In 2016 we also designed the No-WiFi challenge and provided the code necessary for teams to develop against and participate in the challenge.

Our most recent contribution to the SPL was a fast object detection architecture and accompanying dataset [9]. Previously we released a dataset and evaluation of deep learning architectures for ball detection [2] with related works [3] and [4]. The distance and accuracy of our strong kick design was a notable contribution in early years of the SPL. In 2011, our "localisation without goals" technical challenge presented our latest efficient and robust localisation system which was based on extensions to the line based registration algorithm due to Cox [1] and was published in [7] and [8]. Other technical contributions by the team include: early development of the b-script system for specifying behaviours, development of a lightweight modular architecture, and kernel fixes to the Aldebaran Linux kernel to deal with a number of camera driver issues[2]. Over the years we have also hosted members from other RoboCup teams for extended research visits at our lab.

Within Maynooth University, we have a number of research groups active in the area of robotics. RoboEireann provides an excellent means for engagement with the CS and EE undergraduate community. In particular, every year academic staff associated with RoboEireann have supervised undergraduate projects and internships that expose students to both the practical and cutting-edge aspects of robotic software development. Although this would be possible without RoboCup participation, the association with RoboCup is a very significant motivating factor that greatly affects the students' desire to get involved. Since our initial involvement in RoboCup we have had a number of undergraduate students who, as a consequence of their involvement in the team, have completed Masters and PhDs in robotics in our respective labs.

In 2016 Maynooth University launched a new B.Sc. programme in Robotics and Intelligent Devices. The students from that programme now constitute most undergraduate members of the RoboEireann team. The programme's syllabus draws on the wide array of research and postgraduate level activities in both departments including our participation within RoboCup. The programme incorporates a focus on modern mobile autonomous robotics, including hands-on

[2] https://github.com/mp3guy/linux-aldebaran/commits/release-1.12/geode

experiences with modern robotic software and platforms (such as the Nao) and laboratory sessions with the RoboEireann codebase in the later years.

Furthermore our involvement in RoboCup has played a key role in the significant success in attracting research funding from Science Foundation Ireland (SFI) that have supported both a three year Summer Internship in Autonomous Robotics (SIAR) programme and outreach activities to promote engagement of the Irish public with science, technology, engineering, and maths as part of the SFI Discover Programme. In total, the SIAR programme funded 30 summer internships over a 3-year period for both national and international students at Maynooth University. The Discover Programme has funded outreach activities for robot soccer demonstrations seen by thousands of children, families, and the wider public as part of the annual National Science Week.

## 6 Other

RoboEireann is a collaborative effort between the staff and students of the Computer Science and Electronic Engineering Departments of Maynooth University, both of which have strong research records in the wider areas of computer vision, machine learning, signal processing, control, robotics, and intelligent systems. The team has a long history in the Standard Platform League, having competed since the Nao robot became the standard platform.

Our participation in RoboCup is highly motivating for students and helps ensure the ongoing impact of RoboCup's mission in diverse geographical areas. We look forward to the opportunities presented by RoboCup 2025!

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