RoboEireann Team Description Paper for RoboCup 2023

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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
Team leader: Rudi Villing
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Country: Ireland
University affiliation: Maynooth University

The team working towards RoboCup 2023 comprises the following members:

Staff: Rudi Villing and John McDonald.
Undergraduates: Heather Bruen, Aidan Colgan, Andrew Mitchell, James Petri, Shauna Recto.
Postgraduates: Homay Danaei Mehr, Mark McCormack.

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 anticipate using this same base software for RoboCup 2023.

Between 2018 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-Humand 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 the development and evaluation of a fast and small object detection architecture suitable for the Nao and similar platforms [10] 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.

Since 2021, our most significant contributions to the soccer software itself (outside of hand-written behaviours and architecture code) are the behaviour module (which now provides support for a co-routine based behaviour architecture) and the whistle detector module.

For 2023, the following research and development highlights are in progress:

- We are developing a new machine learned whistle detector. During development we plan to evaluate multiple machine learning methods, including a recent classifier based on transformers [9] which has proved to be 81% accurate in classifying sounds, trained on noisy samples. We have an additional goal of learning to identify the approximate direction and distance of the whistle from the robot also.
- We are further improving the behaviour architecture and experimenting with simplified ways of specifying and customising the behaviour. We are also exploring machine learning and evolutionary algorithm approaches, but this research is at an early stage.
- For RoboCup 2022 we developed a standalone visual referee signal detector. This year we are working to integrate this as a new set of modules into the in-game soccer software which entails training the model with new datasets, revised detection modules, and modifying the supporting behaviour.

4 Past History

RoboEireann first participated in RoboCup in 2008 as part of the Standard Platform League team *NUManoids* which was a joint effort of Maynooth University and the University of Newcastle, Australia. In that year, the first in which the Aldebaran NAO platform was used, we were Standard Platform League's overall winners. Since 2009 we have competed as an individual team under the name

RoboEireann. In total, we have participated in 10 RoboCup events (including remote participation at RoboCup 2022) and have been qualified to every event for which we applied. Our best performance to date as RoboEireann was at RoboCup 2013, where we placed within the top 8 teams. Our two most recent RoboCup soccer results are shown in Table 1. (At RoboCup 2022 we participated in challenges only so no scores are shown in the table.)

Table 1: History of RoboEireann participation and results in recent competitions.

Competition	Stage	Opposition	Score (for-against)
GORE 2022	Swiss-System	R-Zwei Kickers	7 - 0
		B-Human	0 - 8
		HTWK Robots	2 - 5
		Nao Devils	2 - 2
		HULKs	9 - 1
	Quarter Finals	rUNSWift	1 - 0
	Semi Finals	HTWK Robots	2 - 5
	3rd Place	Bembelbots	4 - 2
RoboCup 2019	Round robin 1	NomadZ	0 - 3
		Dutch Nao Team	0 - 0
		Starkit	1 - 5
	Round robin 2	Naova	1 - 1
		Camellia Dragons	0 - 4
		Sabana Herons	0 - 5

As the dates for the German Open Replacement Event (GORE) 2023 clash with our students' academic timetable, it is unlikely that we will participate in this or other open events.

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 Organizing Committee in 2014 and 2015, a member of Technical Committee in 2016 and 2017, and a member of the Executive Committee from 2018 to 2023. 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 [10]. 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

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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 light weight modular architecture, and kernel fixes to the Aldebaran Linux kernel to deal with a number of camera driver issues[1]. 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 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 experiences 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 significant success in attracting research funding from Science Foundation Ireland (SFI) where they have supported both a three year Summer Internship in Autonomous Robotics (SIAR) programme [2] 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.

[1] https://github.com/mp3guy/linux-aldebaran/commits/release-1.12/geode
[2] http://www.eeng.nuim.ie/robocup/siar/siar.php

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 2023!

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