



REDBACKBOTS - TEAM DESCRIPTION PAPER ROBOCUP SOCCER HSL, 2026

School of Computing Technologies, STEM College,
RMIT University, Melbourne, Victoria, Australia.

1 RedbackBots Team Information

RedbackBots is applying to qualify for the RoboCup Soccer Humanoid Soccer League (HSL) in 2026. RedbackBots is an established former SPL team that was founded at RMIT University in 2019. We participated in the former SPL across 2022–2025. Our academic team lead, Dr. Timothy Wiley, has been an active member in RoboCup since 2010 and is currently one of the HSL Executive members. Additionally, we strongly believe in supporting the RoboCup community through our SPL league contributions and active committee memberships.

Team Name: RedbackBots

Team Leader and Academic Supervisors: Dr. Timothy Wiley, Prof. John Thangarajah

Student Leads: Sam Griffiths, Mark Field

Team Members: Aiden Brundell, Stephanie Byars, Benjamin Chandler, Tom Ellis, Mark Field, Sam Griffiths, Peter Hong, Yashal Hookmani, Ronit Israni, Shahira Jasmine Binti Yahaya, Thamadi Kulathunga, Karen Laurentia, Gianluca Monsoni, Luke Mullan, Kim Nguyen, Murray Owens, Eric Pham, Devika Sheeja, James Thomson, Rishi Verma and Kurniawan Zhong Zhen

Affiliation: School of Computing Technologies, STEM College, RMIT University, Melbourne, Australia

Contact Email(s): stem.redbackbots@rmit.edu.au, timothy.wiley@rmit.edu.au

Website: <https://redbackbots.com/>

Qualification Video: <https://youtu.be/OYDhPLzrRIU>

Robots: In 2026 we will transition to the Middle-Sized HSL league. We will compete with the Booster K1 robot as a *standard platform*. We currently have 2 K1 robots and intend to use the robot pool from Booster.

Combined Team: We note that we're in discussions with two other Australian teams rUNSWift (UNSW Sydney) and Nubots (Newcastle University) to form a combined team in 2026 depending on available robots.

2 RedbackBots Development, Progress, and Team Status

2.1 Challenges being addressed in 2026

As a former SPL team, we are transitioning to the Booster K1 under the HSL *standard platform* rules with an unmodified robot. Thus, our primary focus is moving our codebase to the K1. As we are a standard platform team, and our research is within autonomous software, our goal is to use our own software systems instead of provided Booster software. The main exception to this that we will use the Booster K1 walk engine, as our own walk engine for Nao has remained unchanged in our codebase since 2014 and is incompatible with the K1. Additionally, we're continuing our work in using Augmented Reality (AR) for Human-Robot Interaction (HRI), with RoboCup as a test-bed, through our open-source GameSight tool. Finally, we aim to bring our academic's research in Online Deep RL to the K1, for the purpose of learning motions for kicks. Thus, in 2026 we address the following software challenges, that are focused around:

- Migrate our existing codebase for Nao V6 to Booster K1.
- Redevelop the architecture our non-ROS based codebase into a ROS2 architecture.
- Primarily use and continue development of our vision, localisation, and behaviour algorithms.
- Development of our AR tool GameSight for Human-Robot Interaction with RoboCup robots, and continue our user studies of AR and explainability for HRI.
- Training of new motions for kicking via Deep Reinforcement Learning.

2.2 Active Development and Plans for 2026

We have commenced on moving our software infrastructure and algorithms to the Booster K1 robot platform, commencing this is simulation in the 4th quarter of 2025. We received 2 K1 robots in December 2025, and as of submission, have commenced working with the hardware platform in-conjunction with simulation.

We are currently working on the following features of our code base:

- We have ported our software codebase to the Booster simulation environment in Isaac Sim. This includes integration of camera images into our vision stack, and adaption of our abstract behaviour motion commands to the K1 motion engine via ROS2 messages. We are currently integrating with the K1 robot hardware, but this is yet to be completed as of submission due to a hardware fault with our K1.
- We are currently revising our vision processing stack for use with the K1, including revising our architecture for the significantly improved K1 performance (over the Nao V6), and retraining our ML models to work with the different elements of HSL games (such as the ball and opposing robots). This includes revising our vision processing of field features to function with our multi-modal Kalman filter for localisation.
- Additionally, we are continuing our vision system overhaul which we commenced for 2025, incorporating with extensive modifications the B-Human vision library into our codebase (and offer non B-Human based teams). Our next phase is robot detection, which will require a new approach with moving to the HSL.
- We are continuing development of our robot behaviours for playing 5v5 soccer based on our learnings from the 2024 and 2025 competitions. Our current behaviours have issues in reliable execution of fundamental soccer skills, some of which was impacted by late changes with our vision system overhaul. After 2025, we have re-focus our behaviour development with a test-driven methodology to refine our fundamental soccer skills. We have developed a testing framework with standard measures against which we evaluate our soccer skills, such as measuring localisation, kick-off plays, and reliable single-robot goal scoring.
- We are recalibrating and reassessing all our robot behaviours to adapt to the larger platform, differing field sizes, and added hardware performance of the new platform (compared to the Nao V6).
- In November 2025 we concluded a preliminary user study with GameSight on the impact of AR for HRI, with 7 participants. Preliminary results are under review in a conference paper. We intend to updated GameSight based on these preliminary results, and commence a broader end-user study in mid 2026. We are currently preparing a human-research ethics review to conduct a user study at RoboCup 2026.

By the 2026 competition, we anticipate to have completed the following:

- Fully functional implementation of our software in both simulation and on the K1.
- Use our own implementations for our vision, behaviour, and localisation modules during competition.
- Develop new soccer behaviours with a focus on reliability and accuracy, developed through a test-driven methodology.
- Conduct end-user testing with GameSight during the RoboCup 2026 competition.

2.3 RedbackBots Impact and Contributions to the HSL (and formerly SPL)

Since joining the SPL, and first competing in soccer games in 2023, we have strived to actively contribute to the SPL, and anticipate continuing our contributions through the HSL. We actively believe that the league grows through all teams bringing new features to the league.

Since 2023, we have made the following contributions to the SPL:

- Developed and published GameSight, an open-source Augmented Reality (AR) visualiser of GameController information that overlays live player localisation and game state information over the top of the physical field, compatible with the Meta Quest platform. We have conducted research with GameSight into AR for HRI, with multiple published works (Sanfilippo, Zafar, Wiley, & Zambetta 2025; Rodriguez, Ellis, Killeen, Owens, Griffiths, & Wiley 2025), and a best-paper award at the HRI2025 conference.
- We have published works on the visual referee challenge (Lohani & Wiley 2023; Owens & Wiley 2024) at the RoboCup Symposium. We used this in the 2022 technical challenge, and attempted to use it in 2023 game play, though we had integration issues due to our first participation in the Challenge Shield.
- We support student Master's Minor Thesis and Honours projects (Zhen 2025; Owens 2023; Lohani 2022).
- We developed the 3D ball ramp for consistent testing as part of the 2025 SPL leader-board challenges.

- We contributed multiple software infrastructure components to the SPL. We provided a vision overhaul, integrating and simplifying the B-human vision systems outside their complex software architecture as a standalone module. We developed a simple Python 3 based behaviour decision-tree ideal for undergraduate students to build soccer behaviours. We ported our codebase to a buildable Nao V6 Ubuntu 20.04 image for the SPL, providing an independent codebase to be deployed as an independent image increases the diversity of SPL codebases.
- Since 2023, we have developed our own implementations for Ball detection, Whistle Detection, and visual referee signals, to varying degrees of success.

For 2026, we declare the following novel contributions:

- Continued development of GameSight to further our research into AR for HRI and explainability of robot behaviours, including an expanded user-study.
- Migrate our codebase to the Booster K1, and retain our independent vision, localisation and behaviour modules.
- Attempt to train a kick for the K1 via Deep RL, using simulation-to-real training in Isaac Sim.

2.4 Code Releases

Our published releases are:

- SPL 2025 soccer code release is available on GitHub¹. Our 2025 team paper is included in this repository.
- GameSight is available on GitHub².
- Our 3D printable ball ramp developed for the "KICKin-Rollin Challenge" is available on GitHub³.

2.5 Code re-use from other HSL (formerly SPL) teams

We acknowledge the following code-use as part of our RedbackBots software:

- rUNSWift 2020 code release, for the software architecture, locomotion, vision, communication, etc. Major components have since been significantly modified or replaced,
- B-Human (and Nao Devils) 2022 code release, for build and configuration scripts.
- B-Human 2024 code release for our vision system with extensive modifications.
- Nao Devils 2024 code release for whistle detection.

2.6 Lessons learned from previous RoboCup Participation

Our team primarily consists of under-graduate students, and we use RoboCup for both research and education in autonomous robotics. Our team is continuously learning (and re-learning) how to develop reliable and real-time robotics systems with a focus on autonomous software. Our key learnings from 2025 moving into the merged HSL with a new robot are:

- Discussion with many former SPL and HL teams for integrating into a new merged league, and how to work with the K1 hardware as we move away from the Nao V6.
- A prioritisation on reliable execution of fundamental robot skills, such as reliable ability to keep robots localised on the field during games, and reliably scoring goals with a single robot.
- Using a test-based methodology for testing robot behaviours.
- A focus on challenging assumptions when programming for dynamic and real-world systems.

3 Qualification Video Description

Our qualification video privately listed on YouTube, highlights our ability to meet the requirements of HSL qualification. Primarily this showcases our past SPL participation using gameplay footage from 2023-2024 at the international RoboCup events as evidence of our autonomous soccer-playing skills on a standard platform. We additionally show some of our in-progress software stack deployed on the K1.

¹<https://github.com/rmit-computing-technologies/redbackbots-coderelease/releases/tag/coderelease2025>

²<https://github.com/rmit-computing-technologies/redbackbots-gamesight/releases/tag/coderelease2024>

³<https://github.com/rmit-computing-technologies/redbackbots-spl-ballramp>

4 Team History

The RedbackBots team is a small but keen team of combined undergraduate and postgraduate students who are studying at RMIT University. The below table summarises RedbackBots participation in RoboCup Soccer.



(a) Eindhoven 2024 RedbackBots Travelling Team



(b) Salvador 2025 RedbackBots Travelling Team

Year	Participation	Results
2025	Combined Cup	11th place.
2024	Challenge Shield	3rd place.
2023	Challenge Shield	5th place.
2022	Technical Challenges	8th place Technical Challenges overall. 3rd Place Visual Referee Challenge.
2021	Qualified	Withdrew due to COVID-19 travel restrictions.
2020	Qualified	RoboCup 2020 cancelled due to COVID-19 pandemic.

RedbackBots has received the following awards in past RoboCup events.

Year	Award
2025	SPL Open Research Challenge Winner
2025	SPL Innovation Award Winner

Our team, despite our short history, has an active presence in RoboCup Leadership roles. Dr. Timothy Wiley has held various roles including RoboCup LOC (2019), Soccer HSL/SPL Executive (2024 - Present), and Soccer SPL TC (2018 - 2022). Multiple student team members have taken leadership roles including Sam Griffiths (2025 SPL OC, 2026 HSL TC), Mark Field (2026 HSL OC), and Tom Ellis (2024 SPL OC, 2025 SPL TC).

5 Additional Information

RMIT University has made a significant investment in AI and Robotics. The Artificial Innovation Intelligence Lab (AIIL), launched in 2019, is part of the strategic direction of the RMIT Artificial Intelligence Advanced Innovation Experience (RAISE) Hub dedicated to bridging the gap between AI education, industry needs, and workforce readiness by fostering interdisciplinary learning and collaboration. The RedbackBots team is a key element part of the AIIL, fostering education, research, and outreach in autonomous robotics. Additionally, RMIT University is an education partner of Amazon Web Services (AWS), in particular as one of 25 universities world-wide to partner with AWS in launching the RoboMaker platform.

5.1 Research Awards

Our team members have received the following research awards outside of RoboCup venues:

- **Best Paper Award**, alt.HRI 2025. 20th Annual IEEE/ACM International Conference on Human-Robot Interaction (HRI 2025) for Sanfilippo, F., Wiley, T., & Rousi, R. RoboCup Soccer Autonomy Uprising: How Crowds, Referees, and Humanoid Robots are Redefining the Future of Human-Robot Interaction.

5.2 Publication History

RedbackBots has built a track record of publications and thesis work. Additionally, our academic team leaders have an established track record of publications in both the RoboCup domain, and the fields of autonomous robotics, multi-agent systems, planning, machine learning and artificial intelligence.

RoboCup Related Publications

- Wiley, T. & Sammut, C. (2025). Data efficient online learning of robot behaviours via qualitative planning and reinforcement learning. *Robotics and Autonomous Systems*. 194, p. 105122. DOI: 10.1016/j.robot.2025.105122.
- Sanfilippo, F., Wiley, T., & Rousi, R. (2025). RoboCup Soccer Autonomy Uprising: How Crowds, Referees, and Humanoid Robots are Redefining the Future of Human-Robot Interaction. *2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pp. 1131–1139. DOI: 10.1109/hri61500.2025.10974154
- Rodriguez, A. I. S., Ellis, T., Killeen, B., Owens, M., Griffiths, S., & Wiley, T. (2025). GameSight: Augmented Reality Visualisation for the RoboCup Soccer SPL. *Lecture Notes in Computer Science (in press)*, pp. 1–12.
- Owens, M. & Wiley, T. (2024). Lightweight Real-Time Gesture Recognition for Dynamic Soccer Referee Signals. *Proceedings of the RoboCup Symposium*.
- Lohani, P. & Wiley, T. (2023). Hybrid Methods for Real-time Video Sequence Identification of Human Soccer Referee Signals. *Proceedings of the RoboCup Symposium*, pp. 1–12.
- Wiley, T., Bratko, I., & Sammut, C. (Aug. 2017). A Machine Learning System for Controlling a Rescue Robot. *RoboCup Symposium*. Nagoya, Japan, pp. 1–12.
- Wiley, T., McGill, M., Milstein, A., Salleh, R., & Sammut, C. (July 2012). Spatial Correlation of Multi-sensor Features for Autonomous Victim Identification. *RoboCup 2011: Robot Soccer World Cup XV*. ed. by Röfer, T., Mayer, N. M., Savage, J., & Saranlı, U. Springer-Verlag Berlin Heidelberg, pp. 538–549.
- Milstein, A., McGill, M., Wiley, T., Salleh, R., & Sammut, C. (Nov. 2011a). A Method for Fast Encoder-Free Mapping in Unstructured Environments. *Journal of Fields Robotics, Special Issue on Safety, Security, and Rescue Robotics*. 28 (6), pp. 817–831.

Student Thesis Works

- Zhen, K. Z. (2025). Learning Soccer Strategies Against Different Opponents in A Simulated Robot Soccer Environment. Master’s Minor Thesis. Melbourne, Australia: School of Computing Technologies, RMIT University.
- Owens, M. (2023). Visual Referee Signals for RoboCup Standard Platform League. Master’s Minor Thesis. Melbourne, Australia: School of Computing Technologies, RMIT University.
- Lohani, P. (2022). Visual Referee Challenge For RoboCup Soccer. Master’s Minor Thesis. Melbourne, Australia: School of Computing Technologies, RMIT University.
- Wiley, T. (2010). Autonomous Victim Identification. School of Computer Science and Engineering, The University of New South Wales Australia.

Recent Related Works

- Sanfilippo, F., Zafar, M. H., Wiley, T., & Zambetta, F. (2025). From caged robots to high-fives in robotics: Exploring the paradigm shift from human–robot interaction to human–robot teaming in human–machine interfaces. *Journal of Manufacturing Systems*. 78, pp. 1–25. DOI: 10.1016/j.jmsy.2024.10.015.
- Stiemer, L., Groves-Raines, M. M., Wood, L., Mohamed, A., & Wiley, T. (2025). Online Deep Reinforcement Learning of Servo Control for a Small-Scale Bio-Inspired Wing. *AI 2024: Advances in Artificial Intelligence*. Ed. by Gong, M., Song, Y., Koh, Y. S., Xiang, W., & Wang, D. Vol. 15443. Lecture Notes in Computer Science. Springer Nature Singapore, pp. 65–76. DOI: 10.1007/978-981-96-0351-0_6.
- Ord, S., Marino, M., & Wiley, T. (2025). Fixed-Wing UAV System for Aerial Tethered Delivery of Small to Medium Packages. *21st Australian International Aerospace Congress*. Engineers Australia; Royal Aeronautical Society, pp. 262–267.
- Ord, S., Marino, M., & Wiley, T. (2024). Modernising Delivery: A Low-Energy Tethered Package System Using Fixed-Wing Drones. *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 2271–2277. DOI: 10.1109/iro58592.2024.10802785.
- Tennakoon, R. B., Hoseinnezhad, R., Tran, H., & Bab-Hadiashar, A. (2018). Visual Inspection of Storm-Water Pipe Systems using Deep Convolutional Neural Networks. *ICINCO (1)*, pp. 145–150

- Wiley, T., Sammut, C., Hengst, B., & Bratko, I. (2016). A Planning and Learning Hierarchy using Qualitative Reasoning for the On-Line Acquisition of Robotic Behaviors. *Advances in Cognitive Systems*. 4, pp. 93–112.