The NUbots Team Extended Abstract 2025

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Lessons Learned

Leading up to RoboCup 2024, little time was spent on fine-tuning and testing the OpenCR subcontroller since it was assumed to be stable. However, instability issues were revealed to be major problems during games. Many of these issues were fixed during the competition but caused poor performance in early games. For 2025, the team will need to ensure that it allocates development time appropriately and addresses all testing issues.

At RoboCup 2024, the Visual Mesh vision network was unable to detect field lines and balls reliably and accurately due to various non-ideal lighting conditions on the field from overhead lights. This was a crucial lesson in the importance of robustness and dataset diversity in a deep learning model. The team was able to fall back on the new YOLOv8 [2] model that they had trained and integrated prior to the competition.

With the additions of YOLOv8 for object detection on top of the existing vision pipeline; a non-linear optimisation solver for localisation; and a new computationally intensive convex hull algorithm, the Intel NUC 12 units were under high CPU load while also having issues with thread usage inefficiency. Adding these components improved the robot's ability to play soccer but also introduced new problems such as robot instability that caused frequent falls. This is an important consideration moving forward.

Major Problems:

Two of the lessons learnt at RoboCup 2024 involve the vision system. Not only did it perform suboptimally by giving a considerable amount of false positives, it also caused computational issues. Therefore, a major problem the team is trying to solve for RoboCup 2025 is a robust and lightweight vision network that is well trained on a diverse dataset.

However, the vision system is not the only cause of poor computational performance. The behaviour framework avoided race conditions using synchronisation primitives, but this has been shown to result in inefficient computation. To rectify this, a smoother concurrency and parallelism framework for behaviour while ensuring maximum efficiency is required.

Although the behaviour during play has improved much since RoboCup 2023, the robots are severely limited in penalty-behaviour and complicated gameplay. This became greatly apparent in RoboCup 2024 as the team progressed further,

and the games became more complex against more competent teams.

Foot Sensors:
The team has developed a prototype for a foot with electronic force sensors This yields force-data that can be fed to a variety of algorithms for balance, stability and other kinematics-related tasks. A printed circuit board to interface with force-sensitive resistors has been made, and its firmware has also been developed and works in sending force data to the main computer.

New Subcontroller:
The team has begun replacing the OpenCR subcontroller with our new subcontroller 'NUSense'. Over the next six months, there will be extensive testing and general use of NUSense. All robots will be fitted with the new subcontroller three months before the competition. This change is to facilitate faster motor communication and more control over the device.

Computational Improvements:
The team is in the final stage of implementing computational improvements using scheduling with a dedicated thread pool to avoid race conditions in our behaviour framework. NUClear [1] has been upgraded to generate trace analysis, to audit various aspects of the system in need of computational and multithreading optimisations.

Advanced Strategy:
The team is working on logic-based strategy involving teammates and opponents. This includes penalty situations and avoiding collisions. In addition, path planning is currently undergoing major work to ensure optimal paths are chosen and best positioning is obtained to score goals or defend from attackers.

Computer Vision Segmentation:
The team is exploring improvements to the Visual Mesh and other vision segmentation networks, in an effort to consolidate the vision system into one segmentation model.

References

1. Trent Houliston, Jake Fountain, Yuqing Lin, Alexandre Mendes, Mitchell Metcalfe, Josiah Walker, and Stephan K. Chalup. Nuclear: A loosely coupled software architecture for humanoid robot systems. *Frontiers in Robotics and AI*, 3(20), 2016.
2. Rejin Varghese and Sambath M. Yolov8: A novel object detection algorithm with enhanced performance and robustness. In *2024 International Conference on Advances in Data Engineering and Intelligent Computing Systems (ADICS)*, pages 1–6, 2024.