RoboHub Eindhoven: Robocup@Work Team Description Paper 2025

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Abstract. This paper introduces the RoboHub team submission to the RoboCup@Work World Championship 2025. This papers details the current state of our robot and the team behind the robot. We give an overview of the hardware platform, the software framework and technical challenges in navigation, object recognition and manipulation. We outline present and future research interests and discuss relevance to industrial tasks.

Keywords: ROS2 · synthetic data generation · Ufactory lite6 · Groot2 behaviour tree · nVidia ISAAC AI vision · IMU.

1 Introduction

RoboHub Eindhoven is a team of motivated students, teachers and professionals that are working together to discover new solutions for robotic systems. RoboHub Eindhoven is part of the Engineering department of the Fontys University of Applied Sciences. We are challenging ourselves to find creative ways to bring robotics to the next step. Together we want to share our knowledge with other motivated people, therefore we work with companies that want to support us and our technology. Within the RoboHub Eindhoven we are participating at the RoboCup@Work league with the RoboHub team that focuses on the industrial use of autonomous robots.

We have a multi-disciplinary team of students working on the robot, where the core team is complemented with students from our Adaptive Robotics Minor and guided by experienced RoboCup coaches. Furthermore, we created an educational outreach project around our robot. With our educational outreach project we expect to inspire non-technical students to embrace technology and start learning to create and program robots and how to work with robots.

The team already started in 2017 and competed multiple times in the RoboCup German Open. At first we participated using a KUKA YouBot[1], but due to the fact that the YouBot was discontinued we started to investigate the usage of another platform. In 2018 we competed with a prototype of the Probotics Packman platform [2] equipped with a UR3 manipulator [3]. From 2019 onwards, we compete with our custom designed robot platform *Sui^2*, which is also equipped with an UR3 manipulator. Since 2021 we started the development of the new generation of the Robohub Eindhoven competition robot which we started using in the 2023 championship. In the 2024 season we competed with a slimmed down version of the 2023 robot which we developed on to use it in the 2025 season. Furthermore, we have made "Robohub Eindhoven" an official non-profit foundation registered in the dutch "Kamer Van Koophandel". This will make us able to grow further as an organisation and operate more independent.

[1] http://youbot-store.com
[2] https://probotics-agv.eu
[3] https://www.universal-robots.com

2 Description of the hardware

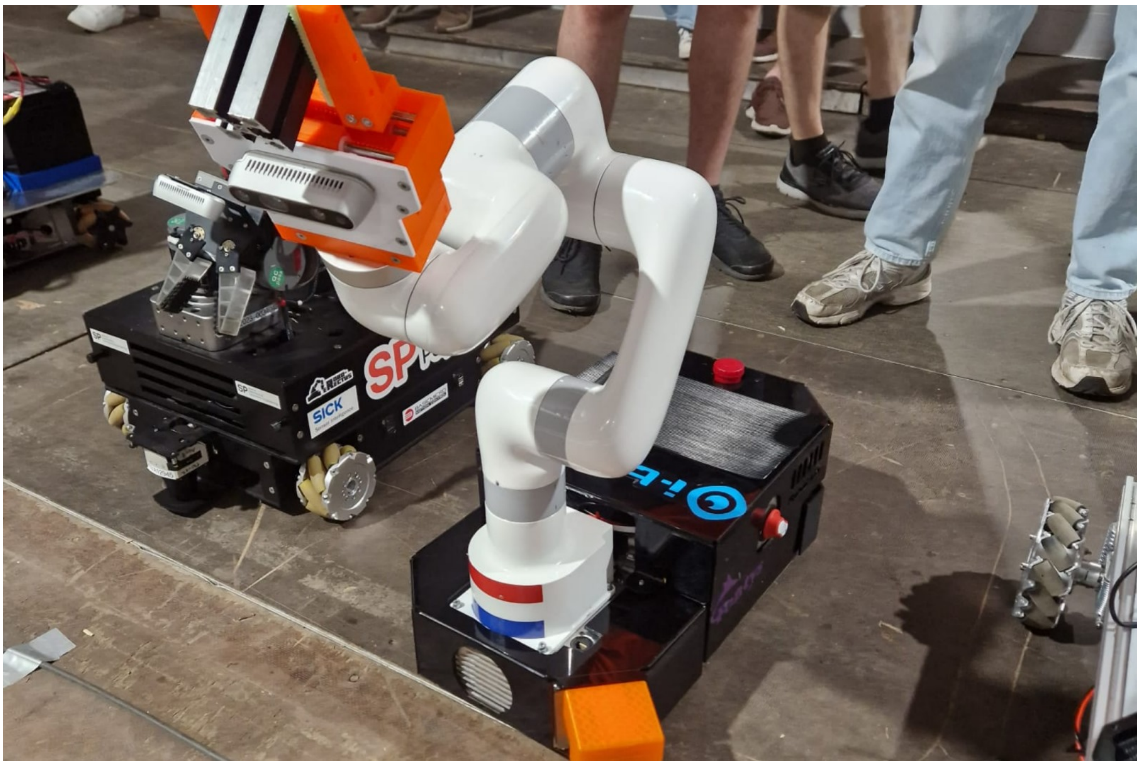

Fig. 1. SLE3K robot at the 2024 competition.

Our current robot design is a slimmed down of the 2023 robot SLICK. The name comes from mainly its slick design and it is the 3rd competition robot built by RoboHub Eindhoven. The sheet metal frame is designed in such a way so the top plate can be opened up to gain access to parts more easily. Furthermore we make use of new Maxon EC45 flat BLDC motors [4]. These motors have an integrated gearbox reduction and encoder making them perfectly suitable for the Maxon EPOS4 motor controllers. As manipulator we make use of the UFactory lite6 [5] robotic arm. We chose this arm because this arm is from very high quality at a very interesting price point. Furthermore the size and payload are perfect for the @work competition. Also, it does not require an external control box which a lot of robotic arms have, which saves a lot of space. The design of SLE3K at the 2024 Robocup is shown in Figure 1.

The robot is controlled by an nVidia jetson Orin NX from Forecr [6]. From here the complete system is controlled making the hardware as simple as possible. This specific model has a canbus connection which we use to control the motor controllers. Furthermore it has enough computing power to navigate and run our vision system.

[4] https://www.maxongroup.com/
[5] https://www.ufactory.cc
[6] https://www.forecr.io/

3 Description of the software

Our software implementation includes the high-level and low-level controls, sensor and actuator processing and monitoring software.

High-level Control: For the High-level robot control we make use of the Robot Operating System (ROS2). ROS2 [2] provides many useful tools, hardware abstraction and a message passing system between nodes. Nodes are self contained modules that run independently and communicate which each other over so called topics using a one-to-many subscriber model and the TCP/IP protocol.

ROS2 and Groot2 behaviour tree: Last two seasons we have mainly been busy rewriting our software. The reason for this is that we have decided to switch from ROS1 to ROS2. This is able to communicate with the current referee box. For this, communication between ROS1 and ROS2 was necessary and we have managed to realise this. In addition to integrating the statemachine, a basis has been made for the navigation. For this upcoming year we are making use of the Groot2 behaviour tree [7] instead of a state machine. See Figure 2 for an example. This packages helps with making small adjustments very easy, aswell as making the step into programming the functionality of the robot very easy for new team members. Furthermore, the logging feature is very helpful for debugging and making sure the robot works optimal. We have partnered up with them to recieve PRO licenses to find out if this is something for our team and maybe in the future for the @work competition.

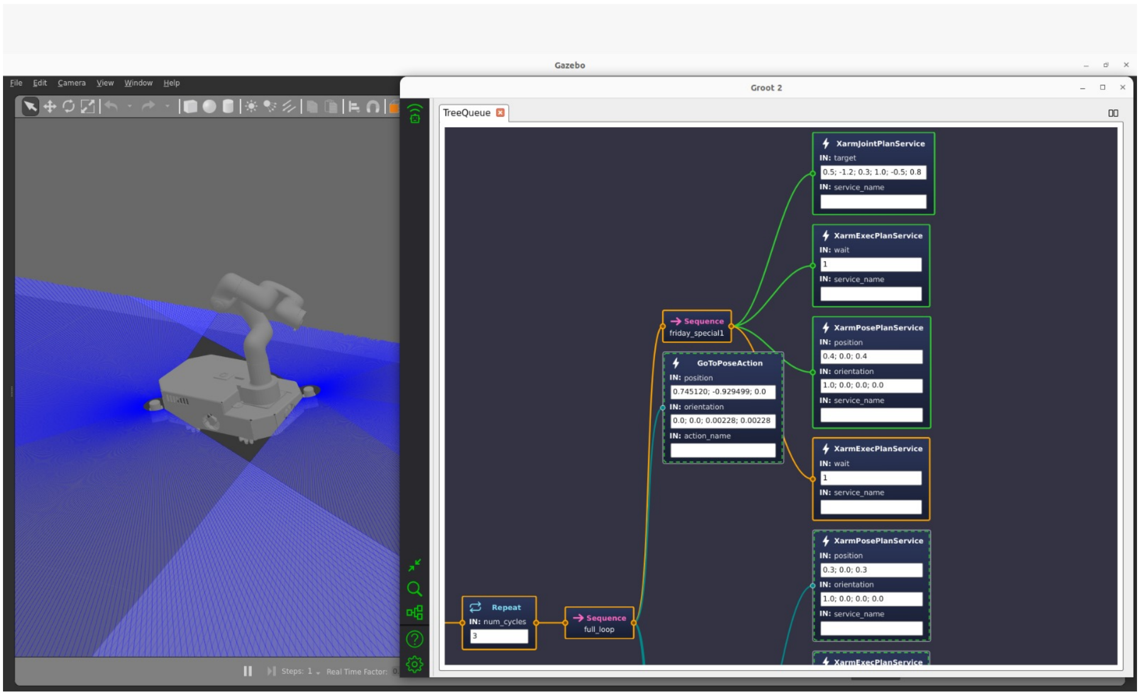

Fig. 2. Groot2 behaviour tree example.

[7] https://www.behaviortree.dev/groot/

Field Oriented Control: Field oriented control (FOC) is a method to control three-phase motors such as the brushless DC motors used in Sui^2. Unlike regular brushless DC motor drivers, FOC drivers control the motor windings with sinusoidal currents witch will get rid of unwanted torque ripples. By keeping track of the rotor position, the torque applied on the rotor will always be maximal as the magnetic field is adjusted to the position of the rotor. By tracking the position of the rotor, the currents in the motor windings can be reduced to the absolute minimum and higher currents are only applied when needed. This results in a stable and coordinated behavior while keeping the current consumption and heat development in the motors at a minimum. The FOC algorithm used in our platform provides a closed loop PID-controller including a third order position profile while accelerating and decelerating. All these properties are ideal for being used within an Autonomous Guided Vehicles as they lead to a precise position control and energy saving behavior of the robot.

Containerization: As of this year we are making use of docker [8]. This helps us with version management and making sure everyone is using the right packages and versions of them.

Localization and Navigation: For localization, SLE3K uses two Hokuyo lidars. The raw lidar data is processed within ROS to perform robust localization. Currently SLE3K uses nav2 MPPI [9] which is a successor to the TEB planner. This package is making us able to control it also very easy as a omnidirectional robot. Furthermore, low level smoothing of the acceleration profiles is implemented to make the robot more controllable. Lastly, we also implemented an IMU sensor to improve movement accuracy and helping with navigation in general.

nVidia ISAAC AI vision: This year we start using the nVidia ISAAC IA vision package [10]. Since we are using an nVidia Jetson Orin NX the implementation of this package is also very straight forward. The reason we chose this is because the input in the system is a 3D model and not a 2D only. This also makes us able to determine the distance of the object to the manipulator more easily while also getting a very stable detection and classification result.

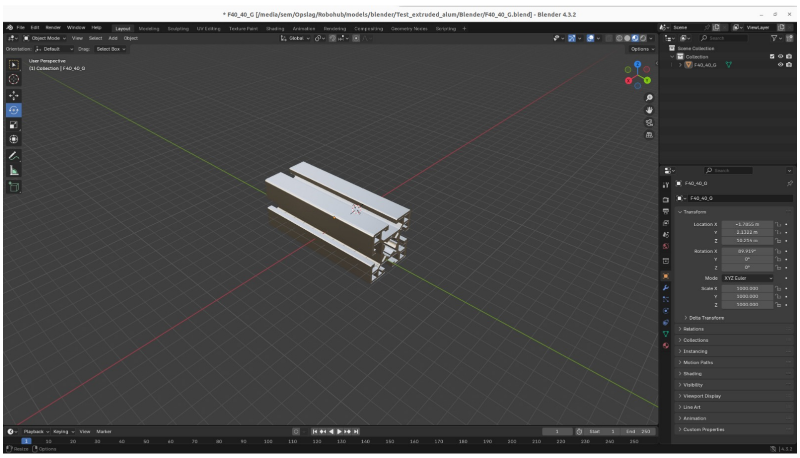

Fig. 3. ISAAC AI vision.

[8] https://hub.docker.com/
[9] https://docs.nav2.org/configuration/packages/configuring-mppic.html
[10] https://developer.nvidia.com/isaac

Barrier detection: We have also developed barrier tape detection which is able to the detect the line on the ground and transfer the location into the coordinate system of the robot. This will be detected by the main camera attached to the gripper of the robot. This one will point to the ground while driving. Currently the plan is to only detect the lines in the driving direction. Our robot does also sometimes drive backwards so a camera on the back might be needed as well but for now we've constrained this development to one camera.

4 Focus and Relevance

There are a wide range of industrial applications for autonomous mobile manipulation, we focus our education and research mainly on the manufacturing and logistic domains.

Industry: We contribute to the ambitions of the Dutch smart industry [11] agenda. We collaborate with several companies where we use our platform as a showcase to explain how logistic and manufacturing companies can benefit from mobile robots in their warehouses and factory floors. We are also involved in research project that are funded by the dutch government and are in close collaboration with industry partners. Such a project is the 'Fieldlab Flexible Manufacturing' where mobile manipulating robots contribute to a flexible manufacturing line by delivering parts just on time at the specific (automated) assembly stations, where all these tasks are strongly related to Industry 4.0 [5].

Research: Our current and future research aims at multiple directions, we aim to have adaptive multi-robot systems that are able to autonomously operate in these complex and diverse environments. Think of industrial tasks where multiple robots navigate in a single warehouse and collaboratively transport the required parts in an optimal way, where robots exchange products during transport. We also are focusing on smart/dynamic path-planning, based on the robots experience. Here high and low level traffic rules can not only be pre-programmed, but also should arise on given knowledge of the environment. Furthermore, we work on a set of robot-safety related issues, as on the natural interaction between humans and robots.

First step in automation:
Taking the first step in automation is a difficult and often can be a scary step to take if you don't know where to begin. We want to make this first step more accessible with small projects by advising companies and by possibly providing a pre-study, a proof of concept or by executing experiments. This can be done a lot cheaper and a lot more accessible than with a big company. The result of this will be constrained to the 'first step'. After this process we will suggest companies which we have gotten to know over the years who could execute the following steps in automation.

Education: First of all we use this competition to motivate and challenge our engineering students to achieve a higher and more professional level in their engineering education. By performing such a project the students get highly motivated, apply their knowledge and push their boundaries to acquire new knowledge to solve the given problems. The team is currently also employing interns and 3 different project groups. Currently we are also working to competing in the 2026 robocup in the SSL league. The first prototype of these robots have been made and are being developed upon currently.

[11] https://www.smartindustry.nl/english/

Fig. 4. SSL robot prototype.

5 Future work

For this year we need to finish;

- The newly developed 3D vision based on the ISAAC AI vision.
- The newly developed barrier tape collision avoidance.
- Implement the Groot2 behaviour tree.

Besides this there are also some hardware topics that require attention;

- New gripper design
- New hardware layout and wiring
- New AGV cover design
- New suspension system

We are planning to publish details on this robot in the summer period and we are happy to answer all question regarding this project. Also if teams need help with the development of their own platform, we are happy to help!

Online Material: Video's of our platform in action is available at our YouTube Channel [12]. Additional team information can be found at our RoboHub website [13]. Furthermore, all software will be published on the teams GitHub [14] page.

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[14] https://github.com/robohubeindhoven