Description of Team Solidus 2025

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Abstract. The solidus team has been playing in the RoboCup Logistics league for many years and is currently working intensively on improving its solution integrating modern AI vision, navigation, obstacle avoidance, and planning and scheduling methods into its architecture. In the German Open 2025, it played with 2 robots for the first time and reached place 2.

Keywords. Client-server, AI planning, scheduling, autonomous robots.

1 Introduction

This paper is part of the qualification process to attend the RoboCup 2025 in Brazil. The paper is organized as follows. Section 2 provides the description of the participating institutions. Section 3 presents the Didactic Concept. Section 4 provides the description of the Team Solidus. Technical Details in Section 5 and finally Section 6 presents the history of the team.

2 Involved Schools

As a technical college, HFT Midland offers education with practical relevance. From the co-operation with the industry and a broadly supporting sponsorship emerges a constantly up-to-date outline of the profession of technicians in the subject areas of machinery construction and systems technology. In this way the close connection to the employment market is secured. Our outline of profession is characterized by competence and the ability to develop solutions for specific problems. HFTM offers state-of-the art laboratories of machinery construction and systems technology to students with the possibility to transfer their theoretical knowledge into professional practice.
With over 1300 students, the computer science department of HSLU is one of the largest educational institutions for computer science in Switzerland. The AI Robotics research lab works at the intersection of AI and robotics with a specific focus on multi-robot navigation, human-robot interaction, and optimization of logistics, production scheduling, and planning.
Both partners bring in complementary expertise:
HFTM Biel: hardware (including full equipment of 200K CHF to play in Robocup), communication protocols, physical object manipulation, industrial know-how)

HSLU AIR: mobile robot navigation & localization, ROS, AI planning & scheduling, software architecture.

Fig. 1. Machinery construction lab

Fig. 2. Automation technology lab

3 Didactic Concept

Our concept of education was specifically adapted according to the implementation into the professional practice mentioned above. Our theoretical sequences are always short and appropriate. Immediately consequent upon the theory the trained elements are implemented into software and/or realised in a physical device. (Sensors, actuators). Based on different evaluations we took our decision for the Robotino by Festo, which is especially appropriate with all its hardware components. The visual feedback with a real movement of a robot is ideal and appeals to the different skill levels and learning styles. This combination also fits the demands of industry 4.0, which is a main topic of our education concept.
In this way, the base of digital technology is already trained with the bloc based programming language RoboView. Subsequently the course follows: Base of programming in the code based world with JavaScript and some excursions to self-made blocs with Phython. The new concept with the separation of gripper and motion, forces the students to think about communication interfaces between different partners, such as PLC's, axes-controllers and microcontrollers. Classic TCP communication such as specialized Industrial M2M Protocols like MQTT, OPC-UA are topics of these studies.
In the area of specialisation ICT, the course «Object Oriented Programming» and «Algorithms» follows, and afterwards the Logic of the game and the logistics will be programmed entirely with Java. At the same time the Linux-course is starting, which bases on the operating system of the Robotino's basic board. With this know-how, the students start the work on the RoboCup project. There are two modules to the student's disposal with 80 lessons each, the process-oriented engineering and the process module with the implementation.

4 The Team Solidus

The HFT Midland provides their second-year-students the opportunity to practise on the topic of robots. For that purpose, Team Solidus was founded in the year 2013.

The team aims to provide the opportunity to ambitious students to deepen their knowledge in the field of robotic engineering and programming. During their study the students can already work on robots practically. The obtained knowledge is necessary to continue developing with the three Robotinos of Festo as well as to adapt them to the professional practice and modify them.

With the means of suitable hard- and software, the robots should be able to move in a certain space autonomously as well as to place objects and find them again.

The ultimate goal of the RoboCup Project is to use the learned technology in a comprehensive practice project and to experience the real problems in the hardware world.
The involved peoples in the implementation are exclusively students and our approaches are usually pragmatic but **solid** and not experimental, unproven research or highly mathematical. Therefore, the competition with universities is a very ambitious aim for us.

5 Technology

5.1 Software

In 2022 we completely reworked our software solution and only kept the gripper subsystem. We follow a client-server approach with the robots being autonomous clients responsible for workflow execution, navigation and obstacle avoidance, as well as machine operation. On a centralized server, we keep a digital twin of the factory, the

planner and the scheduler. We also developed a virtual test system to be able to thoroughly our solution. All our components integrate via messaging based on MQTT.

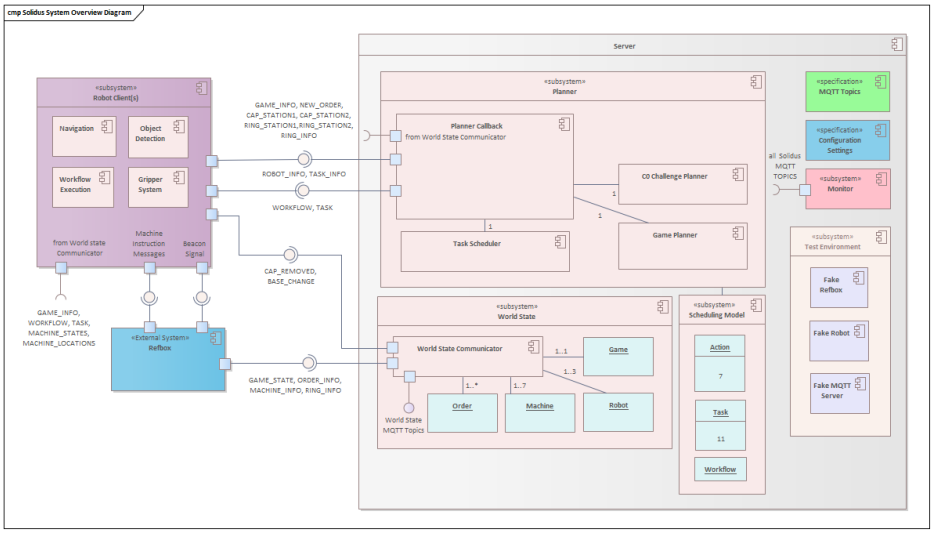


Fig. 3. System Overview Diagram

The robots are equipped with an additional camera for reliable Aruco marker detection and run several Ubuntu systems to be able to implement our code using ROS 2.

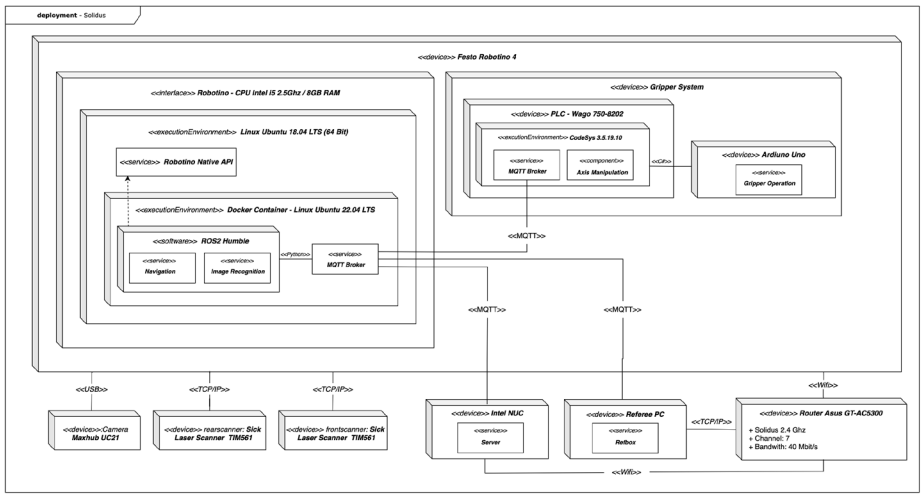


Fig. 4. Deployment Diagram for the robot client(s)

Fig. 5. Solidus System Architecture with HSLU<->hftm Interface

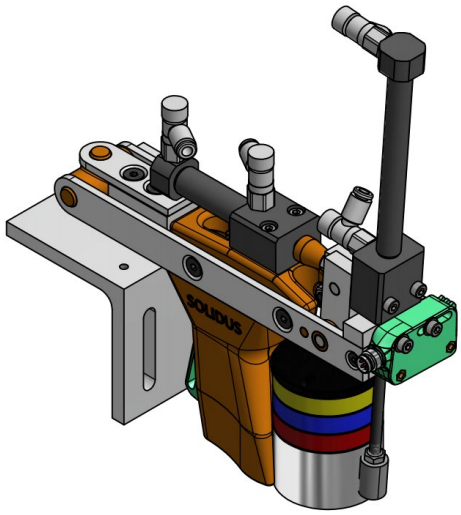
5.2 Hardware

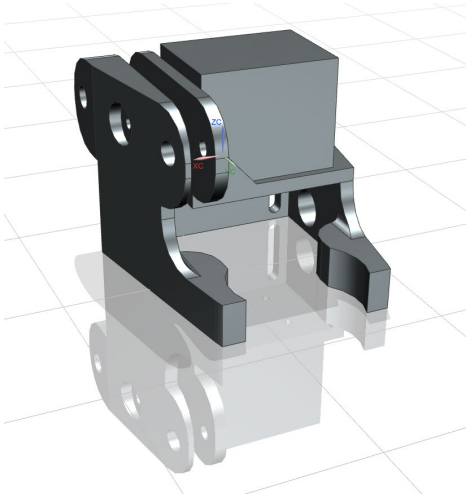
Gripping has always been one of our strengths. (In 2016 we won the Technical Challenge in gripper design). This is certainly due to the nature of the training, as we train practical mechatronics and mechanical engineers. Also on the initiative of the new students, we

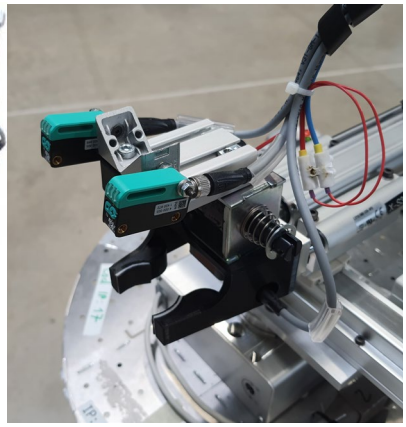
ventured to redesign the gripper this year. The pneumatics of the holding mechanism were replaced by a lifting magnet. Now our gripping process is even faster and more flexible to grip from different directions.

For that we use 3 electrical axes which are able to adjust the gripper to the right position, even when the Robotino doesn't stand correctly in front of the station. The three axes are controlled by a PLC and 3 motion-controllers. The sensorial part of the gripper is made by several optical captures over the IO-Link protocol

Figures 6-9 Selfmade grippers one (left) new one [old and (right)]





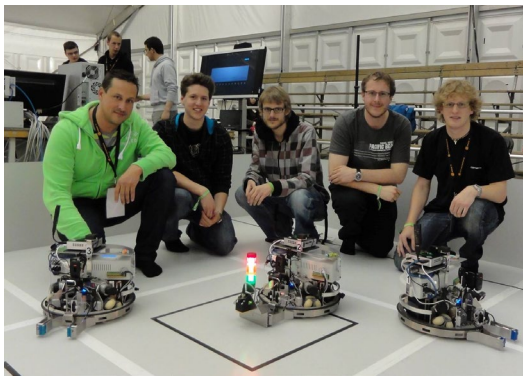


6 Solidus' RoboCup History

6.1 Progresses and Successes

Year/Competition	Major Topic / Change	Rank
2014 / João Pessoa	RobotinoV2 with NFC Puck "Hockey" Game	5
2015 / Hefei	RobotinoV3 / New Refbox Comm / simple rectangular drive system in java / Exploration	2
2016 / Leipzig	New Concept with MPS Stations / Self constructed electropneumatic gripper	2
2017 / Nagoya	New Field, Zones adaptions, simple drive system in java	3
2018 / Montreal	New Drive System and Map Routing	5
2019 / Sydney	New PID Drive, Map and Routing Visualisation	4
2020 / Corona	Entry Challenge with different Skills/Levels / D-Star / Proxmox Robotino Setup / Spectator-AR / Aruco-Tags	-
2021 / Biel Online	Robotino V4/Rest-API/Challenge Implementation/New self made Laser/Localisation Library/Remote Competition	3
2022 / Bangkok	New from scratch with Low-Code Tools:(RoboView/Node-Red/Challenges/New magnetic gripper.	3
2023 / Bordeaux	New collab with HSLU, ROS drive, navi-&localisation, MPS-Approach with RoboView/3D-printed Gripper/Servo	3
2024 / Eindhoven	Collab HSLU (lead), ROS 2 (drive,map,nav,local). Dynamic planner. Gripper optimisations, consistent MQTT Communication, client-server architecture	3

6.2 Teams



2013 Eindhoven

2014 Joao Pessoa

2015 Hefei

2016 Leipzig

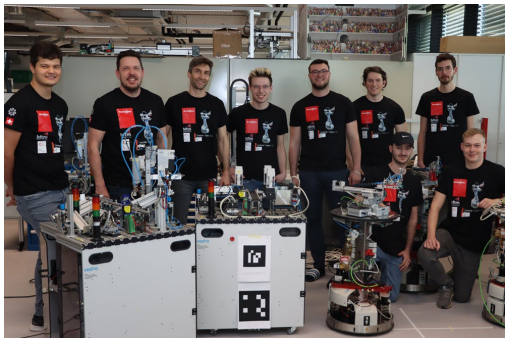
2017 Nagoya

2018 Montreal

2019 Sydney

2020 (no RC)

2021 (VCR-RC)



2022 Bangkok

2023 Bordeaux

2024 Eindhoven

7 Rulebook Confirmation

We confirm that our 3 robots, all software systems and the behaviour of the robots and team members will satisfy the requirements and rules given in the RCLL Rulebook 2025.