Description of Team Solidus 2023

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Abstract. The aim of this paper is to describe our institute and our Team Solidus. Instead of a big technical research approach, we put the emphasis on the didactic concept including the Robotino integration in the classroom, entry challenges and finally some of our special technical solutions.

Keywords. Solidus, didactic, classroom, robotino, Java, iot, mqtt, roboview, robosim, opencv, Industry 4.0, PLC, gripper, challenge

1 Introduction

This paper is part of the qualification process to attend the RoboCup 2023 in Bordeaux France. The paper is organized as follows. Section 2 provides the description of the Technical Institute of Applied Science HFTM. 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, the 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, namely by the ability to develop solutions for specific problems.

During the study the HFTM offers their students in the state-of-the art laboratory of machinery construction and systems technology the possibility to transfer their theoretical knowledge into the professional practice.

This year there is a cooperation of HFTM Biel and Hochschule Luzern - Informatics. 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 Informatics: mobile robot navigation & localization, ROS, AI planning & scheduling,software architecture.

Fig. 1. Machinery construction lab

Fig. 2. Automation technology lab

After two years of full-time study, our qualified technicians are already fully steeled for new professional challenges thanks to their practically orientated education. In comparison to other educations on the tertiary level they reach an extremely high state of practical training and applied education. Our full-time program for technicians in automation is unique in Switzerland.

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

Since the code base has grown since 2015 and our students are only in RoboCup for one year, there is not enough continuity. The training quality and the reusability thus depends on the cleanliness of the code and the documentation. This is usually not the strongest skill of technicians, especially if they have just freshly learned programming.
Thanks to the new challenges which would make a redesign necessary anyway, we decided to start this year from scratch again.
Now our new approach is to use low-code tools as much as possible. So we now choose RoboView's stable and controlled algorithms for driving, gripping and AR-Tag-Recognition.
For communication, data conversion, visualisation and service control we use node red, a prototyping tool, which is very agil and flexible.
The game logistic master agent and the robotinos services are programmed in Java.

To facilitate the modular and distributing development, all elementary subcomponents communicate over OPC-UA, MQTT, REST or ProtoBuf.

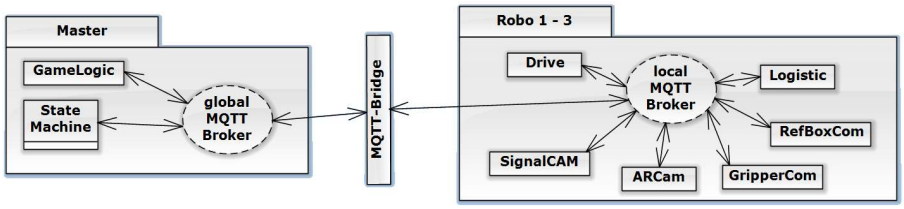


Fig. 3. Communication diagram

The localisation and positioning is mainly based on odometry, with small corrections resulting from the IR-sensors and the AR-Tags. Environmental recognition and edge detection is made with Douglas Peucker and Ransac algorithms.

To avoid the obstacles, we use a dynamic map with static machines and temporary robots. For path and logistic planning, we have further algorithms (A*).

This year we will also develop a full visualisation of the Game field and the events on it. So far we are not finished yet and cannot show anything in this paper yet.

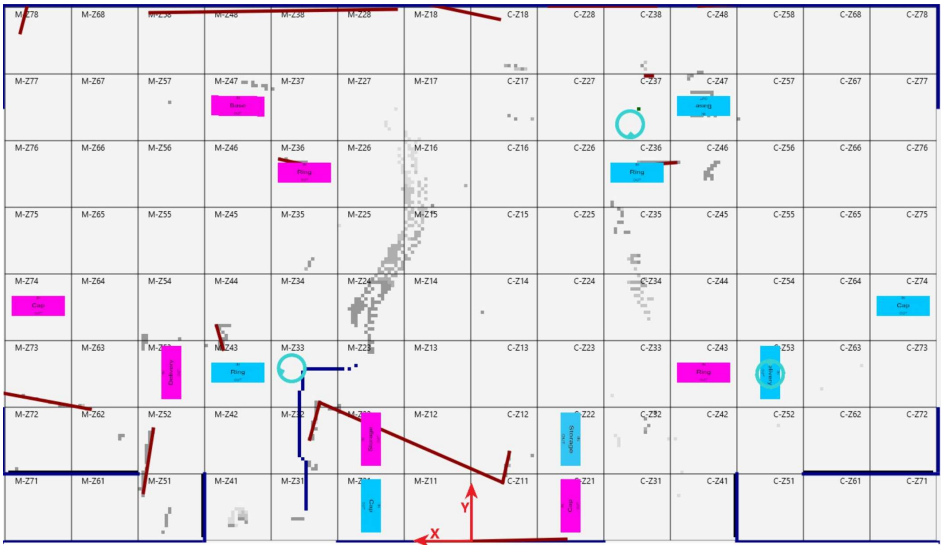
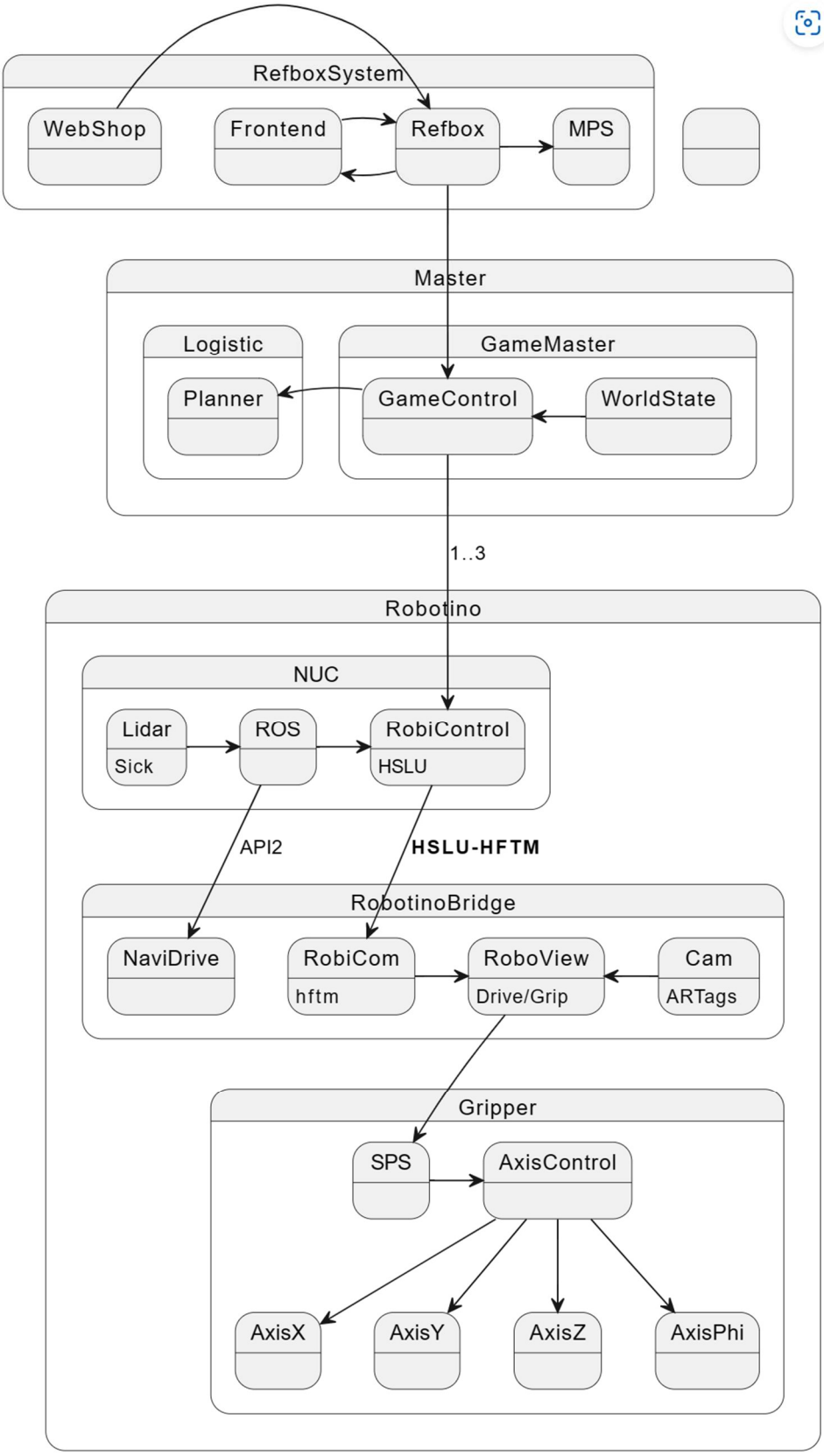


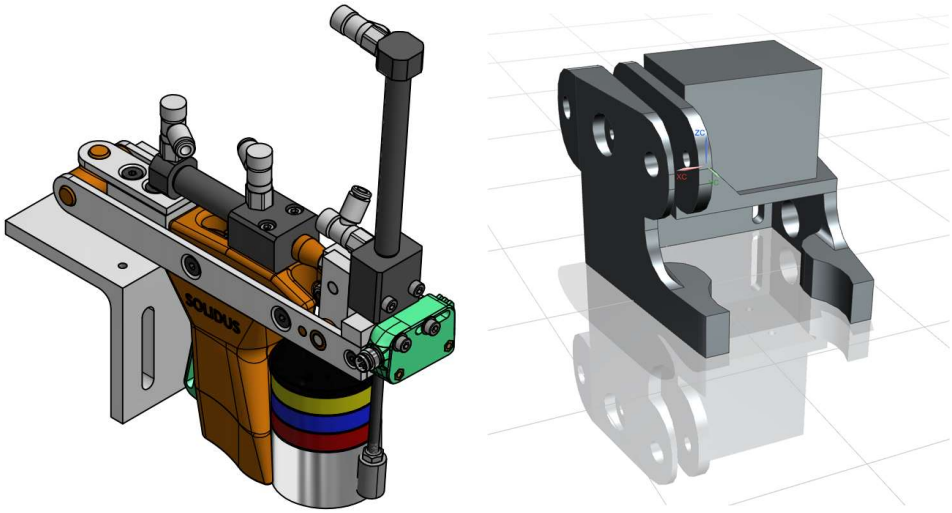
Fig. 4. Environment recognition(2021, now replaced with ROS (not yet finished)


RefboxSystem
WebShop
Frontend
Refbox
MPS
Master
Logistic
Planner
GameMaster
GameControl
WorldState
1..3
Robotino
NUC
Lidar
Sick
ROS
RobiControl
HSLU
API2
HSLU-HFTM
RobotinoBridge
NaviDrive
RobiCom
hftm
RoboView
Drive/Grip
Cam
ARTags
Gripper
SPS
AxisControl
AxisX
AxisY
AxisZ
AxisPhi

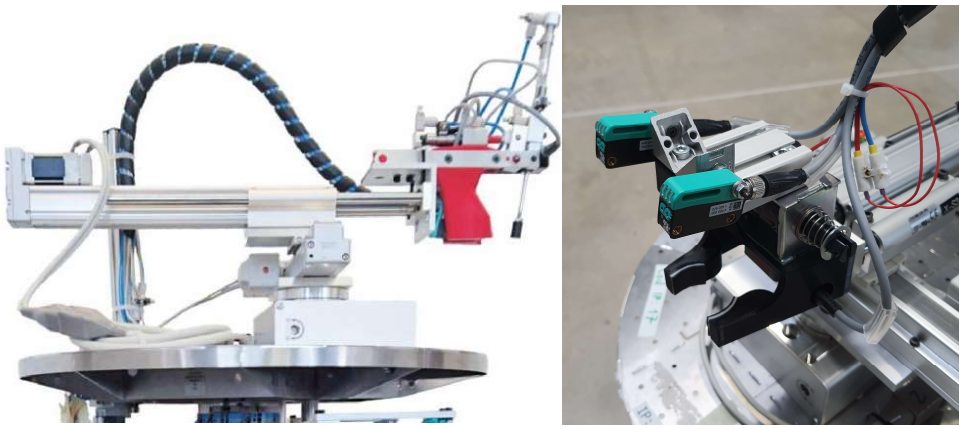
5.2 Hardware

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 [old one (left) and new one (right)]

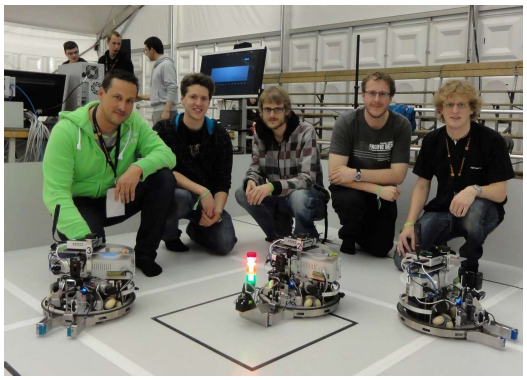


6 Solidus' RoboCup History

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

6.2 Teams



2013 Eindhoven

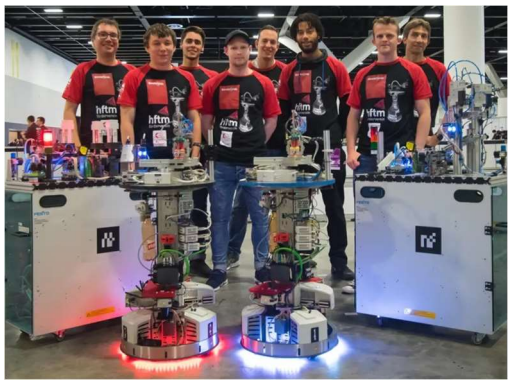
2014 Joao Pessoa

2015 Hefei

2016 Leipzig

2017 Nagoya

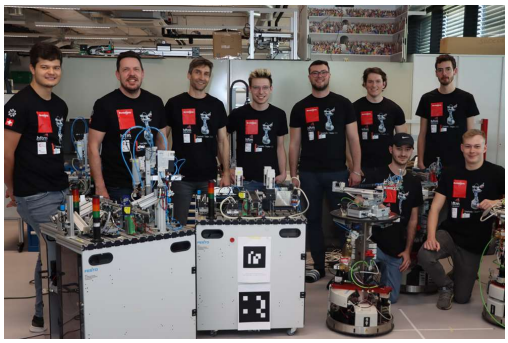
2018 Montreal



2019 Sydney

2020 (no RC)

2021 (VCR-RC)



2022 Bangkok

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 2023.