RoboCup@Work 2016 TDP- Team RobOTTO

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Abstract. TeamRobOTTO is a student-organised team from Otto-von-Guericke University Magdeburg, formerly participating in the Robocup Logistics League since its founding in 2010 and now participating in @Work since the GermanOpen 2015. We hope to utilize the different viewpoints of CS, Electrical and Mechanical Engineering students to solve @Work's unique challenges while fostering knowlegde exchange between the different mayors.

Keywords: RoboCup@Work, Team RobOTTO, RoboCup2016

1 Introduction

RobOTTO was founded as a Robocup Logistics Team in 2010 by 9 students from different mayors, enabling an exchange of knowledge and approaches between the members. Reaching second Place 2010 in Singapore the team continued to attend each following RoboCup, with further successes in 2012 (4th Place) and 2013 (2nd Place). In 2012 a first attempt at a second competition resulted in an 8th Place in the 2D Soccer Simulation League. With regards to broad rule and equipment changes in the Logistics League 2015 we decided to participate in @Work, as the required KUKA YouBots were already in use by our CS-Department, thus providing a pool of already experienced students and facilitating easy integration into courses and research projects.

2 Team Structure

2.1 Members by Mayor

- Mechatronics
  - Martin Seidel - Head of Development
  - Hauke Petersen - Pathplanning and Motion
  - Finn Süberkrüb - Custom sensor integration
  - Kai Rüssel - Arm Kinematics, CAD-Design
  - Jan Hintz - URDF-Modeling

- Computer Science
  - Kai Seidensticker - Refbox and Statemachine
  - Philipp Busse - Networking , URDF-Modeling
  - Juliane Höbel - Object Recognition
  - Lukas Hoyer - Object Recognition
- Logistics
  - Lea Pusch - Organisation, Logistical Analysis
- Electrical Engineering and Information Technology
  - Nils Harder - Gripper and Electronics
  - Rodion Marynych - Object Recognition
- Cybernetics
  - Magnus Jung - Object Recognition
  - Johannes Kopton - Object Recognition

2.2 Team description

Currently the Team consists of 13 active members, with a total of 25 since its founding in 2010. A new generation of students began working on the project in the last couple months, focusing on the problems of object recognition. Most of last years participants remained in the Team and continue to refine the work started last year after the switch to the @Work league, in Julianes and Kai's case in connection with their masters and Bachelors theses, respectively.

3 Robot Description

As we plan to participate in RoboCup@Work we are using the KUKA YouBot which proved it's capabilities in the last 4 Years and was also already in use within our University. While developing on the Robot some flaws of the standard Equipment surfaced which we will try to remedy by modifying and exchanging components with COTS Hardware to save on costs.

3.1 Changes to the standard Platform

Sensors We decided on using an Intel Realsense RGB-D camera which provides us with registered pointclouds at close range as well as an normal RGB-Image. Our current focus lies in a better utilisation of both to improve our detection of Objects in bad lighting conditions or with reflecting surfaces interfering with the structured light providing the depth information. Due to last years experiences we decided to increase our focus on the RGB-Data, as the depth-information provided by the Realsense Camera proved to be highly dependend on object angles and lighting when trying to image smooth surfaces e.g. the Aluminium Parts.

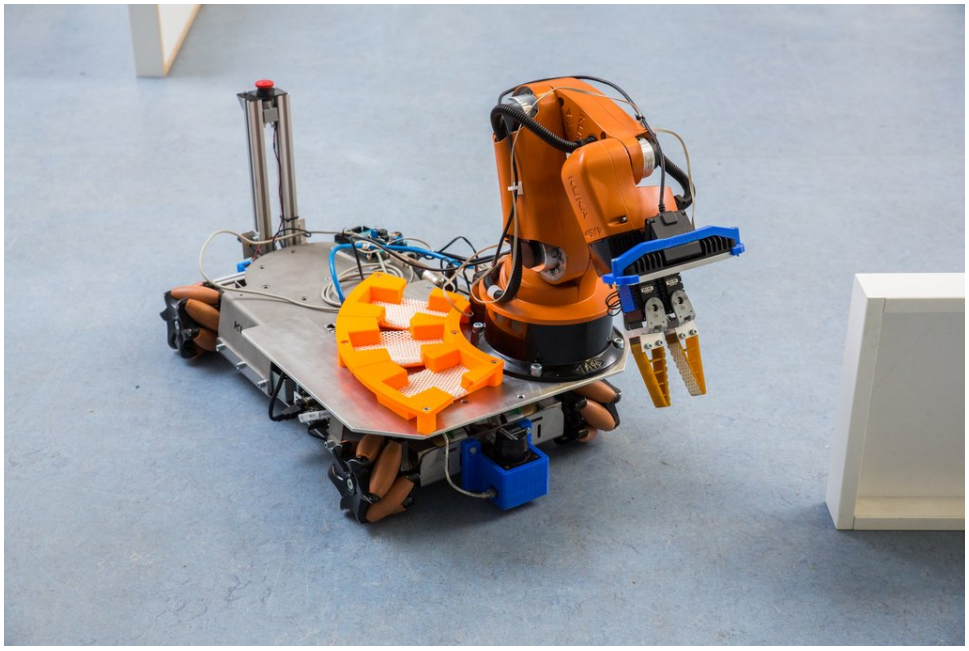

Fig. 1. Modified KUKA YouBot

Gripper Objects in @Work have varying shapes and sizes and early testing showed that the normal metal gripper on the KUKA YouBot is quite difficult to use with many objects. Our current gripper is based on an custom 3D-Printed holder with Servomotors from Dynamixel and Finray-fingers, which are controlled through an Arduino. Current developments focus on correctly identifying and handling error cases like the loss of an Object and improving the grasping of not perfectly aligned objects.

Computing An i7 NUC was fitted into the robot as an replacement for the original Atom-based computer, to enable the usage of more complex algorithms and parallelisation of processes (for example Vision and Arm Movements). Additionally an Arduino was fitted to the chassis to enable the usage of cheap sensors popularised by the DIY-Community and provide a stepping stone for students unexperienced with programming to experiment without needing the whole development stack used on the main robot.

Laserscanner Mounting Brackets Realiably adjustable mounting brackets were designed and 3D-Printed by the team to prevent tilt errors even at the edge of the URG-04LX's measurement range and shield the expensive sensors in the case of accidental collisions.

3.2 Future Modifications

Batteries and Power Supply We originally planned to replace the batteries and powersupply completely for an lithium-ion based system, but the experiences gathered while transporting batteries by plane for last years WorldCup in Hefei put a stop to that plan as Lithium-Batteries in the required size are not allowed to be transported on passenger planes without special permits. Our alternative solution for the mid-term will be to replace the internal charging circuit to enable full capacity charging and prevent the all to often deep discharge of one battery cell which seems to be caused by the control-panels power draw even if the robot is turned "off".

Additional Sensors mounted above the tables Finn is currently testing linear distance sensors mounted above the normal table-height to enable rudimentary collision avoidanve between the manipulator Arm and the Environment. If the tests prove successfull it is planned to use the Pointcloud data of our Realsense sensor in conjunction with the Trajectory planning implemented in the MoveIt stack to enable gripping in obstructed spaces (near shelves, the edge of the arena etc.) without the need to hardcode all possible combinations.

4 Current Software Projects

4.1 Path Planning for industrial robots

The goal of this project is to analyse and evaluate the most important approaches for path-planning (for example: potential field method, relative velocity diagram, dynamic window approach etc.) in order to fulfil all requirements for the RoboCup Logistic League and @Work contests. Since there were changes in the rulebook of RoboCup Logistic League regarding the playground and the expanding of the RobOTTO Team to @Work it is necessary to change the navigation and path calculation. The current navigational stack is mostly based on the standard ROS Nav-Stack with small changes to the Global-Planner plugin and an completely rewritten local planner focused on fast and predictable movement and an understandable codebase. Current developments focus on ways to enable the detection and avoidance of barrier tape without reducing the robots speed too much.

4.2 Flexible State Machine for automatic Task Planning

Kai S. works on a flexible framework for finding an optimal task and worker structure to solve complex industrial use cases like @Work. For this mission he uses a modular Statemachine to connect the functional submodules present on the robot and works on a dynamic taskplanner to reduce redundant actions when the robot has to solve multiple tasks. In this context the interfaces between the different modules programmed by different Team Members will have to be changed to fit into the new software architecture.

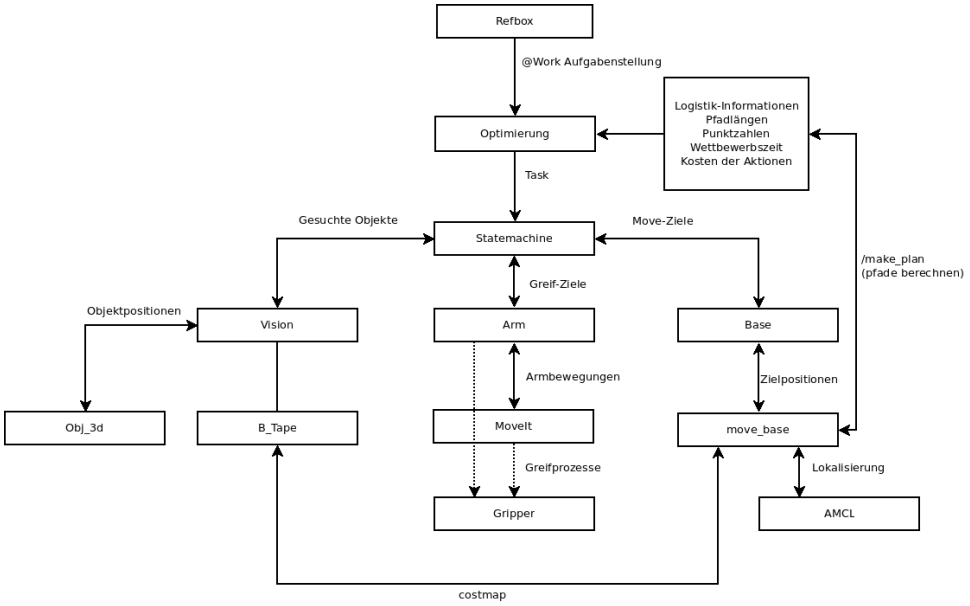

Fig. 2. Currently Planned Architecture

4.3 Integration of the MoveIt Trajectory and Kinematics Stack

The current Kinematics-Package for the Manipulator Arm used by the team, SAMIA, was built by former member Stefan as an byproduct of his Masters Thesis and subsequently adapted for the @Work competition. But with Stefan gone we now face problems maintaining and extending the codebase, as it grew naturally together with it's creators understanding of ROS and Object-Oriented programming. Due to these factors we decided to try to integrate the OpenSource MoveIt stack into our system as an replacement and are currently working on the logic connecting the task-planning interface with our internal state machine.

4.4 Alternative Algorithms for Object Recognition

Most of our new members are busy experimenting with different approaches for object recognition with the goal of enabling the robot to be able to use a diversity of algorithms when evaluating the vision data. In that context Rodion and Johannes are working on algorithms using the 2D-RGB data, Juliane is refining her work on the PCL-based detection and Lukas is working on the logic combining the different algorithms.

5 Conclusion

With the influx of new team members and the continued participation by last years members we are cautiously optimistic that we will be able to build upon

the work done last year while cleaning up the kruft left by frantic developments during the WorldCup. While the new developments started this year might not be as stable as more standard OpenSource or COTS solutions we believe that our educational focus on self-implemented solutions will be a boon for the members personal development even if it dampens our competetiveness in the short term.

Acknowledgment

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