

UvA@Work Customer Agriculture Order



Intelligent Robotics Lab
Faculty of Science
University of Amsterdam
The Netherlands



Mid-Term Report

Sébastien Negrijn

Janosch Haber

Stephan van Schaik

Arnoud Visser

<http://staff.science.uva.nl/~arnoud/research/atwork>

January 31, 2014

Abstract

The goal of the UvA@Work team is to demonstrate that the KUKA youBot platform is capable of performing a Professional Task as defined in the Field Robot event 2012. This task specifies a robot that retrieves a flower as ordered by a customer. For this task three key components are required: Human Robot Interaction, Path Planning and Manipulation.

1 Team description

The Intelligent Robotics Lab (IRL) is an initiative of the University of Amsterdam (UvA) which was founded to coordinate the efforts of the robotic teams of the university. It acts as a governing body for all the robotic teams of the university, which participate in various leagues of the RoboCup and the International Micro Aerial Vehicle Competitions. This initiative will enable collaboration between the teams, as most state-of-the-art techniques in the field of Robotics can be applied in many applications, although every time in a slightly different manner. The IRL arose in 2012 from the Dutch Nao Team, when students wanted to apply their experience in socially more relevant applications.

Experience

The University of Amsterdam has been active in the RoboCup since 1998 in form of varying teams such as the Windmill Wanderers, Clockwork Orange, Dutch Aibo Team, the Amsterdam Oxford Joint Rescue Forces [1] and the UvA Rescue Team [11, 10].

Currently the Intelligent Robotics Lab (IRL) is active in three competitions. Next to the @Work competition, the Dutch Nao Team is active in the RoboCup Standard Platform League and the Amsterdam Oxford Joint Rescue Team is active in the RoboCup Rescue Simulation League. This section briefly describes the origin of these teams and their achievements. Overall, however, the main focus of the robotics teams is to write intelligent software to create smart applications.

Dutch Nao Team The Dutch Nao Team was founded in 2010 by several Artificial Intelligence students in order to participate in the RoboCup. RoboCup is an international research and education initiative, attempting to foster Artificial Intelligence and Robotics research by providing a standard problem where a wide range of technologies can be integrated and examined, as well as being used for integrated project-oriented education. The Dutch Nao Team competes in the Standard Platform League, which is a RoboCup robot soccer league, in which all teams compete with identical robots. The robots operate fully autonomously, i.e. there is no external control, neither by humans nor by computers. The current standard platform used is the humanoid NAO by Aldebaran Robotics.

The team consists of Artificial Intelligence Bachelor and Master students, supported by senior staff-member Arnoud Visser. Since it was founded in 2010, it participated at several events and published on several occasions¹. This year, the Dutch Nao Team will participate at the Iran Open 2014 and is one of twenty teams selected for the 2014 World Championships in Brasil [4].

Amsterdam Oxford Joint Rescue Team The University of Amsterdam is active in the Rescue Simulation League since 2003 in Padova [9]. In 2006 the first Virtual Robot competition was held, which directly resulted to the Best Mapping award [8]. The team from Amsterdam started a cooperation with Oxford University in 2008, which continued for 4 years [1]. In 2012 the team operated again under its original name; the UvA Rescue Team [11].

During those years the team won several prizes, published a number of journal articles, book chapters, conference articles and theses. It's approaches are described in the yearly Team Description Papers and their the developed source code is published under public licence with a public license. A complete overview of those contribution can be found in [12].

¹For an overview see: <http://www.dutchnaoteam.nl/index.php/publications/>

UvA@Work The UvA@Work team was founded in September 2013 as part of the Intelligent Robotics Lab, and consists of bachelor students Artificial Intelligence (AI) and Computer Science (CS), who are being supported by a senior staff member.

Thus far, the team has participated in the RoCKIn@Work Camps 2014 work shop in Rome, Italy [7]. The work shop offered both lectures and practical sessions on various topics such as navigation, object manipulation and human robot interface. In the latter case, they have been awarded the title: "Best practical demonstration on human robot interface."

2 Motivation and Objectives

The international FieldRobotEvent was founded in order to motivate students to develop autonomous field robots. Since the start in 2003 the FieldRobotEvent has become a platform for innovations and interdisciplinary co-operation in field robotics. The competition has evolved since the initiation in more and more challenging tasks: in 2012 the challenge consisted of navigating through straight, curved and partly fragmented rows of plants (so called container fields), recognition and detection of different types of plants, as well as localisation and orientating in the field.

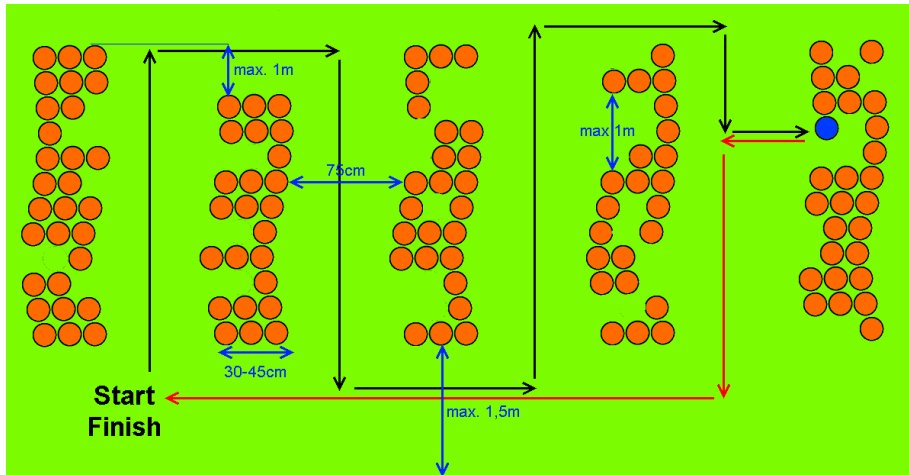


Figure 1: The customer order task - find the ordered plant (blue) in a container field full wth other plants (orange) and bring it back to the start.

3 Approach and Realization

3.1 Human Robot Interaction (HRI)

In context of the RoCKIn Camp 2014 in early 2014, the UvA@Work team started working on a Spoken Language Understanding (SLU) application for optimized customer-robot interaction. This form of Human Robot Interaction allows for a native communication with the robot through spoken natural language. It is recorded by an attached microphone and sent to the online google

voice recognition service. The returning result in form of written words is fed to a language model system, tagging words and applying a grammatical structure. As a next step, contained objects and actions are grounded in reference to a prebuilt database of environment and robot. These grounded objects and actions are then used to create a series of commands that can be sent to the robot's actuators as ROS topics - thus converted into a language that is "understood" by the robot. Tested in RoCKIn Camp Rome were basic directional commands as well as emergency "STOP".

3.2 Navigation Task

As the accessible terrain may change when plants are removed, added or relocated, an internal map representation must dynamically be updated when the robots moves. Because the location of the desired plant is not (exactly) known at the start of the search, some kind of greedy mapping could be used. As soon as the plant is found and picked up though, pathplanning can be used to calculate the most efficient way back to the robot's initial position (and thus the customer). As still the map may have changed during the pickup, even the pathplanning should be dynamical as well. In order to implement this, a first version of D*-Lite [3] was developed and tested. As for now, it is assumed that the configuration of the setup does not change so that path planning can be carried out by basic A* (illustrated in Fig. 2). The full details of this approach can be read in the project report [2].



Figure 2: The setup used for the project 'Navigating youBot through a rose field with A*'.

3.3 Manipulation Task

When a desired plant is identified, it needs to be picked up and set onto the platform mounted on the KUKA so it can be carried back to the customer. This manipulation task desires precise arm and gripper motion planning, involving the interpretation of received depth images and avoiding collisions. A first step in this was taken at RoCKIn Camp, Rome 2014, where industrial parts were identified from depth images, providing information for the subsequent gripping motion.

3.4 Multi Agent System

Apart from the actual competition challenge, the problem setting could also be approached with an intelligent multi agent system: When using two robots, one could be equipped with two arms, being able to pick up larger objects. As no space for transportation would be on the first youBot, a second

youBot could act as a carrier, driving to the picker's location, being loaded and then returning to the starting position. This could decrease the response time of the system when multiple orders or an order of various flowers, would have to be carried out.

4 Results and measures of success

The FieldRobotEvent 2012 has clear measure for success:

1. The robot has 3 minutes to show the identification of a plant. Finding (and signaling) the ordered plant within a radius of 0.5 m results in 10 points, within a radius of 1.0 m results in 9 points, within 1.5 m in 8 points etc (points = $11-2*\text{radius}$). Navigating to the right row will give a bonus multiplication of 1.5 to the gathered points in this subtask.
2. Picking the ordered plant within 2 minutes. Picking the ordered plant WITHOUT any manual intervention gives a bonus of 20 points. Picking the ordered plant with manual intervention (put robot in right row and in front of ordered plant) gives 10 points.
3. Last, the robot delivers the plant, for this task a maximum of 2 minutes is allowed. Delivering the ordered plant gives a bonus of 10 points. Penalty of 1 point per 0.5 meter distance from starting point is subtracted.

This detailed scoring setup allows for precise benchmarking in the various

5 Equipment

5.1 Sensors

Our KUKA youBot will be equipped with a sensor suite consisting of an Asus Xtion Pro Live to create disparity map, a Hokuyo LX30 laser scanner for a occupancy grid map, an Xsens MTi-G-700 motion tracker and possibly an Ricoh Theta 360 degree view camera. The perception will be based on the image processing (opencv based) and point cloud (pcl based) stacks integrated in the Robot Operating System ROS

5.2 Robot Operating System (ROS)

ROS is a broadly used framework for robotic application development. It supplies an easily extensible environment of basic components (nodes) which can be combined flexibly to form applications. Furthermore, it comes with an range of packages, libraries, drivers and simulation programs that simplify the use of standard platform robots. For the development of implementations on the KUKA youBot, the team of UvA@Work uses ROS Hydro Medusa, the newest remastered branch of ROS.

6 Economic analysis of proposed solution

The Dutch platform for Robotics RoboNED has recently made an analysis of the application areas where robotics could have the biggest economic impact [5]. The Netherlands holds a leading position

in agriculture in terms of productivity and efficiency. In horticulture important drivers for agrobotics are increasing labor costs, the limited availability of sufficiently trained labor, and the poor image of the sector due to the employment of (illegal) foreign workers who are not familiar with Dutch labor regulations. Agrobotics might also support quality improvement of the harvested product. The potential is high, because currently there are only a few commercially available robotic systems. In horticulture, robots are currently available for producing cuttings, planting in trays, plant protection, sorting and packing. No commercial examples are known for harvesting and crop maintenance. As result of this analysis, agriculture has been identified as an application area where the Netherlands has a good position to have create robotic systems which will have an impact on a world scale.

Robots in agriculture need to fulfil two main functions: mobility on the farm and manipulation of objects. Robotics is defined as the intelligent transformation of sensing into mechanical action. Research is generally focused on sensing, mobility (e.g. autonomous vehicles), manipulation, and end-effectors. However, not much attention is paid to intelligence, navigation and manipulation in unstructured environments. This project tries to have impact precisely focused on the latter three aspects.

7 Relevant Achievements and Publications

The University of Amsterdam is one of the four universities which has been provided with a KUKA youBot to participate in the KUKA challenge. The full details of the application can be read in the application paper [13].

7.1 Order picking with the KUKA youBot

With the arrival of the KUKA youBot a team of students started to investigate the possibilities of order picking. This was done over a 3 week period as part of a first year AI bachelor course ‘Search, Navigate, and Actuate’. During this period the gripper of the robot was fitted with a color camera. This camera was then used to locate cubes or items of a specific color by using a blob detector. A graphical user interface (GUI) was created in which an end user could specify which item was to be returned. On each run a maximum amount of cubes would be picked up and returned to the operator in order to simulate an actual warehouse robot that has a certain amount of space in which it has to fit objects. Two of the students that have worked on this project are now part of what has become the UvA@Work team. A picture of the setup that was used during this period can be seen in Figure 3. A short demonstration of the progress of this project can be viewed in a video².

The full details of this project can be read in the project report [6].

7.2 Visual Odometry with the Ricoh Theta

The Ricoh Theta camera is a full 360 degree spherical camera with two lenses, where the images obtained are automatically stitched together. Initial calibrations efforts indicate that the images are stored in perfect spherical projection. As a result, the image can directly be wrapped around a unit sphere. This means that every image point has the same center of origin, which makes conversions to other projections (perspective, panorama or bird-eye view) easily possible.

²<http://www.youtube.com/watch?v=XheQRnMvB4o>

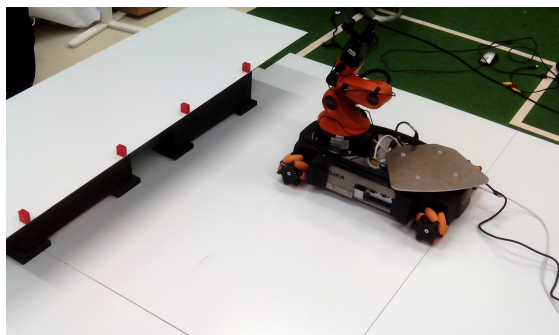


Figure 3: The setup used for the project 'Order picking with the KUKA youBot'.



Figure 4: Image captured with a Ricoh Theta from the KUKA youBot.

When mounted on moving platform, both the disappearing points are visible (which indicated the direction of movement) and a ring of maximal optimal flow, which can be used to estimate the amplitude of the movement. Currently the orientation can already accurately estimated from the optical flow, an accurate estimation of the translation is under study.

8 Team Members

The current project team consists of four members ??:

Sébastien Negrijn - Bachelor AI student

Sébastien Negrijn is currently a second year AI student at the University of Amsterdam. He has participated in the Standard Platform League in both the Iran Open 2013 and the RoboCup 2013 at Eindhoven after which he was elected as member of the 2014 Organizing Committee of Standard Platform League. His interest in the KUKA youBot has grown after seeing it in action at the RoboCup. He will function as the team leader during the upcoming events.

Stephan van Schaik - Bachelor CS student

At the moment, Stephan van Schaik is a third year student of the BSc. Computer Science programme at the University of Amsterdam. In his spare time he is mostly fascinated by embedded systems, low-level system programming, and thinking not only about how to solve rather complex



Figure 5: Image captured with a Ricoh Theta from the KUKA youBot.

problems, but how to structure the solution in the most effective and elegant manner. Therefore he has taken the role of software architect upon him, investigating and realizing a dedicated framework for the team to use.

Janosch Haber - Bachelor AI student

Janosch Haber is currently enrolled as a second year Artificial Intelligence Bachelor student at University of Amsterdam. Joining the UvA@Work team in mid-October he has taken the task of developing and implementing the path-planning modules for the team's KUKA youBot. As this being his first y working with real-life robots he is looking forward to gain more programming-, project- and team experience in the course of the upcoming competitions and workshops.

Arnoud Visser - Lecturer AI

Arnoud Visser originally studied physics at the University of Leiden. At the University of Amsterdam since 1991, he participated in several national and international robotics projects. Inside the RoboCup initiative, he participated in several soccer and rescue leagues. Last year he was associate chair of the competition in Eindhoven. Currently he is chairman of the Dutch National Committee and Executive for the Rescue Simulation League.

References

- [1] Nick Dijkshoorn et al. "Amsterdam Oxford Joint Rescue Forces - Team Description Paper - RoboCup 2011". In: *Proc. CD of the 15th RoboCup International Symposium*. Istanbul, Turkey, 2011.
- [2] Jasper van Enk. *Navigating YouBot through a rose field with A**. Project Report, Universiteit van Amsterdam. Science Park 904 1098 XH Amsterdam, 2013.
- [3] Sven Koenig and Maxim Likhachev. "D* Lite." In: *AAAI/IAAI*. 2002, pp. 476–483.

- [4] Patrick de Kok et al. *Dutch Nao Team - Team Description for Robocup 2014 - Joo Pessoa, Brasil, Qualification edition*. Universiteit Amsterdam, TU Delft & Maastricht University. 2013.
- [5] D.J.B.A. Kranenburg–de Lange et al. *Dutch Robotics Strategic Agenda - Analysis, Roadmap and Outlook*. RoboNED. 2012.
- [6] Sebastien Negrijn et al. *Basic order picking met behulp van de KUKA YouBot*. Project Report, Universiteit van Amsterdam. Science Park 904 1098 XH Amsterdam, 2013.
- [7] Sébastien Negrijn et al. *UvA@Work - RoCKIn@Work Camp 2014 - Rome, Italy*. Team Description Paper, Intelligent Robotics Lab, Universiteit van Amsterdam, The Netherlands. 2013.
- [8] Max Pflingsthorst et al. “UvA Rescue Team 2006; RoboCup Rescue - Simulation League”. In: *Proc. CD of the 10th RoboCup International Symposium*. 2006.
- [9] S. B. M. Post, M. L. Fassaert, and A. Visser. “The high-level communication model for multi-agent coordination in the RoboCupRescue Simulator”. In: *7th RoboCup International Symposium*. Ed. by D. Polani et al. Vol. 3020. Lecture Notes on Artificial Intelligence. Springer-Verlag, 2004, pp. 503–509.
- [10] Mircea Traichioiu and Arnoud Visser. *UvA Rescue - Team Description Paper - Agent competition - Rescue Simulation League - Iran Open 2014*. Tehran, 2014.
- [11] Arnoud Visser. *UvA Rescue - Team Description Paper - Virtual Robot competition - Rescue Simulation League - RoboCup Iran Open 2014*. Tehran, 2014.
- [12] Arnoud Visser. “*UvA Rescue Technical Report: A description of the methods and algorithms implemented in the UvA Rescue code release*”. Technical Report IAS-UVA-12-02, Universiteit van Amsterdam. 2012.
- [13] Arnoud Visser. *UvA@Work Customer Agriculture Order*. Application Paper, Universiteit van Amsterdam. Science Park 904 1098 XH Amsterdam, 2013.