UvA@Work, Team Description Paper RoCKIn2014 - Toulouse, France

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I. Introduction

The UvA@Work team consists of three Artificial Intelligence (AI) bachelor students supported by a senior university staff member. It was founded at the beginning of academic year 2013-2014 as part of the Intelligent Robotics Lab[1]. This initiative strives to involve students of the Universiteit van Amsterdam (UvA) in robotics. It also acts as a governing body for all the UvA's robotic teams such as UvA@Work, The Dutch NAO Team [1] (RoboCup Standard Platform League), the Amsterdam Oxford Joint Rescue Forces [2] (RoboCup Rescue Simulation League) and Maneki-Neko [3] (Micro Air Vehicle competition) to guarantee continuation of research, education and competition experience. It also enables sharing any gathered knowledge between the different teams.

After its first competition experience with the Kuka youBot at the RoCKIn Camps 2014 in Rome, the UvA@Work team is looking forward to participate in the upcoming event in Toulouse.

[1] http://www.dutchnaoteam.nl/index.php/irobolab/

II. Hardware

The KUKA youBot used by the UvA@Work team is equipped with a sensor suite consisting of an Asus Xtion Pro Live to create a disparity map, a Hokuyo UTM-30LX laser scanner for occupancy grid mapping and a Microsoft LifeCam HD-5000 for RGB vision as can be seen in Figure 1. The Asus Xtion Pro is mounted well above the youBot platform to allow for a broad view of the local surroundings. These broad overviews can be processed as both, RGB and depth images. The Hokuyo UTM-30LX laser scanner is mounted in front of the youBot platform and provides a high precision depth plane over a 270 degree angle. Finally, the Microsoft LifeCam HD-5000 is mounted on top of the youBot's end effector to assist pick-up and placing tasks.

Being part of the KUKA Innovation Challenge [4], the UvA has temporal access to a second, sponsored youBot.

III. Software

A. 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

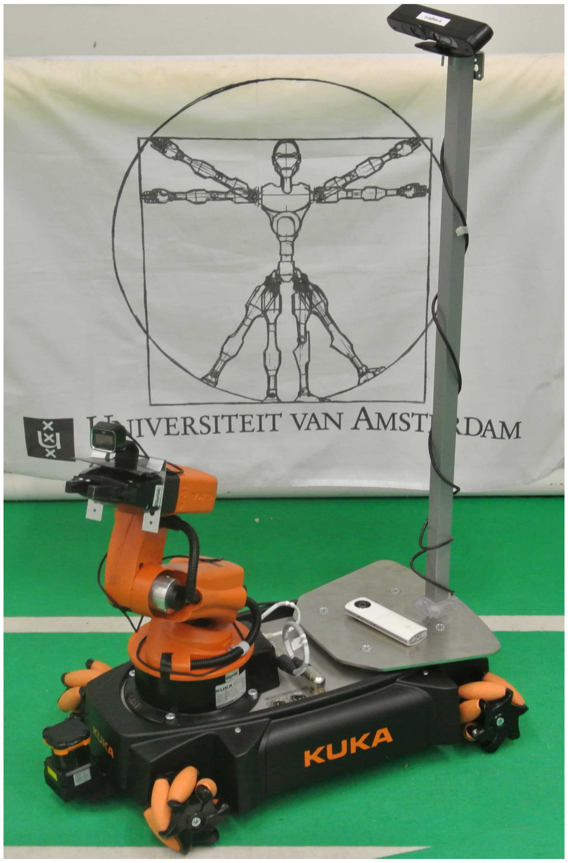

Figure 1. The Kuka youBot mounted with all its sensors: Asus Xtion Pro Live, Hokuyo UTM-30LX and a Microsoft LifeCam HD-5000.

can be combined flexibly to form applications. ROS also provides a parameter server which allows nodes to use shared parameters. In the current implementation these shared parameters are used to change the local workings of each node depending on the task that needs to be carried out. Furthermore, ROS comes with a 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 the ROS Hydro Medusa version.

B. Image Processing Pipeline

The Image Processing Pipeline (IPP) currently consists of 7 nodes: webcam_controller, openni2, image_controller, image_thresholder, datamatrix_detector, tag_detector and object_detector.
The webcam_controller takes care of retrieving image streams from the different RGB cameras mounted on the robot. In the current implementation, only one camera can be used at a time due to limitations in data capacity of the usb-bus. To work around this limitation, the active camera can be assigned depending on the current task by using ROS parameters. For depth cameras the standard ROS package Openni2 is used. These two packages send their images to the image_controller node. Depending on the ROS parameters specified, the received input is passed on to the right detector and/or image_thresholder node. The detectors are used to locate datamatrices, tags (coloured sheets) or objects (as specified in the rulebook) in the image frame. These detectors also rely on the use of the OpenCV2 library. Finally, the detectors send obtained features to the action_controller.
By using this pipeline, each node can operate on a separate thread. Therefore the current implementation is only limited by the image throughput of the cameras used.

C. Localisation Pipeline

As of now the SLAM_GMapping package is used for full mapping and localisation of the surrounding area and position of the robot. With the data provided by this package, an A* algorithm [5] is used which returns an optimal path between the current position and the goal in reasonable time. This path is send to the action_controller and processed into movement. This implementation is based on the large amount of research that has already been conducted on this topic by the other robotic teams. Nonetheless, the UvA@Work team has developed an implementation of D*-lite [6] which can account for changes in the environment during movement. In contrast to the static A* algorithm, D* efficiently updates the generated path if necessary and does not require a complete recalculation.

D. Manipulation Pipeline

Once localisation and navigation tasks are completed, the next step is to fulfil the manipulation

challenge. This could be picking up and precisely placing one of the industrial parts of the RoboCup and RoCKIn@Work challenges. Being a Dutch team however the UvA@Work decided to also specialise on a different exercise: Because agriculture is very important sector in the Netherlands, Uva@Work is investigating if it is possible to let the youBot find and pick up a specified flower.
A prerequisite for pick-up is that the transformational function between perception-space and configuration-space of the robot arm is known. To obtain it, the Move-It module of ROS is extended with a path-planning algorithm developed by Dorst *et al* [7], preferable an anytime incremental variant like [8].

The advantage of using a path-planning algorithm in the configuration space is that evasing the enviroment becomes native in the planning. The challenge with this method is the transfer of real-world coördinate points to the configuration-space of the robot. Once the Inverse Kinematica of the Kuka YouBot is calculated, the obstacles in the real world can be mapped onto the configuration-space. After this, the path-planning in the configuration space becomes a trivial problem that can be tackled by several search-algorithms like D-lite [6] or Dorst's algorithm [7].*

The observation of obstacles are thus mapped in the planning of the kinematica of an action. Therefor the problem of evading obstacles can be solved and the flora should be preserved.

E. Human Robot Interaction (HRI)

In context of the RoCKIn Camp 2014 in Rome, the UvA@Work team started working on a Spoken Language Understanding (SLU) application for optimised customer-robot interaction. As SLU allows for a native communication with the robot, Human Robot Interaction is tailored for real-word use.
Spoken commands are 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 than used to create a series of commands that can be send to the task_manager node within the ROS framework - thus conversed into a language that is "understood" by the robot. Tested in RoCKIn Camp Rome were basic directional commands as well as emergency "STOP".
This SLU interface can also be used as an alternative to the standard command-line @Work interface used to specify the task to be carried out.

F. Action Manager

The action manager takes care of all movement required by the Kuka youBot. It does so by listening to the task manager. All actions are partially depended on the current state of the robot. Therefore the action manager also keeps a updated version of the current joint states.

G. Reusability of the Software

During development of the code, UvA@Work focused on creating task-specific nodes that can be used as independent modules in the ROS framework. On top of that, various top-layer instances were created to centrally manage and control the modules. All information streams are assigned to unique default topics that can be subscribed to by other nodes where necessary. By doing so, modularity of code and re-usability of modules can be guaranteed.
The code of the UvA@Work team is available at github[2] where the reusable task modules will be made publicly available, following the initiative of SwarmLab[3].

IV. Research Areas

The University of Amsterdam has been active in the RoboCup since 1998 in form of varying teams such as the Windmill Wanderers [9], Clockwork Orange [10], Dutch Aibo Team [11], the Amsterdam Oxford Joint Rescue Forces [12] and the UvA Rescue Team [13].

Currently the Intelligent Robotics Lab (IRL) is active in three competitions: Next to the @Work

[2] https://github.com/IntelligentRoboticsLab/KukaYouBot
[3] https://github.com/swarmlab/swarmlabatwork

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.

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 occasions[4]. This year, the Dutch Nao Team has participated at the Iran Open 2014 and is one of twenty teams selected for the 2014 World Championships in Brazil [14].

The University of Amsterdam is active in the Rescue Simulation League since 2003 in Paduva [15]. In 2006 the first Virtual Robot competition was held, which directly resulted to the Best Mapping award [16]. The team from Amsterdam started a cooperation with Oxford University in 2008, which continued for 4 years [17]. In 2012 the team operated again under its original name; the UvA Rescue Team. During those years the team won several prices, 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 licenc with a public license.
Since its establishment in September 2013, the UvA@Work team has participated in the RoCKIn@Work Camps 2014 workshop in Rome, Italy [18]. This workshop offered both lectures and practical sessions on various topics such as navigation, object manipulation and human robot interaction. In the latter case, they have been awarded the title: "Best practical demonstration on human robot interaction."

V. Innovative Technology

The University of Amsterdam is one of the four universities which has been provided with a KUKA youBot to participate in the KUKA innovation challenge. The full details of the application can be read in the application paper [19], mid-term report [4] and video report[5].

A. 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 calibration 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 centre of origin, which makes conversions to other projections (perspective, panorama or bird-eye view) easily possible.

When mounted on a moving platform, both the disappearing points are visible (which indicate the direction of movement) as well as a ring of maximal optimal flow, which can be used to estimate the amplitude of the movement. Currently, orientation can already accurately being estimated from the optical flow, an accurate estimation of the translation is under study [20].

[4]For an overview see: http://www.dutchnaoteam.nl/index.php/publications/

[5]2http://www.youtube.com/watch?v=XheQRnMvB4o

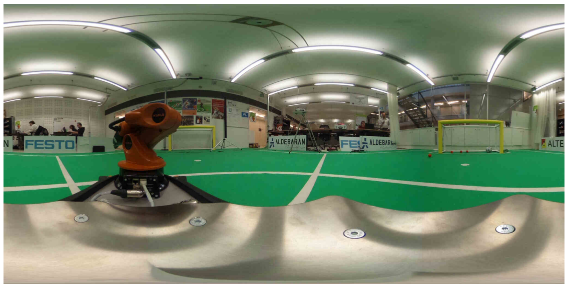

Figure 2. Image captured with a Ricoh Theta from the KUKA youBot.

B. *Kinect K4W (Developers version)*

The new version of the Kinect, which is to be released at the end of this year, outperforms the previous version both in resolution and speed. Yet, the "Kinect for Windows" (K4W) does not yet work in ROS. The official OpenNI software only supports the ASUS Xtion and PrimeSense's own devices. By just adding the Kinect's USB ids to OpenNI, a patch was created for older Microsoft Kinect for Xbox versions. At the moment, no one has yet produced a similar patch for K4W. UvA@Work thus currently is working on a ROS implementation for the K4W.

When a working implementation is developed, an initial study will be performed to see what the impact of the higher resolution and speed will have on the perception of objects typical for the RoCKIn competition.

VI. Applicability and Relevance to Industrial Robotics

The EU-Robotics platform has recently made an analysis of the application areas where robotics could have the biggest economic impact [21].

In the Netherlands, this again appears to be the sector of agriculture: They already hold a leading role in terms of productivity and efficiency but still there is need for more automation. Important drivers for agro-robotics here are further quality improvement, increasing labour costs, the limited availability of sufficiently trained labour, and the poor image of the sector due to the employment of (illegal) foreign workers. 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 and sorting and packing. No commercial examples are known for harvesting or 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.

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