Eurathlon 2013

Scenario Application Paper (SAP) – Review Sheet

Team/Robot FKIE
Scenario Mobile manipulation for handling hazardous material

For each of the following aspects, especially concerning the team's approach to scenario-specific challenges, please give a short comment whether they are covered adequately in the SAP.

Keep in mind that this evaluation, albeit anonymized, will be published online; private comments to the organizers should be sent separately.

Robot Hardware

The robot is built by using a commercial tEODor by Telerob. A 7 degrees-of-freedom (DOF) manipulator taken from a telerob telemax EOD robot is mounted on the vehicle.

Processing

ROS running on Linux is used to manage the robot's parts.

Communication

WiFi radio link used. No cable communication or other. Radio WiFi link shoud suffice in the addressed scenario.

Localization

Autonomous GPS waypoint navigation with two 2D laser scanners

Sensing

Cameras on the manipulator and laser scanner. An environment model is built by using 2D laser scanners and moving them in the environment to build a 3d point cloud of the robot's surroundings. The model is used to avoid collisions during manipulation and assist the operator. The solution is appreciated.

Vehicle Control

Assistance functions are present, that compute pre-grasp positions from a click in the point cloud, so the operator (here the team member) can approach the valve or the object on the loading platform with the gripper in a very simple and comfortable way. Autonomous GPS waypoint navigation with two 2D laser scanners for detecting possible collision with obstacles.

System Readiness

Hw 9 . Sw 8.

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Overall Adequacy to Scenario-Specific Challenges

The vehicle seems to be adequate to scenario-specific challenges with automatic assistance to the operator that may be essential in accomplishing the required task. The impossibility to detect railway tracks An issue may be an issue, but an accurate supervision can solve it. From 0-5 the score is 4.

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Team FKIE

Scenario Application Paper

Mobile manipulation for handling hazardous material

Author: Bastian Gaspers, Jochen Welle

Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE

Research Group Unmanned Systems

e-mail: { bastian.gaspers, jochen.welle}@fkie.fraunhofer.de

Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE
Research Group Unmanned Systems
Fraunhoferstr. 20
53343 Wachtberg
Germany

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Fraunhofer FKIE/US Mobile Manipulation Scenario Application Paper

23-27. September 2013,

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EURATHLON 2013 – Robot System

Abstract

This paper presents out robot manipulation platform and the system we will use at the Eurathlon 2013 mobile manipulation scenario. We modified and combined a manipulator with a tracked robot platform and a variety of sensors for different intelligent assistance functions. These can be used to help the team opening or closing valves, grasping and moving unknown objects like an open canister with hazardous material.

Introduction

The Unmanned Systems group of Fraunhofer FKIE has a long standing experience with robot competitions. It was involved in the organization of all past European Robot Trial events. Additionally, it took part in the competitions from 2009 on. The team never was officially ranked in order to avoid conflicts with other groups. Nonetheless, the results the team achieved are on par with other groups. The main interest of the team is to use as much autonomous software as possible to solve the different missions during the Eurathlon 2013 event.

Vehicle

The tEODor from telerob is a twin-track vehicle, designed for teleoperated Explosive Ordnance Disposal (EOD) and observation in difficult outdoor environments. The tracks can be moved separately to guarantee a good manoeuvrability, even on steep slopes. The tEODor is about 140 cm long, 70 cm wide and 40 cm in height (without mast). It has a weight of about 220 kg and can

Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE
Research Group Unmanned Systems
Fraunhoferstr. 20
53343 Wachtberg
Germany

carry an additional payload of about 350 kg. The maximal speed of the tEODor is 3 km/h. The mast is at the rear of the robot and carries a camera and lights that can be panned and tilted.

We heavily modified the tEODor for autonomous navigation and to carry a custom payload box with a mounted manipulator. The payload box has a built-in PC that is connected with the tEODor chassis and the manipulator to be able to control their movements. The PC is connected to the remote station via WiFi. We use laser scanners at the front and at the rear of the robot for navigation purposes. The whole system is rainproof and built for outdoor use.

The tEODor, the telemax manipulator and most of the components used for the modifications are commercially available, but the system as a whole is a unique prototype.

Manipulator

We use a payload box that is equipped with a 7 degrees-of-freedom (DOF) manipulator taken from a telerob telemax EOD robot. It has a parallel gripper that can be opened and closed. The third joint from the base is a prismatic joint that enables the manipulator to extend the upper arm for about 30 cm. Thus, the manipulator has a range of around 1.7 m. To control the manipulator, we have an interface which runs a 10 Hz control loop, so we get positions of all manipulator joints with a precision of 0.1 degrees.

Control Station

On the robot a common PC platform with a modern Intel i7 CPU is used together with a Linux operating system. The Robot Operating System (ROS) is used as robot middleware which is available open source under a BSD license. The software itself is mostly experimental software used in diverse research projects and during presentations. As input devices, we use a mouse or touchpad and a gamepad to assist the semi-autonomous grasping and to take over control of the manipulator or the platform, if necessary.

Sensors

The manipulator is equipped with two cameras. One camera is at the first link, providing some overview of the manipulation scene. The second one is at the gripper link, pointing towards the tool-center-point, which is the exact middle of the gripper jaws. Additionally, we installed a

Hokuyo UTM-30 laser range finder to the wrist of the manipulator to get a 3D environment model of the robot's surroundings.

The vehicle itself is equipped with a telescope mast that carries a pan-tilt unit with a second laser scanner (Hokuyo UTM-30) and an additional camera. This camera can be used to follow the manipulator and its end-effector from a different angle, like a third-person view. For 2D waypoint navigation and simple obstacle avoidance, we have two 2D laser scanners (Hokuyo UTM-30 / Sick LMS) mounted to the front and the rear of the robot. For localisation, we want to use a GPS device combined with robot odometry, we get from the tEODor platform.

Communication

For communication we plan to use freely available WiFi components that should be able to cope with the distance from the control station to the robot in the described mobile manipulation scenario. We use IEEE 802.11 a/b/g with flexible channel planning at 2.4 GHz and 5 GHz frequencies.

System Readiness (TRL)

We have a set of tested assistance functions that run on our demonstrator hardware, the system is for development use, but rainproof. As the electronics we use was chosen to be ruggedized, vibration and shocks from driving should not harm the robot. So the TRL of thehardware, we present at the Eurathlon, is 5. The software TRL is between 4 and 5.

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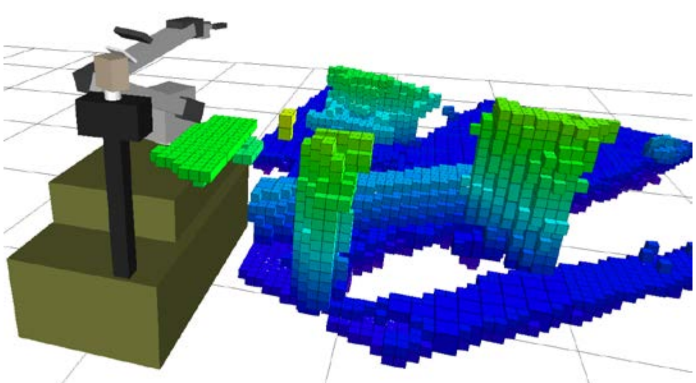
EURATHLON 2013 – Scenario specific description

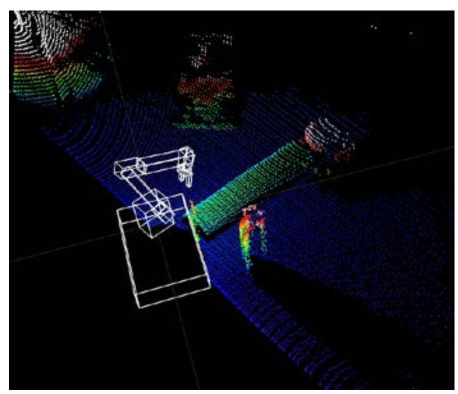
Navigation of the Vehicle

We use autonomous GPS waypoint navigation with two 2D laser scanners. As described before, they are installed in the front and rear of the robot vehicle. They measure distances in a 180° field of view with a frequency of 40 Hz to determine whether a chosen path towards a GPS waypoint is collision free. Contrary to the scenario description, this kind of sensor installation is not able to detect railway tracks in the way of the vehicle, so we plan to overlook the navigation and interfere if necessary.

Environment Model

As described earlier, we use 2D laser scanners and move them in the environment to build a 3d point cloud of the robot's surroundings. This environment model is used to avoid collision of the manipulator with the environment during motion planning. The point cloud model further serves as interaction specification interface. So, the user may select a point of the model and the software is able to plan a pre-grasp position and to execute these plans.





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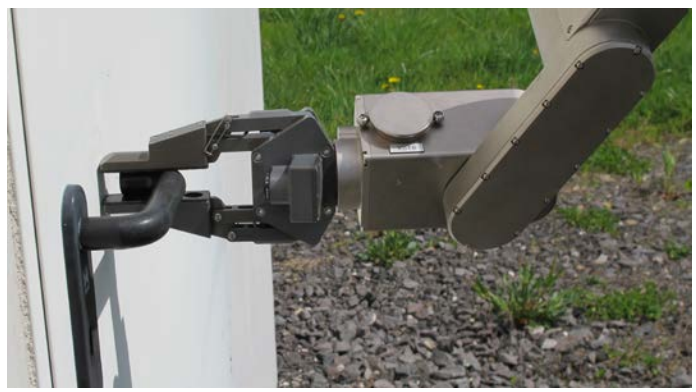
Moving the Manipulator

As the manipulator has a length of about 1.7 meters, we expect to have no problems reaching the loading platform of a lorry and manipulating there. We have assistance functions, that compute pre-grasp positions from a click in the point cloud, so the operator (here the team member) can approach the valve or the object on the loading platform with the gripper in a very simple and comfortable way. While moving the manipulator, the environment model is used during the planning phase to check if a planned path is collision free.



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