Eurathlon 2013

Scenario Application Paper (SAP) – Review Sheet

Team/Robot FKIE
Scenario Autonomous Navigation

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 hardware seems to adequately cover the scenario. It is around 500 KG with long lasting lithium-ion battery and tracked drive with a payload of around 100 KG. Both the chassis and payload are rain-proof for adverse weather conditions. The SAP doesn´t state exact measures, but it offers a photo of the prototype.

Processing

Processing is covered by a commercial PC platform with an Intel i7 CPU running the Linux Operative System. Good to see the team uses standard ROS tools.

Communication

It uses a Proxim WLAN access point with the possibility of using repeaters if available. Optionally it uses UMTS. Due to the specific scenario and the technologies used, the robot may have problems regarding communication but it has autonomous navigation functions which makes it independent of direct radio communications in order to perfom its tasks.

Localization

The robot covers the localization using GPS, Galileo and GLONASS for outdoor localization, combined with LIDAR based SLAM techniques.

Sensing

The robot´s main sensor is a Velodyne HDL-64E 3D laser range finder which is good for medium-range sensing of up to 100m. For short range, it uses two SICK LMS511 2D laser range finders mounted on the front and on the back with an opening angle of 180º. Additionaly the system has a 360º camera prototype composed by 8 small cameras. The system also integrates a GPS and initial measurement unit with the capacity to estimate heading.

Vehicle Control

The vehicle is intended to be autonomous, but tele-operation is also possible, including the possibility of sending waypoints.

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System Readiness

Technology Readiness is considered to be at level 5 for both, hardware and software but field tests in similar scenarios will be performed during this year which could improve this level.

Overall Adequacy to Scenario-Specific Challenges

The robot appears to be adequate for the scenario, but as stated in the SAP, frequent modifications on the hardware cause a certain probability of hardware failures. Moreover, in the specific scenario, it is probable that the robot will lose communication with the central stations in many areas. Since the TRL for both hardware and software is at level 5, it is recommended to make more field tests before the event, which will be done according to the SAP.

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Team FKIE

Scenario Application Paper

Autonomous Navigation using GPS, GLONASS and GALILEO

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Eurathlon 2013

FKIE/US Autonomous Navigation Scenario Application Paper

23-27. September 2013,

Berchtesgaden, Germany

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 vehicle is a prototype that was built by RUAG in Switzerland in collaboration with the engineers of our group. It is a robot in the 500 kg class with a long lasting lithium-ion-battery and tracked drive. In this class it is one of few robots that have a closed-loop controller for the engines, which allows sending velocities to the robot from the computer and makes autonomous navigation a lot easier. This is quite unique, because most of the robots of this size are built solely for tele-operated EOD missions and just let the operators control the power of the engines directly. Usually they are not equipped with any odometry sensors at all.

The top speed of the vehicle is roughly 25 km/h and the payload is estimated at 100 kg. The chassis is water-resistant, but should not be submerged completely.

The payload is also a prototype. We invented a modular payload concept that allows easy exchange for different applications. For the Autonomous Navigation, we will use a payload box that is equipped with a fast PC and a Velodyne HDL-64E 3D laser range finder for obstacle avoidance and mapping during autonomous operations. The payload itself is rain-proof.

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Processing

The internal computer is a commercial PC platform with a modern Intel i7 CPU running a Linux operating system. The Robot Operating System (ROS) is used as robot middleware and is available as open source under a BSD license. The software itself is mostly experimental software used in diverse research projects, presentations and robot competitions.

Communication

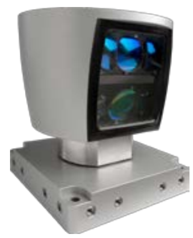
The robot is equipped with a Proxim WLAN Access point with dual radio supporting the Wireless LAN standards IEEE 802.11a/b/g. The Proxim AP is able to build a dynamic mesh network with other Proxim APs which can be used as repeaters to extend the network range of the whole system to more than one kilometre under optimal conditions.
Optionally, the system can be connected via UMTS modem to an infrastructure radio network and upload mission data to a dedicated internet server, allowing synchronization with multiple control stations in real time. Due to the high level of autonomous navigation functions, the system is independent of direct radio communication links to the control station. Therefore, its operation range is limited by its power supply only. Temporary or even complete communication failures do not hinder the system in its mission.

Localization

The robot is equipped with a combined GPS receiver and inertial measurement unit. The system can also receive Galileo or GLONASS data to enhance the position calculation. The localization of the system is further enhanced with LIDAR based SLAM. The map is registered in a global coordinate system whenever a GPS fix is available and GPS is used to control the consistency of the map. Optionally, the system can transmit its map to the control station or display its position on Open Street Map data on the control station.

Sensing

The robot is equipped with a Velodyne HDL-64E 3D laser range finder which is mounted on top of the vehicle in a central position. The laser provides a 3D point cloud of the entire surroundings of the robot in a range of up to 100 m. The Velodyne 3D Laser is the main sensor used for obstacle avoidance and mapping at the same time. There is a gap in the 3D sensor data close to the robot. In order to close this gap for obstacle avoidance, the robot is equipped with two SICK LMS511 2D laser range finders facing front and back with an opening angle of 180°.



Additionally the robot is equipped with a 360° camera prototype which consists of eight small cameras facing in all directions which is used by vision algorithms in order to detect Objects of Potential Interest in the scenarios autonomously.
The vehicle delivers odometry information which is quite good, but does not account for slip or adverse terrain conditions. Additionally, the system is equipped with an integrated GPS and inertial measurement unit with double GPS antenna to estimate the heading. This unit is used to increase the accuracy of the odometry readings.

Vehicle Control

The vehicle is navigating autonomously during the mission. Only for security reasons a person will be following with an e-stop. The vehicle uses its built map to do path planning in the scenario. A road detection mechanism will ensure that the vehicle takes advantage of easily traversable paths and avoids obstacles.

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The control station can intervene in the navigation at any time, given there is a communication link. An integrated GUI supplies the operator with all available sensor information to safely control the vehicle even in complex situations. A semi-autonomous operation mode enables the operator to send waypoints to the vehicle. The reference map for the waypoint selection is supplied either by external sources like Open Street Map or Google Earth, or comes from the vehicle itself.

System Readiness

Both the hardware itself and the software are prototypical demonstrators. The hardware is assembled and maintained by a team of well-trained engineers. Nonetheless, frequent modifications on the hardware cause a certain probability of hardware failures. The software is developed as part of diverse research projects. It is evaluated in diverse experiments and demonstrated to the contracting entities on a regular basis, but is not audited according to industry standards. Field tests in front of the Eurathlon event in similar environments will take place later this year.
TRL: 5, both soft- and hardware.

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EURATHLON 2013 – Scenario-Specific Challenges

Autonomous navigation using GPS, GLONASS and GALILEO

The software has been deployed for ELROB 2010 in Hammelburg, ELROB 2011 in Belgium and ELROB 2012 in Switzerland. Apart from minor enhancements over the years, the basic principles of the software have proven to be able to handle very different types of terrain, from forest environments to alpine mountainous terrain.
The tracked vehicle is able to traverse loose gravel, negotiates significant slopes and can pass through water. Negative obstacles are detected and avoided using the 3D laser sensor and the road detection software.
Dead ends can be avoided using the constructed map. At the same time the map gets updated with new information constantly, so that changing obstacles are considered by the high level path planning system.

The localization of the vehicle for navigation purposes is happening in the constructed map, which is registered to GPS whenever possible. This allows the system to cope with temporary GPS failures. As the system operates autonomously and all necessary calculations are done on-board, the communication to the control station is not vital to the vehicle. If the communication link is severed, it will continue its mission. If equipped with UMTS it will transmit reduced status information and OPI locations to the control station via the internet. OPIs are transmitted as compressed image files together with a map coordinate and optional UTM coordinates (if available) encoded in their filename. The map is transmitted as compressed image.

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