Eurathlon 2013

Scenario Application Paper (SAP) – Review Sheet

Team/Robot FKIE
Scenario Reconnaissance and surveillance in urban structures (USAR)

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 is based on the Telerob platform. The platform is able to climb stairs and it is ready for non-flat terrain. Then, it seems a good configuration for the USAR scenario.

Processing

The robots integrates a powerful Intel Core i7 computer running Linux and ROS. Then, the system has enough computational capacity to implement high autonomy operational modes.

Communication

The robot implements a dual radio COTS WLAN system. The robot can optionally use cellular communications. Although it is true that its high level of autonomy makes the system less dependent to communicaiton failures, I think that it could be interesting to have an alternative wireless system, at least for command and control, with robust wireles technology such as FHSS.

Localization

The robot uses GPS as its main global localization sensor. It also uses SLAM to localize and map the environment where no GPS is avialable. For that purpose it uses a LIDAR as its main navigation sensor.

Sensing

The robot counts with a LIDAR for navigation, three cameras (one of it is used to automatically detect OPIs), and odometry sensors. This sensor suite seems appropiate for the USAR environment.

Vehicle Control

The vehicle control is mainly autonomous under the operator supervision. Even advance autonomous modes such as path planning is implemented in the presented solution.

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System Readiness

The robot is a prototype but has been succesfully used in different experiments with close conditions as the ones that will be presented in the EUROATHLON 2013 competition. However, the technology readiness level is not as high as of a commercial product.

Overall Adequacy to Scenario-Specific Challenges

The presented system fulfills all the requirements of the USAR scenario including mapping of the inside of the structure. It also implements high autonomy operational modes. The only point that I think it could be improved is the communication system. I think that a redundant communication datalink could increase the robustness of the system. For the rest, I think this is a nice system to test on the field whether a high autonomy level really improves the operation of such vehicles.

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Team FKIE

Scenario Application Paper

Reconnaissance and surveillance in urban structures

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Fraunhofer FKIE/US USAR Scenario Application Paper

23-27. September 2013,

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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 Telerob telemax is a small and versatile robot designed for remote controlled bomb disposal operations. It is suited for narrow spaces, because of its slim 4-track drive. It can cope with high slopes and stairs, because of its four adjustable flippers. The original system is worldwide in service for several years. The systems weight is roughly 80 kg and the battery lasts up to 4 hours. The vehicle can travel at a top speed of 10 km/h.

Our version of the telemax is a heavily modified. We removed the manipulator and placed a custom payload on top of the original chassis. This payload contains a common PC which is attached to the telemax itself in order to control the vehicle. The PC is optionally connected to a remote control station via Wi-Fi. Additionally the vehicle is equipped with a Hokuyo UTM-30 laser range finder which is used both for obstacle avoidance and mapping during autonomous operations. The complete system is rain-proof. Deep water should be avoided, though.

The telemax platform itself is commercial available, but our modifications are intense and therefore the system as a whole should be classified as prototype.

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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 GPS receiver and inertial measurement unit. The main localization of the system is happening with laser based SLAM, tough. The map the robot builds is registered in a global coordinate system whenever a GPS fix is available to localize the robot against the mission coordinates given in UTM coordinates. The system can transmit its map to the control station or and display the robot's position on Open Street Map data on the control station.

Sensing

The robot is equipped with a lightweight Hokuyo UTM-30 laser range finder which faces front and has an opening angle of 270° and a maximum range of 30 m. The sensor itself is waterproof and designed for outdoor robotic activities. It is the main sensor used for obstacle avoidance and mapping at the same time.

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Additionally, the robot is equipped with multiple cameras; two build into the chassis of the vehicle by telerob and one attached to the vehicle at a higher point to allow a better overview for the operator. The higher camera is also used by vision algorithms in order to autonomously detect Objects of Potential Interest in the scenarios.
The vehicle delivers odometry information which is quite good, but has no measures to cope with slippery surfaces or similar. Additionally the system is equipped with an inertial measurement unit and magnetometer which are 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 build map to do path planning in the scenario and explore the most promising areas.
The control station can intervene in the navigation at any time, given there is a communication link. There exists an integrated GUI to supply the operator with all available sensor information to safely control the vehicle even in complex situations. A semi autonomous operation mode is also available in which the operator sends waypoints to the vehicle which he can select in a map of the environment. The map either is supplied by external sources like Open Street Map or Google Earth or the operator can use the map build by the vehicle itself.

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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.

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EURATHLON 2013 – Scenario-Specific Challenges

Reconnaissance and surveillance in urban structures (USAR)

The system can navigate in an urbane structure mostly autonomous. Stairs can be climbed autonomously, too, but they are not detected autonomously. So the operator will have to look for stairs and tell the vehicle to climb them, when he wants to change stories.

The localization is planned to happen via SLAM. That means the system will build its own map of the building with the help of its odometry readings and laser range finder measurements. The map can be registered with GPS, if there is reception at times. The mission results, i.e. the map and Objects of Potential Interest are transmitted to the control station either via Wi-Fi or via UMTS. In the later case the system is using a dedicated internet server. OPIs are transmitted as compressed image files together with a map coordinate and if available UTM coordinate encoded in their filename. The map is transmitted as compressed image.

Because the system builds a map and uses high level path planning algorithms to navigate the building, it can cope with both changing door statuses and dead ends a like. Non-static obstacles of big scale might pose a risk to the map building process but otherwise won't harm the navigation capabilities of the system. The map is constantly updated by the laser sensor, so if obstacles disappear, they will be removed from the map, too. The map building was already employed in a forest environment which did involve a lot of navigation on non level ground, too. The results in this environment were good, so non level ground seems to be no big issue to the system.
Together with map building an exploration technique is used to always explore the most promising "unknown" areas of the constructed map. More critical than exploring the whole area is to not explore parts outside of the scenario area. This is handled by placing virtual obstacles in the map at the area borders.

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