Eurathlon 2013

Scenario Application Paper (SAP) – Review Sheet

Team/Robot ELP
Scenario Search and rescue in a smoke-filled underground structure

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

Operating time and distance?
- 15 hrs

Why is the vehicle suitable for outdoor/off-road/rough terrain scenarios? What about rain and humidity?
- PackBot 510EOD, field proven, commercially available platform, ruggedized designed to be used outdoors

What kind of outdoor/indoor obstacles can the vehicle overcome? How? What about steepness, high inclinations, stairs?
- Max Climb angle 50 degrees; capable of climbing various stairs

Which standards (DIN, ISO, IEEE etc.) are used?
- IP67

Processing

Hardware and software complexity issues? Reliability? Common software frameworks or all proprietary? Any special approaches in the realization of the system?
- Pentium 4 ETX; flash memory (Common OS: Linux and iRobot Aware 2)

Communication

How is the communication between vehicle and control station realized? Prototype or commercial system? WLAN? UMTS?
- standard WLAN (IEEE 802.11g); optionally 4.9GHz (80211a-derivative)

What is the expected communication range? What is the influence of weather, especially rain and humidity, and environment, e.g. buildings, hills, dense forest?
- 1.2km line of sight; yes

How does the system react to temporary communication failures and interruptions? Any novel methods to increase robustness? What bandwidth / which communication means are required to keep the system running?
- the system is caable of extending its operational range by use of MESH-networking, optional Fiber optical spooler (250m); if necessary UMTS, LTE or satellite links can be established

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Localization

What is the indoor/outdoor localization system? GPS, inertial navigation, sensor-based localization or any combination thereof?
- digital compass and pitch/roll sensors, 3-axis accelerometers, UAP built-in position sensors, GPS

Sensing

What is the location and mounting of the sensors? Sensor type, range and field of view? What are the sensor characteristics and why is the choice of sensors suitable?
- localization of the sensors is not given in the SAP, contains interfaces for many different sensors; 4 video cameras with both visible and non-visible (IR) led illumination
Sensor fusion strategy? Any means employed to build models of the external environment?
Is there an internal sensing system to sense the vehicle state? Odometry? If odometry, how does it cope with real-world challenges like debris, slippery surfaces, vibrations?
- 3D-model of itself for purpose of collision avoidance
Camera system? Used only by a human operator or is a vision component part of the overall sensing system?
- four cameras pointing to the ground: optival flow analysis of each camerag

Vehicle Control

How does the vehicle cope with non-standard manoeuvres like abrupt braking, starting on a steep hill or making a sharp?
- PackBot 510EOD
To what extent is the system working autonomously? Or is it purely tele-operated? If applicable, how are complex operations implemented, e.g. waypoint following, off-road path finding or obstacle avoidance?
- seems to be teleoperated?
How is the vehicle controlled when not in autonomous operation? Is there any support offered by the control station? Semi-autonomous or assistance functions?
- Should the robot lose contact with the operato control unit, it will retro-traverse up to 20 meters in 5 meters intervals in order to re-satablish communications
Is there any automatic recovery behaviour in case of a communication loss?
- Should the robot lose contact with the operato control unit, it will retro-traverse up to 20 meters in 5 meters intervals in order to re-satablish communications

System Readiness

How mature is the system? Is it fully functional? Which components are still under development?
- the hw and basic functionality ok, autonomous operation not developed?
How would you rate the Technology Readiness Level (TRL) of hardware and software?
- HW TRL9 SW TRL3 (teleoperated?; their own estimation TRL9)
Regardless of scenario-specific challenges, what are problems and open issues to be solved before the contest
- autonomous operation?

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Overall Adequacy to Scenario-Specific Challenges

Can your system navigate in an unstructured environment (non-geometrical)?
- yes, PackBot

In underground structures, there is no GPS reception. What do you do for localisation?
- utilizing its compass and internal odometry (based on las GPS signal prior to entering the structure)

What sensor information will be passed on to the operator? How do you transmit and display the position of your vehicle and of detected Objects of Potential Interest to the operator?
- WLAN and optionally 4.9 GHz

How will smoke, dust and pitch black darkness effect your sensing? How will your system cope with non-visible obstacles? Can your system handle high humidity?
- thermal camera, RADAR sensor

As radio communication will be problematic, what if your system loses contact?
- back tracking

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Team ELP

Scenario Application Paper

Search and rescue in a smoke-filled underground structure

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Vehicle:

The PackBot 510 EOD is a field-proven, commercially available platform that is deployed throughout the world. It is a modular, ruggedized, lightweight (approx. weight: 30 kg depending on configuration) and highly maneuverable platform capable of carrying numerous different payloads.

The vehicle is IP-67-rated and can be submerged in 1.2m depth for over 1 hour. PackBot can climb hills in excess of 50° depending on surface conditions and is capable of climbing various different kinds of stairs.
Two Flippers mounted in the front of the robot assist in climbing stairs and overcoming obstacles.

Available payloads include manipulator- and camera-arms and communications- as well as sensory and computational payloads. By utilizing standardized hardware-Interfaces (Power, USB, Ethernet, Video) and a powerful, embedded Linux platform, it is very easy to add additional sensors and extend the system with further capabilities.

The operational runtime with 4 Li-Ion Batteries averages 15 hrs., depending on driving activity and power consumption of external sensors.

Processing:

On-board Pentium 4 ETX-Computer with integrated flash memory. The System is based upon the "Common OS" Linux-Platform and the iRobot Aware 2 Software Framework.
The software is field-proven, with thousands of units deployed across the world.

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Communication:

The system supports any IP-based communications medium. The chassis features a built-in 2.4 GHz Wireless LAN radio (802.11g). Optionally, a 4.9 GHz (802.11a-derivative) radio-module can be mounted for improved performance in environments where the 2.4 GHz-Band cannot be used. Typical effective communication ranges go up to 1.2km line of sight and beyond, depending on conditions.

The system is capable of extending its operational range by use of MESH-networking.

An optional Fiber optical spooler system carrying up to 250m of optical cable.

If necessary, communication may also be established using UMTS or LTE cellular Networks, as well as satellite links.

Localization:

The PackBot features a built-in digital compass and pitch/roll sensors. Furthermore, 3-axis accelerometers are utilized to detect hard impacts that might damage the robot.

The User Assistance Payload (UAP) features built-in position-sensors and accelerometers as well as a high-precision GPS.

Positional data acquired by the Robot is displayed on the Operator Control Unit (OCU) and is displayed as an overlay of a digital map or Aerial Photo. The route traveled by the robot is also displayed, along with any locations identified as “Points of Interest”.

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Sensing:

PackBot carries built-in absolute and relative sensors to monitor the positions and movements of its joints. The system maintains a 3D-model of itself for purposes of collision avoidance.

Furthermore, all motor voltages, currents and temperatures are constantly monitored as part of a built-in health-monitoring, failure recognition and diagnostics system.

In addition, the robot carries 2-way audio and 4 Video-Cameras with both visible and non-visible (IR) LED-illumination.

The system features interfaces for additional sensors, such as RADAR, LIDAR, Hazardous material and Radiation detectors, temperature and humidity monitors, as well as additional cameras (Thermal or wide-angle)

System Readiness

PackBot 510 EOD is a matured, field-proven, fully functional and ruggedized platform.

TRL: 9 for both hardware and software. (some additional sensors may however be a lower TRL)

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Search and rescue in a smoke-filled underground structure:

PackBot is utilizing its compass and internal odometry to determine its course and distance travelled from its known starting location.

This information is then utilized to draw a map indicating the path travelled by the robot, which is both presented to the operator on the OCU and stored inside the robot in case it needs to retro-traverse. Should the robot be able to acquire a GPS-Signal prior to entering the structure, the map is be drawn in relation to the last-known position of the robot. The operator uses the data on the map to determine the location of the robot.

Smoke and Dust, as well as humidity do not affect the functionality of the system. In order to be able to “see” even in completely dark and smoke-filled environments, PackBot will carry a thermal camera and possibly also an imaging RADAR-Sensor. The regular cameras carry visible and IR-Illumination, which will help in general darkness but most likely will not be effective in smoke due to reflections.

Should the robot lose contact with the operator control unit, it will retro-traverse up to 20 meters in 5 meter intervals in order to re-establish communications with the OCU.
Furthermore, MESH-Networking Technology may be utilized using either stationary nodes dropped off by the robot or a smaller, mobile repeater node to increase effective communications range.

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