Team/Robot    IAIR/SMMS
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
Based on commercially available research platform PIONEER 3AT, limited to flat surfaces and small slopes.

Processing
Laptop equipped with NVIDIA GPGPU GF540M for parallel computing, achieving real-time performance.

Communication
WLAN, ASUS RT-AC66U Wi-Fi 802.11ac router.

Localization
The SLAM system is the team’s main contribution: An improved SoA 6DSLAM algorithm is used to generate a globally consistent 3D metric map.

Sensing
Low cost 3D laser measurement unit, inertial measurement unit XSENS MTI-G

Vehicle Control
Autonomous navigation with semantic objects identification and online path planning.

System Readiness
Although based on successful previous work in the EU-FP6 ViewFinder project, this is still a research project.

Overall Adequacy to Scenario-Specific Challenges
The online 3D metric map building looks impressive. But it is questionable whether the vehicle is a good choice for this task. It might cope with the scenario - but only as long as the terrain does not get too rough. Additionally, it remains unclear how OPIs can be detected.
Eurathlon 2013
Scenario Application Paper (SAP)
TEAM: IAIR (J. Będkowski\textsuperscript{12}, P. Musialik\textsuperscript{12}, K. Majek\textsuperscript{12})
SCENARIO: Reconnaissance and surveillance in urban structures (USAR)  
23-27. September 2013, Berchtesgaden, Germany
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Abstract:
In this scenario we would like to evaluate Small Mobile Mapping System (SMMS) in realistic conditions. We are motivated by the fact that small mapping system can be easier deployed on the side in USAR scenario rather than large machine. There may happen major difficulties to deploy large UGV when the transportation infrastructure is demolished. SMMS is supposed to be deployed in the field with the effort of one operator per robot. Our mapping system is composed of low cost 3D laser measurement unit (range 20m), inertial measurement unit (XSENS MTI-G), mobile platform (PIONEER 3AT robot) and computer equipped with NVIDIA GPGPU GF540M for parallel computing. We presented major improvements into 6DSLAM algorithm based on real-time data registration and loop closing using semantic matching. Thus, our approach efficiently improves the applicability of 6DSLAM in realistic scenarios. We have evaluated the system in the field, where obtained 3D metric maps were compared with geodetic measurements obtained with accurate terrestrial 3D measurement system (Z+F Imager 5010). The results from the field proof the applicability of our SMMS in the field. SMMS is shown on figure 1.

Figure 1: The prototype of Small Mobile Mapping System.

Description of mobility:
Current prototype is built based on commercially available research platform PIONEER 3AT. It is limited to drive on flat surfaces and able to move over relatively small slopes, therefore we do not consider this mobile platform to be used in difficult/extreme terrain. It can work up to two hours.
**Description of localization and mapping**

Localisation and mapping was our main research effort [3]. We developed low cost shock resistant 3D laser range finder based on LMS SICK 100 mounted onto rotated head. Our approach is based on improved SoA 6DSLAM algorithm described in [1]. To map environments without occlusions, multiple 3D scans have to be registered. After the registration phase performed in real time a semantic loop closing technique finds matchable scans. If their registration result falls below a threshold, these scans are considered as overlapped. Local maps and robot poses are organized into a graph. Once loop is detected and loop error is distributed over all scans, a 6-DoF graph optimization algorithm [2] for global relaxation is used. The result is globally consistent 3D metric map. To deploy our SMMS into the field we decided to extend SoA 6DSLAM by additional functionalities to cope with problems occurring in real task scenarios. Figure 2 demonstrates the extended architecture of the mapping algorithm. The additional functionalities are:

- data decomposition (we implemented regular grid decomposition to improve Nearest Neighbor Search procedure by decreasing the computational time),
- data filtering and sub sampling (instead of filtering existing in SoA approach, our methods efficiently eliminates noise and dynamic obstacles such walking people),
- 6DoF GPUICP (we implemented new ICP methods using parallel computing to obtain real-time execution),
- new loop detector - Complex Shape Histogram (it is efficient loop detector using semantic information),
- loop error distribution over all scans (it helps LUM procedure to create consistent map).

The result of mapping in realistic conditions is shown on figure 3.


Figure 2: Extended SoA 6DSLAM (left) by additional functionalities to cope with problems occurring in real task scenarios (right).

Figure 3: The result of mapping in realistic conditions. Top – USAR like building. Bottom – underground garage.
**Navigation in USAR like environment**

We developed new robot control architecture based on parallel computing capabilities of on-board robot computer. This architecture controls the sequence of algorithms used for autonomous navigation in difficult terrain such USAR like scenario (figure 4). Following control algorithms are executed in the loop:

- data registration,
- semantic objects identification (floor, wholes, slopes, walls, traversable/not traversable area, etc…)
- path planning,
- computation of qualitative decision concerning navigation.

Robot is able to update navigation plan during 3D data acquisition. All computation is performed on GPGPU, therefore it is possible to achieve the performance considered as a real-time (constant execution time).

![Figure 4: The sequence of algorithms used for autonomous navigation in difficult terrain such USAR like scenario.](image)

**Communication**

During Eurathlon 2013 we would like to evaluate new communication module based on Router ASUS RT-AC66U Wi-Fi 802.11ac 5GHz.

**Acknowledgement**

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