

Underground Mobile Mapping Platform from Japan

Common mobile mapping systems heavily rely on positioning using GNSS. However, concrete, soil and other materials block GNSS signals, thus impeding their use when inspecting pipelines, subways or other underground corridors. Furthermore, such corridors are often narrow, which requires the system to be compact. In Japan a platform equipped with laser scanners and a camera which has been developed for mapping a wide variety of narrow underground spaces.

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Regular inspection of underground corridors is important to detect deformations and damage. The success of above-ground mobile mapping systems (MMSs) triggered us to design an MMS for use in inspecting underground corridors. The main constraints which necessitated the adaptation of conventional MMSs included:

- No receipt of GNSS signals below ground
- The system should be able to fit through manholes with a diameter as small as 60cm
- The system should be able to map corridors with a diameter as small as 80cm
- A working speed of 300 metres per hour is sufficient
- Corridors may be long, so cable-less power supply is required
- Batteries must have a long service life

Figure 1, Parts are assembled inside a corridor.

Platform

To solve the manhole issue, we have designed a modular all space mobile (ASM) system; all individual parts can fit through a 60cm-diameter manhole. After being passed through the manhole, the parts are assembled inside the corridor (Figure 1). To ensure compactness, the platform has not been equipped with an engine; instead, a human operator pushes or pulls the platform manually, or pulls it along using a rope. The platform including sensors weighs 100kg and has a length of 170cm, a width of 100cm and a height of 80cm (Figure 2).

Sensors

The main sensors (Figure 3) on board are: three laser scanners, 6 HD cameras configured to one camera system to cover a full circle, an inertial navigation unit (IMU) and odometers attached to each of the four wheels. The IMU provides the orientation and the odometers the distance. One laser scanner measures cross-sections and the other two lasers are used for determining objects for correcting the

IMU orientation data. Each scanner captures a 270-degree arc across track with a frequency of 4,050 points per second. The spacing between cross-sections depends on the speed of the platform; at 300m/h the spacing between subsequent scans is 0.5cm, which is the minimum for most applications. The camera system can take both photos and videos. An on-board notebook PC collects the data and monitors the survey.

Figure 2, Above-ground operation of the ASM (top) and inside a corridor.

Survey and Products

The ASM is positioned by using a total station to track a marker fixed to the platform. If direct tracking is not possible, the marker

is fixed to the corridor wall at a position visible from both the ASM and the total station. The coordinates calculated from the total station measurements are combined with the data obtained from the odometers and lasers to provide input for the 3D-SLAM (Simultaneous Localisation and Mapping) algorithm. The resulting positions and orientations enable georeferencing of the point clouds and images/videos. The point clouds can be further processed using

Figure 3, Sensors and other devices of the ASM.

free software such as Bentley Pointools View for real-time visualisation, Open Source CloudCompare for generating meshes, and Quick Terrain Reader. Plain views and along and across-track views can be automatically generated from the point clouds, and diameters of the tunnel segments can be determined. Comparison with the design enables deformations and damage to be detected. Figure 4 (see below) shows a georeferenced point cloud obtained from combining an above-ground survey with a corridor survey.

Concluding Remarks

We are working on reducing the weight and size of the platform to enable corridors as narrow as 40cm in diameter to be mapped. The ASM will be further robotised by mounting an electric motor and a remote control system. To broaden the range of spaces the ASM can operate in, it will be further modified so that it can also navigate staircases.

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Figure 4, Merged point clouds of above-ground area and corridor.

<https://www.gim-international.com/content/news/underground-mobile-mapping-platform-from-japan>
