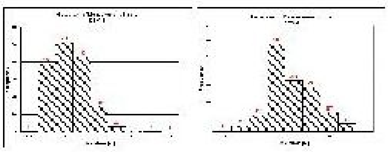
ACCURATE ENOUGH FOR URBAN AREAS

Mobile Mapping



Mobile mapping systems can quickly and accurately acquire geo-data at a high level of detail. Features especially beneficial in urban areas where construction and layout rapidly change and traditional surveying is rendered virtually impossible, and not only during rush hours. A mobile mapping system consists basically of a vehicle equipped with positioning sensors and laser scanners. It may also have mounted digital cameras, as with the Topcon IP-S2 described in this article, or other sensors such as thermal sensors and ground-penetrating radar.

The very core of a Mobile Mapping System (MMS) consists of a positioning system comprising a GNSS receiver integrated with an Inertial Measurement Unit (IMU). Such systems, which have been on the market for some time, are installable on any vehicle for direct geo-referencing of geo-data acquired by laser scanners, digital cameras or other sensors.

Rich Data
To improve accuracy, external odometers may be attached to the vehicle wheels; actually, these devices are indispensable in urban areas where GNSS measurements may sometimes be impossible due to satellite signals blocked by high objects such as buildings and trees.
A control unit to which all devices are connected and from which they are steered eases life for the operator during data capture. Laser scanners enable collection of 3D coordinates of millions of points. Three-dimensional virtual reality of the scene can be attained when the laser data is combined with close-range imagery, preferably recorded simultaneously by digital cameras mounted on the same vehicle. The resulting rich data can be conveniently processed in the office, either manually or using software.

Configuration
Usually an MMS will be equipped with laser scanners. Initially these were scanners that scanned in two directions, horizontally and vertically, but current systems consist of multiple-profile scanners performing dynamic scanning perpendicular to the direction of travel. Laser-scanner configuration depends on the number and type of scanners, and required output. The number of digital cameras and their positional placement on the vehicle depends mainly on application and the preferred method of information extraction from the recorded images. For example, manual processing of images by stereoscopic viewing requires another configuration than that required when panoramic images are used, or to determine coordinates of individual points based on intersection. Topcon's IP-S2 consists of a control unit connected to a computer via ethernet cable to which the following components are attached:

- GNSS receiver: data rate 10Hz, L1/L2 GPS + Glonass
- IMU: data rate 100Hz, gyro bias 1°/hour
- two external odometers: 10,000 ticks per revolution
- three laser scanners: scanning frequency 75Hz, typical range 30m
- spherical camera: maximal frame rate 15 images/second, panorama stitching resolution 5,400 x 2,700.

The system also supports IMUs based on Micro Electro Mechanical Systems (MEMS) technology. Up to six digital cameras and up to six laser scanners can be mounted. The parameters of individual devices are controlled through a web-based interface. The interval between two exposures of the digital cameras can be set according to time or travelled distance. Data acquisition is preceded by alignment aimed at initialising IMU values and fixing the GNSS solution. The alignment procedure should be performed in areas with good GNSS coverage to ensure high-quality positioning. This initial step can be carried out either while stationary (static alignment) or with a moving car (kinematic alignment). The latter entails large changes in vehicle heading while driving, and collection of sufficient data to enable proper computation of position and orientation.

At the end of a survey the alignment procedure should be repeated to improve accuracy
Alignment takes only a few minutes at the start and end of the survey, and careful performance of the procedure always pays off, since incorrect alignment may render hours of measurement useless.

Post-processing
Post-processing of IP-S2 MMS data can be divided into trajectory computation and processing of collected data. Trajectory computation uses all data from GNSS receiver, IMU and odometers. Data transfer rates of images can be increased by using raw data formats, enabling capture of up to tens of high-resolution images per second. Exterior orientation parameters are computed for high-resolution panoramic images created during post-processing.

These images can be further processed in the PanoramaGIS software package using the intersection photogrammetric method. Figure 2 (top) shows an overview orthophotomap of vehicle trajectory, consisting of camera projection centres (blue dots) as created by the software. The selected images marked in green are shown at the bottom of Figure 2. These are automatically retrieved by the software through mouse clicking in the overview orthophotomap. The next step includes attaching position, reflection intensity and colour to each laser point. Position, in the preferred coordinate system, and intensity are determined from the laser data, while colour stems from the images. Using Topcon's Spatial Factory it is possible to measure simultaneously in the images and/or in the Digital Surface Model (DSM) created from the laser points (Figure 3).

Since identifying points is easier in an image than in laser point-clouds, the determination of, for example, a distance, is performed by mouse clicking in the image while the distance itself is computed from the DSM.

System Accuracy
To test the accuracy of the system, the Z-coordinates of the projection centres as calculated during post-processing were confronted with two test lines: constructed on the D2 highway from the junction with the D1 highway to Blučina (DTM-1, DTM-2).

The accuracy of both DTM-1 and DTM-2 is better than 1cm. Over a length of 40km, images were captured every 2.5m. DTM-1 was compared with 1,514 projection centres, and DTM-2 with 1,555 projection centres, ensuring a sufficiently large dataset for accuracy computation. Assuming camera height remains constant while driving along a highway, this constant value can be subtracted from the Z-coordinates of the projection centres. The resulting values represent the Z-coordinates of the projection centres on the ground, and these should thus be equal to the Z-coordinates of the test lines. Figure 4 shows the resulting histograms. The standard deviation of the confrontation with DTM-1 is 2cm, and for DTM-2 this value is 2.8cm: sufficiently accurate for most mapping applications for open and urban areas.

Concluding Remarks
Mobile mapping systems equipped with laser scanners and digital cameras are able efficiently and accurately to capture road signs, road facilities, utility grids, and greenery. They are an excellent
means of collecting geo-data for urban planning and 3D modelling of cities with subsequent
visualisation.