TESTING STATIC AND MOBILE LASER SCANNERS

Measuring Open Pit Mines

Terrestrial laser scanning enables the acquisition of massive amounts of geo-referenced spatial data in a fraction of the time required by traditional methods. The remote scanning positions also improve worker safety. The author tested static and mobile laser scanning to gauge efficacy in mining applications, including volume estimates. The high-density Lidar point-cloud data acquired during the field test allows for 3D representations of mines, generation of maps of unstable slopes, and calculating accurate volume estimates of removed material.

Static scanning was carried out with ILRIS-3D (Intelligent Laser Ranging & Imaging System), and the mobile mapping survey was done with the Lynx Mobile Mapper. With its 10kHz data acquisition rate, a range of over 1.5km, robust field performance and portability, ILRIS-3D has great capabilities for measuring and imaging mines. We demonstrated the suitability of the system for open pit mine applications by surveying a gold mine in Brazil and a coal mine in Indonesia.

Continual Motion
Mobile mapping has proved efficient in many applications, including highway and road construction, infrastructure database development, asset inventory, architectural design studies and environmental change detection. Mobile mapping has recently also shown its potential in mining applications. The Lynx Mobile Mapper is equipped with two Lidar sensors, each collecting data at rates up to 200kHz, that is, 400,000 points per second when using both sensors. The range influences data density: the closer to the area, the denser the dataset. Designed to be mounted on a vehicle in continual motion while carrying out the survey, the mobile mapper uses an onboard GPS receiver and inertial navigation system (INS) to geo-reference the data. We demonstrated the suitability of the system by recording a coal mine.

Gold Mine
The survey of a gold mine in Brazil was aimed at analysing a landslide which had occurred a few months earlier, and calculating the volume of loss of material (Figure 1). To capture the entire extension, 1.5km by 1km, with a depth of about 700m, the mine was scanned from six positions, the coordinates of which were determined using a GPS receiver mounted on top of the scanner (Figure 2). The 1.5-km range of ILRIS-3D enabled the acquisition of detailed scans of each mine face from its opposite side. The scan duration was ten minutes per location, and produced five million points per scan, covering the rock face with surface details at cm-level.

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required two weeks. The six scans were aligned to a single point-cloud and converted to a single mesh. A digital terrain model (DTM) was then generated, allowing Lidar ground data to be classified by removing all points above or below a designated surface. The entire mesh was then automatically geo-referenced based on the six GPS positions. A virtual reference plane, necessary for the calculation of volume, was established by importing a geo-referenced polyline obtained from a previous survey carried out using traditional methods (Figure 3). The volume comparison identified landslide loss of material of about 8,350 m$^3$ from the upper part of the rock face (Figure 4). In addition, contour lines were extracted for comparison with the previous survey.

**Coal Mine**

The survey of a coal mine in Indonesia had two objectives: firstly to capture the general morphology of the mine, and secondly to determine the volume of coal extracted over a one-year period, October 2008 to October 2009. To capture the very long extension: 1.5 km by 10 km with a depth of 1,000 m, forty scans were required for the October 2008 survey, resulting in 200 million points. The field survey was completed in two days, whereas traditional methods would have required five weeks. The October 2009 survey was limited to the area where coal had been extracted, and for which volume calculation was needed. Both surveys were geo-referenced using a total-station and provided detailed models of the surfaces before and after coal extraction. Contour lines were also extracted and imported into AutoCAD for comparison and analysis.

**Canyon**

The survey of a coal mine in North America was aimed at creating a DTM and contour lines and, in some areas, calculating volume. This mine covers a canyon with a width of about 300-400 m. Five kilometres were surveyed while the vehicle drove at a speed of 20 km/h, collecting 200 million points in about two hours (Figure 5); previous measurements with traditional methods required about three weeks. A GPS base station set up near the mine’s office building collected data at a frequency of 1 Hz. This data was combined with the GPS and INS data collected onboard to calculate a Smoothed Best Estimated Trajectory (SBET) using commercial software. The SBET was then merged with the laser ranges, angles and intensity data to generate the final geo-referenced point-cloud. This stage required four hours in the office. Another commercial software package created the DTM and the contour lines and calculated volume.

**Concluding Remarks**

The surveys described here demonstrate that terrestrial laser scanning, compared to conventional methods, can be up to fifteen times faster. The managers of the three mines, distributed all around the world, all benefited from importing a final mesh into their own software for calculating volumes and other uses. All surveys resulted in the generation of a detailed DTM of the entire area, irrespective of terrain and access limitations. The dense point-clouds allowed geological analysis such as rock face stability assessments. The resulting accurate and extensive digital database gives mine engineers access to a wealth of information for supporting future operational decisions.

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