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Point clouds at depth

Laser scanning technology captures volumetric data in the form of a point cloud.

Francois du Toit of Hatch discussed the use of survey technology in the design of underground structures at the recent Structures for Mining & Related Materials Handling Conference in 2009. This event was claimed to be the first of its kind in the world, with the Southern African Institute of Steel Construction considering hosting more in the future. Typically, the design of underground structures assumes a certain excavated profile into which the structure will be placed. A problem arises when the excavation size is not planned. This means that the structures designed for the intended rock outline have to be adapted to the actual excavation without compromising structural integrity or functionality. Another alternative is to 'slipe' the excavation to the required shape to accommodate the structure. Both alternatives incur costs, delays and the possibility of compromising structural integrity and safety.

Du Toit believes that a far more practical solution to the problem is to modify the design in the consultants' office after the excavation is complete and before steel fabrication commences. This is only possible if an accurate three-dimensional model of the as-excavated rock face profile is readily available. Technological advances in laser scanning make the generation of three-dimensional rock models possible and cost-effective.

Du Toit says that laser scanning technology is used to capture volumetric data in the form of a point cloud. A scanner emits pulsating laser beams, which sweep over an object and measure coordinates of points on its surface systematically. The distance to a point on the

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surveyed object's surface is determined by one of two methods: measuring the time of flight of a light pulse emitted from and reflected back to the scanner, or measuring the phase difference or shift of a continuous beam of light or laser energy emitted from and received from and received back by the laser scanner.

By varying the horizontal and vertical angle at which the light pulse or beam is emitted, a scanner can, by producing one point at a time over several thousand points per second, build up an image of the object or environment being probed. The direction of the light pulse or beam being emitted is varied by a set of rotating mirrors that flip horizontally and vertically in combination with a fixed or rotating light source.

He notes that there has been a marked improvement in the equipment and application of laser technology over the past decade and that this trend would continue. Equipment is becoming more compact and easier to operate. Meanwhile, operating software is being upgraded continuously and becoming more sophisticated. It is now practical to do most of the data processing on site and to inspect completeness and the quality of the results prior to leaving the field. This enables immediate rescanning or additional scanning with minimal extra time, effort and cost required. Du Toit believes that it will become standard for scanners to have cameras built into them, enabling scan data to be textured with the photographs and to combine point clouds with spherical photography for panoramic viewing.

Some scanners already allow for a global positioning system (GPS) antenna to be fixed directly onto them. This will allow the routine use of a GPS to control surveys in combination with precise optical instruments and laser scanning. 3S technology, which is a combination of remote-sensing, GPS and geographical information systems, is a development that will facilitate the use, manipulation and presentation of spatial data for engineering and mining in a three-dimensional environment.

Du Toit says that new generation scanners do not have to be stationary on a tripod, but can be mounted on a vehicle with GPS, navigation and mass-storage devices, so entire towns and cities and industrial and mining complexes can be scanned and photographed on the run. Future applications of laser scanning could include:

- continuous monitoring for early warning of a stope, tunnel or surface slope that is prone to failure;
- routinely scanning excavations to monitor progress and calculate material volumes; and
- scanning a shaft from a moving conveyance for routine inspections and the monitoring of guide-rail alignment and condition. ○

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