3D SPATIAL INDEXING FOR LIDAR DATA

YobiLiDAR

To exploit the full potential of Lidar data, three-dimensional (3D) spatial indexing capabilities are required in vendor systems. Multiple software packages are currently needed, which entails importing and exporting different file formats, thus losing accuracy and increasing costs. The YobiLiDAR project has developed a single system which, combined with new functionalities in Oracle Spatial 11g, empowers storage and analysis of Lidar data in a Database Management System (DBMS).

Since the mid-1990s there has been a clear upward trend in sales of aerial Lidar systems; 250 have been sold and the rate at which they are entering the market doubles every three to four years (Figure 1). Organisations as diverse as Google Earth, the North Carolina State Department of Emergency Management, and Ireland's Department of Communications, Marine and Natural Resources now exploit such data. Laser pulse rate is also doubling every two years, and GPS+Glonass high accuracy can now be achieved, further improved by the use of 'fitting' software such as TerraMatch.

Unexploited Advantages

The rapid commercial and technological evolution of Lidar poses challenges regarding full exploitation of the resulting 3D point-cloud. This new wave of 3D data ought to be available for manipulation and deployment by a wide range of users rather than just those with technical knowledge and specialty software. However, many of the advantages remain unexploited due to the inability of GIS systems to fully support 3D data in a spatially accurate and meaningful manner. A viable alternative is to integrate all functionality within a Spatial DBMS (SDBMS). Until recently, SDBMS did not support 3D data management. However, since its last release, Oracle Spatial has included new data types for the storage of 3D point-clouds and Triangular Irregular Networks (TINs). But the functionality has limitations when handling large datasets. New indexes may help overcome this.

Quadtree and R-tree

Indexing is used in traditional databases to accelerate operations on large datasets. In the spatial domain indexes are used to organise space and objects within it so as to eliminate traversing a complete table when performing spatial queries. Given the sheer size of aerial Lidar datasets, efficient indexing is crucial. SDBMS vendors offer either space-based 'quadtree' or object-based 'R-tree' as spatial index structures. In a quadtree each node has four child nodes, while the space is decomposed into 2D cells. The 3D extension of a 2D quadtree is the octree in which each node has eight child nodes and thus divides the space into cubes. This approach has not yet been implemented in any commercial system. The R-tree is currently the only truly 3D index available in Oracle Spatial. R-tree indexes are based on Minimum Bounding Rectangles (MBR); this makes them difficult to apply on point data, as the definition of an MBR on data points is arbitrary. What is more, vendors implement R-tree approaches differently, which affects the performance of the indexing technique itself and consequently impairs accurate comparisons between systems.

Octree Index

Part of the University College Dublin YobiLiDAR project (1) is devoted to providing an octree-based 3D index for Lidar data relying on the extensibility properties of Oracle Spatial. The project, sponsored by Ireland's National Digital Research Center (NDRC), aims at developing indexing methods for Lidar point-cloud data stored in an Oracle Spatial 11g database (Figure 2). This facilitates search and manipulation of very large 3D point-clouds in an effective and timely manner, and enables a large 3D Lidar point-cloud consisting of millions of points to be treated as a single dataset without the need for it to be split into multiple tiles. This may, for example, be of use in the increasing controversy surrounding 'right-to-light' claims, being used more and more as the basis for thwarting planning permission for large projects. In such a case an existing Lidar set could be used to accurately evaluate how a proposed structure might impact surrounding structures in terms of light.

Concluding Remarks

In the YobiLiDAR project we have also developed a 3D Viewer allowing graphical manipulation of Lidar point-clouds (see Figure 3) and tailored it for 3D visual analysis and manipulations not currently available in the Oracle viewer. In addition to standard rotation/pan/zoom operations, point-clouds and TINs can be rendered, new features included, and their impact on existing data analysed.

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