Lidar

This issue of GIM is largely devoted to emergent Lidar technology. We have a feature on 3D-visualisation of Lidar data co-authored by new contributing editor Dr Bharat Lohani of IIT Kanpur India, and no fewer than two product surveys, one on Airborne Lidar Systems, the other on Lidar software. Two regular features, Technology in Focus and Companyâ€™s View, this month address processing the product of Lidar survey, point-clouds. Lidar is without doubt a most successful data-acquisition technique. As an acronym of Light Detection and Ranging - some prefer to read Lidar as Laser Imaging Detection And Ranging - the term has become a â€˜proper nameâ€™, spelled like your own first and surname with the initial letter the only capital.

Beneficial Features

Although the rise of Lidar as an operational system began just a decade ago, its history dates back to the sixties when it was first tried out. In the 1970s experimental systems were developed. Accurate positioning remained a bottleneck until, in the early nineties, GPS became a reliable, stable and precise positioning technology. Today Lidar is recognised as an advanced technology with many beneficial characteristics: high rates of data capture (up to 100km2/h) and levels of automation, right up to 3D-reconstruction of the real world. Lidar also features low cost per point, high accuracy and precision and a high level of detail (up to millions of points per square kilometre), while the final solution is largely independent of terrain type, characteristics and daylight/weather conditions.

Millions of Points

Airborne Lidar systems are multi-sensor, usually consisting of a reflectorless laser sensor, a positioning system and a digital camera. The laser sensor determines distance from the platform to arbitrary points on the Earthâ€™s surface by measuring the time interval between transmission of a train of pulses (up to 250,000 pulses per second!) and return of the signals. A rotating or nutating mirror enables scanning perpendicular to flying direction. To compensate for mechanical instabilities and guarantee constant alignment, fibreglass optics may be mounted in front of the mirror. A positioning system is required to transform range measurements into 3D terrain coordinates, and this comprises two coupled main parts: GPS and Inertial Measurement Unit (IMU). The aim of the GPS is to measure the position of the laser sensor. Sampling frequency is in the order of a few Herz. The IMU, also called Inertial Guidance System (IGS), uses a combination of accelerometers and gyroscopes to detect rate of change in acceleration and attitude; the latter usually defined as pitch, roll and yaw. Position is calculated by two times integration of accelerations along the three perpendicular axes. Accumulation of measurement errors means an IMU suffers from drift, resulting in discrepancy between its true and apparent position. IMU positions are, however, not useless: since sampling frequency lies in the order of several hundreds of Herz, IMU positions may fill GPS gaps. To compensate for drift, IMU position is updated every time a GPS position becomes available. Integration of GPS and IMU measurements is done using Kalman filter technology. In contrast to GPS, IMU does not require external aid. As an autonomous system it is immune to any interference from the outside world, such as jamming. Integration of the two systems improves accuracy of positioning and precision.

The Real World

Depending on system, flying height, speed and number of flyovers, point densities up to some dozens per m2 can be acquired. Helicopters are better suited for high-resolution coverage because they can easily limit their speed. Since Lidar is an active system, data acquisition is independent of sun illumination, while no shadows are generated. Weather and visibility only slightly affect flown survey. Height values may be effortlessly obtained in areas of low textural variation, such as beaches and dunes. Wavelengths in the near infrared part of the spectrum (typically 900nm, 1,060nm and 1,500nm) are non-penetrative, so that pulses will be reflected from forest-stand foliage and other vegetation. Since the footprint is of limited extent (typical beam divergence being a few milli-radials to sub-milli-radial) some of the signal may reach the ground if vegetation is not too dense. The last part of the return signal may thus represent distance to the ground and the first part canopy height. Some systems, in addition to the first and/or last part of the return signal, collect four or eight samples, or even the entire return pulse, enabling determination of vertical surface structure such as roughness, height and shape of objects, canopy density and height of trees, and reflectivity.

Adjustment

The value of Lidar data appears to full advantage when combined with other datasets such as aerial and satellite imagery and topographic data. Lidar provides useful information for all stages of infrastructure works, such as corridor planning, environmental-impact simulation, optimal movement of earth works, determination of (rail)road deformation and detection of obstructions such as fallen trees after storms. Lidar also provides information for the creation of 3D-digital city models and aerial monitoring of electricity power-lines. Other applications include flood-hazard zoning, river-flood modelling and assessment of post-disaster damage. The accuracy and resolution of Lidar are so high that geo-scientists are apparently being forced to adjust their erosion and floodplain models.