Photon Lidar, a Promising Advance in Mapping Applications

Airborne Lidar has matured over the last two decades into a mapping technology routinely used for 3D modelling of urban areas, capturing boreal forests, seabed mapping and many other applications all over the world. The speed with which the laser pulses are fired continues to soar and for a number of commercial systems it has reached the impressive number of one million pulses per second. Multiple pulses in air and (full) waveform digitisation are other developments which found their way to the users in recent years. Last year Optech introduced Titan, the world's first multispectral airborne Lidar. Without doubt the enhancements and advances will continue to emerge. One seemingly promising recent advance for mapping applications is photon Lidar (also known as Geiger-mode Lidar). But what is photon Lidar?

In conventional Lidar systems one pulse provides data on the reflectivity, the range and, when using (full) waveform digitisation, the surface structure of the footprint of the single pulse on the object – *one* pulse results in an information nucleus for *one* object point. The return signal contains thousands of photons. In contrast, the photon Lidar approach creates an array of points from a single pulse fired by the system – one pulse is divided into dozens or hundreds of sub-pulses. The partition of one pulse into many is enabled through the use of diffractive optics which split the outgoing pulse into an array of sub-pulses. The optics can be tailored to the needs of the user; the size of the array may be, for example, such that a quadrangle of 10 by 10 sub-pulses is generated from one pulse emitted by the sensor. The partition of the pulse in a 10 by 10 array enables one pulse to capture a point cloud of up to 100 points. The returns from the individual sub-pulses are captured by a receiver also consisting of a 10 by 10 array. So, one pulse does not cover one footprint, as conventional airborne Lidar does, but rather captures multiple individual adjacent points resulting in a high point density. The sensitivity of the sensor is so high that the range to the surface of an object can already be determined even if just one photon is present in the return signal. Therefore, it is of no great concern if many photons in the fired pulses or return signals get lost in the atmosphere. As a result, the distance from sensor to the object may be much larger than for conventional Lidar. Similarly the swath width may be larger which reduces the number of flight lines, and hence data acquisition time, without affecting point density. A typical conventional airborne Lidar survey may be flown at 1,000m to 1,500m while a photon Lidar survey may achieve equivalent point densities at a flying height of 4,000m to 5,000m and the number of flight lines may be reduced by a factor three.

Are there no snags? Yes, there are. Photon Lidar detects only photons and registers the time of flight but not the strength of the return signal and thus no waveform digitisation is possible. By using RGB and NIR cameras the first shortcoming can be compensated for while the reconstruction of the surface structure, which is the main asset of waveform digitisation, can be derived from the dense point cloud. The ability to operate at low power levels is an advantage but requires on the other hand highly sensitive sensors which may wrongly detect solar photons as return signals. The effects of this type of noise may be diminished by careful design of beam divergence, spectral width, filters and other system parameters. Up until now, photon Lidar is not in use for the commercial collection of geodata. Before it can become a proven technology, further research is required to obtain thorough insight in the accuracy and reliability characteristics and into the ways to improve these major surveying parameters.

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