Photon Lidar

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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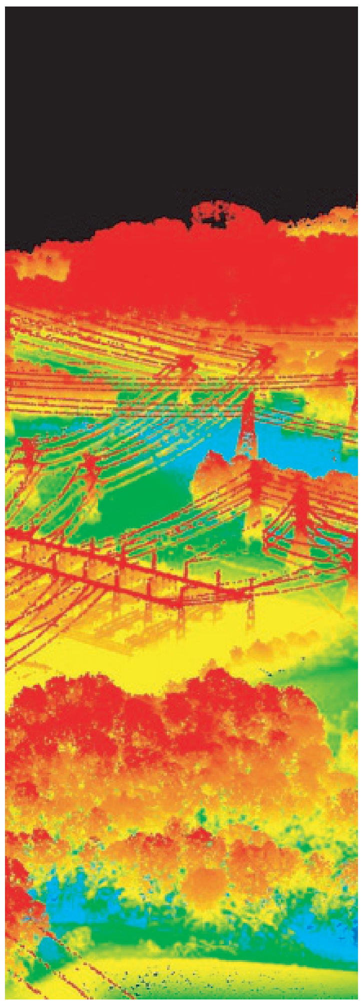

Dense Image Matching

Point clouds are increasingly a prime data source for 3D information. For many years, Lidar systems have been the primary way to create point clouds. More recently, advances in the field of computer vision have allowed for the generation of detailed and reliable point clouds from images - not only from traditional aerial photographs but also from uncalibrated photos from consumer-grade cameras. Dense image matching is the powerful technology underpinning this development.

Understanding photogrammetry
A good understanding of dense image matching requires insight into the way photogrammetry works. Photogrammetry in itself is not a new technology; it has been applied in practice for decades without many changes to its fundamental concepts. In photogrammetry, 3D geometry is obtained by creating images of the same object from different positions. This makes a single point on the object visible as a pixel in multiple images. For each image, a straight line can be drawn from the camera centre through the pixel in the image. These lines will intersect at one point, which is the 3D location of the object point.

However, this requires the position and orientation of each image to be known. To this end, so-called tie points are used to link all the images together. Each tie point is a well-recognisable point that is identified in all images where it occurs. Sufficient tie points allow for the reconstruction of the relative position of all images. Additionally, known points or ground control points (GCPs) with 3D world coordinates should be added to obtain scale and absolute coordinates. Tie points and GCPs are combined in a bundle block adjustment, resulting in the 3D coordinates of all tie points and, more importantly, the position and orientation of each image.

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Pioneering Dubai

Dubai has always been a pioneer and lead from the start when it comes to innovation and the application of new-age technologies to modernise the functioning of various organisations. Furthermore, the city has spearheaded several initiatives intended to make the world a better place to live in for its inhabitants. However, the activities are not just limited to Dubai. Some of the Emirates' initiatives extend to diverse parts of the globe. The Mohammed Bin Rashid Al Maktoum Global Initiative is one such step that aims to improve the world through humanitarian, developmental and community work in the areas of combating poverty and disease, spreading knowledge, empowering communities, and entrepreneurship and innovation for the future.

Several projects launched by the Initiative, in the above mentioned areas, have benefitted 130 million people from over 100 countries across the developing world and the future looks even brighter. Geospatial data and imagery assume great significance in giving impetus to these initiatives by providing crucial intelligence to people on the ground and thus making sure that the efforts are directed in the right direction and produce the best possible results.

In order to give further impetus to the use of these technologies, the need of the hour is to showcase the immense benefits of these technologies on a global platform. The hosting of the 2020 ISPRS Congress in Dubai will not only be a boost for the further promotion and propagation of these technologies in the region but will also give the participants a chance to experience the traditional Middle Eastern culture with a delectable mix of some of the most advanced and ultra-modern architectural creations on the planet. To find out more about these initiatives and support Dubai's bid for hosting ISPRS 2020, please visit Dubai Municipality pavilion at booth no. 69.

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