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Increasing Survey Value Through LiDAR Technology

Laser Scanning technology adds depth and detail to traditional surveying applications

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Abstract

Laser Scanning or LiDAR technology is well suited to the survey profession. The smart surveyor will discover that LiDAR is more than “just another tool in the box”, and instead adds a means to supply added value to their end product. The application of LiDAR technologies can be applied to the traditional Civil and Architectural fields that surveyors have inhabited in the past. The increased detail of LiDAR data gives today’s surveyor the ability to deliver a more complete and valuable product to their existing clients. A picture is worth a thousand words, imagine how much more that picture is worth if supplied with accurate XYZ data.

Presenter Bio

Robert J. Mellis is a Professional Land Surveyor licensed in Florida. Mr. Mellis has 30 years surveying experience performing boundary, topographic, control, design and construction surveying activities. He’s currently employed by Bentley Systems Inc. where he works as a Solutions Engineer, responsible for helping to develop new methods and technologies of integrating different software applications to streamline work processes. He is a certified instructor in Microstation, Bentley Civil and Geospatial products.

What is LiDAR

The science of **Li**ght **D**etection and **R**anging or **LiDAR** has been around for over 40 years. Until the late 90's it was used primarily in guidance systems for long range missile deployment. Recent advances in technology have now made it available to the general public for practical and cost effective applications that provide more precise details of structures and facilities, in a reduced time frame less than that of conventional means.

In its most simplistic terms, the technology works by sending out a beam of light on a modulated frequency. The light is then reflected off a surface and the distance to the reflected location from the base is computed. Strength of the return signal is also noted, which determines the spectral properties of the actual point observed when displayed graphically. The result is a dataset or "point cloud ", of sometimes millions of individual points. The detail, to which the returned scanned image applies, is dependent upon the scan interval. Scan intervals can be as great as 1 meter for mapping large areas, or as fine as 1 micron, used in quality control for manufactured parts.

Most scanners incorporate a digital camera, or a coaxial mount for a camera. The photographic image aids in processing the point cloud data by providing additional detail. Point cloud data is essentially colored pixels, with simple XYZ intelligence. The addition of the photo image, allows for creating feature images and QA/QC of the scanned data.

What are its applications

There are two basic types of scanning technology, *Mobile* and *Static.* The equipment and methodology of scanning is essentially the same. The main difference between the two methods is that Mobile scanning employs additional sensors, Global Positioning Satellite (GPS) and Inertial Movement Units (IMU) to account for the movement of the platform.

Aerial LiDAR

Aerial LiDAR is currently the most popular form of mobile scanning. It is used in both fixed wing aircraft and helicopters. The laser scanning equipment is combined with both Global Positioning Satellite (GPS) and Inertial Movement Units (IMU) to provide precise coordinates to the scanned data. These systems provide extremely precise and accurate maps used in a multitude of civil, geospatial and environmental applications. Most times it is combined with digital photography to aid in the creation of topographic maps precise enough for design functions. Aerial LiDAR is used in the same way that conventional photogrammetry has been employed in the past. Civil design, GIS and Environmental mapping benefit most from the higher resolution data supplied by aerial LiDAR.

Terrestrial Scanning

Terrestrial LiDAR makes use of the same technology in aerial scanning however there is one significant difference. Unlike aerial scanning, there are times objects such as a light pole or bus shelter may prevent the scanner from picking up information behind it. To counteract this "shadow effect" two scanners are employed to scan ahead and back, assuring no area goes un-scanned.

The scanners are mounted upon a moving platform such as a motor vehicle, with the GPS and IMU equipment inside. The speed of the vehicle is determined by such factors as required detail (greater the detail, slower the speed) and limitations of the actual hardware itself. Some scanners are capable of acquiring data at an extremely high rate, while others are not so advanced.

Static Scanning

For most applications the scanner is set up on a tripod used to support survey instruments. It is generally controlled by a laptop computer which is connected via a cable or wireless link. The scanners used for Static scanning are the same as those used for Mobile scanning. Since the scanner is not moving, GPS and IMU controls are not necessary. Coordinate orientation can be acquired by either scanning known control points or by entering coordinate values for the individual scanner locations after the fact.
In manufacturing applications, the scanner is usually attached to an articulating arm that is either controlled robotically or manually.

Scanning Application Matrix:

Industry	Mobile Scanning Aerial	Mobile Scanning Ground	Static Scanning	Comments
Architecture	X	X	X	Buildings and Features, Restoration, Floor Plans
Civil Engineering	X	X	X	Bridges, Tunnels, Roadways, Structures, Rail, Topography / Features
Geospatial	X	X	X	Utilities, Buildings, Land Use, Topology
Mining		X	X	Faces, Quantities, Stockpiles, Strata
Manufacturing			X	QA/QC, Asbuilts, Floor Plans
Sciences	X	X	X	Archaeology, Geology, Medical
Forensics			X	Crime and Accident Investigation, Scene Preservation
Plant / Works		X	X	Power, Chemical, Refineries, Utilities
Environmental	X	X	X	Wetlands Delineation, Flora Classification, Biome Management

How it adds value over traditional survey methods

LiDAR adds value to your survey work in multiple ways. The two most obvious are the ability to scan data in a much denser format and the speed with which you can acquire that data. Using conventional survey tools, the density of the data is dependent upon the interval in which you locate points. Whether it is random shots or cross sections, there will be large areas of data that will be left out. Even the most diligent of field surveyors will miss a point or two on occasion. With a scanner set to a finer interval say one meter, more points will be located and a much higher density and the likelihood of missing a critical point is diminished to where it is almost an impossibility. A scanner will also collect data faster than is humanly possible. Combine the speed with the precision and the value of your survey time itself is increased greatly.

Densification and Detail of Data

As mentioned scanning allows the operator to gather data in greater detail. Issues in the past that could only be noted now can be mapped in detail significant enough to leave nothing to the interpretation of written or verbal communication.

An excellent example of this are cracks. Cracks in structures or surfaces such as pavement or concrete can now be mapped in extremely fine detail. The end user of the data can now see the crack outlined in the scanned data. This definitely increases the value of the data itself as no traditional survey method can locate and identify it in a detail that is of a useful measurable quantity. If one were add a photo background to the scanned data, which is easily done with most scanners, the user of the data now has the ability to easily trace that crack and determine the seriousness of it.

The densification also leads to much greater detail and usefulness of data in deformation monitoring. The precise detail of scanning will highlight even the slightest movement of the monitored surface.

Surveyors have always considered themselves “expert mappers” and rightfully so. With the increased detail available through scanning technology, surveyors can now map objects that normally would be outside the realm of possibility. An obvious item would be the pipe works of a refinery. A surveyor with great effort might be able to map fittings and even bolt patterns, but then would have to spend an inordinate amount of time connecting these individual points into a picture of useful intelligence. With a scanner, these pipes could be scanned and mapped in great detail at high speed. With the post processing software available, these pipes could be “filled in” if you will, as cadd elements in a fraction of the time that would be used in more conventional means.

Speed in Acquiring data

Scanners are designed to map objects at a predetermined resolution. This resolution is determined by the operator based on the required precision of the data. Scanners can acquire data at ranges from 5000 to 11,000 points per second. Consider for a minute how many points you can acquire in a day using conventional tools such as total stations and GPS, and compare that to the number of points you can gather with a scanner over the same area in much less time. Time savings in field work average 80% using scanning as opposed to conventional means. Less time spent acquiring data, translates to more time to acquire data. In all fairness, the time to process scanned data and bring to a finished product is longer than that of conventional survey data. At current rates, it takes 2 – 3 times longer in the office to bring scanned data to a state o f completion than conventional means. However the technology and development of processing software is growing at a phenomenal rate. Ease of use and more experienced

technicians are closing this gap rapidly. It will not be long before the time to process scanned data is the same as conventional data. Currently collaborative efforts are underway between hardware and software manufacturers to develop uniform standards for file formats of data. This will allow surveyors to move the data easily between software applications without any loss of intelligence at the same time as allowing the surveyor to expand their capabilities with scanning technology. The American Society of Testing and Materials or ASTM (www.ASTM.org), is an international organization that has several committees devoted to laser scanning and its applications. These committees referred to as the E-57 group is made up of a combination of hardware, and software providers as well as current users of scanners and end users of data. Their efforts have gone a long way to easing the burden of processing and using scanned data.

Additional Benefits of Using Laser Scanners

Additional benefits to using scanners are realized mostly in a financial sense. We have discussed how you can acquire more precise data in less time. In static scanning one can set up the equipment in a location removed from most of the hazards encountered while surveying. Add this to the fact that no individual has to identify the actual point being scanned. Now you have created a situation where even the most hazardous of projects can be mapped with much greater safety. A roadway intersection can be scanned without anyone ever actually setting foot within the traveled way. Structures can be scanned without any one having to climb up and around them. Less risk means lower insurance costs and fewer workers compensation claims. The increased precision is results in fewer errors which are reflected in errors and omissions and liability insurance premiums. Not to mention the money saved, by businesses that choose to pay these claims out of pocket as opposed to paying through their insurance provider.
Scanned data is available for cursory review as soon as it's collected. With a laptop computer connected to the scanner, one can observe the data as its being scanned. This immediate feedback allows the operator to confirm on the spot that data has been captured covering the required area to the required density and precision. No longer will field personnel have to return to the job, to acquire additional data that should have been gathered in the initial visit. Finally, less people are required to operate a scanner. Even with Robotic total stations and GPS, usually a second person is required to guard and watch over the base station or instrument. In more rural settings this is rarely an issue, but in suburban and most critically urban environments it is a major concern. With only person on each crew a survey business can further reduce overhead and increase profitability on a project.

Conclusion

Laser scanners are not cheap. That is a fact, but neither was GPS when the technology first was applied to surveying. Over time the price of equipment will become more palatable for the mass market. However a prudent surveyor can look at the investment now and see almost immediately results that will more than offset the costs. By increasing the quantity and quality of the data, acquiring it in less time with less labor, the equipment and software will pay for itself rather quickly. Combine this with being to better satisfy your clients, and expand into markets one would not normally consider open to surveyors and you can see that utilizing LiDAR technology will indeed add value to your survey product and your overall bottom line.