SHORTCOMINGS IN SPATIAL DOCUMENTATION OF HERITAGE SITES

Laser Scanning Technology Challenged

In this month's Insider's View Prof. Heinz Rüther puts some critical points on the shortcomings of laser-scanning technology in the spatial documentation of heritage sites. We invited manufacturers of laser-scanning sensors and software to comment on his challenging observations. Nearly 70% of the companies responded (ten in total) and seven felt qualified to reply: Optech, Riegl, Leica Geosystems, 3rd Tech, Visual Learning Systems, TopoSys and I-SiTE 3D Laser Imaging. We thank all respondents for their time and effort.

Critical observations made by Prof. Heinz Rüther include the following. (1) The processing time of laser-scan data can be up to ten times that of the time needed for acquisition. (2) The creation of surface-models free of scan holes and with correct edges is difficult. (3) Software for photographic texturing of the scanned surface is not yet perfected. (4) Lack of pragmatic, affordable software which enables the archaeologist, conservator or architect to make practical use of the 3D-models generated and (5) the temptation on the part of the layperson to produce aesthetically appealing 3D computer models without considering reliability or accuracy. Although Heinz Rüther is particularly referring to terrestrial laser scanners, we also include here responses from manufacturers of airborne Lidar technology, because their observations are of interest. The replies are published in order of appearance in my email inbox.

Lay Temptation

Since respondents mainly focus on the first four issues, I would like to start with a few statements on the fifth and last: temptation facing the layperson. Indeed, whenever a new technique emerges, enthusiastic laymen may find themselves overwhelmed by visionary perspectives, snatch at the technology and start experimenting. In my opinion this is far from a threat; we should welcome the novice as advocate and promoter of new technology. In my experience, the moment comes when the layperson or user of some passionately created product discovers that something is either missing or wrong, and from that moment on the conviction is born of the need for input from an expert, in particular the geomatics specialist. In this context I would like to quote some thoughts I put down over six years ago in the columns of this journal (GIM International, July 2001 Vol. 15(7), page 11, and reproduced in my book Geo-information Engineering: Changing Technology in a Changing Society, page 86).

Knowledge for Quality

Much geo-information can today be produced in a cheap way by virtually anybody who buys a computer and a GIS package and who is sufficiently skilled to read manuals. However, do the great advances in computer technology mean that the processing steps can be performed more or less blindly The production of geo-information is a process, a chain of activities. Throughout the existence of our profession, not the measuring or information extraction process itself has been central, but the quality-assurance process as decisive factor. Measuring and information extraction can be done by anybody, but to arrange the measuring and the processing of the data in such a way that errors and inaccuracies are avoided with the minimum effort in terms of money and time is key. […] The virtual buttons of information-technological tools alone cannot produce high-standard geo-information […] The availability of knowledge on quality control of the entire geo-information process is key to producing reliable geo-information. These three: tools, skills and knowledge are the tripod of any proper geo-information process, but the most important of these three is knowledge.

Optech Inc

Optech, a world leading Lidar-scanner manufacturer, shares Professor Rüther's opinions, observations and conclusions that laser scanning of heritage sites 'is clearly here to stay'. The entry of all new technologies onto a market characterised by established techniques and practises means learning curves for both user and manufacturer. The user must invest time in learning how best to apply the product in their applications. The manufacturer must heed user feedback to improve offerings and ultimately satisfy user requirements. This has been true of the introduction of all types of geomatics technology: photogrammetry, electronic survey instruments and GPS. Concerns over expensive and time-consuming processing software are valid. The acquisition of a new scanner should allow the user to freely select appropriate processing software. A prudent review of scanners will reveal that customer-focused scanner manufacturers such as Optech deliver raw scan data, enabling the user to process the data using existing software or to choose which software will meet all their requirements, not just those of the scanner. Some manufacturers force the user down a pre–determined application path by limiting them to a closed data format. With proper training and the correct post-processing software an experienced user becomes more efficient and is able to minimise time spent data processing. However, it is the complexity of the end deliverable that dictates overall processing time. In Optech's experience it is not unheard of for a proficient user to process data at a 1:1 ratio to time taken for collection, depending on the final deliverable; other deliverables may require far longer.

RIEGL Laser Measurement Systems GmbH

Field archaeologists are confronted in their everyday work with the need for 3D documentation of cultural heritage. There are not only monuments like the pyramids or Stonehenge. The majority of archaeological remains lie buried in the ground and are revealed by stratigraphic excavation; the capabilities of a terrestrial laser scanner fit perfectly the need for detailed documentation of any excavated surface and form the immaterial units of any archaeological stratification. They represent the forth dimension, time, and that is what archaeology is all about. Integrating the latest laser-scanner hard and software made by RIEGL provides not only the said effectiveness and required robustness but makes it possible to speed up the documentation process by 80% compared to conventional drawing, and up to 40% compared to the use of total-stations. Several well-designed software solutions are available to help the archaeologist in his work, for example:
- RiSCAN PRO (www.riegl.com) allows users the combined data acquisition of laser-scan data and calibrated photographs. Triangulated meshes with high-resolution textures are calculated within minutes
- PHIDIAS (www.phocad.de), a CAD-based application, makes use of 3D-mono-plotting technique. The raw point-cloud and raw photographs can be used to immediately draw 3D-CAD objects as polylines and surface models
- aSPECT3D (www.arctron.com) is optimised for the needs of restorers, conservators, archaeologists and excavation technicians. It was specially developed to simplify the processing of amorphous 3D-surfaces and irregular structures that so often occur in architecture, art-heritage and archaeology. 3D-models can be quickly and easily structured, classified, divided into their constituent elements and prepared for scientific analysis or damage mapping.3D laser scanner technology is still under development. But its application will be common sense at the high endof archaeological fieldwork far sooner than would be believed from Prof. Rüther´s critical statement.

Leica Geosystems
Prof. Heinz Rüther makes two points about the shortcomings of point-cloud and related software for heritage applications. One concerns the excessive time needed to create fully-fledged, watertight, photo-realistic 3D-models. The second is the assertion that there is a 'lack of pragmatic, affordable software which enables the archaeologist, conservator or architect to make practical use of the generated 3D-models". A key premise here appears to be that the only practical use of laser-scan information for heritage applications is in the form of 'watertight, texture-mapped 3D-models'. Based on experience at Leica Geosystems, I believe that this paints an incomplete picture. While such models are one of the useful deliverables employed by such professionals, they are not the only one. In many instances simple distance or coordinate measurements, 2D and contour drawings, and approximate 3D-models based simply on raw point-cloud data can provide information invaluable to such professionals. For these needs, the office processing time is today often far less than the 10X cited, and an order of magnitude less in some cases. Furthermore, Leica Geosystems' new Leica TruView software provides the ability to view, measure and mark up or annotate photo-overlaid scan datasets over the web for free! While such photo-overlaid scan datasets do not constitute a formal, texture-mapped 3D-model, this pragmatic point-cloud software can provide high value for these professionals at the best price of all: free.

3rdTech Inc
Professor Rüther says that 'Laser scanning of heri–tage is still at an early stage of development…' and I agree… but it's not as early as it once was. He has highlighted 'technical shortcomings'. Here are some technical advances. In the early days of 3D laser scanning, scanners were expensive, heavy, slow and provided no colour. The software was costly and difficult to use, even for engineers. Now there are smaller, faster, affordable 3D-scanners. Several offer colour-capture and, most importantly, software development has been dramatic. 3rdTech has as a company focused on tools for creating useful, photo-realistic 3D computer graphics models of the real world. Our DeltaSphere scanner captures high-resolution digital photographs, along with 3D-range data. SceneVision-3D software makes it fast and easy to produce a 3D-model from multiple scans. There is a user-friendly tool for colour alignment that can produce remarkably realistic models with high-resolution colour. SceneVision-3D enables the production of 'aesthetically appealing 3D computer models' without sacrificing 'reliability or accuracy'. Furthermore, SceneVision-3D has not been designed for engineers or surveyors, but rather for experts in other fields, like forensics or archaeology. Product development is driven by our customers. DeltaSphere began with limited software functionality. Our customers, early adopters of the technology, criticise what we have on offer and ask for new functions, and we strive to provide solutions to more of their problems. We'd love to have Professor Rüther be one of these early adopters so we could add his needs to our development plans.

Visual Learning Systems Inc
Clearly there is room for improvement in the collection and processing of laser-scan data, but the advantages outshine the inadequacies and the list of shortcomings is becoming shorter. Aerial Lidar systems are beneficial in extracting terrain information in hard-to-reach and hostile areas. More impressively, Lidar data is unique in that it reveals complete and highly accurate (±15cms vertical) elevation information, presenting the potential for automated 3D-feature extraction. LIDAR Analyst software provides this processing capability, automating the collection of attributed 3D buildings, trees and bare earth from airborne Lidar data with speed and accuracy. Validated in co-operation with scientists at ERDC-TEC for the US Navy and ALES consortium in 2005, the LIDAR Analyst automated building algorithm pinpointed eleven thousand buildings in nine minutes with 97% accuracy and identified a hundred thousand trees in six minutes. LIDAR Analyst is a proven solution, utilised prolifically within federal geospatial and intelligence agencies for feature extraction, modelling and complex simulation. More information regarding this software, along with Feature Analyst and Urban Analyst, also available from VLS, can be found at www.lidaranalyst.com.

TopoSys GmbH
TopoSys has an outstanding role as a Lidar sensor-system and software manufacturer and well-known high-end Lidar service provider for precise elevation models and true-ortho images. For more than a decade we have been serving dozens of customers annually. Based on this experience we would like to comment on some of Prof. Rüther's statements. Long processing times, scan holes and incorrect edges are not shortcomings of laser scanning; they are shortcomings of the service provider and the technology utilised by him. There are some low-price, low-quality service providers out in the marketplace and the current preference on the part of the end customer always to choose the cheapest provider is driving a trend towards lower quality. A well equipped, well-experienced (and well-paid) service provider needs far less processing time and will provide his customer with error-free data. We at TopoSys, for example, have an average processing ratio of 1:0.75 to 1:3 using our processing software TopPIT, including the processing of laser data and fully automated processing of four-spectral-channel true-ortho images. The images perfectly match the laser data because we acquire both raw datasets in parallel, using our integrated laser and camera sensor systems Falcon or Harrier. We are constantly faced with new end customers using laser data for the first time. To avoid misinterpretation as highlighted by Mr Rüther we see a strong need for close interaction between project partners, and a need for sustainable consultant services in Lidar provision to 'educate' an inexperienced end user in how to interpret and correctly use the data provided him. In conclusion, I want to point out that our experience with the sensor systems we operate and the software we use shows we and our customers have already achieved great results in the mapping of heritage sites.

I-SiTE 3D Laser Imaging

Prof. Heinz Rüther raises some valid concerns regarding the use of laser scanning. Given limited space, I can attempt to address only the first, that processing time can be up to ten times longer than the time needed for acquisition, implying that it is generally too high. This I agree with, but to ascribe this shortcoming exclusively to the post-processing software is to miss the opportunity of overcoming the problem. Users of laser-scanning technology often have the mindset that, once a scanning system at their disposal has produced point-cloud data from a number of set-ups and some accompanying photographs have been taken, the rest is up to the 'post-processing software'. The hard parts, registration of the point clouds, faithful modelling of environmental surfaces free of holes, and mapping photo-realistic texture onto the geometry, happen almost magically when acquisition hardware has been designed to lend a hand. We have demonstrated this in wide-area scene mapping with the 4400 Series laser scanners and tightly integrated Studio software. Survey-location features built into the instrument (survey set-up, back-sighting telescope and level compensation) ensure that multiple point clouds combine seamlessly. Software algorithms that accept more information from the hardware than just the geometry of points do a superior job of surface reconstruction. A built-in calibrated camera that captures photography simultaneously with the scan at 40Mpixel ensures complete avoidance of the tedium of calibration procedures or manual texturing in software. I'm not claiming that we've perfected the solution, but the approach we passionately believe in, intelligent integration between hardware employed to capture the scene and software used to produce the result, is one that we've shown to largely mitigate this particular area of concern.

Concluding Remarks

Laser scanning is a generic data-acquisition technique. A large range of different types of objects may be captured three-dimensionally by a laser scanner; objects at a heritage site are just one class of such. Sometimes the user may expect too much of an exciting new technology, and it may come as a surprise even to the manufacturer in which fields the technology finds its main application. Each application, whether 3D-mapping of a chemical plant, monitoring of bridges and other civil-engineering applications or heritage documentation, requires specialisation in capturing and processing technology, and such experience can only be gained by trial and error. There is no magic button that has simply to be pushed after acquisition of 3D point-clouds to produce perfect reconstruction. It takes time before a new technology becomes a well-established tool within a certain field of application. It is good to hear that all respondents are willing to listen to users and to improve their products according to criticisms received.

Affiliations of Respondents

Optech: Dave Adams, product manager, Industrial & 3D Imaging Division.

Riegl: DI Nikolaus Studnicka, RIEGL LMS GesmbH and Dr Wolfgang Neubauer, VIAS-Vienna Institute for Archaeological Science.

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