Study on Improving the Efficiency of Transportation Projects by Using Laser Scanning

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Abstract— Laser checking is an earthly laser-imaging framework that makes profoundly exact three-dimensional pictures of articles for use in standard PC helped plan programming bundles. This report portrays consequences of a pilot study to research the utilization of laser checking for transportation applications in Iowa. Laser scanning technology has been successfully demonstrated on numerous projects related to developing bridge as-built drawings, highway widening, power plant retrofits, refinery expansion projects, water utility construction project archives, rock face surveys, dam foundation surveys, cave scanning, tie wire inspection, and visual effects for movies (Cyra, 2002). In several cases, field and office time was reduced using laser scanning compared to conventional methods.

Keywords: Laser Scanning

I. INTRODUCTION

As transportation projects become more complex to design and build, it is important to take advantage of appropriate innovative technologies for reducing project cycle time. Laser scanning is one such technology that has potential benefits over standard surveying techniques such as total station or aerial photogrammetry for providing accurate as-built drawings. Laser scanning is a terrestrial laser-imaging system that quickly creates a highly accurate three-dimensional (3D) image of an object for use in standard computer-aided design (CAD) software packages. It is anticipated that such a system can produce more accurate as-built data and/or drawings in less time compared to the standard approaches.

The first activity of the project involved learning how to use the Cyrax 2500 laser scanner and Cyclone software. A Cyra trainer provided training to six people (four from the Iowa DOT and two from Iowa State University) using a two-session format. The first session occurred in June 2002 and lasted approximately one week. A follow-up training session was provided in July 2002 and lasted two days. Training began with an overview of the Cyclone software then moved to the field where a complete indoctrination of the laser scanner was provided. A training manual was also provided, which helped to further explain the intricacies of the hardware and software.

II. FIELD SETUP

Hands-on laser scanning training was performed using the intersection of Grand Avenue and Lincoln Way in Ames, Iowa, and the Union Pacific railroad bridge at Grand Avenue (refer to Figure 5). Several important concepts were learned during the field training exercise. First, it is important to create a database for the soon-to-be-scanned point cloud data to reside. A unique database is established for each pilot project. Second, it is important to establish a coordinate referencing system that helps tie all of the scans together during the registration process and identifies the location of all points in a known reference system. Globe targets were introduced into the scene as registration objects and were scanned and surveyed to identify their x, y, z coordinate location. Each target needs to be acquired after the initial scan and given an identification number. A coordinate file from survey control is then imported into the scanworld database before the registration process begins. Third, it is vital to include at least three targets in each scan as this is essential for precise registration of the various scans. Fourth, laser scanning time varies depending on the scanner resolution. For example, the highest resolution (999 x 999 pixels) required about 16 minutes whereas a 250 x 250 pixel scan takes about 5 minutes to complete.

Fig. 1

III. DATA PROCESSING

The main steps involved in processing the point cloud images captured from the field were registration, fitting and editing, mesh editing, developing contours and line drawings, and using the virtual surveyor function. Each activity is described in more detail below.

IV. SCANNING

The scanning crew consisted of two operators (Edward J. Jaselskis and Zhili Gao), plus one coordinator (Dennis O'Brien). Table 2 shows the basic information related to the number of scans and duration of each scan. Scanning time defines the difference between start and end times of scanning. Start time is when the scanner begins to take the point cloud image while end time is the time point of disconnection from computer to scanner. Scanning times varied per scan primarily because scans were performed using different resolutions. For example, the research team used a lower resolution scan for much of the borrow pit (250 x 250 pixels) compared to a high-resolution scan on the new concrete paving pilot test (999 x 999 pixels). The highest resolution scans took approximately 16 minutes versus about 5 minutes for the lower resolution scans.

Project	No. of Scans	Total Scanning Time (hrs.)	Average Scanning Time (min.)
Intersection and railroad bridge	*	*	*
Section of highway and pair of bridges	30	14	28
New concrete pavement	3	1.6	32
Bridge beams on unfinished bridge	5	2.9	34.8
Stockpile	3	1.5	30
Borrow pit	17	4.4	15.5

Table 1: Field Scanning Information for Pilot Projects

*Accurate times were not recorded for the intersection and railroad bridge pilot project since this was part of the training exercise.

V. SCANNER RESOLUTION

The scanner resolution should be adjusted according to the image being scanned and the desired level of accuracy. The higher the resolution implies a better defined image but at the cost of longer scan times. The highest quality scans (999 x 999 pixels) took approximately 16 minutes each. Large timesavings can be experienced if less image quality is satisfactory. The research team found that an 850 x 850 pixel scan was sufficient for most cases. For targets that are farther away (>50 meters), it is best to use a higher resolution scan so as to acquire enough points to define the globes during the target acquiring process. For the borrow pit and stockpile pilot tests, a lower resolution scan of approximately 250 x 250 pixels seemed appropriate. A 100 x 100 scan did not provide enough pixels to easily locate and acquire the targets

VI. ELEVATION MEASUREMENTS

Elevation measurements were taken of the I-235 roadway centerline, lane edges, and shoulders using the Cyclone virtual surveyor. The measured results were exported into an ASCII format file. To determine the accuracy of those data points and to compare them with those from other surveying methods such as aerial photogrammetry, an ASCII file was converted into a MicroStation and GEOPAK file to create the plan views of I-235 as shown in Figures 29 and 30.

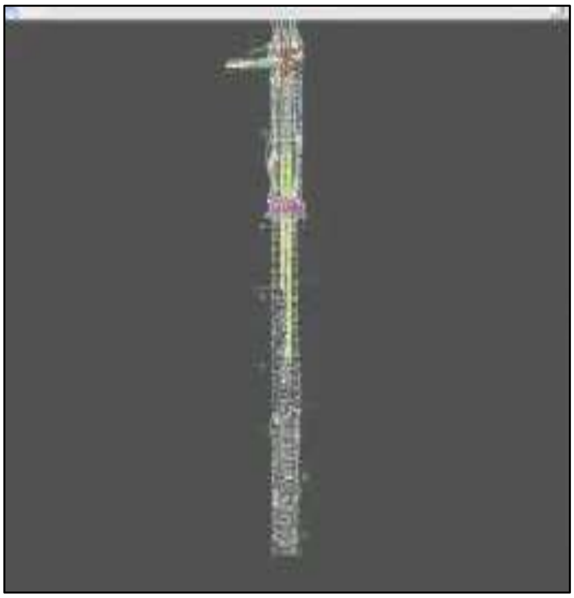

Fig. 2: 2D Drawing of I-235 Roadway Elevation within MicroStation

Fig. 3: Close-up View of I-235 Roadway Using MicroStation

VII. CONCLUSION

It appears that laser scanning has its place in helping to design and build transportation projects for the right applications. The technology was particularly helpful for measuring bridge beam camber. Laser scanning also demonstrated its precision for measuring volumes of a soil stockpile. It seems to take a significant effort to become proficient with this technology and then one needs to continue using it to maintain a level of sharpness. It is also possible to develop as-built drawings, but it seems to be rather time consuming with the version of the Cyclone used in this study (Version 3.2). Version 4.0 is designed to make developing 2D and 3D drawings more easily done by allowing one to more easily identify edges of objects (e.g., top edge of curbing).

Should the Iowa DOT invest resources in this technology? That depends on the number of times it is necessary to measure rock quantities and beam camber, record archival structures in 3D, assess bridge damage, etc. If there are sufficient opportunities to use this technology, then it is recommended that the Iowa DOT purchase the

Cyclone software and purchase or rent the scanner; initially, it may be prudent to rent the scanner. If there are very few occasions, then the Iowa DOT should use more traditional approaches to capturing these data or hire a consulting firm with this expertise to provide the laser scanning services.

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