Summary of Final Report, BC354-87
May 2005

ACQUISITION OF LASER-BASED DATA MEASUREMENT SYSTEMS

PROBLEM STATEMENT

The events of 9/11 showed that traditional damage assessment techniques were rapidly becoming obsolete. The University of Florida was fortunate to have participated in a research project that included using a scanning 3D imaging system to quantify some of the damage at the site of the Twin Towers. A final report prepared for the National Science Foundation recommended using 3D imaging technology for pre/post event condition assessments. This technology, however, may also have various applications for transportation, particularly critical infrastructural condition assessment.

OBJECTIVES

The major objectives of this research included the following:

1. Acquire the technology: at the time of the study, the OPTECH ILRIS 3D imager and the MINOLTA Vivid 910 Laboratory laser scanner were determined to be appropriate to investigate transportation applications of the technology.

2. Conduct preliminary tests using both systems. The ILRIS was evaluated as a tool to (1) determine bridge deflections during loading and (2) develop targets for rapid identification. The MINOLTA was evaluated as a non-destructive testing (NDT) strain measurement system using microspheres as targets.

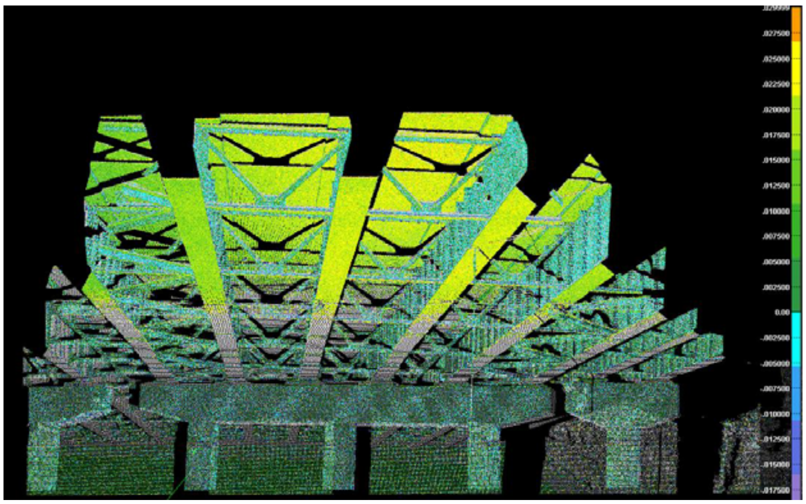
FINDINGS AND CONCLUSIONS

An OPTECH ILRIS 3D imager was acquired, which was the only available version at the time of purchase. Various firms are now selling similar products. As a complementary piece of equipment, a MINOLTA Vivid 910 Laboratory laser scanner was also purchased. The idea was to use this very accurate scanner to measure induced strains in concrete elements. While the scanner was not designed for this purpose, researchers investigated whether analytical software could be developed to enable the real-time strain/damage data acquisition and analysis.

Two tests were conducted to evaluate the capabilities of the ILRIS 3D system. Deflections were measured on two bridges during load application. Researchers found that the instrument was capable of rendering measurements comparable to those of a linear variable differential transformer (i.e., within 5 mm). In addition, a substantial amount of effort was expended to develop targets that could be placed on the bridge and used as reference locations. This would facilitate the determination of differential movements among the targets. A novel concept using hemispherical shaped domes (constructed from wood and Styrofoam plastic) was tested. Typically, flat-surfaced objects are used as targets. However, since they have a finite size, the laser cannot consistently pinpoint a specific location on the target. Hence, the size of the target dictates the accuracy of the system. Of course, making them smaller would help, but then it is possible that the laser will not “see” them. The use of hemispherical shaped objects provides two important benefits. One, they can be made larger so that the laser will locate them, and two, their geometry allows for accurate triangulation of their center point. This was one of the most important tasks, and, while successful, further work on this topic is needed Additional research is being performed to create software to track target movements.

Researchers developed a target system consisting of half spheres placed along the surface of the structure and then performed tests to determine the minimum size of the target as a function of target distance. By simply affixing several of these targets to the side of a bridge or overpass, engineers can monitor relative movements in the event of a vessel or vehicle impact. When the laser pulses are acquired from target returns, any three or more points allow one to compute the location of the sphere's center. This procedure can then be performed to find the same center point regardless of the angle of the laser (since it is assumed that the member being scanned displaces during a test, the relative angle between a particular target and the laser changes). For multiple targets, the relative movement between them can be determined by observing the movements of their center points.

Researchers not only developed the targets but an algorithm that can rapidly locate the targets from the data set. Matlab mathematical software was used as the framework. Researchers also evaluated the software packages, Polyworks and Minolta Polygon Editor, that came with the two laser systems, specifically with regard to their potential to perform the same function as the custom algorithm. Using the commercial applications, however, requires that the targets be processed manually on a target by target basis, a task that is exceptionally labor and time intensive. Researchers anticipate that these time and labor demands will be minimized with the development of a software program that will automate the process.



3-D image of a structure

BENEFITS

The benefits of utilizing these devices are enormous. Pre-scans of critical infrastructures (overpasses, bridges, intelligent highway signs, etc.) taken with the ILRIS can be compared to post damage data. This will allow for rapid assessment of a structure's safety. Since the laser is setup remotely from the structure, there is no need to alter traffic during a test, which will eliminate labor and user costs associated with maintenance of traffic. Measuring the deflection of a bridge over a waterway is also now possible.

The laboratory MINOLTA laser will provide strain data over an area, as opposed to a single point on a loaded structure. In addition, it can detect microcracks, which is a capability for which traditional point location strain gages are unsuited.

Finally, there are numerous potential other applications for this equipment. For example, texture measurements of flexible highway pavements can signal a roadway's potential for hydroplaning, and rapidly computing the amount of soil in a haul truck can ensure that FDOT does not overpay contractors..

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