Laser Scanner Demonstration*

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Overview

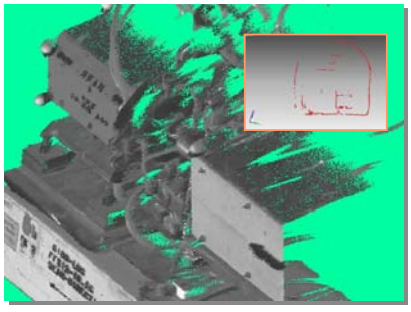
In the Summer of 2004 a request for proposals went out to potential vendors to offer a three-dimensional laser scanner for a number of unique metrology tasks at the Stanford Linear Accelerator Center (SLAC). Specifications were established including range, accuracy, scan density, resolution and field of view in consideration of anticipated department requirements. Four vendors visited the site to present their system and they were asked to perform three unique tests with their system on a two day visit to SLAC. Two of the three tests were created to emulate real-world applications at SLAC while the third was an accuracy and resolution series of experiments. The scope of these tests is presented and some of the vendor's results are included.

Tunnel Test

This test is designed to simulate a typical tunnel area at SLAC. Situations are occasionally encountered where new beamlines or other construction changes will take place requiring an as-built 3D record of the area. This test will demonstrate the general abilities of each vendor's laser scanner system.

Tunnel Layout

Testing was located in the Stanford Linear Collider (SLC) in the South Final Focus (SFF) area. This area includes various magnets plus a Beam Position Monitor (BPM) and a collimator. Additional mock magnets were added to the tunnel ceiling to test the vertical abilities of each candidate laser scanner. The picture insert shows several of the 1.5 inch (38.1 mm) spheres that allow registration of the scans.



Sample Laser Results

The above image shows the results of the laser scan performed during the vendor demonstrations. This one is from an animated "fly-by" of the chosen scanner: Zoller+Fröhlich's (Z+F) Imager 5003 [2]. The picture insert is a profile of this tunnel area.

Building Test

This test is designed to illustrate the abilities of each candidate laser scanner when asked to capture and register a building and floor plan. This will be useful for locating new or existing buildings at SLAC for a future Geographic Information System (GIS). The test will show how well several independent scans can be integrated.

Alignment Laboratory and Building

Each vendor was asked to use their laser scanner to capture the façade of the building shown above as well as the interior of the laboratory. With this information a rudimentary floor plan could be created. Some vendors demonstrated how the laser scanner data could be converted into primitive shapes and objects to create a floor plan. These shapes were then saved into a format that CAD drawings could utilize.

Registration Targets

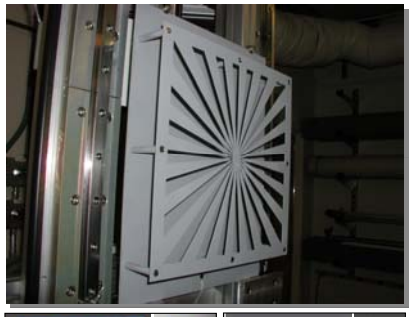
The vendors used a set of common targets to tie each scan together. Some used large spheres placed through-out each scene while others used different shapes such as flat paper sheets. Laser scanners can easily capture and display text allowing easier and faster target identification.

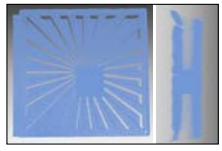
Accuracy Test

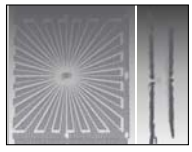
This test took place in the Sector 10 alignment laboratory and is designed to challenge each scanner's ability for accuracy and resolution. By using typical 1.5 inch (38.1 mm) spherical targets, this test provides a true indication of how well each scanner will work in often less challenging actual operations at SLAC.

Horizontal and Vertical Tests

All the vendors were asked to measure a series of 1.5 inch (38.1 mm) spheres distributed along the Sector 10 laboratory wall. For the horizontal accuracy test the scanner was placed near the wall as shown in the picture above. Distance accuracy was tested relatively independent of angular accuracy. Conversely, the scanner was placed perpendicular and away from the line of spheres providing a practical indication of the angular accuracy of each instrument. A vertical line of spheres was also tested.







Scanner	No. of Points	Pts. / Surface [mm^2]	Angle [°]
HDS4500	123262	0.82	0.0232
iQsun880	132000	0.88	0.0216
GS200	2055087	13.74	0.0014
Imager5003	123183	0.82	0.0232

Resolution Test

A box with varying opening widths was used to establish the resolution abilities of each candidate laser scanner [1]. As the side view blue image above illustrates (GS200 data), noise between the two planes is high. One of the tested systems used a type of real-time non-clipping data filter as shown in the grey image on the right (Imager5003). Also presented are the estimated point resolutions based on the scans from each vendor [2].

Evaluation Results

HDS4500
Leica Geosystems HDS

iQsun880
iQvolution

GS200
Trimble / Mensi

Imager 5003
Zoller+Fröhlich

Score Results From Evaluation Testing

Company	Scanner	Price			Accuracy	Speed	References	Evaluation				Score
		Hardware	Upgrade	Mean				Software	Test 1	Test 2	Test 3	Mean
Leica	HDS4500	5	0	3	6	10	10	8	8	10	3	7	718
iQvolution	iQsun880	10	5	8	2	10	0	0	5	0	3	2	373
Trimble / Mensi	GS200	5	0	3	7	2	10	10	2	5	5	6	543
Zoller+Fröhlich	Imager5003	2	10	6	7	10	10	3	8	10	10	8	805

Note: A rating can be from 0 to 10. Each rating is multiplied by the given ratio (e.g. Price is 15% meaning multiplied by 15). A maximum of 1000 points can be achieved [1].

Discussion

Four vendors responded to a request for bids. Demonstrations took place from June 29th to July 8th 2004. Leica's HDS4500 and Z+F's Imager5003 stood out in the final analysis. The actual hardware considerations including a guaranteed upgrade path made the Imager5003 the choice for SLAC. Leica's Cyclone software was better suited to our needs and therefore was the software of choice.

References

[1] Boehler et. al., "Investigating Laser Scanner Accuracy"; CIPA Symposium, Turkey; October 2003.

[2] Fuss et. al., "*Investigation on Laser Scanners*"; IWAA2004 paper, CERN; October 2004.

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