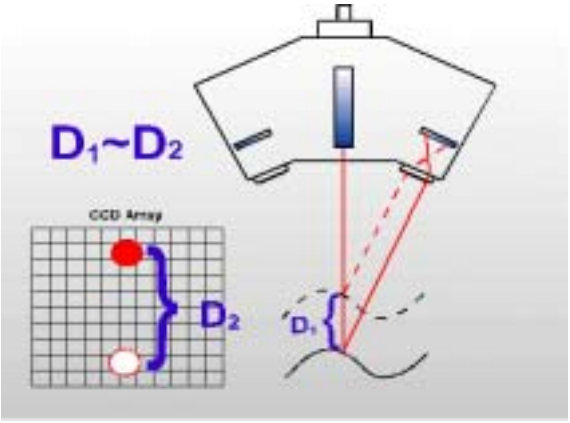
3D Laser Scanning

1 *WHAT IS 3D LASER SCANNING?*

In essence, laser scanning is to 3D objects what photocopying is to 2D objects. Laser Design's Surveyor family of 3D Laser Scanning Systems makes use of a laser sensor that is mounted to a 3 - 6 axis computer controlled positioning system or retrofitted to an existing CMM. We even have a portable model that sits on a camera tripod. An object that is to be scanned is placed on the bed of the digitizer and our Scan Control software then drives the laser sensor above the surface of the object. 3D coordinate locations which lie on the surface of the object are recorded by the scanning system according to scan density and pattern parameters set by the user. These XYZ coordinate locations are stored in a file that can be converted to IGES or ASCII formats for input into nearly any CAD/CAM system or specialized point-cloud processing software on the market today.

2 *WHAT IS THE PRINCIPLE BEHIND THE LASER SCANNING?*



All of the Laser Design's scanning systems utilize laser-triangulation based technology. The heart of the technology is a dual camera probe which emits a diode based laser beam from the center as shown in the picture. The beam is split into a plane of laser light that comes out of the probe and shines below on the surface of the object being scanned. Thus it forms a profile on the surface of the part.

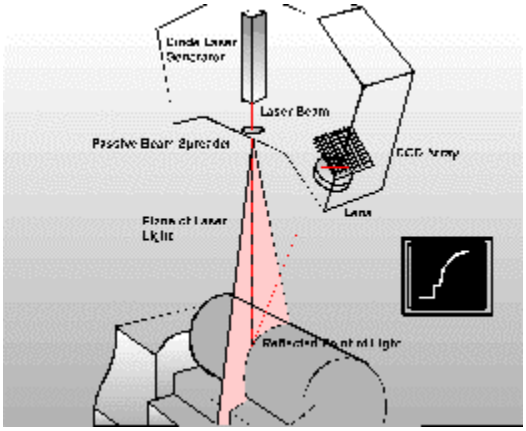
A two-dimensional CCD (Charge Coupled Device) array similar to the one used in a home video camera is mounted on either side of the probe. They reside inside two identical optical sensors. The reflected light form the profile on the surface of the object activates the pixels on the array inside one of the two sensors. The reason for having two sensors instead of one is that if for some reason the view of the profile on the surface of the object is blocked for one sensor there is always the second sensor that can pick up the same profile. The user can toggle between the two sensors

The shape of that single "2D" profile is recorded by the digital CCD and subsequently, based on the calibration and look up tables of the lasers, a Z position is determined and stored for each pixel value by the software. This location along with the machine axes positions are used to compute the X,Y,Z coordinates of the points along that profile. Hundreds and thousands of similar profiles are thus collected as the probe marches over the object and the software stores this information into a database for later retrieval. Each profile comes into the database as a single polyline entity with

points

distributed along the length of the line. These polylines are also displayed graphically on the computer screen as they are gathered.

but only one is active at one time.



3. *WHAT ARE THE MAIN ADVANTAGES OF LASER SCANNING?*

The primary advantage of laser scanning is that the process is non-contact, fast and results in coordinate locations that lie directly on the surface of the scanned object. This allows fragile parts to be measured and makes the scanned coordinate locations especially useful to CAD/CAM systems where splining or surfacing through true surface coordinates is desirable.

The laser's high resolution and thinner beam also permits scanning of highly detailed objects where mechanical touch probes may be too large to accomplish the task. Also, while many touch probe systems attempt to compute true surface coordinates by sensing probe deflection, there are certain geometries where probe deflection can be "fooled".

Finally, once true surface coordinates have been collected for an object, a single set of data can be used to generate roughing and finishing tool paths for machining, feed CAD/CAM and analysis software, drive rapid prototyping equipment, and allow "electronic archiving" of physical objects.

4 *WHICH INDUSTRIES ARE ALREADY USING YOUR SYSTEMS?*

We have an installed base that includes nearly every industry imaginable. Automotive, aerospace, consumer electronics, medical, railroad, sports equipment, toy, jewelry and container manufacturers are all using our systems and endorse the technology. Two military branches and a leading manufacturer of space shuttle components also use our equipment. Companies in countries all over the world including Japan, France, Italy, Korea, Singapore, Spain, Brazil, China and India have also purchased systems and recognize that laser scanning is here to stay and will continue to define state-of-the-art

manufacturing.

5 *HOW ACCURATE IS IT?*

The standard laser resolutions offered by Laser Design are 0.0004" and 0.0008" although we have built custom systems with lasers having a resolution as fine as 0.00006". When considering any optically based measuring systems, it is important to realize that there is a difference between the terms *resolution* and *accuracy*. Resolution is simply the smallest change in distance that the sensor is capable of detecting. Accuracy, on the other hand, is a function of the optical qualities of the object being scanned. If the object has a matte surface, then resolution and accuracy will be nearly the same. If the object has a glossy surface however, the laser spot may "shimmer" and dance slightly on the CCD array. This shows up as "noise" in the laser data which can be filtered and smoothed to a certain extent within Laser Design's Surveyor Scan Control software. On the other hand if the surface has light absorbing finish (too black) so it doesn't return enough light to the sensors, the part can be sprayed with a variety of coating materials to enhance the laser readability but as obvious doing that will add a little coating material build-up on the part.

Naturally, the mechanical accuracy of the positioning system also comes into play when discussing accuracy. Our Scan Control software accepts feedback from optional linear scales and supports the use of a laser interferometer to build compensation tables that correct subtle mechanical inaccuracies inherent in any machine.

The volumetric accuracy specifications in our literature are based upon our ability to digitize a ball-bar oriented several ways within the work envelope and have the measured length of the ball-bar vary by no more than the stated accuracy of the machine. A ball-bar is defined by the American Society of Mechanical Engineers (ASME) in their standards document, ASME B89.1.12M-1990, as a rigid bar to which a precision tooling ball is mounted on each end.

6 *HOW FAST IS IT?*

Much like a 35MM camera, the laser has exposure settings that need to be adjusted depending upon the nature of the object being scanned. In general, dark colored objects require longer exposure settings than light colored objects and longer exposure settings require the system to operate at slower velocities if data integrity is to be maintained. The point sampling distance requested by the user also affects scanning speeds. In general, we have experienced "real world" scanning speeds of 3000 to 4000 points per second although some situations may require slower scanning speeds and other situations may permit scanning at full scan rate of the probe which is 14,400 points per second. In any case, laser scanning tends to be much faster than a CMM and somewhat

faster than mechanical tracing systems.

7 *IS THE LASER SAFE?*

The Laser probes employed by our scanning systems use a diode based class II laser. It has a very low power output with ratings at less than 1mW and a 670nm wavelength (visible red spectrum). It utilizes passive beam spreader and has no moving parts. Class II lasers are still ocular hazard, but viewing time in order to do the damage to the eye is significantly longer than for instance for a class III laser.

8 *WHAT SHAPES CAN I DIGITIZE?*

In addition to XYZ positioning, Laser Design supports computer controlled object rotation and laser orientation. This allows scanning of virtually every side of a 3D object and eliminates the traditional problem of scanning undercuts. Laser Design's Surveyor Scan Control software includes powerful data manipulation tools which can blend data from multiple views together into a single data set with the use of tooling balls.

Additionally there are several other CAD/CAM packages available in the market today that blend the data collected at different orientations into one complete 3D model using various powerful data matching algorithms.

9 *WHAT ARE THE LIMITATIONS OF LASER SCANNING?*

Although used in a variety of inspection applications, laser scanning is not intended to compete with the micron accuracies of some CMMs. As a rule, CMMs are better suited to measure geometric parts where basic dimensions, hole locations, diameters, flatness and roundness measurements are required for accept/reject types of applications. Laser scanning tends to be better suited for the measurement and inspection of contoured surfaces and complex geometries which require massive amounts of data for their accurate description and where doing this is impractical with the use of a touch probe. Also laser scanning comes into play for picking fine features that are inaccesible to a touch probe.

IS LASER SCANNING "EASY" TO DO?

Every Laser Design's scanning system comes equipped with the Surveyor Scan Control. Surveyor Scan Control is a menu and mouse driven software that is used for driving the

laser probe over the part with the aid of a joystick as well as retrieving data and storing it on the hard drive. It allows "programming" of the system so that the laser probe mounted on a motion control system will follow a "pre-defined path" in 3D space over the object being scanned. Programming itself is totally "graphical" and no "code" needs to be written. Though it is easy to use, some prior experience with a 3D CAD/CAM package is desirable.

HOW IS THE DATA OBTAINED FROM LASER SCANNING USEFUL?

The data acquired from laser scanning, can be used during the product design phase to input physical models into CAD/CAM world, during the manufacturing phase to generate tool paths for machining and also during the quality assurance phase to verify dimensional accuracy of the final product. For a detailed account of various applications the laser scanned data is being used for, please go to www.laserdesign.com

HOW DO I MANIPULATE LASER SCANNED DATA?

There are several extremely powerful software packages available in the market today that can import data from our systems and use it for a desirable outcome. Laser Design Inc. proprietary software Surveyor Scan Control can be used for data collection as well as initial processing and clean up. Typically the raw data collected from the system is de-spiked, filtered and smoothed depending upon the quality of the data obtained and the application it is being used for. A 3D model is then created either with software programs like Geomagic Studio. The choice of the software to use greatly varies depending on the application and other circumstances.

WHAT IS SURVEYOR SCAN CONTROL?

Surveyor Scan Control is Laser Design Inc. proprietary software which comes with all the Laser Design scanning systems. The two primary functions of Surveyor Scan Control are to jog the machine in 3D space in order to physically adjust the laser probe over the object that is being scanned and to collect the data from the laser. (See Question 2 above). It organizes the 3D point coordinate information on each and every point collected during scanning and stores this information in a file on the hard drive. This file can be retrieved later for editing. The same coordinate system is valid during data-editing as in scanning.

The scanning can be set-up using Surveyor Scan Control such that the laser probe will follow a pre-defined path in 3D space while scanning the part. The set up programming is entirely "graphical" and no code needs to be written. Moreover, Surveyor Scan Control has powerful macro capabilities also that allow the user to automate the

scanning process as well as store and recall the scanning parameters in case the same or a similar part is scanned again. For further information on Surveyor Scan Control you may log on to www.laserdesign.com

WHAT KIND OF TRAINING IS PROVIDED TO USE SURVEYOR SCAN CONTROL FOR SCANNING?

Laser Design offers Quick Start Training that prepares a new user for using Surveyor Scan Control for scanning and data editing. Advanced training is also provided for experienced users. For further information and a training schedule log on to our web site at www.laserdesign.com .

WHAT OTHER SOFTWARE PROGRAMS ARE USED IN ADDITION TO SURVEYOR SCAN CONTROL FOR PRCOCESSING SCANNED DATA?

Laser Design offers a variety of software packages and modules for processing scanned data based on the application.

Geomagic Qualify and PolyWorks Inspector are revolutionary software programs for performing 3D best-fit analysis of actual scan data to CAD nominal. Best-fit registration is done either in space to minimize part deviation, or directly to part datums. Once the registration is complete, tolerance bandwidth is defined and results are displayed in a 3D, color plot showing point deviation from nominal as color gradients. At a glance, you will know the accept/reject status of the part. Inspection results can finally be conveyed in a format that is easily understood and communicated. Verdict also provides other tools such as GD&T and point comparisons to cross sectional data. These plots will display actual/nominal point deviation as color "whisker plots" showing magnitude and directional differences from nominal or you may measure on screen the actual difference.

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