3D Digitizers for Engineering

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3D digitizing systems permit you to create a digital model from a physical part. The process is appealing because it can be difficult to create models of complex objects using computer tools without the aid of a 3D input device. Recreating an existing part from scratch, even with a computer, is like copying a printed page by retyping it. Although 3D digitizers are not as straightforward as a photocopy machine, the intent is the same.

You can render and print a digitized model to communicate shape information, extract dimensions from it to show size information, and use the 3D database to manufacture a replica using rapid prototyping (RP) and CNC machines. You can also include the 3D model in multimedia or animation software as a learning or assembly aid.

The challenge of the digitization process in manufacturing is to capture adequate detail and resolution. Adding a digitized model to a Hollywood film is often much easier than reverse engineering a part for prototyping or manufacturing. The only criteria for a movie or TV commercial is whether or not it looks good. No one from the audience measures the object to see if it meets a given tolerance.

In manufacturing, RP and CNC machines require clean, complete, and accurate information. If areas on the model are incomplete or missing, it may be difficult or impossible to build the part. If edges, grooves, and features of the part are not fine and crisp, the results may be less than satisfactory.

Most 3D digitizing systems are best at digitizing organic shapes such as free-form sculpted surfaces. When you see an advertisement or a catalog from companies offering digitized models, often you see objects such as human anatomy, animals, bones, skeletons, and so on. You may also see cars, trucks, motorcycles and airplanes, although they can be more difficult to digitize. Highly engineered parts, such as enclosures for electronic devices are usually the most difficult for 3D digitizers. That's why these systems aren't used widely for the reverse engineering of precision mechanical parts.

How the technology works

Most 3D digitizing systems are either a non-contact device or one that uses a touch probe. Touch probe systems are the least expensive, but they are manually operated. You must touch the object for every 3D point you want to produce. This makes it challenging, if not impossible, to produce computer models at a high resolution. For instance, if the tolerance is +/- 0.020-inch of the part you want to reverse engineer and manufacture, you must digitize points no greater than 0.020-inch apart. This is difficult, considering that 0.020-inch is about the thickness of 6 sheets of copy paper.

Non-contact digitizing systems are the only practical choice for high resolution scanning of mechanical parts. They collect from 20 to more than 25,000 points per second and provide resolution of better than 0.001-inch to 0.020-inch, depending on the particular technology. Laser digitizers have become the most popular non-contact systems for most applications. They use a basic principle called triangulation that works like this: If light arrives on a surface from one direction, and if the light is seen from another direction, the location of the point can be inferred. That's how lasers and sensors work in harmony to create x/y/z coordinates of points on the surface of an object. Movement of the laser light and sensors, as well as the part itself, provides multiple degrees of freedom. Through this combination of motion, laser digitizers capture the shape and size of odd-shaped objects.

Digitizing speed comes from the light moving quickly across the surface as the sensors detect the location of the light. Resolution comes from the distance between the points, which can be restricted by the size of the illuminated area on the surface. If the illuminated area measures 0.030-inch, don't expect 0.010-inch resolution. Accuracy of the process comes from a number of factors, including resolution, the system's optics, and the precision of the mechanical parts that make up the system. The object itself can also impact the accuracy of the data. If it has a dark or shiny surface, the data will not be as good as if it is white or light gray and dull. For these reasons, you need to be careful and must consider a number of factors when determining the accuracy of the data.

Fine edges, sharp corners, and grooves can also cause problems. Each time the laser light falls off a sharp edge, the light spreads or scatters. The result is usually a jagged edge in the data. Most systems produce triangles from the points. If you were to zoom in on the jagged edge, you would see irregular triangles along the edge that do not form a straight line. This problem is less severe with systems that illuminate the surface in a very small area. As the lighted area increases in size, the resolution drops and fine features of the part become worse.

Deep openings and concavities can also be problem areas. If the opening to the surface is smaller than the angle created by the triangulation process, the laser and sensors cannot project and see the light. The result is missing data in the polygonal mesh surface that appear as holes in the model.

For one reason or another, we are led to believe that automation systems fully automate manual tasks. This is misconception that has and will continue to haunt many companies. Successful organizations understand that you must blend new techniques with old ones. The Japanese are especially good at this.

The same is true with 3D digitizing systems for reverse engineering. If what you need is shape and size information from the part -- essentially the information presented in a typical engineering drawing -- consider this: Digitize the object, render the data, and produce one or more raster images of the model using one of several screen capture techniques. Load the raster (e.g., PostScript) image into a CAD system, such as AutoCAD, and then trace the edges of the part. Erase the raster data, leaving the profile information. After adding dimensions, you may have the information you need to manufacture the part. Also, you may be able to use the 2D drawings to create a surface or solid 3D model, enabling you to drive an RP or CNC machine. Note that RP systems, such as stereolithography, require that you have a fully closed, water-tight polygonal model.

View the 3D digitizing process as one of several tools in your tool box. To complete the job, you may need to take manual measurements using calipers. You may need to import the data into a CAD system or use a product such as Surfacer from Imageware (Ann Arbor, MI) to repair triangles or fill in missing areas. The fabricated part may also require some amount of hand work. Grooves, corners and edges may require clean-up, such as cutting, filling, and smoothing using traditional model-making techniques.

3D digitizing is appealing because it produces 3D data that can be used in many ways. If the shape, size, or color of the object are obstacles, consider using the part as a pattern for a molding process. Silicon rubber tooling, for example, is a good way to produce 2 to 20 urethane duplicates of a part.

If the part you want to reverse engineer is not too large, doesn't have a lot of intricate detail and hidden areas, and has an acceptable surface finish, 3D digitizing -- coupled with one or more computer or manual techniques -- may be the way to go. Be prepared to experiment and learn as you go. Also, listen carefully to those who have tried to digitize similar parts. They can save you lots of time, agony, and money.

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