Capturing Concepts with 3D Scanning and Modelling

Today, aesthetics play pivotal role as a key product differentiator. 3D scanning and modelling provides designers with a shorter and smarter way to create newer concepts. Next-generation 3D laser scanners showcase high accuracy, portability, ease of use and integration with 3D modelling software tools

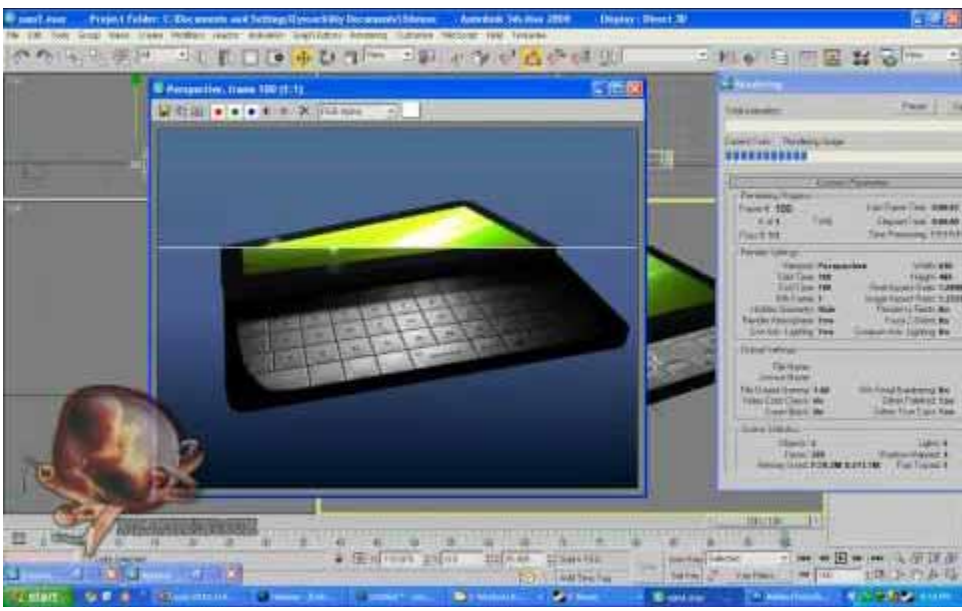
■ SHWETA DHADIWAL BAID

What is the difference between HTC's Hero and Motorola's Flipout Square mobile phones? Though both are Android phones with innovative design—Hero with an angled chin and Flipout with a square shape—there is a huge difference in user experience while using the same software on a smaller screen (where you have to scroll down often to view the menu) and also in the placement of the microphone and speakers.

In order to improvise any existing product, designers need to create its 3D model by reverse engineering. This is where 3D scanning comes into play. Earlier more applicable for mechanical engineers engaged in computer-aided design, it is today very important for embedded design engineers too to understand the industrial design of the product.

According to Rahul Singh, senior designer from Longcheer, "3D measurement is a technique to analyse and measure the existing objects, which helps while developing a new concept taking an inspirational motivation from the existing objects."

A wide range of applications including robotics, aeronautics, medical electronics, gaming and biometrics require acquisition of the three-dimensional geometry of a shape to sustain competition of the aesthetics. Many of these applications require the 3D data to be captured in real time.



3D image modelling of a cellphone's keypad using the software

Getting a low-cost, high-speed, real-time 3D scanner has always been a challenge despite the availability of different acquisition methods. Today, there are a number of portable laser scanners available in the market. Some of the latest technologies that go in today's scanners include ARM processor and digital light processing (DLP).

3D measurements: scanning and modelling

Three-dimensional measurements are carried out along all three axes and used to understand the geometry of an object for redesigning, reverse engineering, modelling of existing products, creating concepts and more. 3D scanning helps in gathering the required data to model your imagination. To realise a concept and share your imagination with others, 3D modelling helps a great deal.

3D scanning is a process which analyses the real-world object and collects the data on its shape and appearance. The scanners are similar to cameras but the purpose of a 3D scanner is different in the way it produces point-cloud data of the surface of the geometry.

"When you move a 3D scanner above an object, it collects information about the surfaces which are not hidden. The camera collects the colour in-

formation about the surfaces, whereas the 3D scanner collects the information about the distance of the various points lying on that surface," explains Singh.

On combining all the data point values, you get a three-dimensional coordinate system for each point, which is good enough to use in any 3D modelling software to generate a well-defined surface. For 3D scanning you need a 3D scanner machine and software to port the scanned data, while for 3D modelling you require the 3D data and 3D modelling software.

In electronic products, quite often the space is limited. Dr Vinay Vaidya, chief technology officer, Engineering & CREST Leader, KPIT Cummins, says, "Fitting the electronics in a given space is a challenge. 3D scanning gives a clear idea about not only the length and width but also the height. Knowing the height of each component gives freedom to the designer in selecting a substitute component meeting the same height constraint. Space available inside the casing is also important from overall cooling perspective."

For most situations, a single scan does not produce a complete model of the subject. Singh says, "Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject."

3D model: Reduce cost, develop faster

The cost of product development is increasing with the demand for compact design and multiple functionalities. 3D modelling gives conceptual design, engineering, manufacturing and sales and marketing departments the ability to virtually explore the complete product before it is built.

Ram Bahadur Diwan, a senior designer at Longcheer, explains, "Traditionally, the product development cycle is design→build→test→fix, while in the case of 3D modelling product development steps are design→analyse→test→build. By using 3D modelling to catch design problems upfront, manufacturers experience fewer change orders downstream."

3D laser scanners & scanning services vendors

- 3Shape
- Artec
- Breukmann
- Capture3D
- Creaform
- Davidscan
- Faro
- GKS
- Handysan
- Konica Minolta
- Mitutoyo
- NextEngine
- Proto3000
- Stienbichler
- Zeiss

3D modelling reduces time, cost and effort for prototype cycles. "Building physical samples or prototypes takes time and money, as a number of prototyping cycles are needed to design a mechanism or enclosure. Today, not more than two-three physical prototype cycles are needed to design a product," shares Vinay Rawat, vice president, product engineering services, Wipro Technologies.

Rohit Walke, Jay Instruments, shares, "3D modelling software may vary according to the application. In electronics, it can be used in sheet-metal, rack-mountable enclosure or plastic enclosure design/modelling for electrical equipment like chassis and motherboards."

"For CAD modelling, there are multiple software like ACAD, ProE, CATIA and Soliedge. But for fast and accurate concept design as well as new modeling, a 3D scanning system coupled with redesign software is used," Walke informs.

Talking about prototyping, Singh says, "Any manufacturing process always needs a tolerance limit for production as every machine has its limit of accuracy which makes it impossible to produce a part with zero tolerance. So before starting mass production of any product, we check it while making a prototype. This includes inputs in the form of man, machine, material and cost."

As the cumulative cost of all these variables is very high, "We use 3D modelling technique to visualise a product and to check the position of various features in a product. Also,

Handheld 3D laser scanner

3D scanning software

- Rapidform
- Easy3D Scan
- SolidWorks
- Geomagic
- Polyworks
- Delcam

3D modelling software

- AutoCAD
- Blender
- Pro Engineer
- CATIA
- Unigraphics
- SolidWorks
- trueSpace

3D modelling helps to check the assembly feasibility of that product with another part," Singh adds. With prototype building, the time consumed is less and the chances of errors are also minimised.

Reverse engineering for improvisation

Reverse engineering is the process of extracting the design from an existing product, with an aim to modify and improve it for the next version of the product, for value engineering or bug fixing. It is most commonly used in automotive, aerospace and consumer electronics industries. Also, "Reverse engineering is important to update products when there is little or no documentation available on the design of the product," shares Rawat.

Dr Vaidya explains, "Reverse engineering connotation can also be used when we are trying to mimic some product and replicate it in a new form. The vital principle while replicating the process is that it has to fall within the legal framework."

Reverse engineering is creating 2D and 3D drawings to regenerate computer-aided designs of an existing product. It is a tedious process to find out all the dimensions, and even if one dimension is missed, you would be unable to replicate the whole thing.

Concept design of a cellphone

You may have experienced this in some designs. For example, while talking on a touch-screen phone, your ear touching the touch screen may cancel the call. Diwan says, "Due to reverse engineering, there are fewer chances for failure. It helps to analyse good and bad features so that the desired features can be retained for a long term, while faulty/bad features can be designed out."

"Reverse engineering is also used in benchmarking competing products and assessing patent infringements. Given the stiff competition in the market today, it is becoming an important tool to stay ahead of times," adds Rawat.

Automated verification

Apart from modelling and reverse engineering, 3D laser scanning is used in quality assurance. Rawat says, "Scanners are placed at the end of production lines to capture the 3D data of pieces as they come off the line. The 3D scanned data is validated against the original CAD data to provide an automated verification of the product. 3D laser scanning also has the capacity to acquire hundreds of thousands or millions of points spread across the entire geometrical figure of the scanned material and thus makes it possible to accurately describe the freeform surfaces and digitise the entire components that may lie inside the object."

"3D scanning helps in inspection and rectification. Often, production tooling fixtures undergo a deformation or damage after a certain time period. If the native CAD data is unavailable for such a fixture, it becomes hard to repair or replicate the same fixture. With 3D laser scanning, one can recreate a local insert which has been damaged or the entire fixture more accurately and much faster than any other 3D coordinate measuring system," adds Rawat.

3D measurements for concept design

It is hard to believe but cellphone companies spend a lot of time and money in creating superb concept phones

even if these phones never hit the market. Concept designs help to peep into the future and are an art in the field of technology.

Handheld 3D laser scanners

Laser scanners are the best choice as they work with great precision with parts and shapes that are complex. As the technology advances, 3D laser scanners will be able to provide invaluable accuracy, resolution and integration at an unimaginable price.

There are a number of innovative handheld scanners available today which give you the benefit of portability to scan the deepest and remotest structure with great accuracy.

Dr Vaidya comments, "Portable laser scanner is one of the forms of new technological changes in 3D scanning as it gives accurate dimensions of an object directly to the machine. Portability allows one to take the 3D scanner anywhere and scan virtually anything, anywhere."

Advancements in semiconductors have made high-speed digitisers easily available. Many engineers believe that next-generation laser scanners will be the most notable and cutting-edge with the ability to recognise even the live features and model the scanned three-dimensional movements.

Just like cameras get their new features, scanners also undergo developments. Portable 3D scanners have innovative positioning targets and easy set-up for self-positioning. Because of the true portable design of the scanner, there is no limitation on the orientation of the scanner or accessibility in restricted spaces.

Structured light for 3D optical measurement

Structured light is one of the most commonly used techniques to obtain 3D optical measurements. The goal of a 3D optical measurement system is to capture the shape of an object in order to construct a three-dimensional model that can be used for measurements and analysis. Applications range from machine vision systems that perform volumetric inspection in an assembly line to biometric systems that perform 3D facial recognition.

Structured light scanning is a variant of triangulation scanning where a pattern of laser stripes is projected on the object being scanned. When the laser line is swept over the solid object, the cameras are used to examine the deformation of the laser line pattern. The primary advantage of structured light scanners is speed, as they can scan multiple points or the entire field of view at a glance.

NextEngine, one of the leading manufacturers of laser scanners, has developed its own multistripe laser triangulation technology that uses four twin arrays of Class 1M solid-state lasers and two CMOS sensor camera modules. The eight lasers are managed by two Microchip microcontrollers and two quad-output operational amplifiers from Texas Instruments. The dedicated laser-control printed-circuit board is mounted to the laser assembly and connected to each laser via a three-lead flex connector.

Ganesh S., a business development manager at Texas Instruments, shares, "DLP-based structured light systems speed up the measurement process by using a digital projector to display a known pattern onto the object and a camera to capture the distortion of the pattern as it reflects off the object. These systems are extremely accurate, quick and cost-effective. The resulting data offers a wealth of valuable insights not easily available today."

Open Source 3D scanner

Open Source has become a *mantra* in many protocols, standards and software. Following the trend, MakerBot has launched the do-it-yourself version of MakerScanner—an Open Source 3D scanner.

The MakerScanner uses the technique of projecting energy into a scene in order to perform range-finding. The basics are similar to stereo vision. A laser pointer (scanning to make a vertical line) and a camera are offset at a certain base distance. As objects approach the sensor, the laser line appears closer to the edge of the camera's image. With correct calibration and some math, the range to each point can be calculated.

The basic hardware and tools needed to build this Open Source scanner include 3D printer, PS3 Eye USB camera, laser line pointer, two AA-size batteries, battery holder and MakerScanner software.

The Open Source 3D scanner from MakerBot is cheap, fast and accurate. The major cost involved is the camera. By using the right type of camera, surprisingly accurate 3D scanning can be achieved at a very low cost.

Does laser scanning fit your application?

There are several laser scanning technologies, but the main concern is which technology best suits your application. Laser scanning is used to scan large areas like terrestrial plains and buildings, to very small electronic components and devices. Some of the laser scanning technologies include confocal laser scanner, triangulation coordinate measuring machine scanner, portable 3D triangulation scanner, etc.

The QC Group suggests the use of a confocal laser scanner for very small objects. This scanner is capable of mapping topography to less than one micron on 3D position. It uses a precision confocal sensor with 0.01-micron resolution. Micro-scanning is used to capture the topography, which also needs to be scaled to a larger size without loss of detail. As in the case of embedded electronics, micro-scanning is also useful for mapping the characteristics of implantable devices or machine components. ●

The author is a senior technology journalist at EFY