UNIT – IV

3D SCANNING

3D Scanning

3D laser scanning is the technology to capture a physical object's exact size and shape using a laser beam to create a digital 3-dimensional representation of the same. 3D laser scanners produce "point clouds" of data from the surface of an object.

3D laser scanning is a way to capture a physical object's exact size and shape into the computer world as a digital 3-dimensional representation. This technique captures information like the complex geometry, intrigue shape, colorized texture, and other details of the 3D object that is scanned.

A 3D scanner collects information about the object being scanned as well as the environment (e.g. room) in which the object is present. If, a person is sitting beside the object that can also be 3D scanned.

3D scanners essentially create a digital copy of a real-world object. This digital copy or the 3D file can then be edited and 3D printed as per the user's requirements. Also, a 3D file can be used for further 3D modeling processes. Generally, in this 21st-century Engineers are using this technology for reverse engineering processes. 3D scanner files are generally compatible with CAD software and 3D printing slicer software.

A single scan is not enough to re-create a complete model of the object being scanned. Normally, hundreds of scans are necessary to capture all of the information from various sides and angles. All of these scans than have to be integrated through a common reference system known as alignment/registration. Finally, the individual scans are merged to re-create the final model. This entire process of bringing together the individual scans and merging them is known as a 3D scanning pipeline.

3D Scanning Technology

3D laser scanning efficiently takes the measurements of contoured surfaces and complex geometries, requiring vast amounts of data for accurate description. Doing this using traditional measurement methods is impractical and time-consuming. Acquiring sizes and dimensions of free-form shapes creates precise point cloud data.

The basic working principle of a 3D scanner is to collect an entity's data. It can either be:

- an object
- an environment (such as a room)
- a person (3D body scanning)

In reverse engineering, a laser scanner's primary aim is to provide a lot of information about the design of an object which in the later stages gets converted to 3D CAD models, considering the compatibility of 3D scans and Computer Aided Design (CAD) software. 3D scans are even compatible with 3D printing, requiring specific computer software.

Types of 3D Scanning Technologies

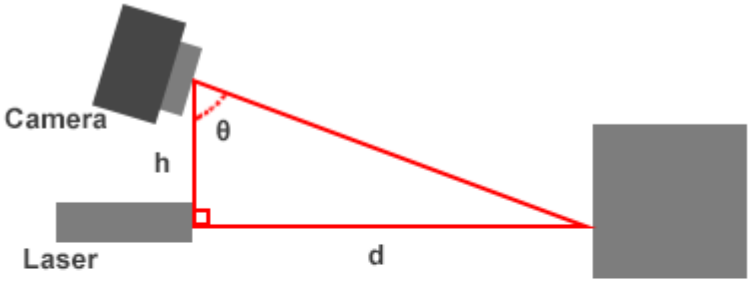
1. **LASER triangulation 3D scanning technology.**
2. **Structured light 3D scanning technology.**
3. **Photogrammetry.**
4. **Contact-based 3D scanning technology.**
5. **LASER pulse-based 3D scanning technology.**

1. Laser triangulation 3D scanning technology:

In this category, the laser scanner projects a laser beam on a surface and measures the deformation of the laser ray.

Laser scanning is often considered to be more versatile than other 3D scanning technologies. As the name indicates, this category of 3D printers projects or delivers laser beams onto the surface of the real-world object. The laser beam returns back to the sensor after being reflected. The 3D scanner gathers and interprets the geometric information based on the time gap between projection and reflection. The scanner uses a camera to record where the laser beam intersects with the object.

The angles of the camera and the laser beam make the scanner identify the exact location where the laser dot hits the object. In addition to scanning objects, laser scanning technology measures distances accurately and precisely. But the 3D scanning technology is considered to be less precise than structured light scanning. Also, it is used primarily by larger 3D scanners to scan large objects like buildings and cars.



h = distance between camera and laser (known)
θ = angle betwen laser and scanner (known)
d = distance between scanner and object (unknown)

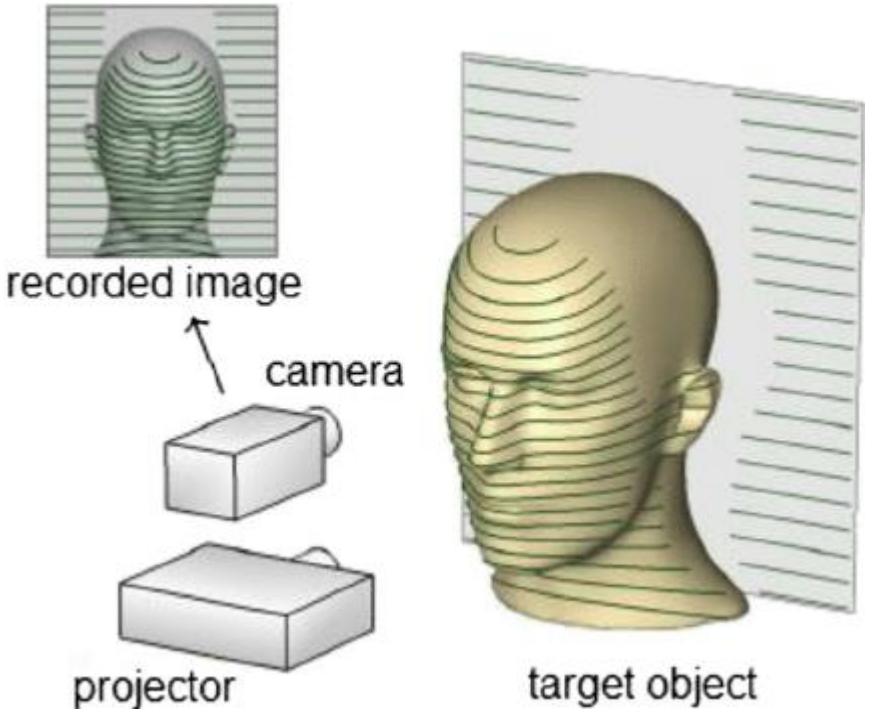
$$d = h * \tan(\theta)$$

2. Structured light 3D scanning technology:

This technology involves projecting structured patterns of light on an object and acquiring a surface's shape by measuring the light pattern's deformation.

This category of scanners produces 3D models by performing two important tasks simultaneously – casting geometric patterns onto the real-world object and taking photographs using a camera. While taking photographs, the camera captures or logs in deviations of every image. While producing 3D models, the 3D scanner determines the location of all existing points based on the displacement of patterns.

These 3D scanners replicate a real-world model digitally and accurately by scanning it continuously from various angles. Also, they use specialized software to create the 3D model accurately by stitching these scanned images. The use of structured light makes this 3D scanning technology deliver extremely precise measurements. Also, structured light 3D printing technology is used widely by stationary and portable 3D scanners.



3. Photogrammetric technology:

It is also known as a 3D scan from photography. It reconstructs an object from 2D to 3D and has specific computational geometrical algorithms for the task. Photogrammetry is cheap, precise, and used to scan large objects such as buildings and stadiums.

This 3D scanning technology produces digital models by stitching multiple images of the same real-world object taken from various angles. The photogrammetric scanners use specialized software to stitch images taken using digital cameras, mobile devices, and camera drones. The software integrated images seamlessly and accurately by identifying pixels corresponding to the exact physical point.

Engineers these days use drone cameras to capture images of mountains, statues, buildings, and large structures. The photogrammetry scanning technology makes it easier for them to create digital models of these large structures by stitching the aerial photographs. Also, this category of 3D scanners helps 3D artists to scan animals and human beings without putting in extra time and effort.

4. Contact-based 3D scanning technology: This process requires contact between the probe and the object, where the probe is moved firmly over the surface to acquire data.

As the name suggests, this type of 3D scanner produces 3D models digitally by contacting or touching the real-world object physically. The 3D engineers need to ensure that the object to be scanned is held in place firmly before starting the scanning process. The accuracy of the contact-based 3D scanning process depends on a slew of factors – timing, movement, and vibration.

Also, contact 3D scanners often alter or deform the object while creating 3D models. Engineers have to make alterations to ensure accuracy and precision. That is why; contact scanners are used primarily for quality control purposes. The engineers do not use this type of 3D scanner for the conservation of objects.

5. Laser pulse 3D scanning technology: This unique process collects geometrical information by evaluating the time a laser beam takes to travel between its emission and reception. It is also known as time of flight technology.