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Rapid Prototyping and 3-D Scanning in designing of orthopaedic product.

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ABSTRACT: *A Rapid prototyping and 3-D scanning are one of the emerging technologies. Through reverse engineering greater possibilities have been made to construct the parts, which are not easy to reconstruct or whose basic dimensions are difficult to measure. Irrespective about the basic information of the product dimensions and construction steps, 3-D scanning can provide detailed information about the product and 3-printing can manufacture the product. The major technology in 3-D scanning and printing are discussed in this paper. The reconstruction of the cane handle with change in dimensions has been done by use of the 3-D scanning and 3-D printing technology. An ergonomically cane handle was constructed and by use of technology in similar way many ergonomic equipments can be prepared. Every sector has many equipments that are need to be ergonomically redesigned to prevent work related and other disorders. Any shape of designed product can be easily manufactured by rapid prototyping and can be tested in any conditions.*

Keywords: 3-D scanning, 3-D printing, ergonomics, cane handle.

INTRODUCTION

Different technologies are linked with different 3-D scanning devices. Every technology has its own merits and demerits. Major classification of 3-D scanners can be done into two categories that are Contact type and Non-Contact type. These two type have further sub categories. But Non-Contact scanners are sub categorised as Non-Contact Active scanners and Non-Contact Passive scanners.

CONTACT SCANNERS

A physical contact is made with the object in the Contact Scanner. It is necessary condition. To scan a object in contact scanner proper fixtures, supporting material and deducted surface are required. Machine is manually controlled by the operator. The CMM (Coordinate Measuring Machine) uses the contact measurement system. It is also used to measure the geometrical coordinates of the product being scanned. Contact scanner has wise application in manufacturing, as it is very precise scanner.

The major drawback of the contact scanner or CMMs is their slow operation. A regular contact has to be maintained with the product which is also very difficult task. Low strength or Valuable products are difficult to scan as it might get damage or changes the originality of the product.

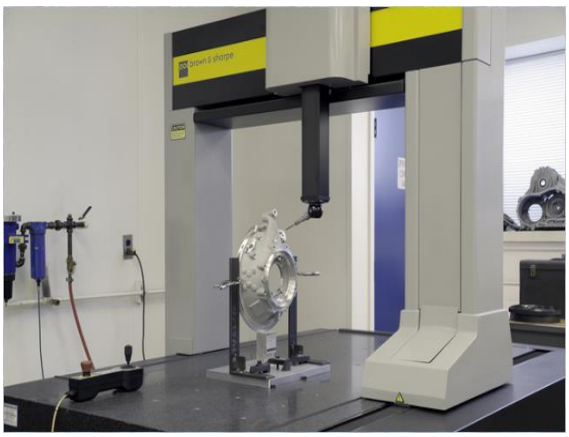


Figure-1: Co-ordinate Measuring Machine (CMM)

NON-CONTACT PASSIVE SCANNERS

No physical contact is required between the scanner and the subject in Non-Contact Active Scanners. No radiations are emitted by the Passive Scanner. Visible light found in ambient radiation is detected by these type of scanners. Apart from ambient radiations, infrared radiations are also detected. No special apparatus is required for passive scanning method except the digital camera.

Low accuracy of scanned product is the major drawback of these scanners.

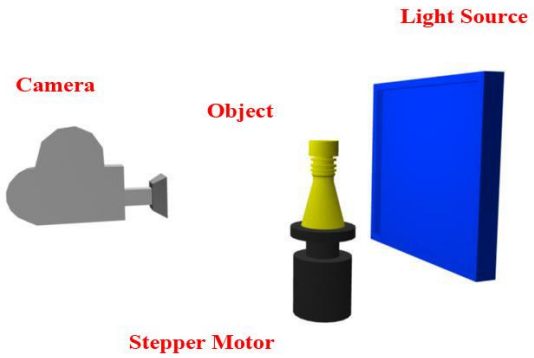


Figure-2 Non-contact passive Stereoscopic Photogrammetry

NON-CONTACT ACTIVE SCANNERS

Active scanner works by emitting radiations such as X rays and ultrasound rays or light and reflection of light is detected by it along with the radiations which pass through the subject. The light emitted by the scanner after striking the product is reflected back to the scanner and information about the distance between scanner and scanned object is also sent back.

The major drawback of this active scanner is their inability to scan surfaces which are reflective, refractive, translucent and transparent.

Technologies used in Active Non- Contact scanner are further categorised into time of flight, triangulation, structured light, modulated light and hand held scanners.

Time of Flight: This type uses laser light equipped with a time-of-flight laser range finder which finds the distance of a surface by timing the round-trip time of a pulse of light. The laser transmits a pulse of light and the amount of time is measured before the detector sees the reflected light. Since the speed of light c is known, the round-trip time determines distance travelled by the light, which is twice the distance between the scanner and the surface. If t is the round-trip time, then distance is equal to (c*t)/2. The accuracy of a time-of-flight 3D laser scanner depends on how precisely the t time can be measured: 3.3 picoseconds are approximately the time taken for light to travel 1 mm.

Triangulation: The triangulation laser shines a laser on the subject and uses a camera to look for the location of the laser dot which appears at different places in the camera field of view, depending on how far away the laser strikes a surface. In this technique the laser dot, the camera and the laser emitter form a triangle. Three pieces of information determine the triangle shape and size. First, the length of one of the triangle sides the distance between the camera and the laser emitter is known. Second, the angle of the laser emitter corner is also known. Third, the angle of the camera corner is determined by looking at the laser dot position in the camera's field of view. In most cases a laser stripe, instead of a single laser dot, is swept across the object to speed up the acquisition process.

Structured light: Light pattern is projected on the target by these type of scanners. The deformed pattern is projected on the target using light source/ LCD projector. Moving targets can be scanned by existing techniques in the real-time. The camera, slightly offset from the projector pattern, looks at the shape and calculates every point's distance in the field of view. They scan field of view or the various points at once. The exponentially more precise profiles are developed than laser triangulation in just second. These eliminates the motion distortion.

Modulated light: These projects a continual changing of light on the target. Linear pattern (sinusoidal pattern) on the target is produced. Reflected light calculates the distance traveled by the light and is detected by the camera. This allows the scanner to disregard the light from sources other than laser, so there is no interference.

HANDHELD LASER SCANNER

With the use of triangulation mechanism, these type of scanners 3D model is created. The handheld device (sensor) projects a laser dot/line on the target. Internal coordinated system collects the data. Therefore, the scanning device position is obtained by collecting data while the object is moving. The scanner uses the reference of surface scanned to get the position targeted. These scanners use the actual shape using external monitoring. To obtain the six degree of freedom more than three or three cameras are used. Apart from this operation an integrated camera is there to determine the orientation. There are infrared light emitting diodes are attached. These diodes are used in both the techniques and these diodes are attached to the scanner. Filters are used to provide resilience.

Figure 3 Non-contact Active Handheld laser scanner

3-D PRINTING

RAPID PROTOTYPE

3-D printing techniques which are widely used in industry are discussed below: -

1.Stereo-Lithography (SLA):

Stereo-Lithography technique was the ultra violet light for photosensitive resin's polymerization. In SLA, on the photosensitive resin which is contained in vat is focused on by the ultra violet laser beam. The beams present are present in particular X and Y direction to polymerize the

resin in different cross-section boundary. In SLA the cured layer of polymer is attached to the particular platform, after working the platform is lowered and new layer is fetched of resin. Since SLA delivers the product with accuracy, good surface finish and highly accurate object, it is widely used in the industries.

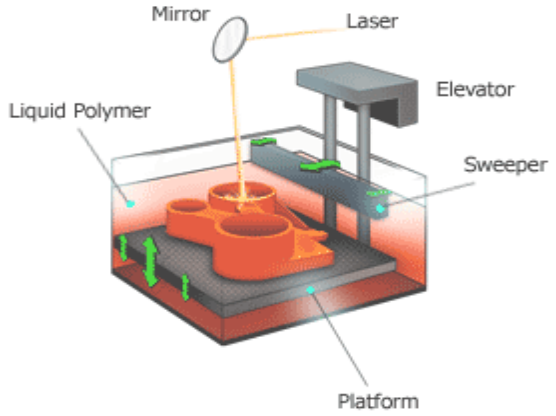


Figure 4 Stereo-Lithography (SLA) technique

The major drawback of this system is post curing of printed object. Providing support to the object is necessary and difficult to remove.

2. Selective Laser Sintering(SLS):

A laser team of high power is used for melting and fusing the material which is in the powdered form. Counter rotating roller is used to distribute the powder in an appropriate quantity. The laser team's cross hatching motuon is used motion is used to fuse the powder within the required section. The factor on which lower of the table depends is the corresponding distance of thickness of layer (0.01mm) before new layer of powder spread by roller on the already built layer. Incase of overhanging portion the support is provided by the unfiltered powder. The SLS system's building time is very less and their is no requirement of curing.

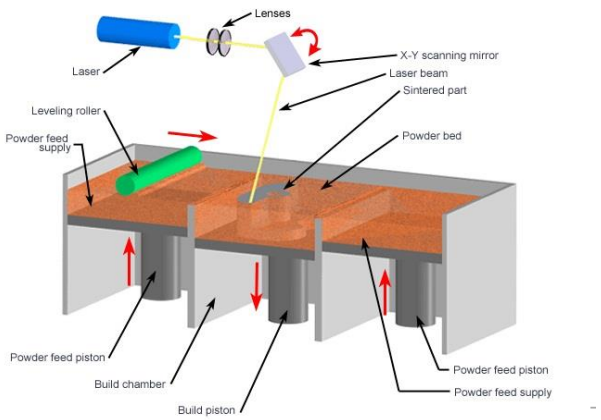


Figure 5 Selective Laser Sintering (SLS) Technique

The major drawback of SLS is surface finish of object produced, which is very rough and changing over of material is also difficult.

3. Laminating Object Manufacturing (LOM):

In LOM technique, web material or paper is used to obtain the cross-section shape of the product using a laser. Feed roll of paper is present to unwound the paper. The unwound paper is staked over the previous built layer using a roller which is heated and helps in melting the coating of plastic present on the paper's bottom side. The profile present on X-Y stage of product is detected by the optics system. After layer cutting from the web is finished, the excess of paper is removed and waste paper is taken away by the take-up roll. All the overhanging and undercut are self-supporting. A laser is used to cut the end product's heavy cross-section and cross hatched areas. A variety of organic and inorganic materials are used such as plastic, paper, ceramic and composite. The product is free from the unwanted deformation and internal stress.

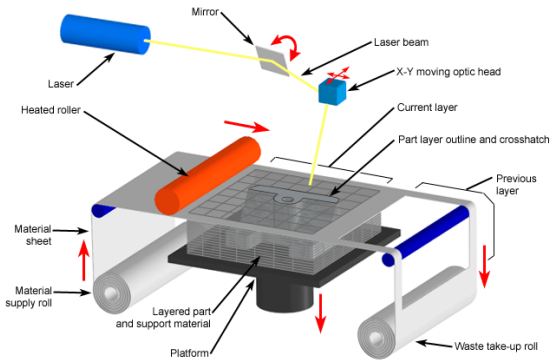


Figure 6 Laminated Object Manufacturing (LOM)

The major drawback of LOM is strength of end product is dependent on the glued layers strength. The construction of hollow part is not possible.

4.Fused Deposition Modelling (FDM):

In FDM the material is added on the product layer by layer. The working of FDM is similar to the SLA technique in which CAD file's layers are added consecutively on the platform. Material used in FDM usually has melting point around 280°C, it directly sticks or cures into the previous layer if extruders introduced with it. Due to this whole chamber of FDM machine is headed and temperature is maintained, so that individual layer sticks properly to each other. Proper timing and temperature is necessary to be optimal. Early and late curing will prevent the introducing layer bonding to the present layer. Supporting fixture is required since the product is produced on the building

platform. Small or thin parts can be produced in the FDM machines with less maintenance cost easy changing of material, nontoxic material and compact in size.

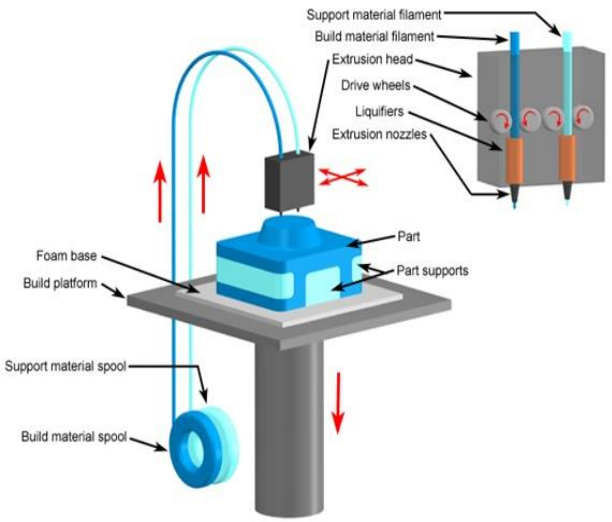
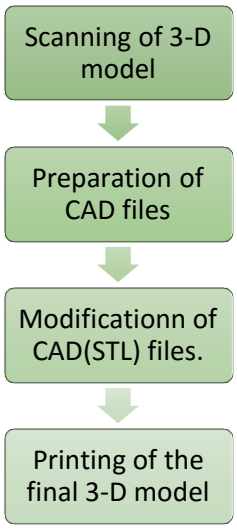


Figure 7 Fused Deposition Modelling (FDM)

5. Polyjet 3D Printing

Polyjet 3D printing's working is similar to inkjet printer's working. As inkjet drops ink, polyjet drops the layer of liquid photopolymer into tray, which us used to build. Software is used to installation of the support material and photopolymer.

This jets the tinny droplets of liquid photopolymer. The unwanted or support material can be removed without much effort. It can be removed by hand or the water. The manufactured products had smooth surface finish and explained aesthetics. It is mainly used for producing jigs, assembly fixtures and for short-run only. The major drawbacks of polyjet technique is its heavy cost and time consuming process and a weak product.



STEP 1: Scanning of model

The GOM scanner is used to scan the existing walking stick handle. The GOM scanner does not require any physical contact and it is best for the conditions of scanning a handle which has many grooves and other surface in which even small movement will not be able to scan properly.

Figure-8: Picture of original handle.

STEP 2: Preparation of CAD files.

The scanned file was further processed in the scanner software to convert the file into STL format (Standard Triangle/ Tessellation language). The STL formal of file is readable in all CAD/CAM software and all the 3-D printing machines also read this format.

STEP 3: Modification of STL(CAD) files

The CAD/CAM software's are used to change the shape of existing handle. The surface on the upper contour of the handle was added. The material was added to provide more support to the carpal bones, which will suppress the dorsiflexion and reduces chances of carpal tunnel syndrome is reduced and ergonomically designed handle is developed. A handle with upper contour providing more support is merged with handle having optimal cross-section and both of the handle were align by aligning their mid plane and centre of mass.

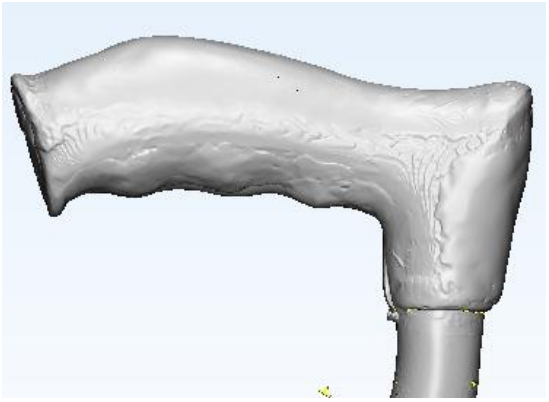


Figure-9: Picture of CAD file after modification.

STEP 4: Printing of 3-D model

The FDM technology was used for rapid prototyping the handle. FDM is cheap and less time consuming techniques. The STL formed prepared in CAD/CAM scanner are fetched into the predefined software of the 3-D printer. In software printing many options are there like hollow, sparse and solid. Sparse was selected and ABS material was used to build.

Figure-10: Picture of 3-D Printed handle.

CONCLUSION

The technologies which provides best results in minimum time with better built quality is ATOS GOM scanner is better if the small object is to be scanned, as this is the only scanner which is a accurate device which can be moved to any place. Moreover, this scanner does not require any repairing and reference points are marked on the surface. The FDM uses the ABS material fir printing. This material doesn't cost much and more over this process time efficient, cost efficient as compared to others. This technology is best suited for the printing of the cane handle.