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Application of RPT in Medical Science: A Review

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Abstract—*This paper provides an overview of RP technology in medical field which is the most recent application of rapid prototyping where it enables the doctor to choose the location of internal fixation of plate on humorous bone in orthopedics and also used for surgical planning of complex operations by Production of prototypes for medical modeling. Now a days, 3D printing is a form of add- on manufacturing process where a three dimensional object is printed by supplementing layer after layer of particular material, which differ from the more usual "subtractive" forms of manufacturing. The first stage of 3D printing involves creating a digital model of the object to be printed. This is usually done with Computer-Aided Design (CAD) modeling software or using dedicated online services provided by some of the 3D printing platforms. 3D scanners can also be used to automatically create a model of an existing object (just like 2D scanners are used to digitize photos, drawings or documents). When an object is printed, the 3D model of the object is discomposed into successive layers that are printed one at time.*

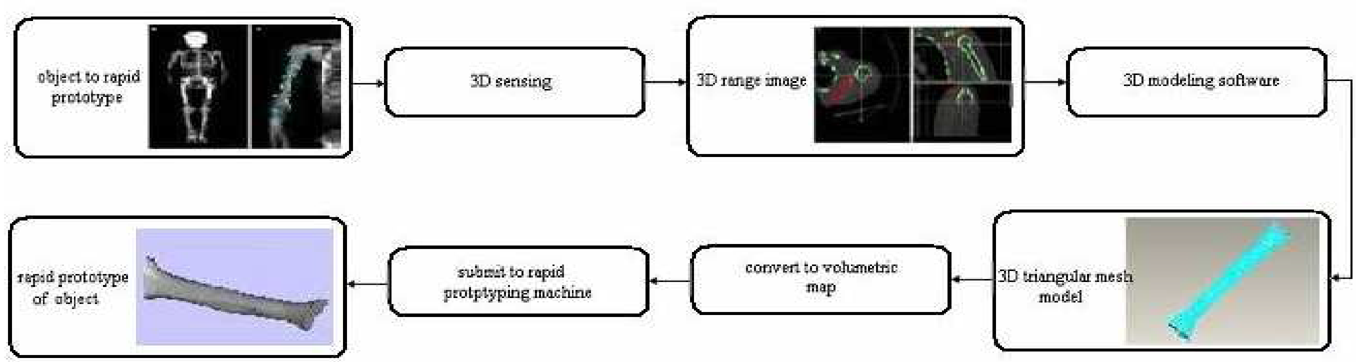
Keywords*: CAD, Computer Tomography (CT), Magnetic Resonance Imaging (MRI), Orthopedics Rapid Prototyping (RPT), 3D-Slicer.*

1. INTRODUCTION

3D printing technology has been started since 1980s. Charles "Chuck" Hull, co-founder of 3D Systems, invented world's first 3D printer (stereolithography) in 1983.In 1987, Dr. Carl Deckard invented selective laser sintering (SLS) process. In 1989, Scott Crump developed fusion deposition modeling (FDM) and went on to co-found Stratasys Inc. Today there are two main companies, 3D Systems and Stratasys, which are leading 3D printing industry.

Since a number of different RP techniques are in application. Now a day's although several rapid prototyping techniques exist, all follow the same basic five-step process. The steps are:

1. Creating a CAD model of the design.
2. Converting the CAD model to STL format.
3. Then Slice the STL file into thin cross-sectional layers.
4. Bulit the model one layer a top another.
5. Finish and Clean and the model



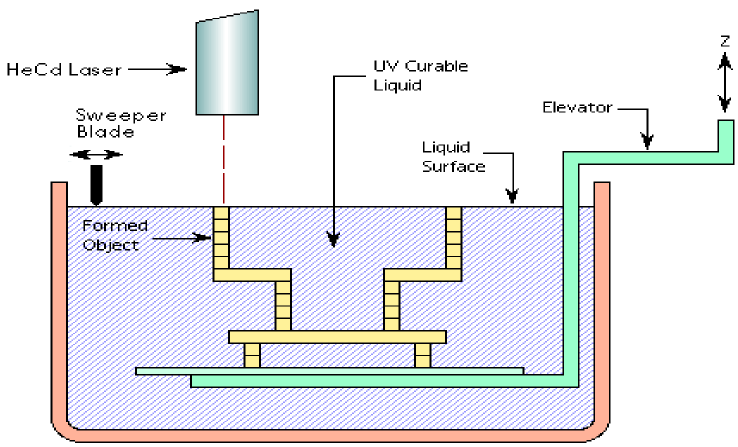
Steps Involved In Rapid Prototyping

Following are the various rapid prototyping process along with there advantage and applications:

- Stereo lithography(SLA)
- Laminated Object Manufacturing(LOM)
- Selective Laser Sintering(SLS)
- Fused Deposition Modeling(FDM)
- Solid Ground Curing(SGC)
- 3D-Printing(3DP

STEREOLITHOGRAPHY

Stereolithography is a important rapid prototyping technology for the production of parts with high accuracy and good surface finish.



Stereo lithography (SLA)

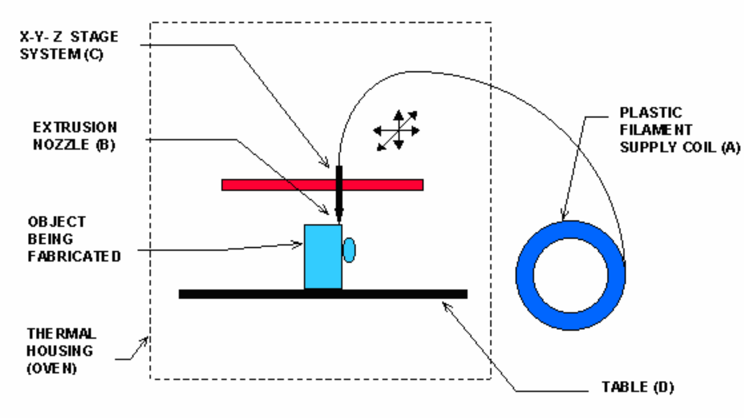
The device which performs stereolithography is called an SLA or Stereolithography Apparatus. Stereolithography utilizing a vat of liquid UV-curable photopolymer "resin" with a UV laser to make parts a layer at a time. On every layer, the laser beam traces a part cross-section pattern on the surface of the liquid resin. Exposure to the UV laser light cures, or, solidifies the pattern traced on the resin and adheres it to the layer below.

Following are the applications of Stereolithography-

- Prototypes for concept models
- Form-fit for assembly tests and process planning
- Models for investment casting, replacement of the wax pattern
- Patterns for metal spraying, epoxy moulding and other soft tooling

FUSED DEPOSITION MODELING (FDM)-

Fused deposition uses various filaments (approximately 1/16 inch in diameter, acyrylonitrile butadiene styrene, polylactic acid, polycarbonate, polyamides, polystyrene) that are forced through a heated extrusion nozzle, which melts the filament on a platform bed. The printer nozzle moves in an x-y-z plane and deposits layer after layer of material that hardens after extrusion. This method provides high geometric accuracy and models that can be sterilized for use in operative setting.

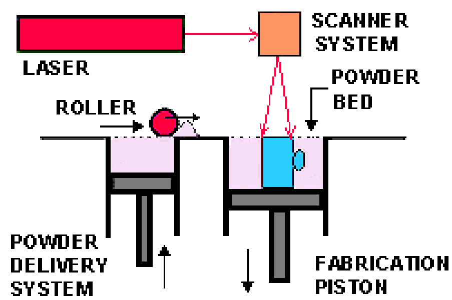


FDM Process representation diagram

Acrylonitrile Butadiene Styrene (C8H8· C4H6·C3H3N) which is also called ABS material is used in Fused deposition modeling method.

SELECTIVE LASER SINTERING (SLS)-

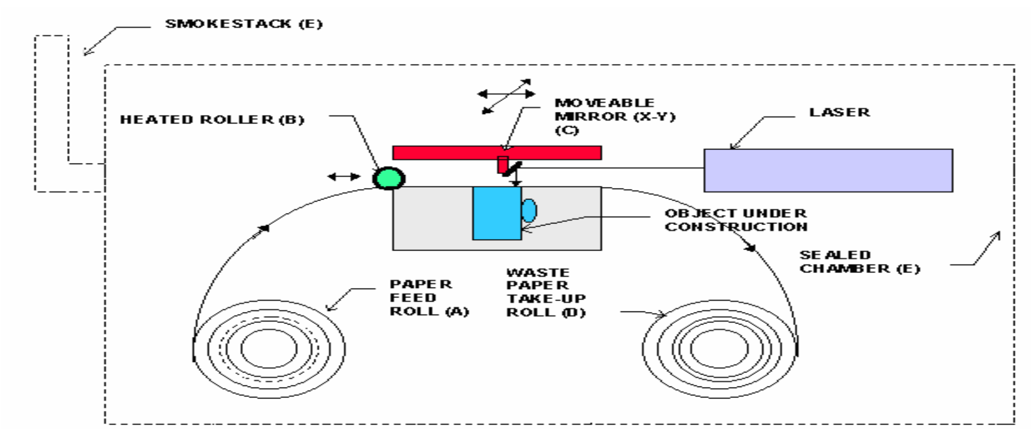
Selective laser sintering uses a high-power laser (carbon dioxide) to fuse thermoplastic powder made from plastic, metal, or ceramic. After laser fusing a cross section, the powder bed drops down 1 layer thickness and a new layer of thermoplastic powder is applied. This method allows a variety of materials to be used, affords high accuracy and resolution but at a higher cost.



Selective Laser Sintering (SLS)

LAMINATED OBJECT MANUFACTURING LOM)

In LOM, a sheet with single-sided heat activated glue is supplied from a sheet supply roll onto the platform. Laser is used to cut cross-sectional outline of the layer. A new layer is bonded to the previously cut layer and a new cross-section is created and cut. Once all layers have been laminated and cut, excess material is removed to expose the finished model.

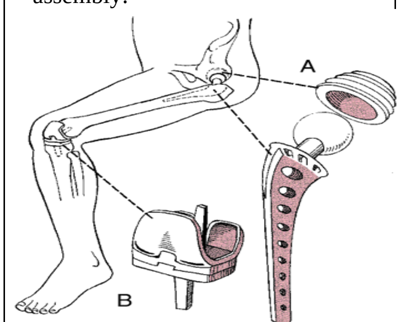


Laminated Object Manufacturing

LITERATURE REVIEW

S. No.	Author	Aim	Output parameter	Conclusion
1.	Akash Balasaheb Dhande Prof. Rahul Krishnaji Bawane Output Review (2017)	This paper presents the procedure for making model of humerous bone in Orthopaedics using rapid prototyping Technologies (RPT). This paper describes rapid tooling methods.	• Production of prototypes for medical modeling (orthopaedics) in general can be classified into two broad categories based on manufacturing process route and type of data available, i.e. designed data and scanned/digitized data. • Designed data is data that is created according to a person's idea on computer aided design (CAD) system system. For this type of data CAD solid model can be directly converted to STL format for use in subsequent rapid prototyping process. • Further data treatment is needed for Scanned data from computed tomography (CT) and agnatic resonance imaging (MRI) scanners which capture soft and hard tissue information based on density threshold value.	• There are a number of commercial software's such as MIMICS, and Go-build which translate this data to the format required by RP systems.
2.	Lucas Krauel Felip Fenollosa Lucı´a Riaza Martı´n Pe´rez Xavier Tarrado Andre´s Morales Joan Goma` Jaume Mora	This paper shows the use of 3D prototypes which involve the creation of a physical model from a 3D computer version for complex Rapid prototypes surgical oncologic Case.	▪ Patients having tumors encasing major vessels that implied complex surgery were selected for surgical planning using 3D prototypes. ▪ 3D virtual models were obtained from routine CT and MRI images. ▪ The models, with all their anatomical relations, were created by an expert pediatric radiologist and a surgeon, image by image, along with a computerized-aided design engineer.	• 3D virtual models A surgeon can have practice on the model before the surgery. • In this study 3D printed models of complex soft tissue tumors with their anatomical relationships By printing different models of each tumor. we were able to explore different aspects required for detailed surgical planning. • The integrated model allowed us to practice on the prototype and simulate the surgery before the operation.

3.	C. A. Grant, PhD, Maree T. Izatt, B.Phty, Robert D. Labrom, MSc, FRACS, Geoffrey N. Askin, FRACS, and Vaida Glatt, PhD	This paper represents benefits of 3D printing technology in spinal surgery.	The main areas of focus are evident: Complex spinal deformity cases in which models have been printed for surgical planning purposes; The design of patient specific drill guides; Most recent advent of printing custom titanium implants.	• Advantage of 3D-printing technology in spinal surgery are custom designed drill guides, templates for pedicle screw placement, and Customized patient-specific implants. • The future success of this technology is dependent on how useful surgeons find the biomodels to be for preoperative planning and consent and/or for intraoperative anatomic reference compared with standard visualization modalities such as CT scans.
4.	George Z. Cheng, MD, PhD, Raul San Jose Estepar, PhD, Erik Folch, MD, MSc, Jorge Onieva Onieva, MSc, Sidhu Gangadharan, MD, Adnan Majid, MD.	Review of rapid prototyping and 3D Slicer as Powerful Tools in Understanding and treatment of Structural Lung Disease.	• The process to generate a physical airway model is straight forward. After downloading and Installing 3D Slicer, the user will need to install the extension for airway segmentation. • 3D Slicer will have to be restarted in order for the extension to take effect. User will then need to load the CT scan, and then select the airway segmentation module. • Once the digital model of the airway has been generated the user can then save the file into .STL format, which can then be sent to a 3D printer for printing . • Using 3D slicer airway segmentation algorithm, one can generate a physical 3D printed airway model. This model can then be used for pre-procedural planning. • The digital model generated from 3D Slicer can be imported into a variety of digital modeling software that allows further manipulation of the digital airway model.	• Main motive of this paper is to provide an initial guide on 3D modeling and printing by demonstrating how to design personalized airway prosthesis via 3DSlicer. • In this article we will review the history of 3D printing from its inception to most recent biomedical applications.

5.	Andreas A. Giannopoulos, MD,* Michael L. Steigner, MD,* Elizabeth George, MBBS,* Maria Barile, MD, w Andetta R. Hunsaker, MD, W Frank J. Rybicki, MD, PhD, z and Dimitris Mitsouras, PhD*	Applications of 3D Printing Cardiography.	• High-resolution, high-quality volumetric imaging is a prerequisite for 3D printing. • CT and MRI are the most commonly used modalities. • 3D rotational angiography can be used when only intracardiac structures or the lumen of a vessel are required in a model. • Alternatively, 3D ultrasound including echocardiography has been recently used to 3D print models of cardiac structures.	• The majority of applications reported involve congenital heart diseases and valvular and great vessels pathologies. • Printed models are suitable for planning both surgical and minimally invasive procedures. • Added value has been reported toward improving outcomes, minimizing perioperative risk, and developing new procedures such as transcatheter mitral valve replacements.
6	• Yuan Zhang Jie Zhu , Zhibing Wang , Yue Zhou , Xia Zhang	• This paper describes builting a 3D-printable, bioceramic sheathed articular spacer assembly for infected hip arthroplasty.	• Total hip arthroplasty (THA) can relieve pain,restore function, and improve quality of life significantly, by replacing or resurfacing the compromised bone and cartilage tissue with a prosthesis mostly referred to as a ‘‘ball and socket’’ assembly.  • Acquisition of bone defect data and patient-customized CAD. • Fabrication of the bioceramic sheath by 3D powder printing. • Manufacture of axial bone cement pillar. our biphasic spacer module, consisted by a bioceramic sheath and a bone cement pillar, is especially advantageous for the following characteristics: (1) Biomechanically, the gradient transition of the elastic modulus, from very hard bone cement to less hard host bone through calcium phosphate layer, is confirmed to be in favor of osteogenesis. • Pharmacokinetically, the 3D printable porous structure of bioceramic sheath can also contribute to the controlled release of the specific drugs to combat infection and tumor.	• In conclusion, here we raise our hypothesis that a novel biphasic spacer module, constituted by a geometry-specific bioceramic sheath, derived from computer aided design and low temperature 3D printing, and an axial bon cement pillar carrying antibiotics, would exhibit enhanced bone repair effect for the infected arthroplasty cases combined with critica bone defect.

CONCLUSION

Additive manufacturing/3D printing/Rapid prototyping has several applications in medical field. In 1990s, 3D printing founded applications in oral and maxillofacial surgery, neurosurgery, and orthopedics. In orthopedics An artificial bone model was fabricated using ABS (Acrylonitrile Butadiene Styrene) by Rapid Prototyping Technology. This technique helps for analyzing the actual bone structure and plate fixation can be done more accurately. Due to RP technologies doctors and especially surgeons are privileged to do some things which previous generations could only have imagined. As the technology grown up, these imaging techniques kept pace. Scientist was able to use CT images to guide creation of physical models of vascular structures in the brain, heart, and lung. These developments have already proved to be very important in clinical care, trainee education, and device development. Perhaps the most exciting part of the technology is the potential use of extracellular matrix to 3D bioprint, which can lead to development of organ printing in the future.

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