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BIOPRINTING- AN APPLICATION OF ADDITIVE MANUFACTURING

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Abstract—By eliminating production steps and using substantially less material, 'additive' processes could be able to reduce waste and save more than 50% of energy compared to today's 'subtractive' manufacturing processes, and reduce material costs by up to 90%. The use of additive manufacturing can potentially benefit a wide range of industries including defense, aerospace, automotive, biomedical, consumer products, and metals manufacturing. In this project, we concentrate on the application of 3D printing in medical area at particular. The objective of this project is to discover the technological advancements in 3-D printing that could greatly affect several aspects of the medical industry. The areas discussed include high-risk surgery, dentistry, and prosthetics. After conducting six interviews with medical professionals, it was discovered that 3-D printing is a viable technological source that all professionals are eager to use and implement into their medical line of work. 3-D printing is a revolutionary technology that has the possibility to positively affect the work of medical professionals, while enhancing the lives of others.

I. INTRODUCTION

3D printing or additive manufacturing (AM) is any of various processes for making a three dimensional object of almost any shape from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control. A 3D printer is a type of industrial robot. 3D printers use a variety of very different types of additive manufacturing technologies, but they all share one core thing in common: they create a three dimensional object by building it layer by successive layer, until the entire object is complete. It's much like printing in two dimensions on a sheet of paper, but with an added third dimension: UP. The Z-axis. Each of these printed layers is a thinly-sliced, horizontal cross-section of the eventual object. Imagine a multi-layer cake, with the baker laying down each layer one at a time until the entire cake is formed. 3D printing is somewhat similar, but just a bit more precise than 3D baking.

II. PROCEDURE FOR PRINTING

There are some procedures for printing. First you must create a computer model for printing the object. For creating that, you can use Computer Aided Design Software like AutoCAD, 3DS Max etc. After the object file is created, the file need to be modified. The object file contains numerous amount of curves. Curves cannot be printed by the printer directly. The curves has to be converted to STL (Stereo lithography) file format. The STL file format conversion removes all the curves and it is replaced with linear shapes. Then the file need to be sliced into layer by layer. The layer thickness is so chosen to meet the resolution of the 3D printer we are using. If you are unable to draw objects in CAD software, there are many websites available which are hosted by the 3D printing companies to ease the creation of 3D object. The sliced file is processed and generates the special coordinates. These coordinates can be processed by a controller to generate required signal to the motor for driving extruder. This layer by layer process generate a complete object.

1. DESIGNING USING CAD
2. CONVERSION TO STL FILE FORMAT
3. RAPID PROTOTYPING

III. BIOPRINTING

The medical applications of 3D bioprinting are numerous, and are thus the subject of intensive research at academic institutions. Researchers have been developing methods to bioprint living aortic heart valves.Poly(ethylene glycol)-diacrylate (PEGDA) is used as a base polymer, because of its biocompatibility and easily tunable mechanical properties. Two different solutions of PEGDA were created with different mechanical stiffness's when cross linked, with the stiffer polymer to be used as the aortic root wall and the compliant polymer to be used as the valve leaflets. Using these solutions, a valve exhibiting mechanical heterogeneity and cytocompatibility was bio printed, which will serve as a base for future development of the aortic valve printing process. The Lawrence Bonassar Laboratory at Cornell University has been working on 3D bio printing cartilaginous geometries. One focus of their research involves the replacement of intervertebral disks with Tissue Engineered-Total Disk Replacement constructs. Tissue engineered intervertebral disks were bio printed with cell-seeded hydrogel constructs, and implanted into male rats. Commercially, Printerinks, a UK company, and Organovo, a U.S. company, have worked together to develop human tissue through 3D printing. Printer cartridges are adapted to use stem cells obtained from biopsies and grown in cultures. The resulting substance is called Bioink.

IV. 3D PRINTING APPLICATIONS IN THE MEDICAL COMMUNITY

Additive manufacturing applications within the medical community are diverse. The technology enables quick, cost-effective development of new medical devices as well as customized end-use products that improve the delivery and results of a patient's care. These economic and outcome based benefits span the medical community from device manufacturers to the patients.

4.1 Anatomical Models for Surgical assistance

Planning, Training and Device Testing, clinical training, education and device testing have relied on the use of animal models, human cadavers, and mannequins for hands-on experience in a clinical simulation. These options have several deficiencies including limited supply, expense of handling and storage, the lack of pathology within the models, inconsistencies with human anatomy, and the inability to accurately represent tissue characteristics of living humans. When it comes to individual patient care, pre- surgical analysis and planning using computed tomography (CT) and magnetic resonance imaging (MRI) scans are still limited to two-dimensional screen images. The advent of 3D printing — especially the capacity to print in multiple materials, colors and textures offers new possibilities in the training, device testing and execution of surgical procedures. 3D printed models made of different materials representing bone; organs and soft tissue are produced in a single print procedure. These models can be designed based on actual patient anatomy to capture the complexity and realism of treating the human body.

4.2 Patient-Specific Surgical Guides

Scanning technology has made it possible for doctors to accurately visualize a patient's anatomy, helping them plan for surgical procedures. But when it comes to the precision needed during joint replacement or to repair bone deformities, this technology has limitations. Doctors must still rely on scan images and experience, as well as generic surgical guides, to accurately place hardware for bone repair. The use of 3D printed surgical guides refines the traditional means of orthopedic care by allowing doctors to shape them to the patient's unique anatomy, accurately locating drills or other instruments used during surgery. This makes the placement of restorative treatments more precise, resulting in better post-operative results.

4.3 Personalized Prosthetics, Bionics and Orthotics

Additive manufacturing is well suited for individualized health care. It enables the creation of prosthetic and orthotic devices tailored to a patient's specific anatomy and needs, making those solutions more effective. In addition to the technical capabilities, the economics of 3D printing are ideal for low volume and custom production, meaning cost often drops even while effectiveness increases.

4.4 End-Use Parts for Clinical Trials

Reducing the time it takes to bring a medical device concept to the clinical trial stage has positive ramifications throughout the medical supply chain. Producers reduce cost and get more products to market faster, and patients benefit from new devices sooner. One barrier to success is the time and cost it takes to manufacture the product and revise it sufficiently to arrive at the right design. Lead times to create the tooling, whether in-house or outsourced, can be lengthy and expensive. Additive manufacturing can drastically shortening the development process. Concepts can be produced overnight in the 3D printer, validated or quickly revised as needed, and be ready for clinical use without the need to implement the full design and manufacturing process. Manufacturers can use these additively manufactured parts to support clinical trials or early commercialization while the final design is still in flux.

4.4 Laboratory and Manufacturing Tools

A more conventional but equally significant application of 3D printing involves the creation of tooling, fixtures and other equipment that lets labs and medical device manufacturers work faster and reduce costs. Tools specific to a lab or process can be created quickly and revised as needed for little cost, simply by changing the tool's CAD file and reprinting it. They can also be stored in a digital file, eliminating the need for physical storage. Hospitals and clinics can benefit by making custom surgical trays tailored to specific needs.

V. Future Scope

Medical applications of 3D printing range from the prototyping and development of new medical devices to the creation of bio-models for surgical planning. The individualized nature of health care is a perfect fit for the customization that 3D printing offers, and is already benefiting individuals through personalized orthotics and bionics. Surgical uses of 3D printing-centric therapies have a history beginning in the mid-1990s with anatomical modeling for bony reconstructive surgery planning. By practicing on a tactile model before surgery, surgeons were more prepared and patients received better care. Patient-matched implants were a natural extension of this work, leading to truly personalized implants that fit one unique individual. Virtual planning of surgery and guidance using 3D printed, personalized instruments have been applied to many areas of surgery including total joint replacement and craniomaxillofacial reconstruction with great success. Further study of the use of models for planning heart and solid organ surgery has led to increased use in these areas. Hospital-based 3D printing is now of great interest and many institutions are pursuing adding this specialty within individual radiology departments. The technology is being used to create unique, patient-matched devices for rare illnesses. One example of this is the bioresorbable trachial splint to treat newborns with tracheobronchomalacia. Several devices manufacturers have also begin using 3D printing for patientmatched surgical guides (polymers). The use of additive manufacturing for serialized production of orthopedic implants (metals) is also increasing due to the ability to efficiently create porous surface structures that facilitate osseointegration. Printed casts for broken bones can be custom-fitted and open, letting the wearer scratch any itches, wash and ventilate the damaged area. They can also be recycled.

VI. Conclusion

Medicine is perhaps one of the most exciting areas of application. Beyond the use of 3-D printing in producing prosthetics and hearing aids, it is being deployed to treat challenging medical conditions, and to advance medical research, including in the area of regenerative medicine. The breakthroughs in this area are rapid and awe-inspiring.

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