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Appication Of Rapid Prototyping In Medical Field

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Abstract— Rapid prototyping (RP) is one of the fastest developing manufacturing technologies in the world today.Rapid Prototyping Technology can be used to convert 3D image into actual physical 3D Model.It is a quite different technology of manufacturing other than Lathe,Milling and other ManufacturingTechnology.The models which one cant prepare by conventional method that can be prepare by Rapid Prototping.In the medical field there is great use of this technology. This technique can be used to prepare medical tools and instrumentation.

Keywords— Rapid prototyping, STL File, MRI Scan,3D Image,SLA,SLS,FDM

1.INTRODUCTION

To compete in today's industry environment, companies must keep up with the leading technologies and processes and also push the boundaries and develop new and improved products and processes. Shortening the lead-time for introducing a new product to the market has always been important to maximize profits and competitiveness. Recent developments in Computer Aided Design (CAD) technologies have significantly reduced the overall design cycle. However, the manufacturing process of the production mold still relies on slow and expensive machining processes. The Manufacturing Industry is an area where time, efficiency and accuracy are the major driving forces behind innovation and research. The most competitive companies are those who continually reduce process times, increase efficiency and improve accuracy. Rapid Prototyping is an area that has and is continuing to reduce production time and increase efficiency and accuracy in developing and manufacturing prototypes compared to traditional prototype manufacture. The research development of Rapid Prototyping (RP) is to give the Rapid manufacturing the needed confidence to go on to customized/tailor made product. Investment casting is a combination of science, experience and art. Prior to final design and pattern construction, it is important to select an investment casting foundry and initiate communications. Typically, each foundry will have unique capabilities, processes and requirements. In addition, pattern specifications will vary with the selection of the metal alloy and the geometry of the part. If producing patterns for the foundry, it is critical that the foundry reviews the design so that it can recommend necessary design modifications to produce the highest quality part. The foundry can also make recommendations that reduce cost, time and weight, while improving cast ability and product performance. Additionally, FDM research is ongoing, so new process guidelines may evolve. The goal of this research is to formulate a generalized Mathematical Model for Optimum temperature & time with given multiple choices of various Shell thickness & RP Part volume and find the optimal Model equation in project for the manufactured any complicated shape regular & non regular in confidence level by using Design of experiment technique.
All the RP techniques employ the same basic five step process. The steps are as follows:
i. Create a CAD model of the design.
ii. Convert the CAD model in to STL format.
iii. Slice the STL model in to thin cross sectional layers.
iv. Construct the model one layer atop another.
v. Clean and finish the model.

The use of Rapid prototyping for medical applications although still in early days has made impressive strides. Its use in orthopaedic surgery, maxilla-facial and dental reconstruction, preparation of scaffold for tissue engineering and as educational tool in fields as diverse as obstetrics and gynaecology and forensic medicine to plastic surgery has now gained wide acceptance and is likely to have far reaching impact on how complicated cases are treated and various conditions taught in medical schools.

2. RP MEDICAL MODEL PRODUCTION

The procedure for making 3D medical models using RP technologies implies few steps:
• 3D digital image;
• Data transfer, processing and segmentation;
• Evaluation of design;
• RP medical model production;
• RP medical model validation.

2.1. 3D Digital Image

3D digital image can be obtained by using computer tomography - CT scanner or MRI data (see Fig. 1). These imaging technologies are used for modeling internal structures of human's body. Medical models made from this data must be very accurate and because of this they require a spiral scanning technique which allows to do full volume scanning. This makes possible to generate a high number of slices (recommended thickness 1-2 mm) and what is very important, the pixel dimension in each slice could be reduced depending on each case. Most CT and MRI units have the ability of exporting data in common medical file format - DICOM – digital imaging and communication in medicine.
Fig. 1 MRI unit

FIG 1:MRI UNIT

2.2. Data Transfer, Processing and Segmentation

After saving CT or MRI image data, they should be transferred to RP or RE laboratory.The scanned file should be informat of stl ot DIACOM. The next step is processing these data, which is a very complex and important step, After the data is exported in DIACOM file format, it needs to be converted into a file format which can be processed for computing and manufacturing process. In most cases the desired file format for Rapid manufacturing is .STL or sterolithographic file format. The conversion requires specialised softwares like MIMICS, 3D Doctors, AMIRA. These softwares process the data by segmentation using threshold technique which takes into the account the tissue density. This ensures that at the end of the segmentation process, there are pixels with value equal to or higher than the threshold value. A good model production requires a good segmentation with good resolution and small pixels.

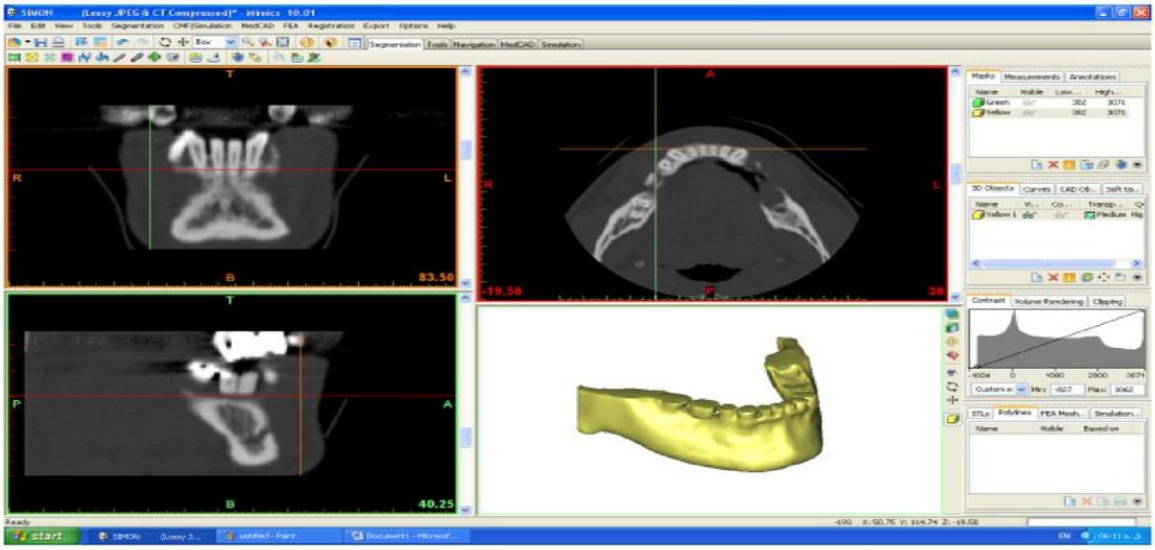

FIG 2:Software Package for Image Segmentation

2.3 Evaluation of Design

This step requires combined effort of surgeon, bio engineer and in some cases radiologist. It is important that unnecessary data is discarded and the data that is useful is retained. This decreases the time required for creating the model and also the material required and hence cost of production. Sometimes this data can be sent directly to machine for the production of model especially when the purpose of model is to teach students. The real use however is in surgical planning in which it is critical that the surgeon and designer brain storm to create the final prototype. There may be a need to incorporate other objects such as fixation devices, prosthesis and implants. The step may involve a surgical simulation carried out by the surgeon and creation of templates or jigs. This may require in addition to the existing converting softwares, computer aided designing softwares like Pro- Engineer, Auto CAD or Turbo CAD.

2.4 Additive manufacturing and production of the model

This step implies choosing the right RP technology according to the purpose of model itself as well as demanding accuracy, surface finish, visual appearance of internal structures, number of desired colors in the model, strength, material, mechanical properties,etc. Finally 3D virtual model in STL format should be inputted into the RP commercial software for production of 3D physical model (see Fig. 3). The quality of physical model is influenced, in the first place, by quality of input STL file but also by orientation of the model in RP machine and by choosing the right parameters for building the model in the same machine.

FIG3:RAPID PROTOTYPING MACHINE

3. Rapid prototyping applications

- Improved quality – existing medical products, devices, parts, equipment, etc. can be improved in quality with possible objectives being stronger, lighter versions etc.
- Patient specific models – development of patient specific parts, e.g. prosthetics, dental products, etc.
- Reduced time to market – is extensively used to reduce the time taken for products to reach the market
- Training aids – prototypes/models can be developed to practice complex operations on models first, rather than "test" on live patients (realistic effects such as blood type substances for specific cuts can be added)
- aid the training of new medical staff
- for educating patients as to treatment they will be undertaking
- User trials – conduct user trials through offering different versions of medical products, which are quickly 3D printed and see which ones perform best
- Design and development of medical devices and instrumentation:-This is the field where applications of RP show the best results. It specially applies to hearing aids but also to other surgical aid tools.
- **Great improvements to the fields of prosthetics and implantation**. RP techniques are very useful in making prostheses and implants for years. The ability to quickly fit prosthesis to a patient's unique proportions is a great advantage. The techniques are also used for making hip sockets, knee joints and spinal implants for quite some time. Both the release of and the improvement of the properties of used materials have had a significant influence on the quality of prostheses and implants made by RP. One interesting example is maxillofacial prostheses of an ear which is obtained by creating a wax cast by laser sintering of a plaster cast of existing ear. Due to RP technologies it is very easy to manufacture custom implants. The made model could be used as a negative or a master model of the custom implant. Many researchers explored new applications of RP in this field
- **Planning and explaining complex surgical operations.** This is very important roleof RP technologies in medicine which enable presurgery planning. The use of 3D medical models helps the surgeon to plan and perform complex surgical procedures and simulations and gives him an opportunity to study the bony structures of the patient before the surgery, to increase surgical precision, to reduce time of proceduresand risk during surgery as well as costs (thus making surgery more efficient). The possibility to mark different structures in different colours (due to segmentation technique) in a 3D physical model can be very useful for surgery planning and better understanding of the problem as well as for teaching purpose. This is especially important in cancer surgery where tumor tissue can be clearly distinguished from healthy tissue by different colour. Surgical planning is most often done with stereolithography (SLA) where the made model has high accuracy, transparency but limited number of colours and 3DP (for more colored models, presentation of FEA results).
- **Design and manufacturing biocompatible and bioactive implants and tissueengineering.** RP technologies gave significant contribution in the field of tissue engineeringthrough the use of biomaterials including the direct manufacture of bioactive implants. Tissue engineering is a combination of living cells and a support structure called scaffolds. RP systems like fused deposition modelling (FDM), 3D printing (3-DP) and selective laser sintering (SLS) have been proved to be convenient for making porous structures for use in tissue engineering. In this field it is essential to be able to fabricate three-dimensional scaffolds of various geometric shapes, in order to repair defects caused by accidents, surgery, or birth. FDM, SLS and 3DP can be used to fabricate a functional scaffold directly but RP systems can also be used for manufacturing a sacrificial mould to fabricate tissue-engineering scaffolds.

CONCLUSION

Technologies are definitely widely spread in different fields of medicine and show a great potential in medical applications. Various uses of rapid prototyping within surgical planning, simulation, training, production of models of hard tissue, prosthesis and implants, biomechanics, tissue engineering and many other cases open up a new chapter in medicine. Due to rapid prototyping technologies doctors and especially surgeons are privileged to do some things which previous generations could only have imagined. However this is just a little step ahead. There are many unsolved medical problems and many expectations from rapid prototyping in this field. Development in speed, cost, accuracy, materials (especially biomaterials) and tight collaboration between radiologists, surgeons and engineers is necessary and so are constant improvements from rapid prototyping vendors. This will help rapid prototyping technologies to give their maximum in such an important field like medicine. Benefits resulting from the use of rapid prototyping equipment may include:

- Reduction of current operating costs (including labor, quality, purchasing, etc.)
- Improved sales and marketing due to the ability to respond to customer requests for bids with actual models
- Improved product development, including improved customer satisfaction and improved product manufacturability
- Improved process development as lead times and costs are reduced, leading to more iterations

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