RAPID PROTOTYPING TECHNOLOGY AT WORK USING CT SCANS

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Abstract. *In this paper we will present a new technology of rapid prototyping through selective laser sintering. We will use CT scans from patient on which we will execute a remodelling for obtaining customised implants. During the CT examination must took care of the chosen program for the study area was chosen so that the patient is not further irradiated. It is mandatory to comply with radiation protection for patients and staff occupationally exposed.*

Keywords: *Rapid prototyping, selective laser sintering, CT scan, radioprotection, 3D CAD*

1. INTRODUCTION

A basic task in 3-D image processing is the segmentation of an image which classifies voxels/pixels into objects or groups. 3-D image segmentation makes it possible to create 3-D rendering for multiple objects and perform quantitative analysis for the size, density and other parameters of detected objects.

A raw 3-D image, whether it is CT, MRI or microscopy image, comes as a 3D array of voxels or pixels. Each voxel has a greyscale range from 0 to 65535 in the 16-bit pixel case or 0 to 255 in the 8-bit pixel case. Most medical imaging systems generates images using 16-bit greyscale range. A 3D image typically has a large number of pixels and is very compute intensive for processing such as segmentation and pattern recognition. A segmented image on the other hand provides a much simpler description of objects that allows the creation of 3D surface models or display of volume data.

Computed tomography (CT) is an imaging technique that uses special x-ray equipment to obtain cross-sectional images of the body. A CT image normally has different pixel intensity range for tissues such as bones, organs and other tissues. The threshold-based "Interactive Segmentation" provides an easy way to segment a CT image for 3D modeling. [1]

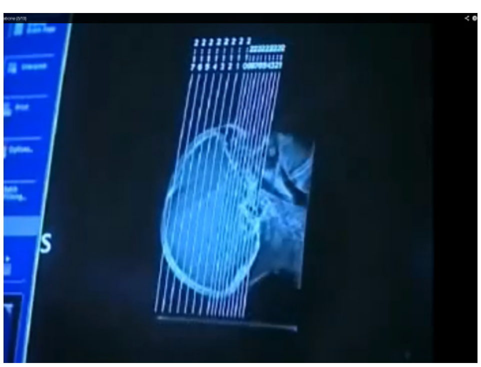

Figure 1. Typical screen of a CT scanner; the slices are clearly seen on the screen

A 3D mesh model can be created from a CT image in 3 main steps:

Step 1. Open the CT image. If the image slices come in as separate files, use the "New Stack" command.

Step 2. Use the "Interactive Segmentation" to generate object boundaries. For small size soft tissues, the manual tracing method can also be used. Boundaries can be edited using the boundary editor.

Step 3. Create 3D mesh models using the surface rendering command. The models can be exported to STL (ASCII and Binary), DXF, VRML, 3DS, OBJ, PLY and other formats for 3D measurement, rapid prototyping, simulation, treatment planning and other applications.

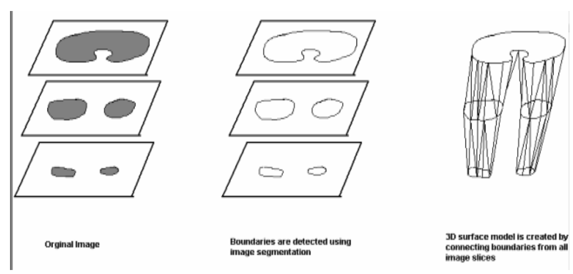

Figure 2. 3D-DOCTOR Work Flow

1.1 Image Segmentation By Thresholding

Defining a region of interest before image segmentation will limit the processing the defined region so no computing resource is wasted for other irrelevant areas. This also reduces the amount of editing needed after image segmentation because object boundaries are generated within the defined regions.

Image segmentation by thresholding is a simple but powerful approach for images containing solid objects which are distinguishable from the background or other objects in terms of pixel intensity values. The pixel thresholds are normally adjusted interactively and displayed in real-time on screen. When the values are defined properly, the boundaries are traced for all pixels within the range in the image. Greyscale thresholding works well when an image that has uniform regions and contrasting background. Following section discusses some of the image segmentation methods implemented in the software. [2]

1.2 3D Printing and Rapid Prototyping for Surgical Simulation and Treatment Planning Applications

3D-DOCTOR exports 3D models to STL (both ASCII and Binary) for rapid prototyping machines, as well as DXF for AutoCAD, 3DS for 3DStudio, Wavefront OBJ, and VRML for viewing on the Internet by others.

Once you have created 3D mesh models in 3D-DOCTOR, you can print them out using a 3D printer and a rapid prototyping machine. If you do not have access to a 3D printer, there are many service bureaus that can provide printing service.

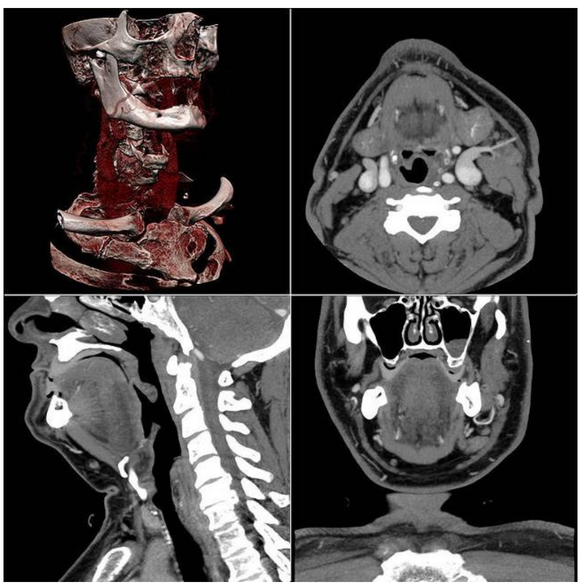

Figure 3. Typical screen layout of workstation software used for reviewing multi-detector CT studies.

Clockwise from top-left: Volume rendering overview, axial slices, coronal slices, sagittal slices.

A study may consist of several hundred slices which the user can scroll through. Images are usually acquired by the scanner in the 'axial' plane. The workstation reconstructs coronal, sagittal or oblique images on demand.

Although visually very appealing, the volume rendering is often of limited diagnostic value, and requires substantial computer resources. Qualitative and quantitative information tends to be more accessible on the cross-sectional images, and many operators prefer to forgo the volume rendering for an oblique cross-sectional series, or a duplicate series displayed with different window settings.

Sophisticated workstation software may include curved-plane cross-sectional reconstructions (which is able to 'straighten' a meandering blood vessel so that accurate measurements can be made), and image segmentation tools (e.g. for semi-automatic calculation of coronary artery calcium content).[3]

1.3 From CT image to 3D model

Thanks to new 3d imaging software, surgeons can now create physical models of their patients' inside

As a radiation protection, in order not to further irradiate a patient using an identical replica spine anatomy.

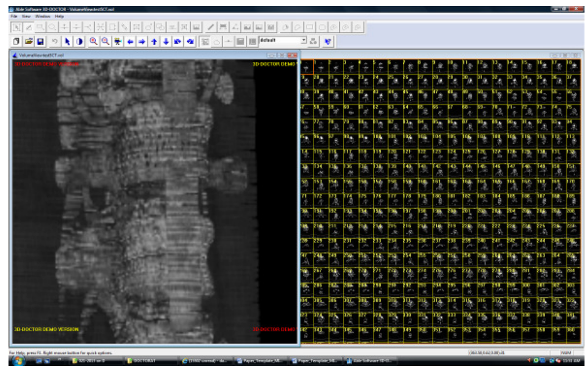

Figure 4. First, the image is segmented to isolate and trace the boundaries of the object of interest within the image set

The developments in 3D imaging technology over the recent years have been focusing on the goals to not only let the physicians and surgeons to see better inside the body, but also create physical models from CT (Computed Tomography) and MRI (Magnetic Resonance Imaging). Using the model a surgeon is able to perform a "mock" surgery prior to ever entering the operating room. Some surgeons find that minutes or hours of operating time can be saved by careful preparation using the model.[4]

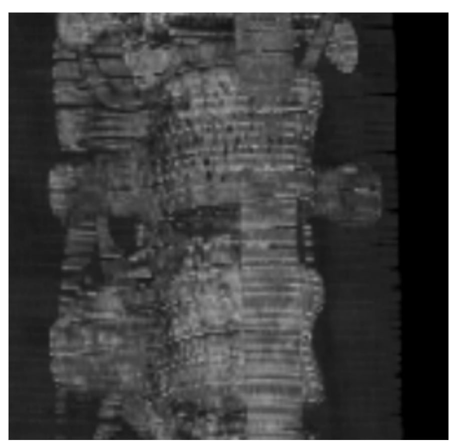

Figure 5. Thanks to the vector-based surface rendering algorithm, a 3D surface model can be created in a few seconds

1.4. Creating the physical model

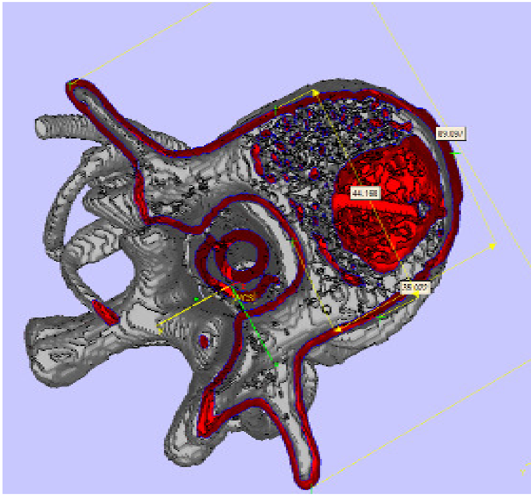

Figure 6. 3D solid rendered imaged, sectioned on Z axis, for better understanding of the interior and for better measurements

The 3D models are then saved to a file format that a 3D printer or a rapid prototyping machine accepts. For example, the STL (stereolithography) file format is commonly used on most 3D printers or rapid prototyping machines. Other standard formats include AutoCAD DXF, IGES and 3D Studio file formats.

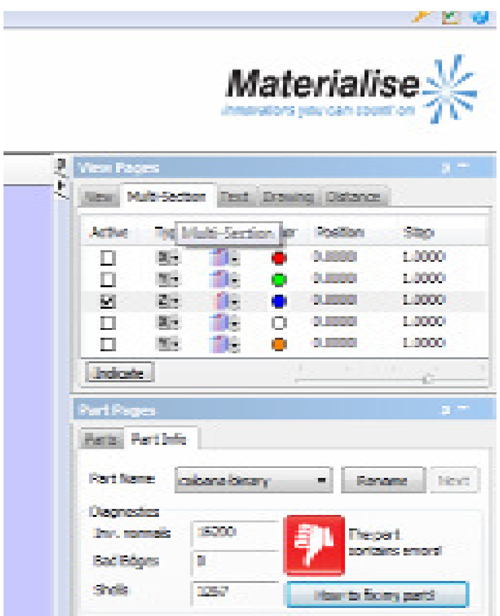

Figure 7. The multi-section page from miniMagics software, enabling a lot of sectioning on XYZ

The model is a great tool for a surgeon to communicate with her patient about the upcoming procedure. Instead of looking at a textbook drawing or a generic anatomical model, the patient gets to visualize the procedure on their own model.

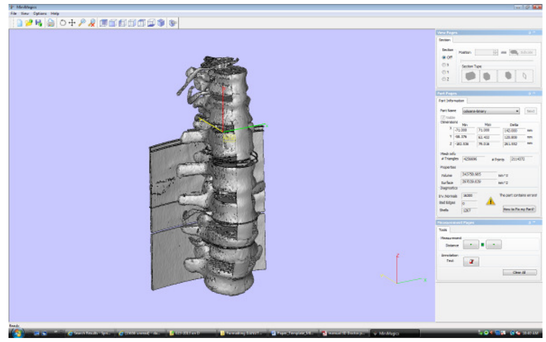

Figure 8. The raw data from 3D-DOCTOR become an STL file for miniMagics

1.5. Surface rendering

Rather than using conventional raster-based surface-modeling algorithms, 3D-Doctor uses a variation on tiling and adaptive Delaunay triangulation algorithms to create vector-based boundary lines that outline the 2-D image or user-selected regions of interest within the image. To create 3-D representations, images are first filtered from the resulting point set. 3D-Doctor [5] uses a variation of the Delaunay triangulation method to generate a set of polygons that allow surface rendering to take place. Because the images are located at preset spatial intervals as determined during the imaging protocol, the system can create a full surface of the 3-D object.

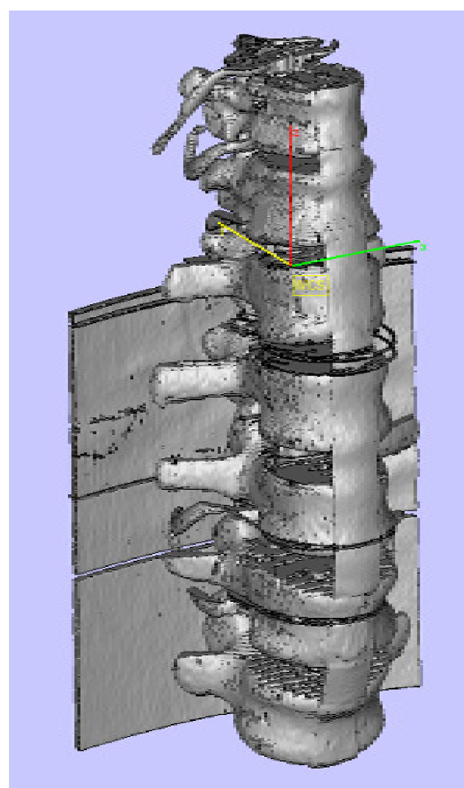

Figure 9. As you see, the STL files needs corrections, the surfaces do not close as a solid

1.6. 3D Complexities

Vector-based data structure uses lines and points to represent object boundaries, instead of marking each voxel in the 3D volume space. The biggest benefit using vector-based structure for object representation is that it makes 3D image segmentation more flexible and makes editing much easier than raster based methods. Vector-based structure has much less data items to deal with than raster-based structure, and handles topology more efficiently for features like islands, holes and branches and the topological relationship between them.

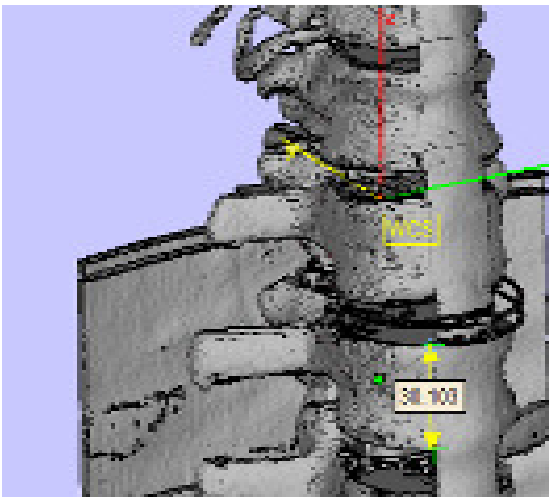

Figure 10. The software allow measurements directly on the solid body

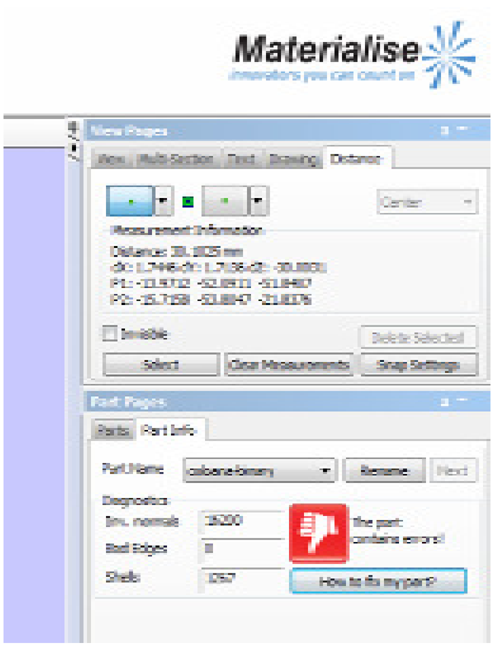

Figure 21. Typical page for measurements and part info; as you see the part contains errors and need to be fixed

As you see the part contains errors and need to be fixed. This can be done automatically in the full version of Magics.[6]

2. ACKNOWLEDGMENTS

In this paper we used demo software and freeware software from various sources.

We mention 3D-DOCTOR, which is a 3D imaging, modeling and measurement software, from Able Software Corp. http://www.ablesw.com.

Also, we use MiniMagics 3 from Materialise, http://www.materialise.com. Materialise is a leader in Additive Manufacturing (also known as 3D Printing).

3.

4. REFERENCES

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[5] http://www.ablesw.com

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