Parametric Solid Modeling of Human Spine Based on Segmentation of CT Scans

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ABSTRACT

Nowadays it is very common to have interdisciplinary projects where technologies and methodologies from one field of engineering are applied to a different discipline. This is particularly truth for computer-based tools that can have a significant positive impact when utilized for non-classical engineering applications. One such technology in the area of CAE (Computer-aided Engineering is parametric solid modeling, and one such field would be the field of biomechanics.

Parametric solid modeling has initially implemented in commercial CAD software around 25 years ago, and biomechanics can be considered a relatively new field as well. In the biomechanics field we have spine biomechanics and orthopedics, that deal with the studying this musculoskeletal systems. One of the most critical problems that medical doctors and researchers encounter is the lack of effective tools to study, in this case, the human spine. The typical approach is to perform studies with cadaver spines, or with some highly-regulated in vivo studies on animals. Both options have many limitations, thus the need by doctors for other tools that will help in their studies.

The objective of this project was to create a fully parametric three-dimensional model of the human spine, with fully parametric implying that critical defining dimension of the model can be adjusted at any point throughout creation, or even once the model has been generated. The intention is to be able to represent and analyze various orthopedic conditions of the human spine, such as scoliosis and kyphosis [2]. The project utilized Computed Tomography (CT) scan data (Figure 1), and applying various computer-based tools [1, 3] it extracted (i.e, segmentation - Figure 2) the corresponding information for each bone element (Figure 3). Further manipulation results in the parametric solid modeling (Figure 4a) of the human spine. This project is one step towards the creation of a customized virtual models where anomalies (Figure 4b), implants can be tested, and surgical procedures and instruments can be probed [4].

Figure 1. CT Data.

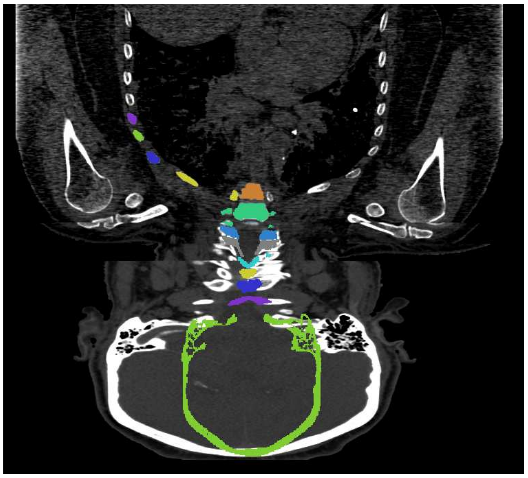

Figure 2. Segmentation to Extract Geometry Information.

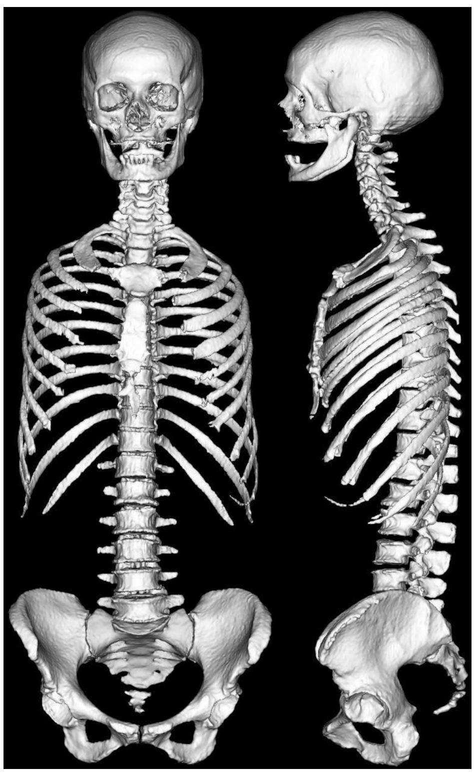

Figure 3. Extracted Bone Structures.

Conclusions

The methodology presented here to extract actual geometry from scanned data has been validated. The geometry that is extracted is used in the creation of 3D computer models that can be used for a variety of orthopedic studies. These 3D models can as well be used to create prototypes where simulated treatments can be performed - something currently being studied at the university.

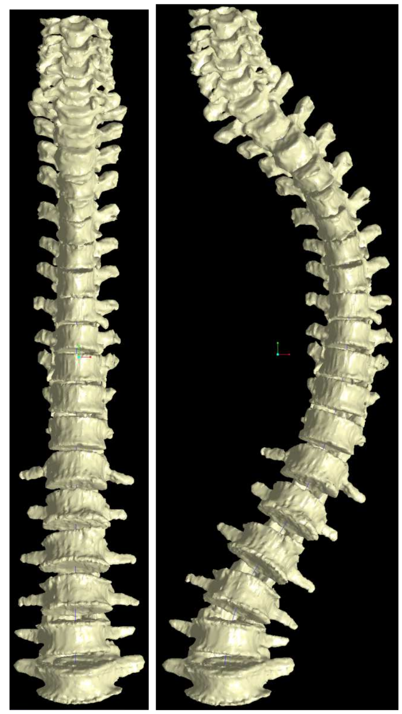

Figure 4. Parametric Solid Model for (a) Normal Human Spine, (b) Anormal Human Spine (Scoliosis).

Bibliography

1. BWH and 3D Slicer contributors. (n.d.) *Introduction*. Retrieved from the SlicerWiki: http://www.slicer.org/pages/Introduction
2. National Scoliosis Foundation. (2009). *Glossary of Terms.* Retrieved from http://www. scoliosis. org/glossary.php
3. Olszewski, R. (n.d.). *Manual segmentation with 3D Slicer for Windows*. Retrieved from the SlicerWiki:http://www.namic.org/Wiki/images/a/ac/Manual_Segmentation_with_3DSlicermj.ppt
4. Verkuilen, Pamela E. (2005). Spinal Abnormalities Rarely Cause Back Problems. Retrieved April 8, 2010 from http://www.spine-health.com/conditions/back-pain/spinal-abnormalities-rarely-cause-back-problems

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