Solid CAD models of Human Laryngeal Cartilage: created from Selbie *et al*.

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Abstract

Finite element modeling of the human laryngeal system is dependent on accurate models of the geometry. Using magnetic resonance images (MRIs) of a human laryngeal cartilage, CAD solid models were created. Updates to this memo can be downloaded at http://www.vocalfolds.org.

Keywords: Laryngeal Cartilage, CAD model, MRI, Thyroid, Cricoid, Arytenoid.

1. Introduction

Understanding the morphology of the laryngeal framework is a crucial step in mapping laryngeal function. It is also a necessary step toward quantitative biomechanical modeling of voice disorders. Accurate dimensions of all structures of the larynx are required, particularly dimensions of those structures which describe function in mechanical terms (e.g., laryngeal muscle orientation, cartilage length/width, and joint size/range).

Because of the difficulty in obtaining and performing experiments on the human larynx, Magnetic Resonance Imaging (MRI) has become a useful tool in obtaining anatomical information in both live subjects and donated samples. In the final form, such images can be used to create geometric shapes.

The purpose of this report is to provide the computer solid models (CAD) created from images of human MRI scans of the laryngeal cartilage. The goal is to present these images with sufficient detail for future researchers to use the results.

2. Creating the Models

Using 128 MRI images of human larynges discussed in NRLD#000001 was obtained directly from W. Scott Selbie, (Selbie, et al, 1998; Selbie, et al 2002). More detail about creating three-dimensional CAD models from images is presented in NRLD#000002 and NRLD#0000004.

Commercial MRI and three-dimensional software packages (Velocity2 and Pro/Engineer, respectively) were used to import the

Figure 1: MRI-based synthetic larynx model fabrication process

images. Grayscale thresholding techniques were used to identify and extract three-dimensional representations of the vocal folds, as well as the cricoid, thyroid, and arytenoid cartilages. Scaling of the images was done in consultation with cartilage data from Hunter and Titze (2005). These images and eventual solid models were output as STEP files.
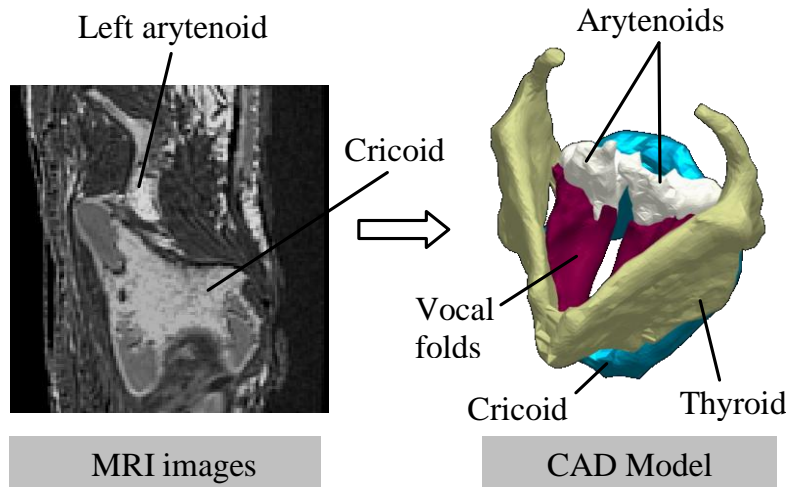
3. Data files

3.1 Files

Three sets of files are presented: [1] a solid shell version; [2] a surface version; and [3] a media movie for visualization of the solid file. The media file is in Windows Media Video format. Besides the major cartilages of the larynx (arytenoid, cricoid, thyroid), a CAD rendition of the vocal folds which match the thyroid geometry file was added. These sets of files were compressed into corresponding 'zip' files called SolidShell_CAD_stp.zip, Surface_CAD_stp.zip, and CAD_moviefiles_wmv.zip respectively.

Table I. Accompanying files.

Structure	Solid shell CAD	Surface CAD	Media
Arytenoid Cartilages (paired)	Arytenoid_SolidsShells.stp	Arytenoid_Surfaces.stp	ArytenoidCartilage.wmv
Cricoid Cartilage	Cricoid_SolidsShells.stp	Cricoid_Surfaces.stp	ChricoidCartilage.wmv
Thyroid Cartilage	Thyroid_SolidsShells.stp	Thyroid_Surfaces.stp	ThyroidCartilage.wmv
Vocal Folds	-NA-	VF_Surfaces.stp	VocalFolds-CT.wmv

3.2 Reading Files

The format of the files is a CAD format STEP (stp) file. While there are many CAD formats, STEP files are the international standard for computer-interpretable representation and exchange of product manufacturing information (ISO 10303). Commercial CAD programs will be able to import these files. There are also free, open source, CAD programs which can open and visualize the STEP file (e.g., FreeCAD was used in making the media visualzations of the files).

Literature

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W. S. Selbie, L. Zhang, W. S. Levine, and C. L. Ludlow. Using joint geometry to determine the motion of the cricoarytenoid joint. J.Acoust.Soc.Am. 103 (2):1115-1127, 1998.

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Acknowledgements

Use Agreement

The scripts, images and text are open to use by the public as a service and part of the National Resource of Laryngeal Data (supported by the National Institute of Deafness and other Communicative Disorders, and hosted by the National Center for Voice and Speech). The scripts, images, model and text enclosed in this memo and accompanying this memo are open to use by the public as a service of the NRLD. However, we ask the reader to respect the time and effort put into this manuscript and research. If the text, images, or included scripts are used, the user agrees to reference to this document, the NRLD, and the source of the original data. We also ask the users to consider contacting the original contributors of the data and give them the right of refusal to (1) participate on papers using the data and (2) have their supporting project acknowledged. The user agrees to freely share with the NRLD any extension software build on the data contained.

Revisions

1.0   Eric Hunter: Main document; Scott Thomson provided the CAD models (April 2012).