# A geometric model for voice production simulation, including the vocal folds and vocal tract

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## Abstract

This report contains a geometric model that could be used in voice production simulation, including the vocal folds and the vocal tract. These can be imported into Tecplot or other CAD software. Download updates to this memo can be downloaded at http://www.nrld.org.

**Keywords**: vocal folds, vocal tract, geometric model, finite element modeling.

## 1. Introduction

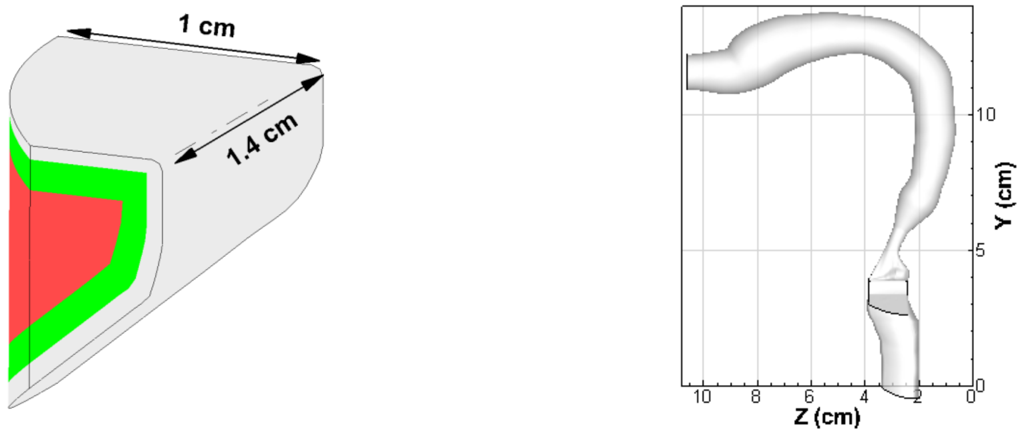
The voice production is a complex interaction process between the glottal flow dynamics and vocal fold vibrations. Computational modeling has been used to understand the physics in this process and has undergone significant improvements from early lumped-mass vocal fold models to the recent continuum mechanics-based models. The continuum mechanics-based models have the advantage that the model inputs (like the Young's modulus) could be directly related with the tissue material property and have the potential to be used in the patient specific modeling in clinical applications.

The purpose of this report is to provide a geometric model for voice production simulation, including a three-layer vocal folds and vocal tract. The model was used in the fluid-structure acoustic coupling simulation in the study of Jiang et al.(2017).

## 2. Model Details

The vocal fold model is shown in Figure 1(a). The geometry of the vocal folds was constructed based on the mathematical model proposed by Titze and Talkin (1979), which has considered the three-dimensional shape of the vocal fold including the anterior-posterior variation. The vocal fold was divided into three layers including the cover, ligament, and muscle (Hirano et al., 1981). Each layer was assumed to be longitudinally invariant. The thickness of the cover and ligament layer was 0.5 mm and 1.1 mm, respectively, adopted from Titze and Talkin (1979).

The vocal tract model is shown in Figure 1(b). The geometry of the larynx was roughly reconstructed from a thin-slice CT scan of the larynx of a 30-year-old male subject (Zheng et al., 2009). The cross-section area of the supraglottal vocal tract was taken from an in vivo-based neutral vowel model proposed by Story (2005), and it was superimposed onto a realistic airway center line from the in vivo MRI measurement (Story et al., 1996) to generate the supraglottal tract model. The length of the supraglottal tract was 17.4 cm, and the length of the subglottal tract was 3.05 cm.




**(a)** **(b)**

**Figure 1. (a) The geometric shape of the vocal fold, contoured by layer information. (b) The geometric shape of the vocal tract.**

# 3. Data files and unpacking

Accompanying this technical note is a compressed file (`NRLD000011-DataFiles.zip`). Within the compressed file are two files, both in the format that could be loaded into Tecplot (www.tecplot.com/): (1) `Tract.dat` showing the geometry of the vocal tract and (2) `Vocal_folds.dat` showing the geometry and three layers of the vocal folds. In both files, the data was packed in a block style, which means all values for the first variable were given, then all values for the second variable, etc. The data format is ASCII which allows for direct editing outside of the Tecplot software.

# Literature


Hirano, M., Kurita, S., & Nakashima, T. (1981). "The structure of the vocal folds." Vocal fold physiology: 33-41.

Jiang, W., Zheng, X. & Xue, Q. (2017). "Computational modeling of fluid–structure–acoustics interaction during voice production." Frontiers in Bioengineering and Biotechnology 5: 7.

Story, B.H. (2005). "A parametric model of the vocal tract area function for vowel and consonant simulation." The Journal of the Acoustical Society of America 117, no. 5: 3231-3254.

Story, B.H., Titze, I.R., & Hoffman, E.A. (1996). "Vocal tract area functions from magnetic resonance imaging." The Journal of the Acoustical Society of America 100, no. 1: 537-554.

Titze, I.R., & Talkin, D.T. (1979). "A theoretical study of the effects of various laryngeal configurations on the acoustics of phonation." The Journal of the Acoustical Society of America 66, no. 1: 60-74.

Zheng, X., Bielamowicz, S., Luo, H., & Mittal, R. (2009). "A computational study of the effect of false vocal folds on glottal flow and vocal fold vibration during phonation." Annals of biomedical engineering 37, no. 3: 625-642.

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## 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; with initial startup funds supported by the National Institute of Deafness and other Communicative Disorders (DC009616) and 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 NLDR any extension software build on the data contained.

## Revisions

1.0 Weili Jiang: Main document (Nov. 2018)
1.0 Brittany Lynn Johnson: Main document final edits (Mar. 2019)