DEVELOPMENT OF A COMPREHENSIVE MORPHOLOGICALLY-REALISTIC MODEL OF THE HUMAN RESPIRATORY SYSTEM FOR DOSIMETRIC USE

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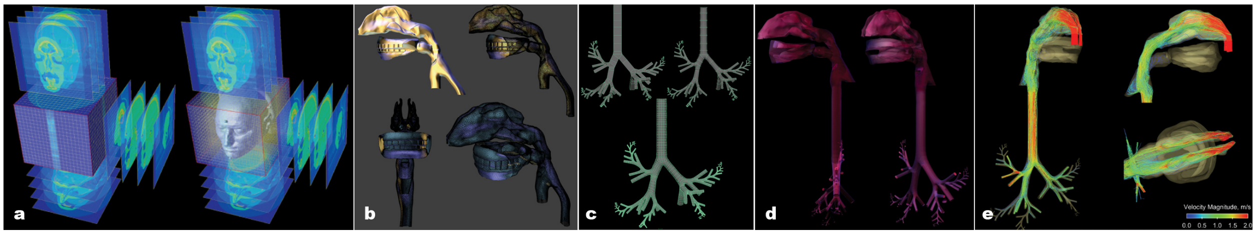

Figure 1: A volumetric data set created from combining a series of MRI images. The image shows how a surface is created by extracting a particular threshold value, called an *isosurface*, from the volume data (a). Extrathoracic airways combined with the oral cavity (b). Bifurcation model combines the pharynx showing one complete 23 generation path in each of five lobes (c). Complete contiguous typical path model, including nasal and oral cavities (d). Traces of the velocity magnitude (cm/s) are shown for an inhalation laminar flow study (e).

Abstract

The homeland security community requires a unique solution to the challenges of studying exposure to aerosol-based contaminants. The goal of this work is to create a comprehensive computational, morphologically-realistic model of the human respiratory system that can be used to study the inhalation, deposition, and clearance of contaminants, while making the model adaptable for age, race, sex, and health.

Keywords: homeland security, biomedical and genomic, aerosol contaminants

1 Introduction and Motivation

The toxic nature of aerosol-based contaminants (e.g., *Bacillus anthracis* spores, ricin toxin, etc.) prohibits studies on humans. The homeland security community requires a unique situation to better protect the public and first responders. The need for a comprehensive computational, morphologically-realistic model of the human respiratory model will assist in estimating thresholds and the need for prophylactic measures.

2 Technical Approach

We started by using magnetic resonance imaging (MRI) slices from the Visible Human Project's (VHP) Brigham and Women's Hospital (BWH) to create a volumetric data set. A threshold value was used to extract an isosurface of the head and nasal cavity, which are soft tissues. The upper and lower gums with teeth were combined to form a complete oral cavity. The tongue was added to the oral model and the upper airway models were then aligned and combined into a single morphology model, including sides and uvula. The branching airways were created using an algorithmic method that generates a single path to each of the five lobes, 23 generations down. From that model, we use subdivision surfaces to create a smoothed, watertight mesh, removing holes and imperfections from the original model. We then combine the nasal, oral, and bifurcations models into a contiguous typical path model. The completed combined model is regridded for CFD and imported into Fluent to validate the model's suitability for CFD studies.

3 Future Work

Upcoming work includes parameterizing the models to allow for manipulation of such features as age, gender, race, disease states, as well as fine controls for the shape of specific features, such as the nasal turbinates.

The model will also feature a dynamic morphology that mimics the changes in the airway structures during a typical breathing cycle. The model will therefore allow for any variation of airway geometries and disease states. The model's flexibility and adaptability could help researchers predict dose from exposure to hazardous contaminants, such as anthrax and ricin, and assist in estimating thresholds and the need for prophylactic measures.

References

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