

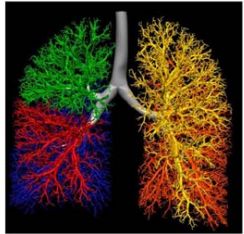
Application of Personalized Airway Trees in Multi Scale Lung Models to Probe Structure-Function Relations in Asthmatics

A. Milutinović, B. Ma, and K.R. Lutchen
Department of Biomedical Engineering, Boston University

INTRODUCTION

The human lungs are a complex system of bifurcating airways. Diseases affecting the airways result in the loss of lung function. Previous computational modeling work by Tgavalekos *et al* (2) called Image-Function Modeling (IFM) investigated which airways in asthma cause the degradation in lung function. The IFM approach uses a three-dimensional lung model and MR ventilation images to predict which airways in the model contribute to the degradation of lung function.

The generic 3D model of the lungs used with IFM was developed by Tawhai *et al* (1). The model represents individual airways as a hierarchy of bifurcating cylindrical tubes—the trachea bifurcates into two airways which bifurcate systematically to fill up the volume of the lung space. The diameters of the airways are randomized based on observed mean and standard deviation of airway diameters found for that particular generation.



3D Lung Model by Tawhai *et al* (1).

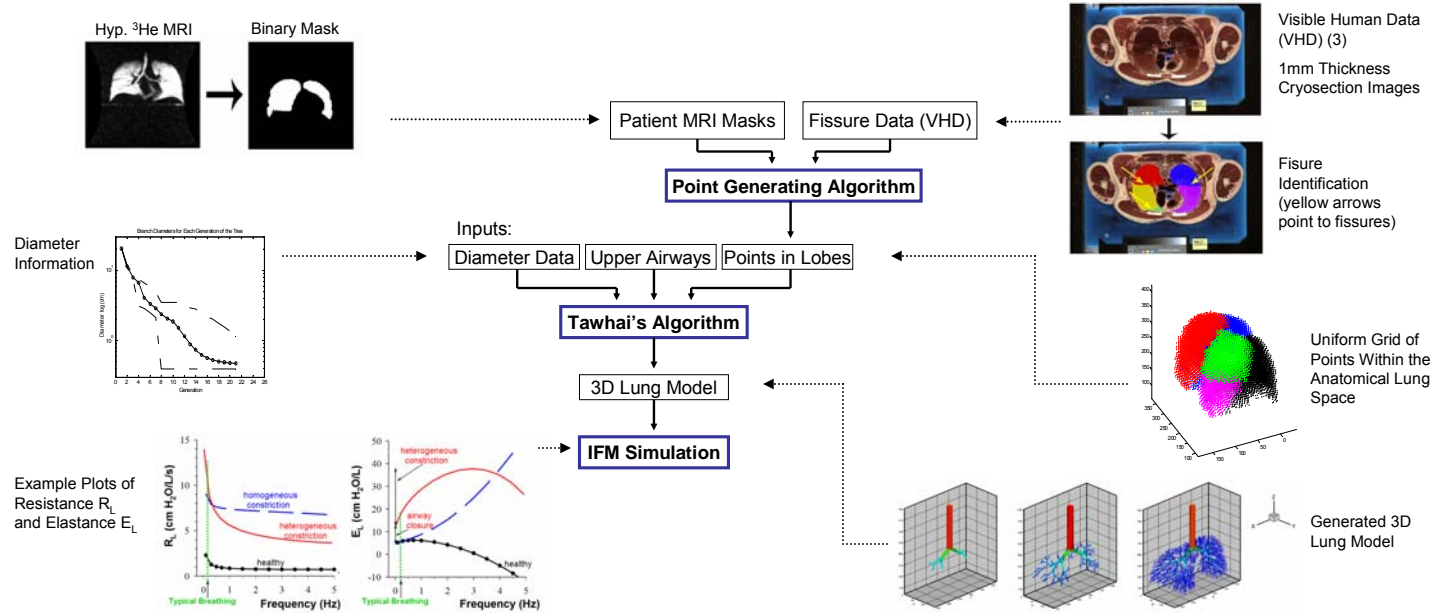
RATIONALE

To date, Image-Function Modeling only functions with the generic lung model. The IFM method would ideally function if the 3D lung model was personalized for each subject for which it predicts airway closures. The overall goal of this project is to develop software that generates patient specific models using the Tawhai algorithm.

SPECIFIC AIMS

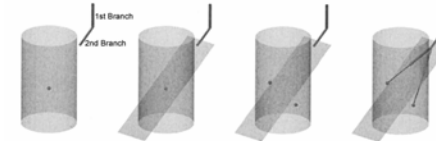
- To implement the Tawhai algorithm necessary for generating the 3D lung model
- To implement the algorithm in generating patient specific, three-dimensional lung airway models via MRI establishing thoracic volume of the lung space
- Advance the upper airway part of the model by incorporating position and diameter data of the upper and central airways obtained from CT imaging, followed by growing of the airway trees distal to the central airways
- Use the 3D lung model to predict mechanical and ventilation function of the airways and examine inter subject variability versus the generic 3D model
- Compare the personalized model to the generic model when matching real patient data using the IFM method

SOFTWARE OUTLINE AND RESULTS (software are boldface and in blue color)



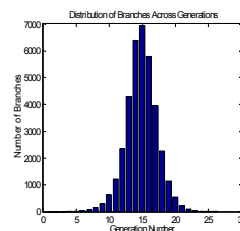
TAWHAI ALGORITHM

Simple Representation of the Tawhai Algorithm:



ADDITIONAL RESULTS

- The overall structure of the code has been developed; Individual components are functional but need further design.
- Tawhai algorithm has been implemented (see figure above of the 3D model)
- The number of branches for each generation in the model approaches the expected Gaussian distribution (right) (1)



FUTURE EFFORTS

- Design of the point generating algorithm to map the fissure locations into the volume defined from the MRI
- To incorporate the anatomically precise upper airways from which the distal airways will be generated using the Tawhai algorithm
- Comparisons of the Tawhai model and the personalized model will be conducted using the IFM software
- Simulations using the personalized model with asthmatic and healthy subject

REFERENCES

- Tawhai, M.N., Pullan, A.J., and Hunter, P.J., Generation of an anatomically based three-dimensional model of the conducting airways. *Ann Biomed Eng.* 2000. 28(7): p. 793-802.
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