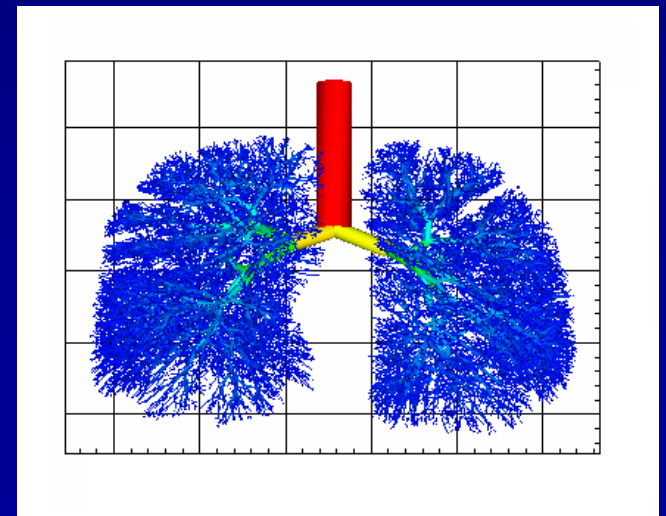




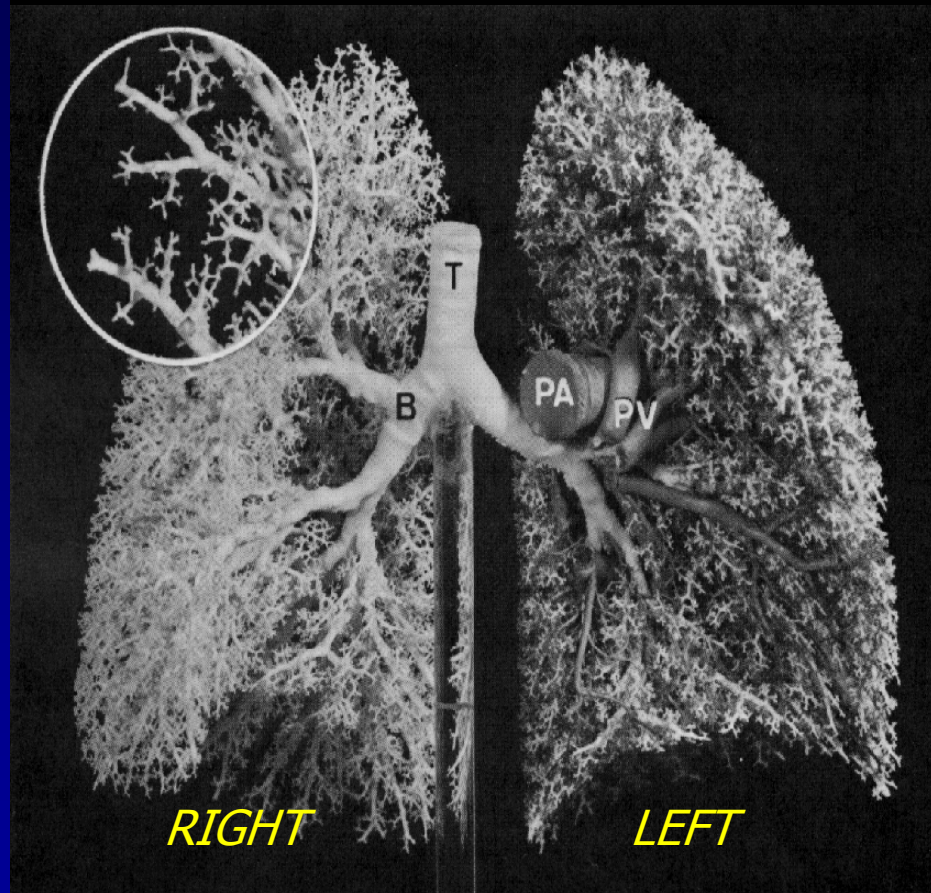
Application of Personalized Airway Trees in Multi Scale Lung Models to Probe Structure-Function Relations in Asthmatics

Aladin Milutinovic
Boston University
Senior Project Conference
Spring 2006

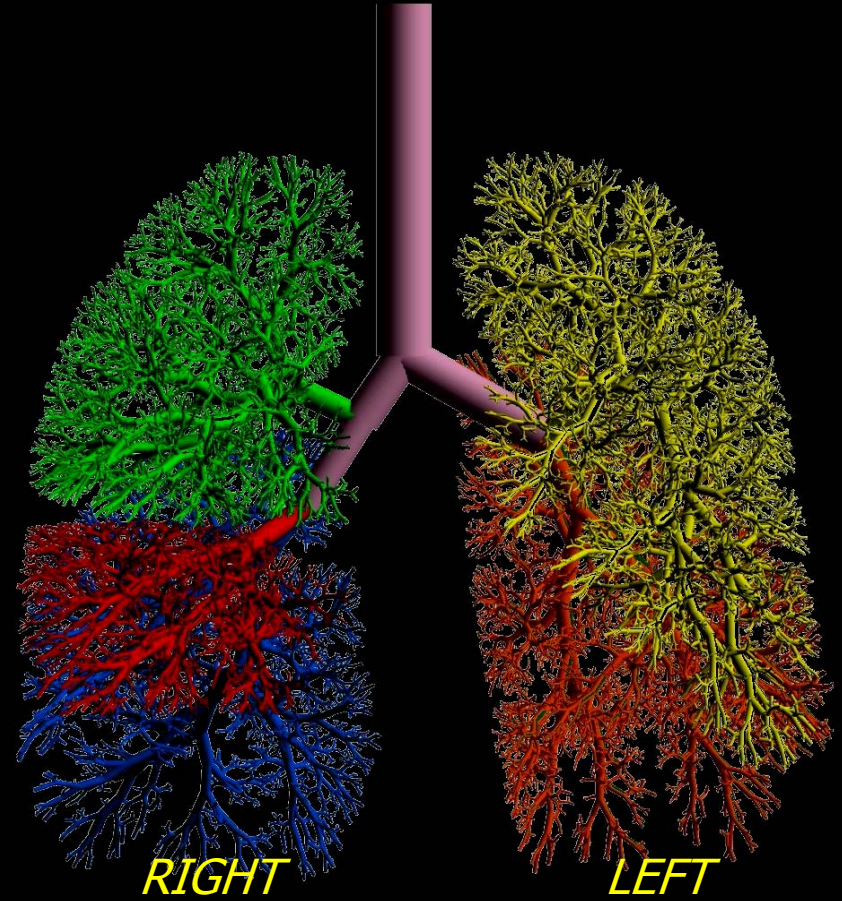




Lung Anatomy



Airway Cast: adapted from West



3D Airway Computer Model: by Tawhai *et al*

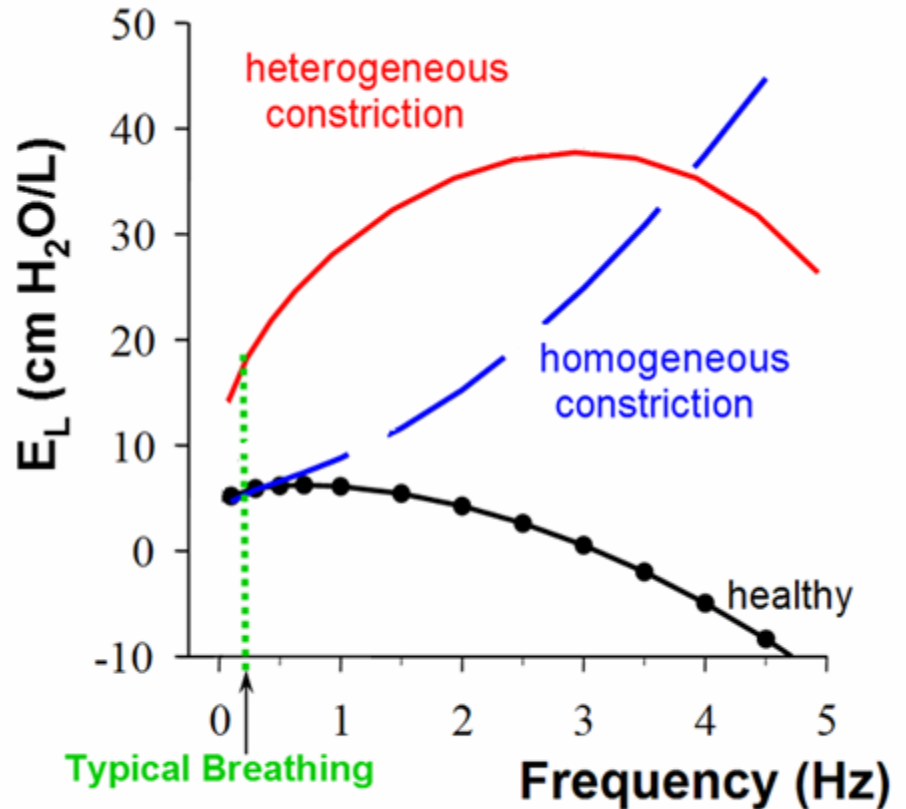
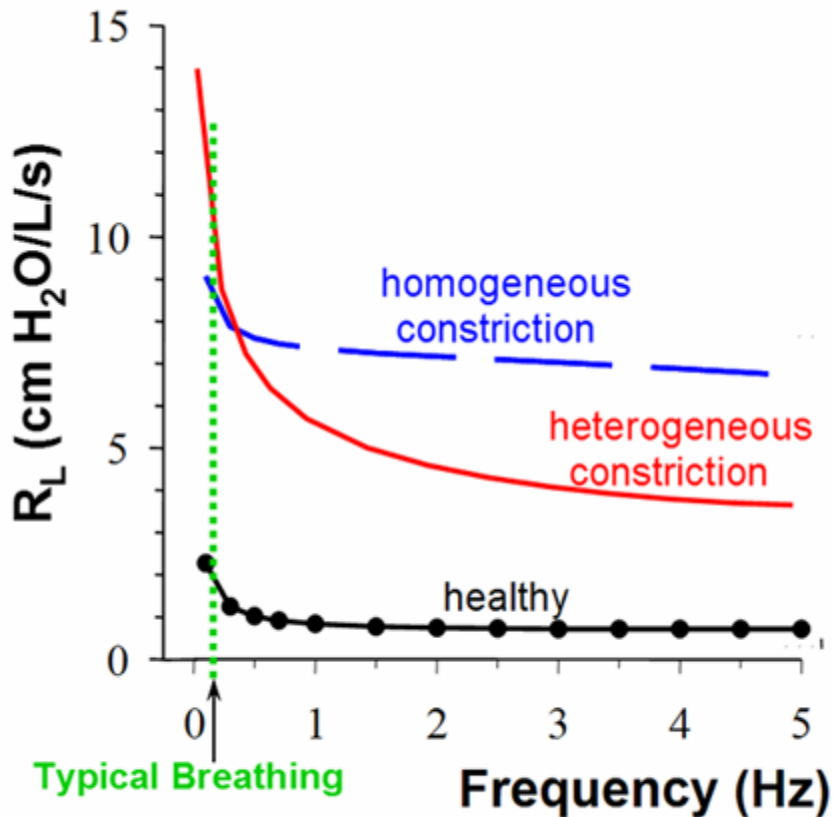
Impact of Airway Constriction Pattern on Lung Properties

RESISTANCE

ELASTANCE

$$P_{tp} = R_L Q + E_L \int Q dt$$

R_L and E_L are a Function of Frequency



Lutchen *et al*

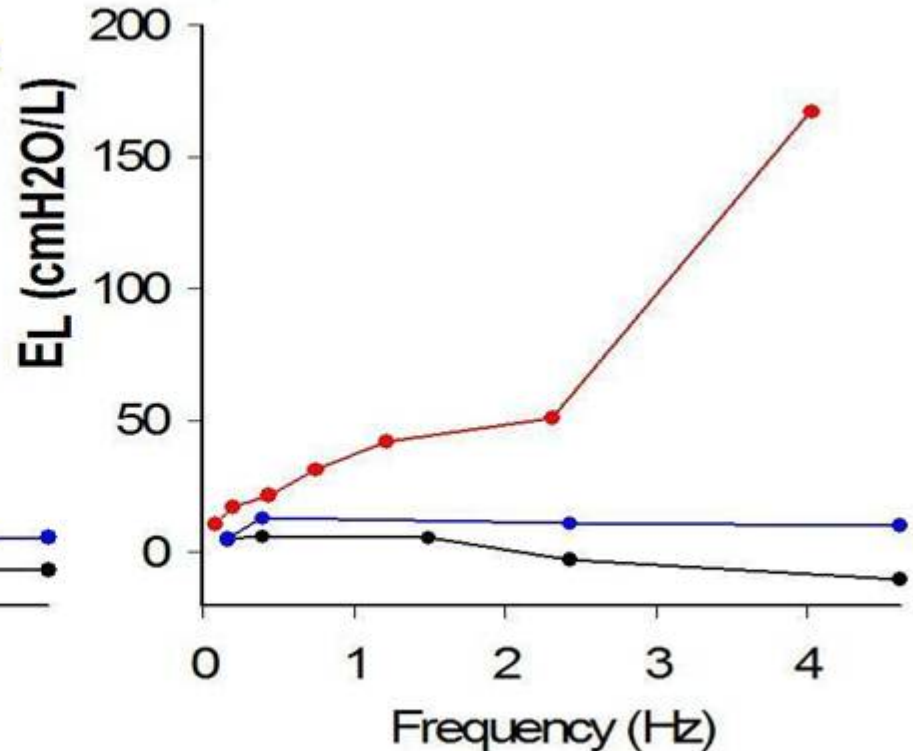
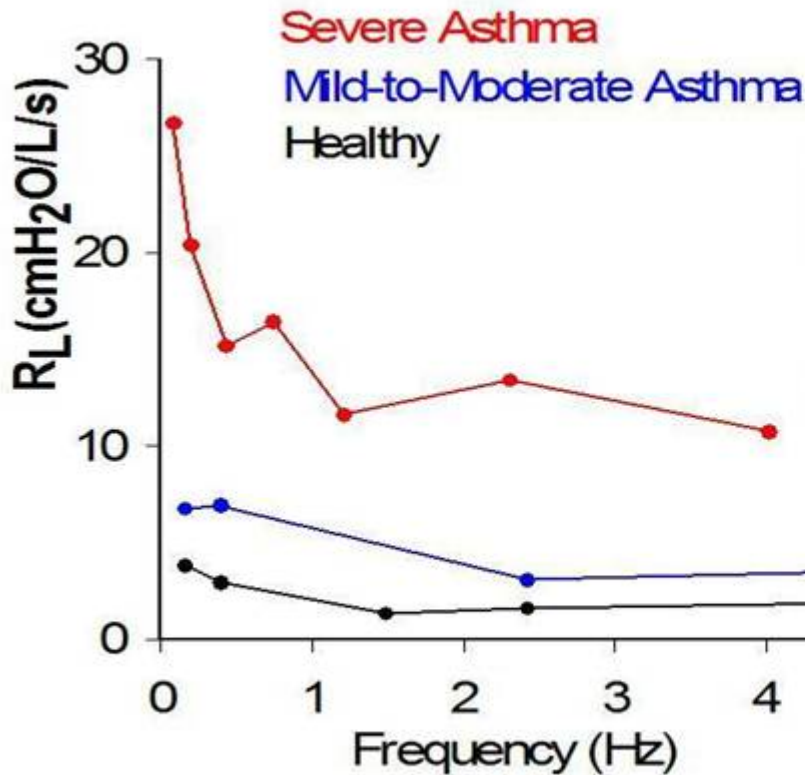
Impact of Airway Constriction Pattern on Lung Properties

RESISTANCE

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Lutchen *et al*



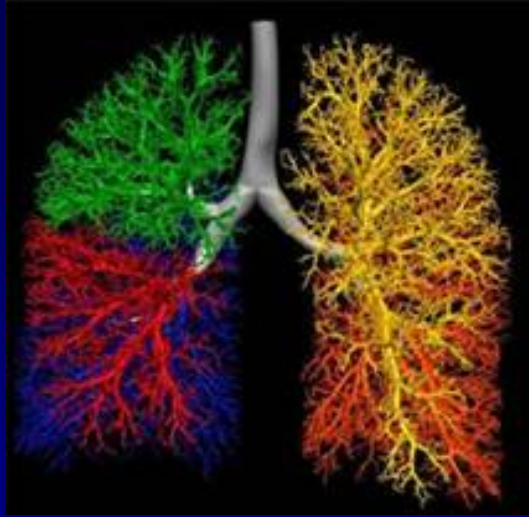
Rationale

- Structurally based models have the potential to predict specific lung function based on structural defects
- Previous approaches have used a single generic version of the Tawhai tree to study the structural components
- Ideally, we want to create patient specific, multiscale, 3D lung models

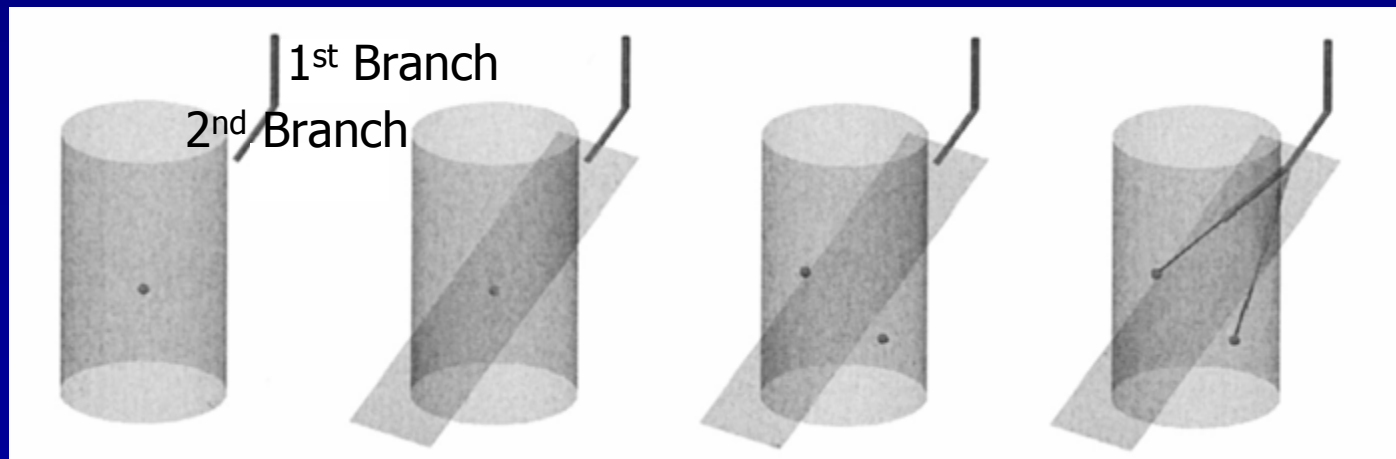
The goal of this study was to advance the Tawhai algorithm by combining Hyperpolarized Helium MRI and Visible Human Project (VHD) data to create personalized multiscale lung models



Tawhai Algorithm

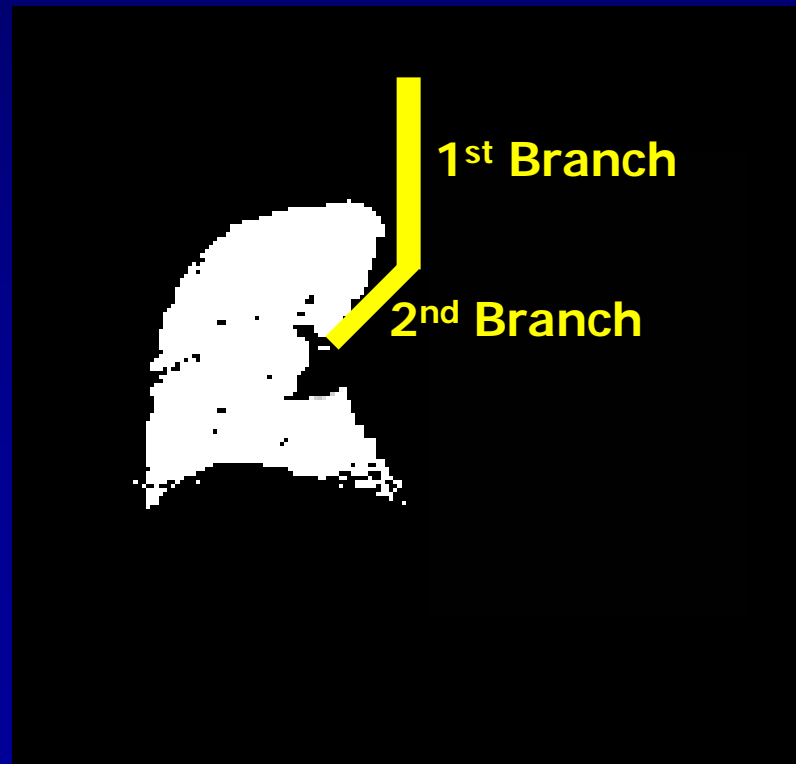


- Generic Multiscale Lung Model by Tawhai *et al.*
- Generated Using a Volume Halving Algorithm





Tawhai Algorithm Coupled to MRI Imaging





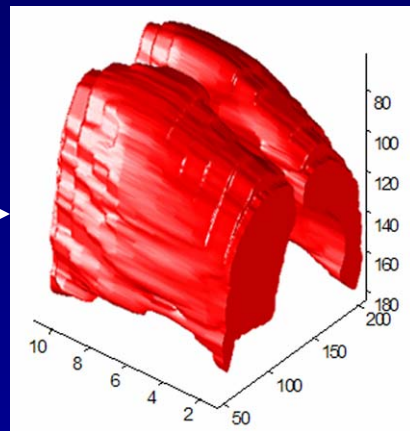
THRESHOLD



FILTER



REGISTER

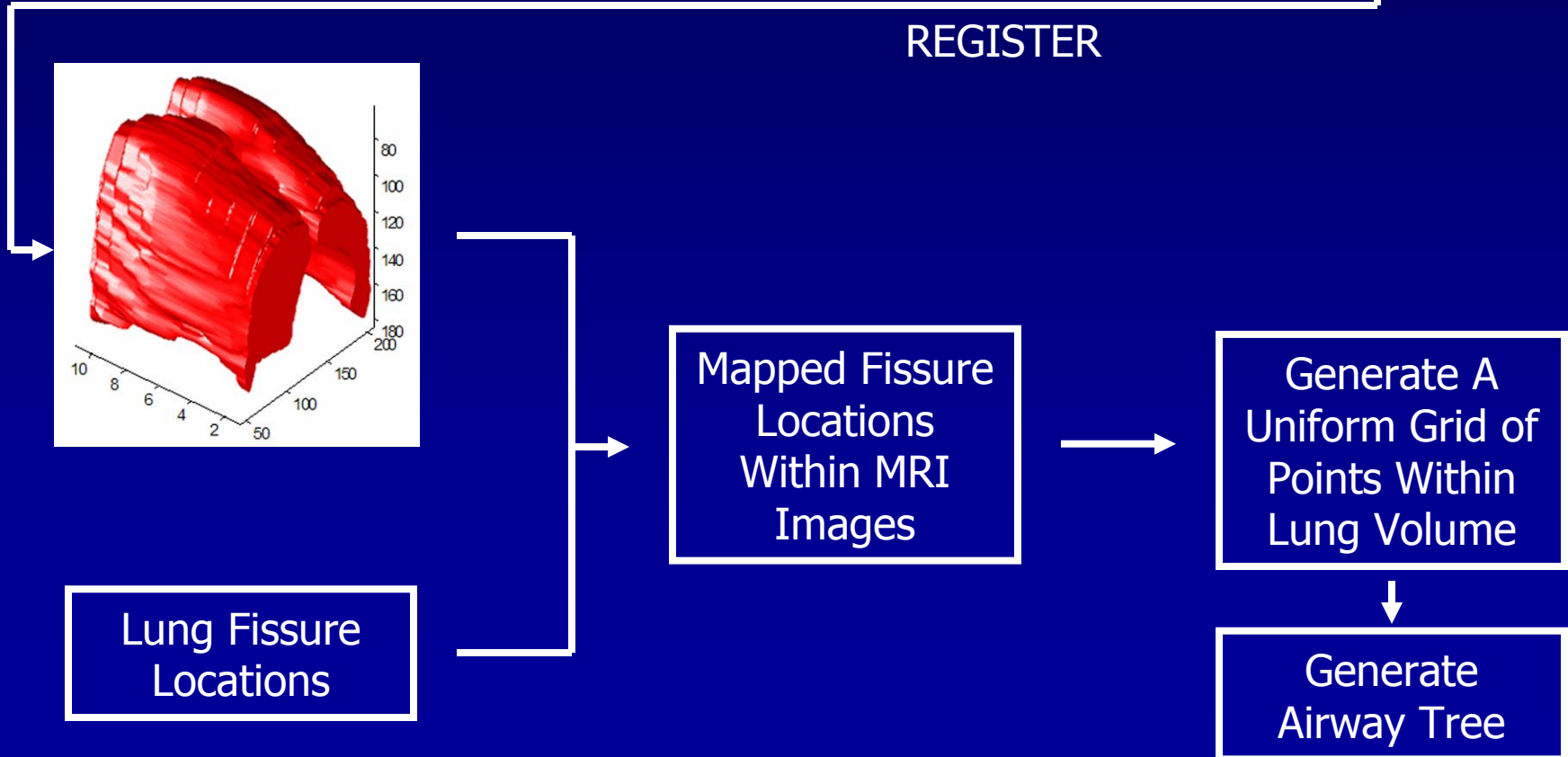


Lung Fissure Locations

Mapped Fissure Locations Within MRI Images

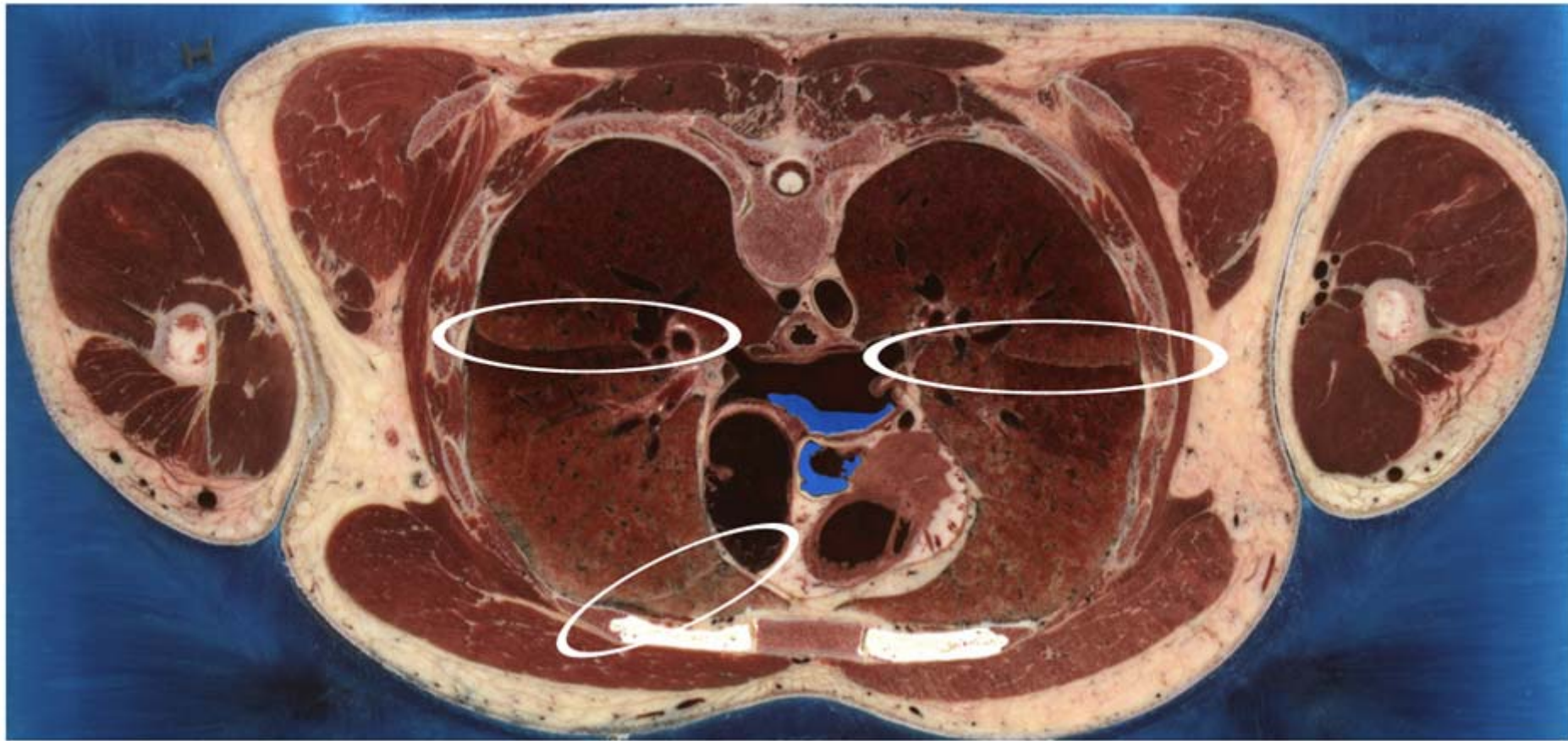
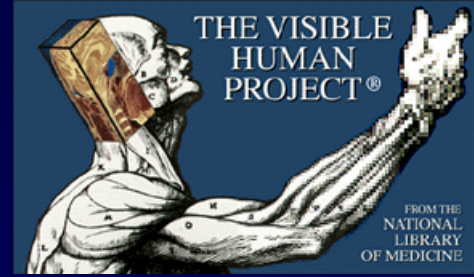
Generate A Uniform Grid of Points Within Lung Volume

Generate Airway Tree



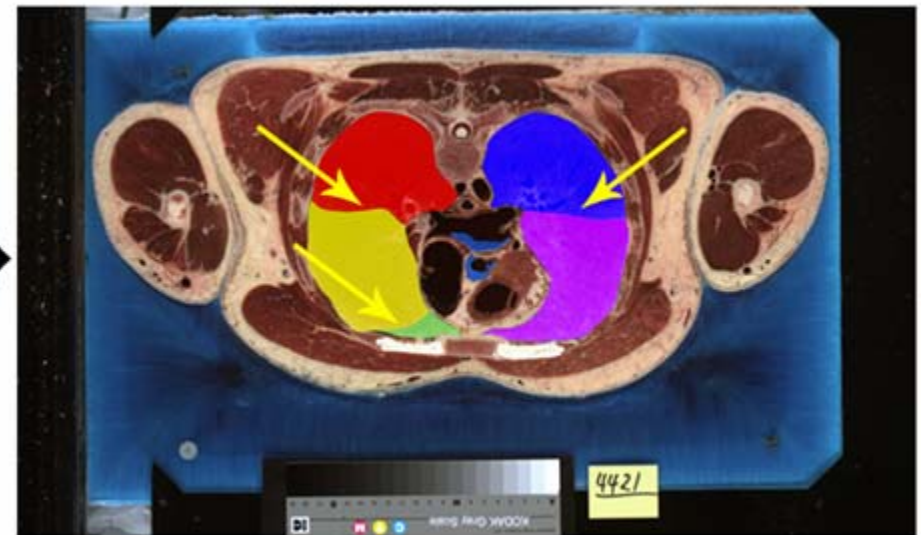
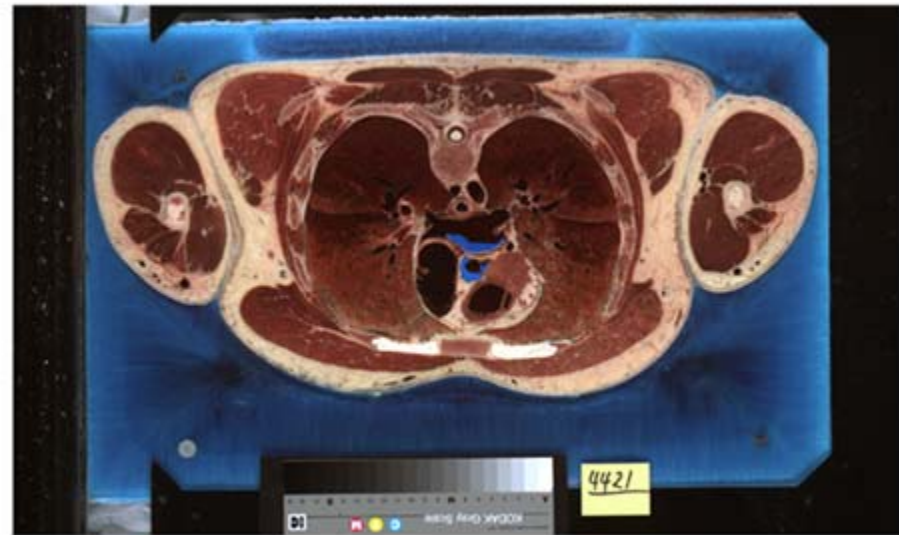
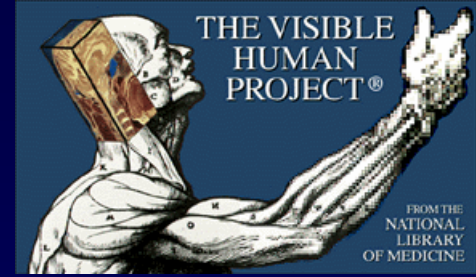


Visible Human Project: Fissure Identification





Visible Human Project: Fissure Identification





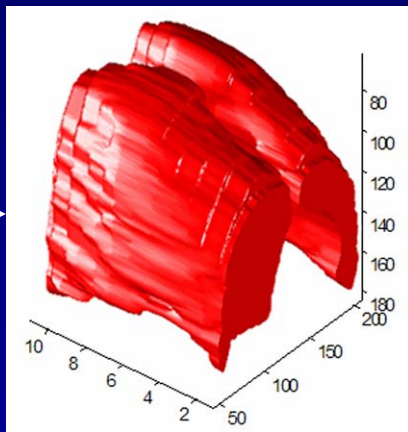
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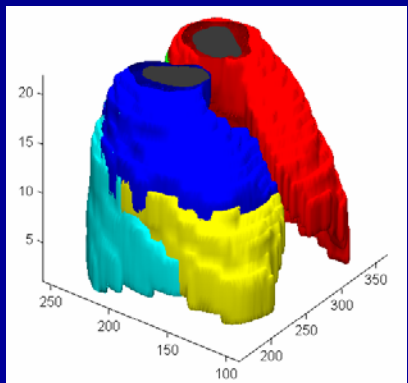
FILTER



REGISTER

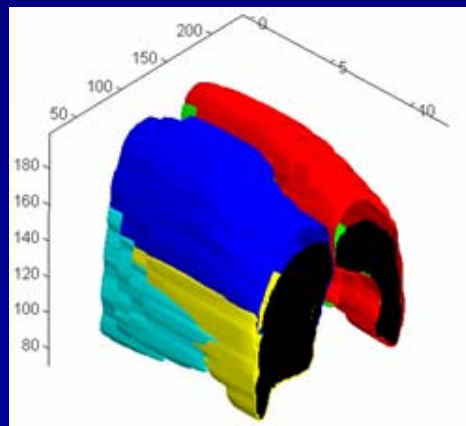


CORONAL SLICES



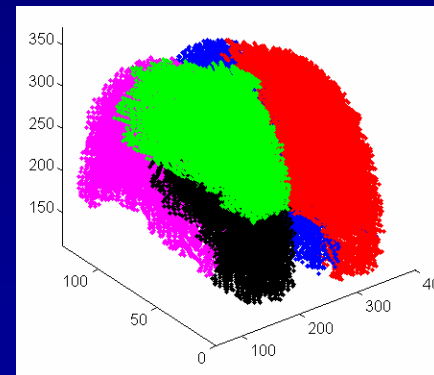
MAP*

HORIZONTAL SLICES



*Betke M., Mullally W., *et al*

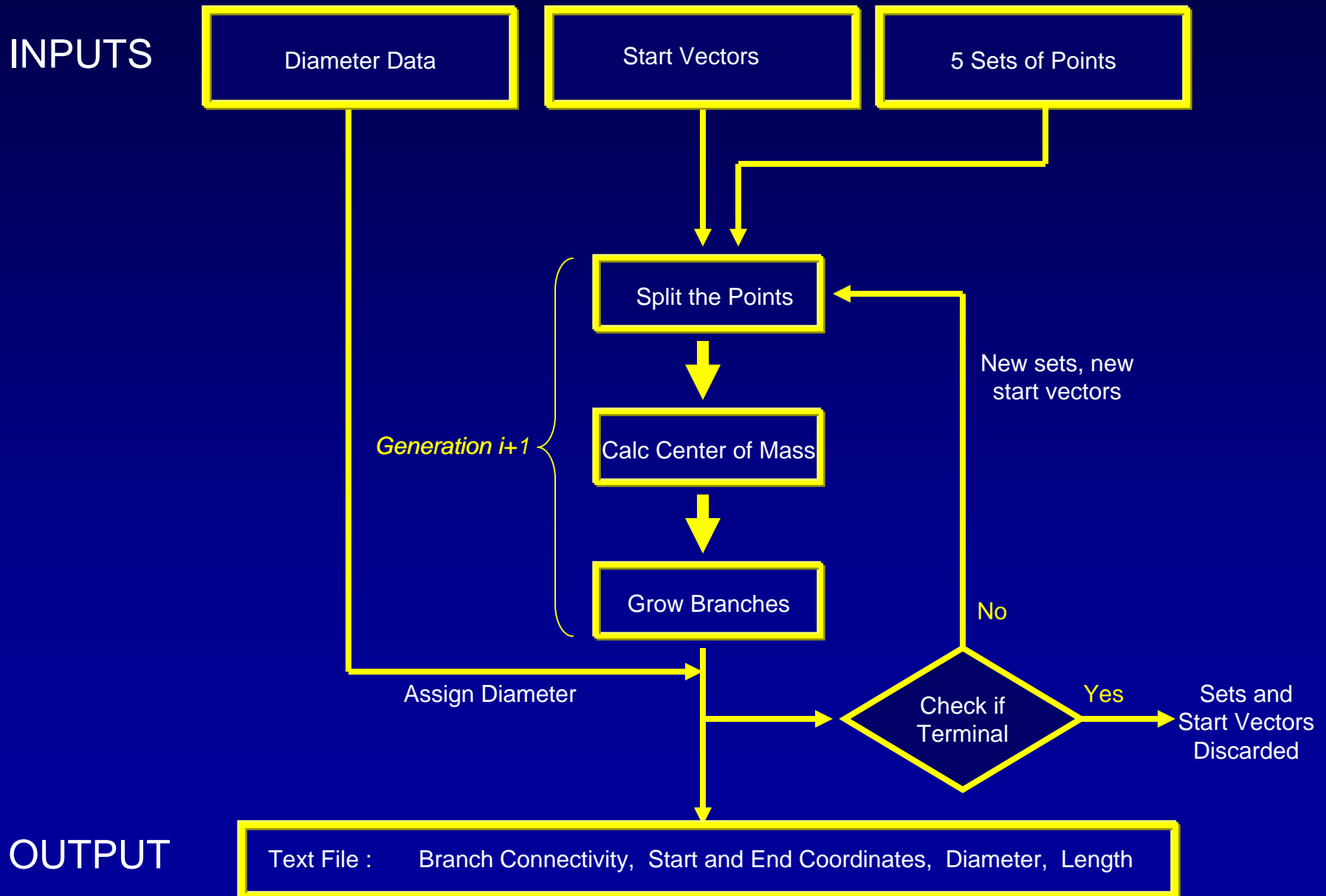
POINTS



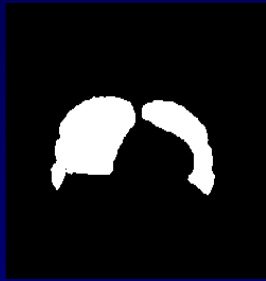
Generate
Airway Tree

VHD
Lung

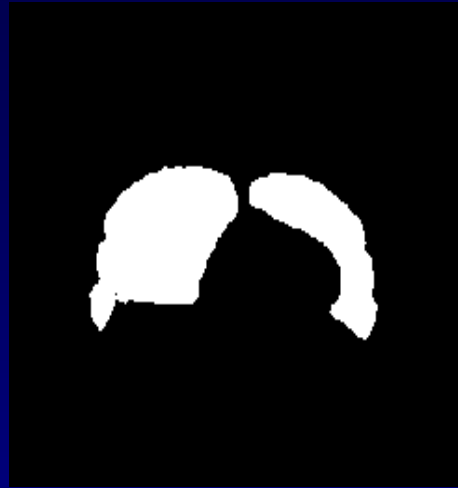
Algorithm for Generating the Model



Uniform Grid of Points

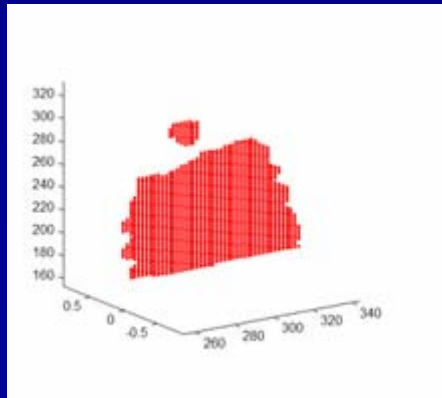


A) Scale

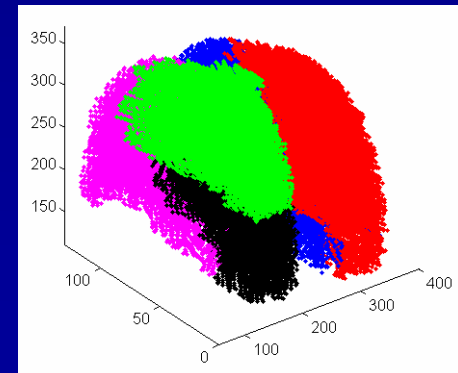


C) Repeat to fill the volume of the MRI thickness

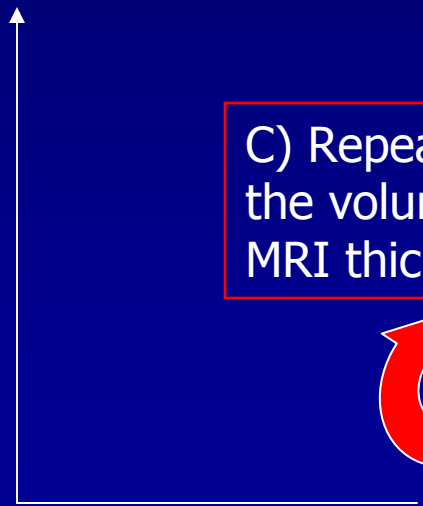
B) Generate Points



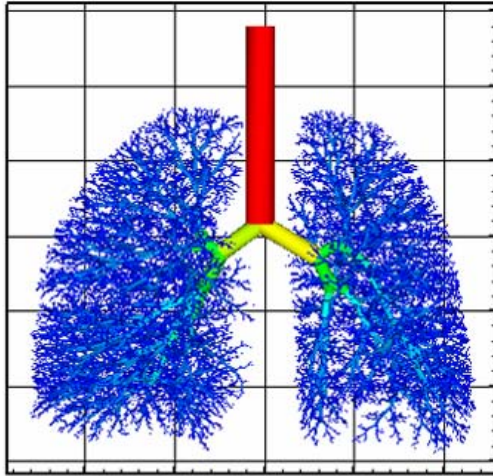
Result



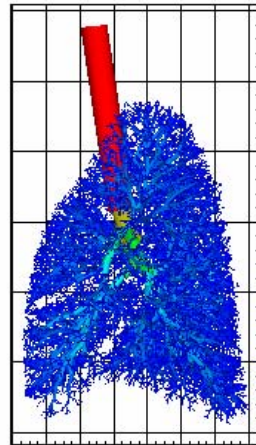
D) Move to next MRI slice, and repeat



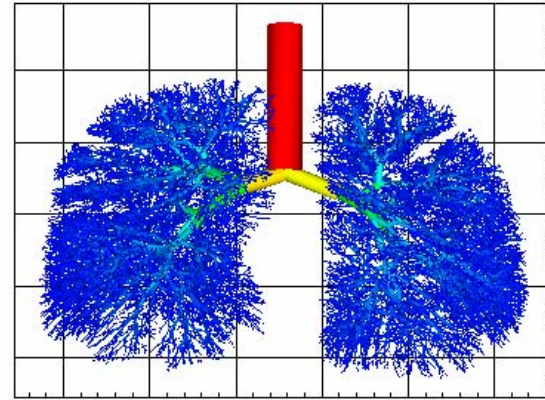
Result: Multiscale 3-D Model



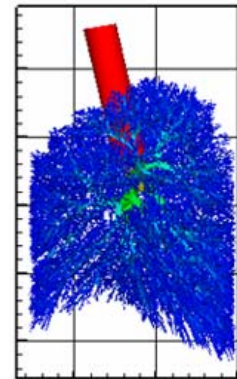
50mm



Tawhai Model



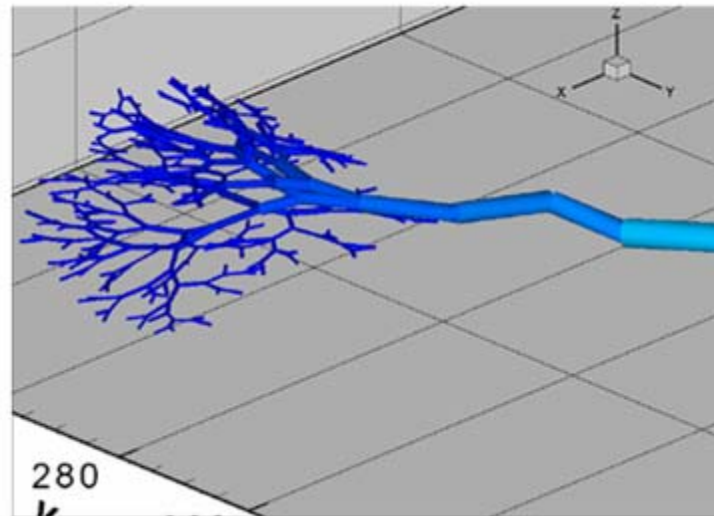
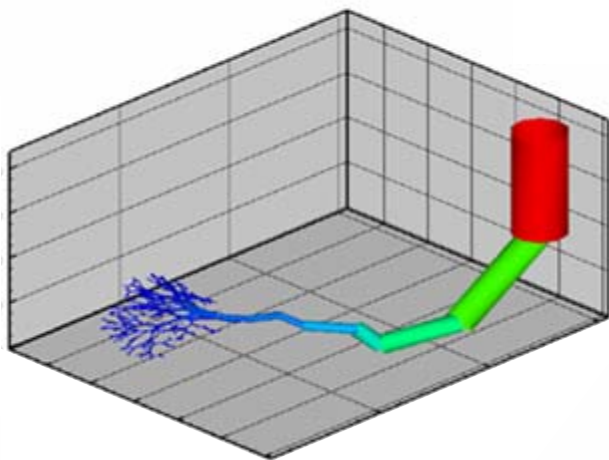
50mm



Personalized Model



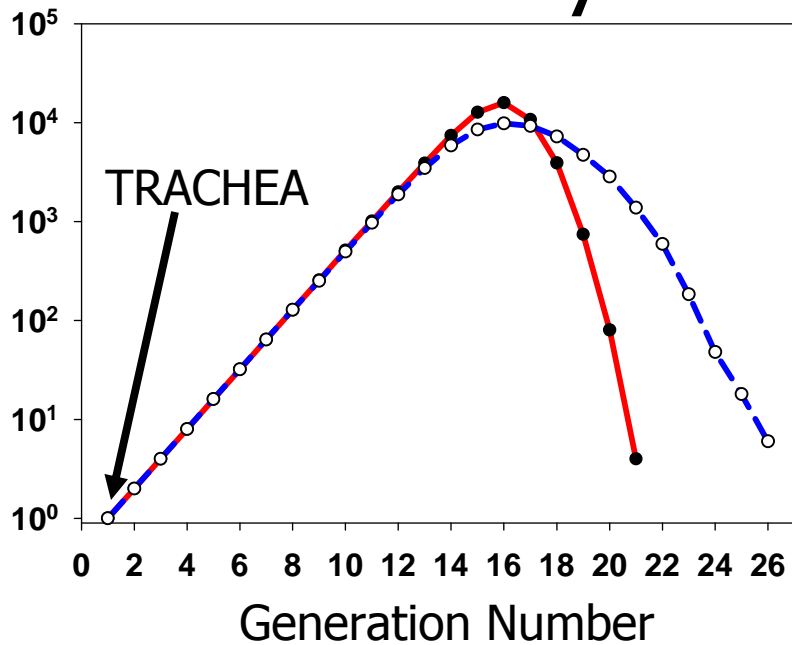
Modalities to View Airway Trees



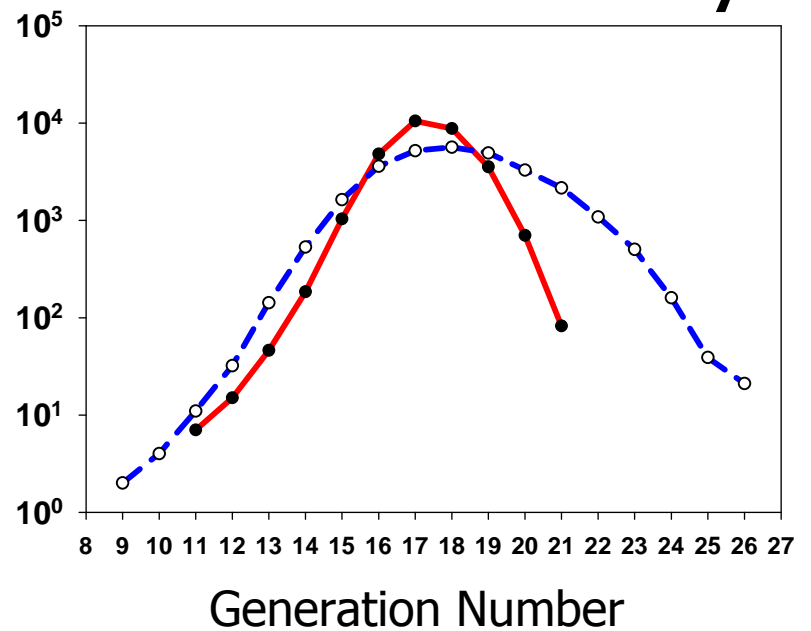
Distribution of Airways



All Airways



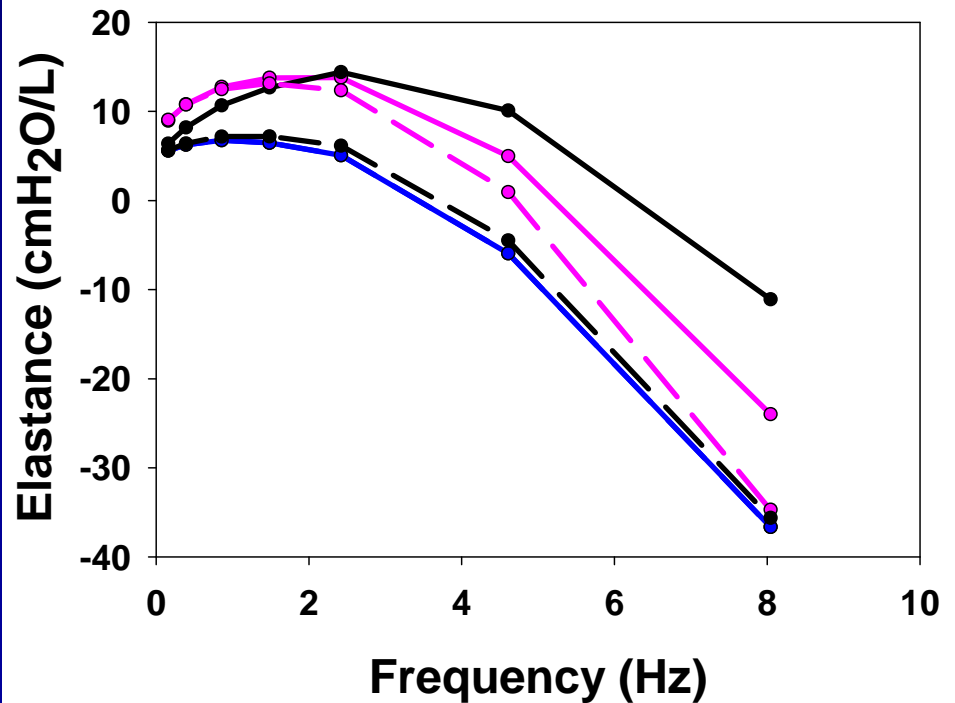
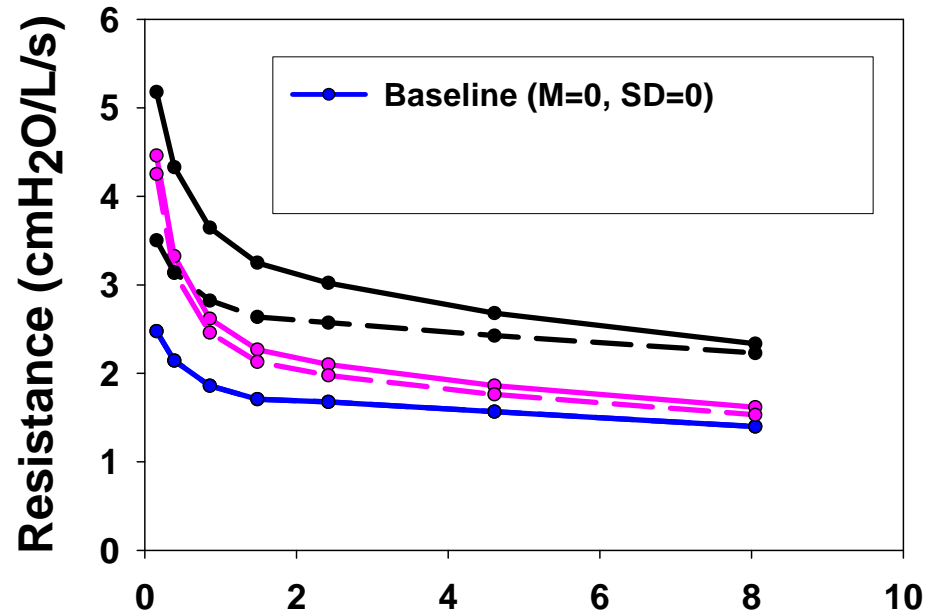
Terminal Airways





Oscillatory Mechanics

— Personalized Model
- - - Tawhai Model



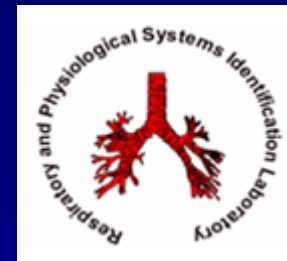


Summary and Future Directions

- We created Personalized 3D Multiscale Lung Models using Hyp. ^3He MRI images and fissure locations from the Visible Human Project
- We found that Personalized models are structurally and mechanically different from the generic Tawhai model
- Future studies should explore sensitivity of pattern matching simulations to personalized models

Acknowledgements

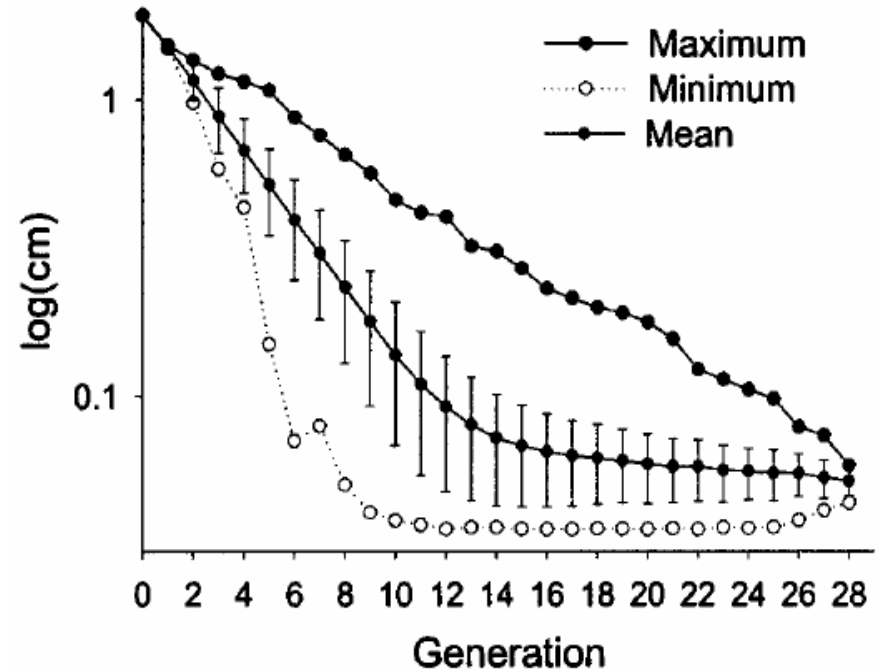
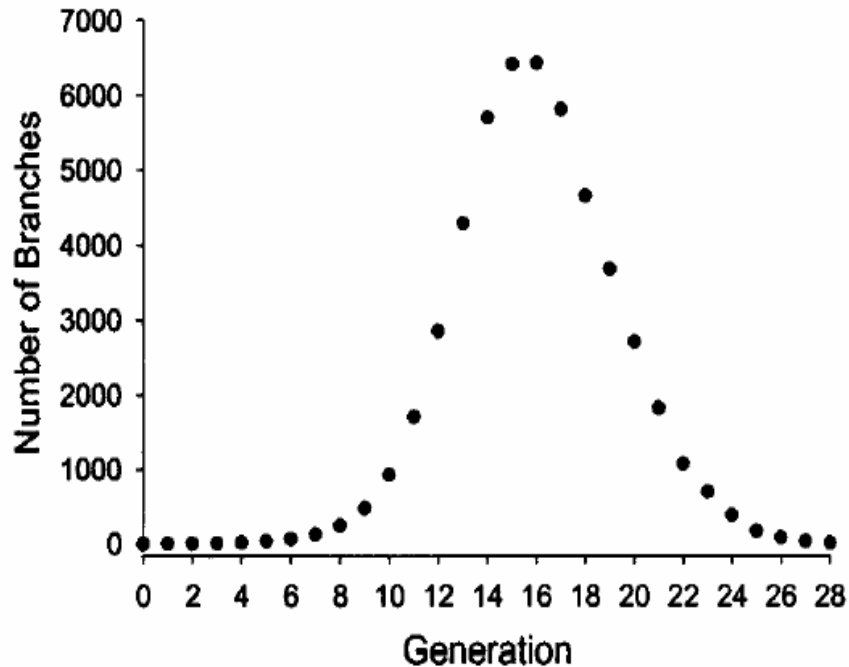
Dr. Kenneth Lutchen
Dr. Baoshun Ma
Dr. Nora Tgavalekos
Dr. Margrit Betke
William Mullally
Derek Affonce
Sanaz Zhalehdoust Sani
Jennifer Kenyon
Adam LaPrad
Heather Rasich
Lisa Campana



**Image and Video
Computing Group**

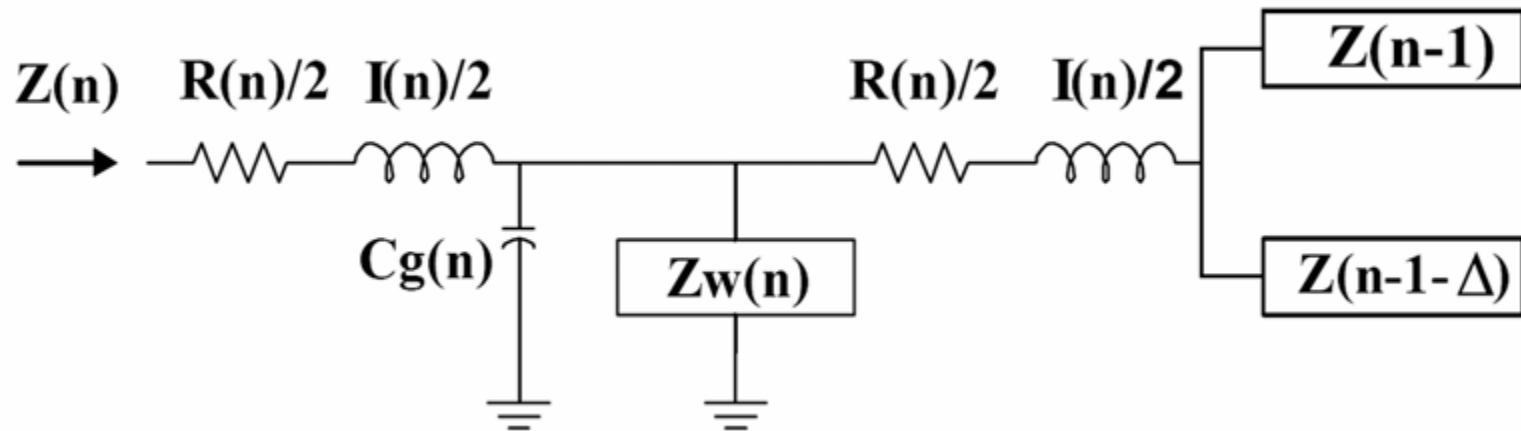


Statistical Morphometric Data on Airway Diameters



*Tgavalekos, N.T., et al., *Ann Biomed Eng*, 2003.

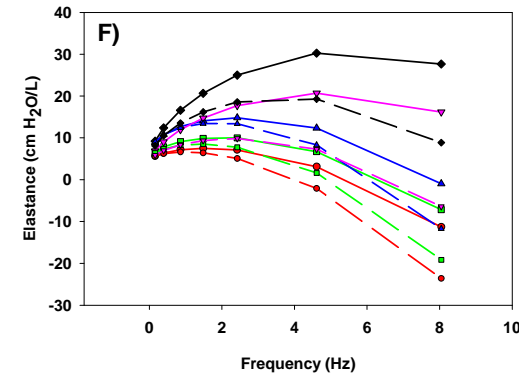
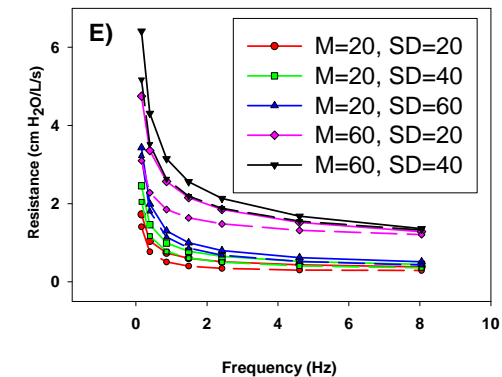
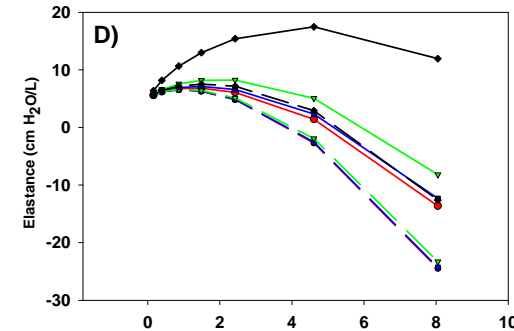
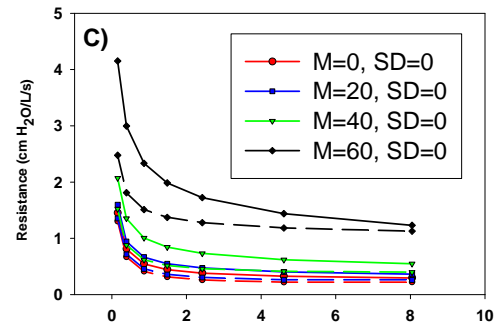
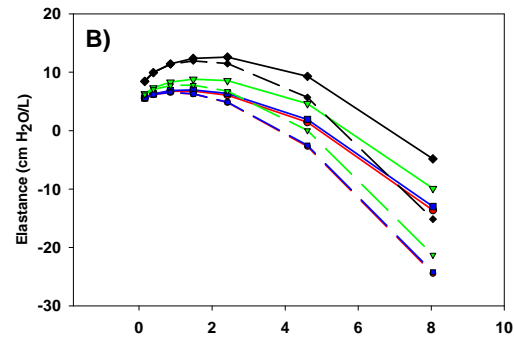
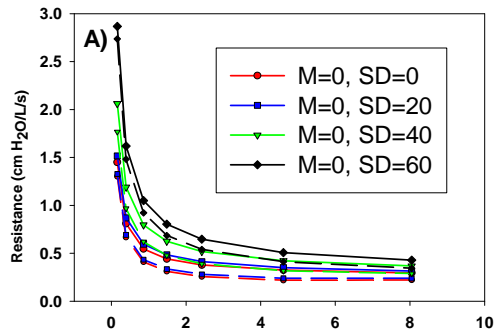
Airway Model: An RLC Circuit



$$R = \frac{8\mu l}{\pi r^4}$$

$$L = \frac{\rho l}{A}$$

Oscillatory Mechanics Simulations



Oscillatory Mechanics for Various Numbers of Airways

