The Multiscale Audible Human Project

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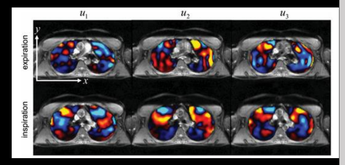
Project Background

Modeling pulmonary poroviscoelastic properties and resulting acoustic response can assist in diagnostics

Acoustic techniques potentially circumvent issues related to application of conventional imaging methods to lungs

Noninvasive Acoustic Diagnostic Tools:

- Auscultation w/ computational analysis
  - Affordable/ rapid implementation
  - Long history of use (Stethoscope)
- Dynamic Elastography - Emerging methods
  - Great potential for diagnosis/monitoring

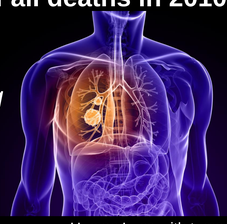


Human Lung MRE during inspiration and expiration[1]

Project Motivation

In the United States lung disease, excluding cancer, resulted in more than 234,000 or 9% of all deaths in 2010

Poor diagnostic sensitivity and specificity underlie the reason that lung cancer remains the leading cause of cancer death in the United States and the world for both men and women



Human Lung with tumor[2]

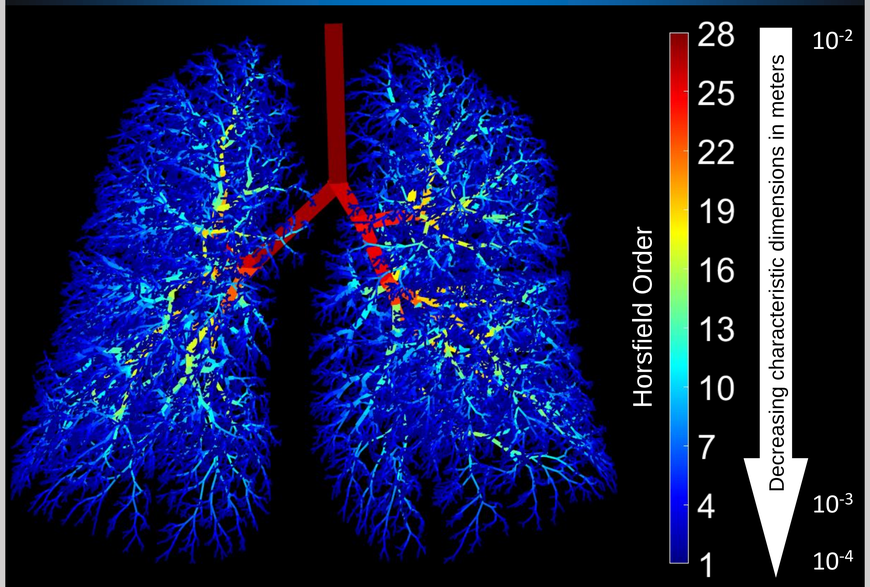
Initial diagnosis and serial monitoring of response to treatment of lung diseases would benefit from improved precision in noninvasively quantifying location and severity of mechanical changes using acoustic techniques

Project Methods

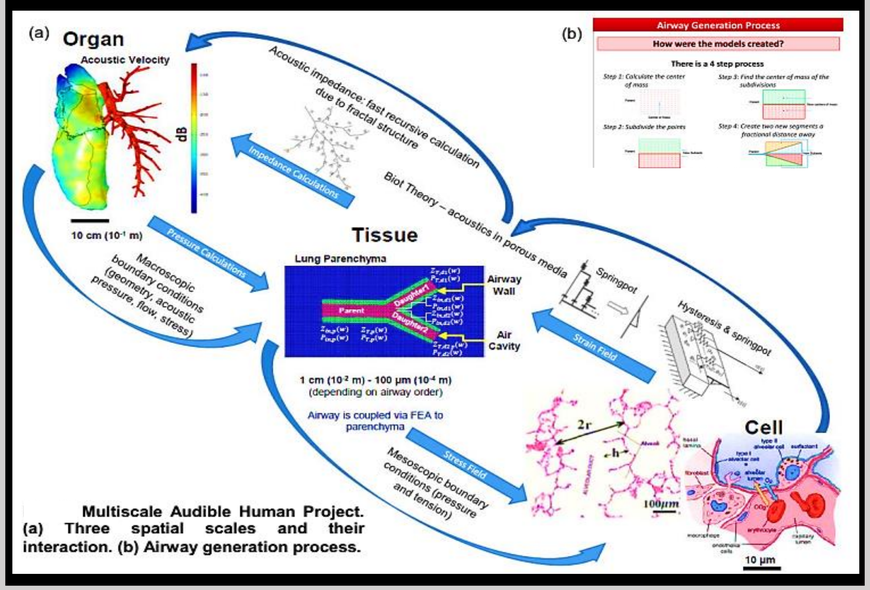
Analytical solution in MATLAB was performed via 1D branching waveguide and compared against FE simulation in COMSOL in coupled acoustic-structure multiphysics model

Airway geometry provided by C-L Lin of the University of Iowa, supported by NIH Grants R01-HL094315 and U01-HL114494

Multiscale Fractal Airway Models



Multiscale Approach

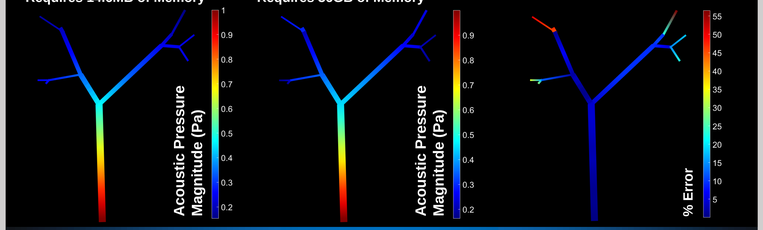


Multiscale Audible Human Project. (a) Three spatial scales and their interaction. (b) Airway generation process.

Analytical vs Numerical Validation

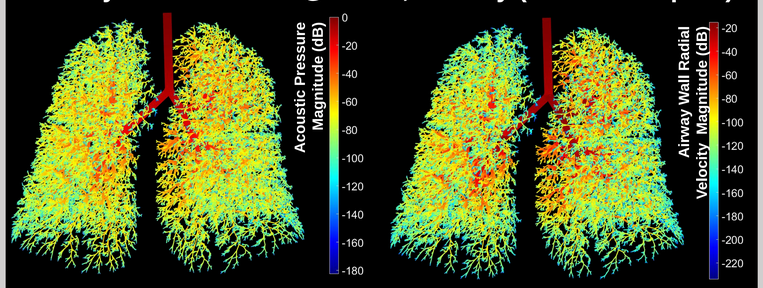
For first few bifurcations shown here. Previously validated experimentally on airway phantom.

MATLAB (0.35s) COMSOL (54m 13s) $\%error = \frac{MATLAB_{abs(p)} - COMSOL_{abs(p)}}{MATLAB_{abs(p)}} * 100$

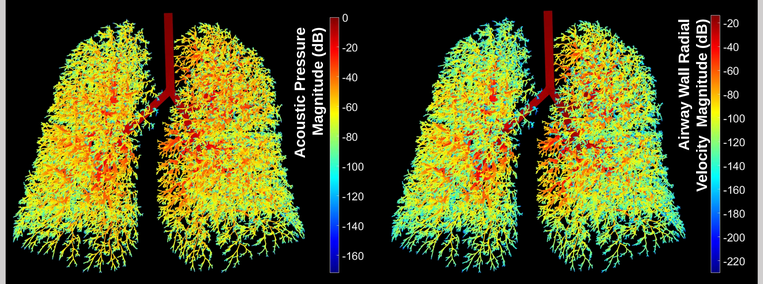


Multiscale Acoustic Maps

Airway Insonification @200Hz, Healthy (87 s to compute)



Airway Insonification @200Hz, Fibrosis (90.1s to compute)



References

Financial Support from NIH grant #EB012142

[1]Hirsch et al. (2013) Magnetic Resonance in Medicine, 69:667-674.

[2] https://www.nih.gov/news-events/nih-research-matters/noninvasive-strategies-lung-cancer-testing

Lab website QR code