Motivation

- **Cardiac Auscultation**: science and art of diagnosing heart conditions via the stethoscope
- Potent, non-invasive diagnostic modality limited by:
  - incomplete understanding between cause (effect) sound
  - human-in-the-loop
  - sequential (uni-site) measurement technique
  - high level of noise
  - large array of heart sounds
  - declining auscultatory skills
- **Vision**: Rescue this valuable diagnostic modality from obsolescence by deploying new tools and ideas from computational science, biosensing and signal processing.

Objectives

- **Goal**: Develop an approach to automated heart sound measurement and localization via a compact acoustic sensor array (the "StethoVest")
  1. Develop image-based computational hemoacoustic models (CHM).
  2. Validate CHMs and develop/test generative (model based) statistical pattern recognition algorithms for abnormal heart conditions using thoracic phantom.
  3. Investigate the physics of murmurs associated with aortic valve (AV) disease using integrative biosensing-CHM approach.
  4. Evaluate auscultome-map based screening for hypertrophic obstructive cardiomyopathy (HOCM).

Impact

- Revolutionize the management of heart disease
  - Inexpensive, non-invasive, accurate
  - Screening of wide range of heart conditions
  - 24/7 continuous, at-home health monitoring
  - Deployable in rural and underserved areas
  - Leverages teledicine, bioinformatics & wearable sensor revolution
  - Healthcare: reactive, expensive and hospital-centric
- Smart, proactive, patient-centric and cost-effective
- Advance medicine, mechanics and modeling, computing, electrical engineering, biosensing, and BIGDATA science.
- Training of undergraduates, graduate students and postdocs in a highly cross-disciplinary environment

Technical Approach

- **Team**
  - W. Reid Thompson (MD)
  - Theodore Abraham (MD)
  - Rajat Mittal (PhD)
  - Andreas Andreou (PhD)

  - **Cardiologists** Clinical studies and measurements
  - **Mechanical Engineering** Computational & experimental modeling and analysis
  - **Electrical Engineering** Sensors, signal processing and pattern classification

High-Fidelity Hemoacoustic Modeling and Simulation

- Biophysics of auscultation involves:
  - flow perturbation
  - propagation of acoustic wave through thorax (lung, bone, muscle, fat)
  - sensing by stethoscope
  - Integrated multiphysics analysis required to understand the physical basis of auscultation

Sound Measurement, Localization and Pattern Classification

- **Biased Gaussian Source Localization using Gradient Flow [GT]**
- **Sensor characterization**

Current Progress

- **Aortic Stenosis Murmur**
  - **Aortic Valve Stenosis**
  - **Flow simulation**
  - Generation 1 model for the thoracic phantom
  - Monitored surface vibrations

References & Misc. Information


Other Collaborators:
Purdue, Luc Mongeau (WAGS University), Albert C. Lardo (BME, JHU), Richard George (Cardiology, JHU).

Undergrad Students: Thomas Klimar, Alexander Lalioun, Ronann Carrero

Project homepage: http://engineering.jhu.edu/lq/tal Projekt/homepage/