Goals

- Improve diagnosis and screening in cardiac disease from non-invasive electrical measurements and Cardiac Electrical Imaging (CEI)
- Connect to CenSSIS Electrical Impedance Tomography group at RPI to provide new methodologies for complete, relatively cheap, cardiac electrical imaging systems
- Collaborate with NIH/NCRR Center at University of Utah on software for Cardiac Electrical Imaging
- Develop efficient, robust, distributed optimization algorithms for inverse solutions, specialized to application

Significance

- Body surface electrocardiograms provide very limited information; more useful would be signals at the heart surface by solving inverse problem
- Diagnosis and screening of cardiac disease still surprisingly inaccurate or expensive and risky. Success of treatment depends on accuracy of diagnosis. CEI could provide cheap, fast, much more accurate tools.
- Development of algorithms for CEI can be applied across application areas, eg to Diffuse Optical Tomography.

Technical Approach

- GOAL: Estimate heart surface electrical activity from body surface measurements and assumed geometry and conductivity map.
- COMPONENTS:
  - Source Model
  - Geometric/Conductivity Model Forward Solution
  - Inverse Algorithm
- CHALLENGE: Inverse Problem Ill-Posed Needs a priori constraints
- OUR APPROACH: USE MULTIPLE CONSTRAINTS
  - No constraint sufficient or even optimal
  - Traditional constraints: 2 norm of solution or spatial derivatives
  - Other constraints
    - Temporal Constraints
    - Max norm constraints
    - 1 norm of gradient constraints
    - Frequency domain constraints
- ADMISSIBLE SOLUTION APPROACH
Ellipsoid Algorithm

Relation to ERC
- Robust Inverse Algorithms: typical subsurface requirements or robustness to model error and measurement noise
- Computationally Efficient Implementations: Use of CenSSISS Biomedical Distributed Computational Platform
- Electrical Impedance Tomography (EIT): proposed joint research effort
  - Output of EIT is conductivity map
  - Input of CEI is conductivity map
  - Current efforts require expensive imaging and time-consuming segmentation
  - Research problems are both experimental and algorithmic
    - Experimental: electrode design, etc., See EIT poster
    - Algorithmic: how to include uncertainties of EIT conductivities into CEI to improve robustness and accuracy

Other Connections
- Long-established collaboration with Cardiovascular Research and Training Institute, University of Utah
  - Sharing of expertise, algorithms, data
  - Provides key expertise to investigate EIT + CEI systems
- PI is investigator in new NIH-Funded NCRR Center for Bioelectric Field Simulation, Visualization, and Modeling at University of Utah (http://www.sci.utah.edu/ncrr)
  - Useful connections for application into new fields, software development, computational imaging

Current Status
- On-going collaboration with CVRTI and NCRR Center, includes funding at NU from NIH/NCRR Center grant
- Work includes algorithm development and software development to integrate algorithms into NCRR Problem Solving Environment, BioPSE

Plans and Project Evolution
- In Year 1:
  - Continue development and expansion of current optimization approach and distributed system implementation
  - Pursue joint effort with RPI EIT group and Utah CVRTI/NCRR group
- By Year 3:
  - Full integration of CenSISS supported CEI algorithms into Utah BioPSE software
  - Working experimental system for combined EIT/CEI testing
- Long-Term Vision: relatively cheap and portable, accurate, robust cardiac diagnostic and screening tool

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