Technical Developments to Enable Electrical Impedance Tomography (EIT) Measurement of Blood Flow to Monitor Cardiac Output Key Engineering Contributions

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Helga Ross
Systems and Computer Engineering,
Carleton University, Ottawa, ON

Outline

- Introduction
- Problem
- Contributions
- Results
- Conclusion
- Future Work

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Introduction

- Heart Disease: "is a group of conditions affecting the structure and functions of the heart."
- Examples:
  - Angina
  - Arrythmia
  - Atrial fibrillation
  - Coronary Artery Disease (CAD)
  - Etc.

Introduction (2)

- CAD
  - Most common form of heart disease
  - Occurs when arteries in the heart are blocked
  - Complications include
    - Angina (chest pain) due to lack of oxygen to the heart
    - Heart Attack due to part heart muscle death from lack of oxygen

Introduction (3)

- Gold Standard for Diagnosis of CAD
  - Angiography
    - Catheter inserted (groin or arm)
    - Guided through artery to a position near the heart
    - Contrast agent is administered through catheter
    - X-rays are taken in conjunction with release of contrast agent
  - Cardiac CT
    - Intravenous pump hookup
    - Contrast agent administered
    - X-ray images are taken in conjunction with the release of contrast agent

Introduction (4)

- EIT
  - Experimental imaging technique where changes inside the body can be imaged using a set of electrodes on the surface
  - Advantages: Portable, non-ionizing, high acquisition rates, relatively inexpensive
  - Disadvantages: Low resolution, high sensitivity to electrode movement, imaging anomalies are not well understood, use of ill conditioned problem to calculate images

Problem

- The goal of this thesis is to develop a collection of Electrical Impedance Tomography (EIT) techniques to allow for monitoring of cardiac output and other parameters of heart function

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Contributions

- EIT Protocol
- Hardware Toolset
- Software Toolset

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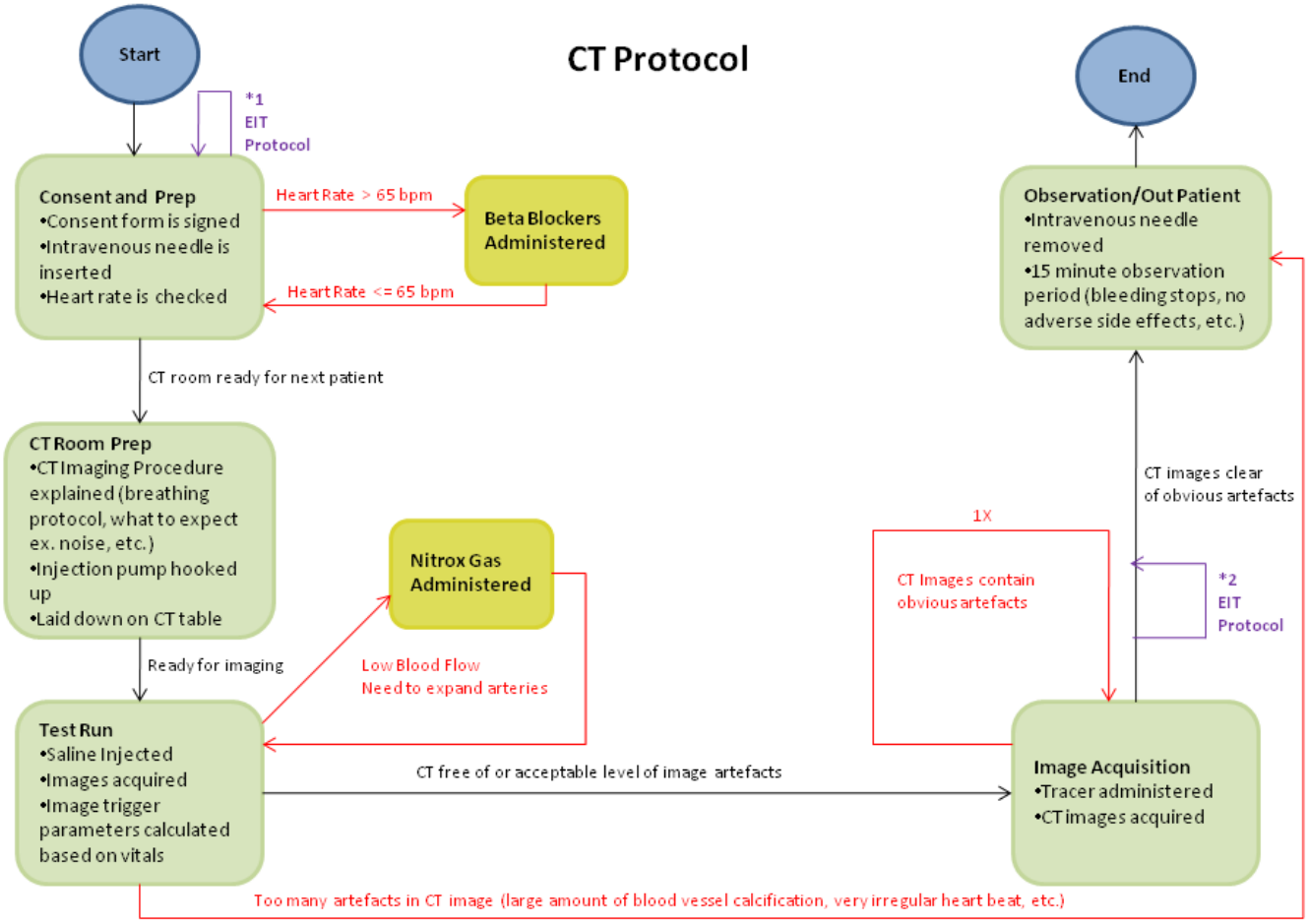
Contributions (CT Protocol)



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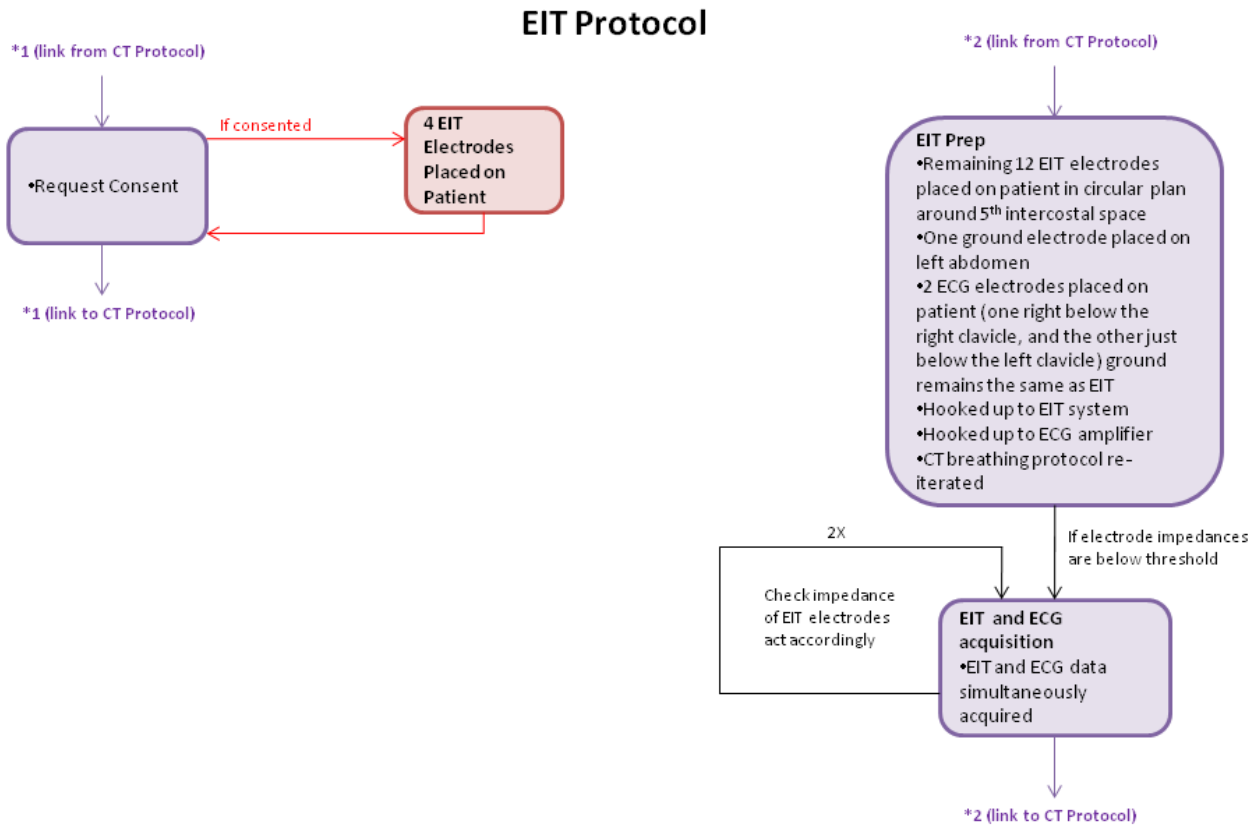
Contributions (EIT Protocol)



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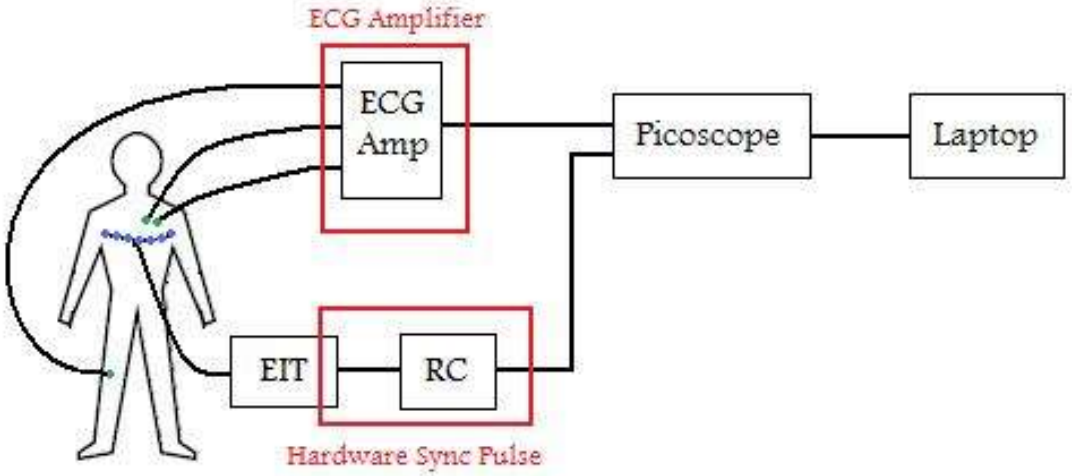
Contributions (Hardware Toolset)



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Contributions (Hardware Toolset) (2)

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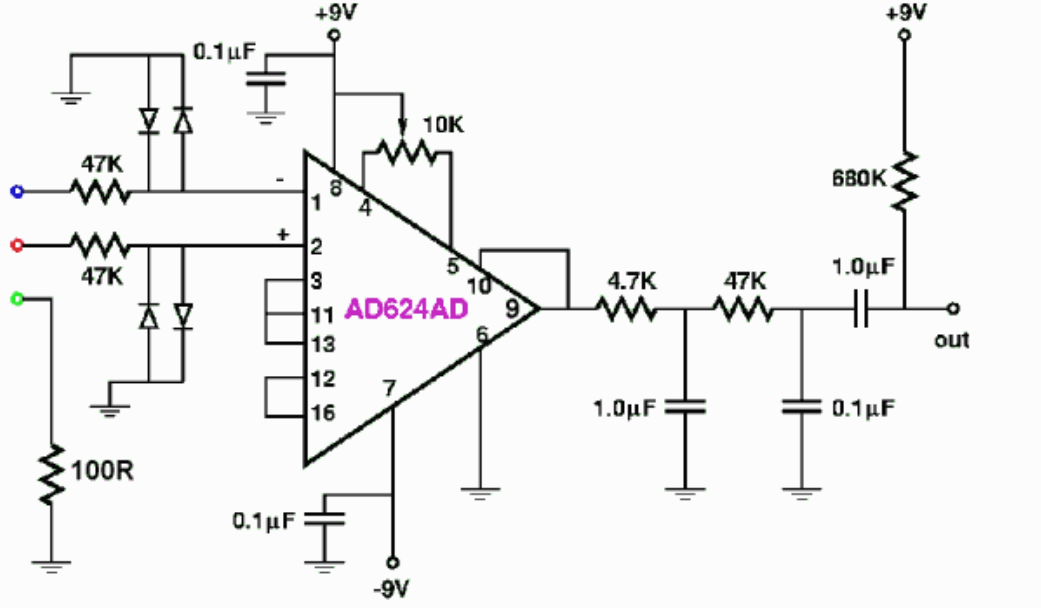
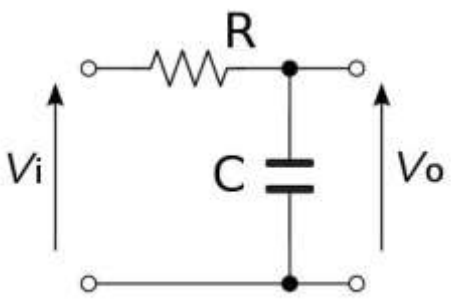
Contributions (Hardware Toolset) (3)





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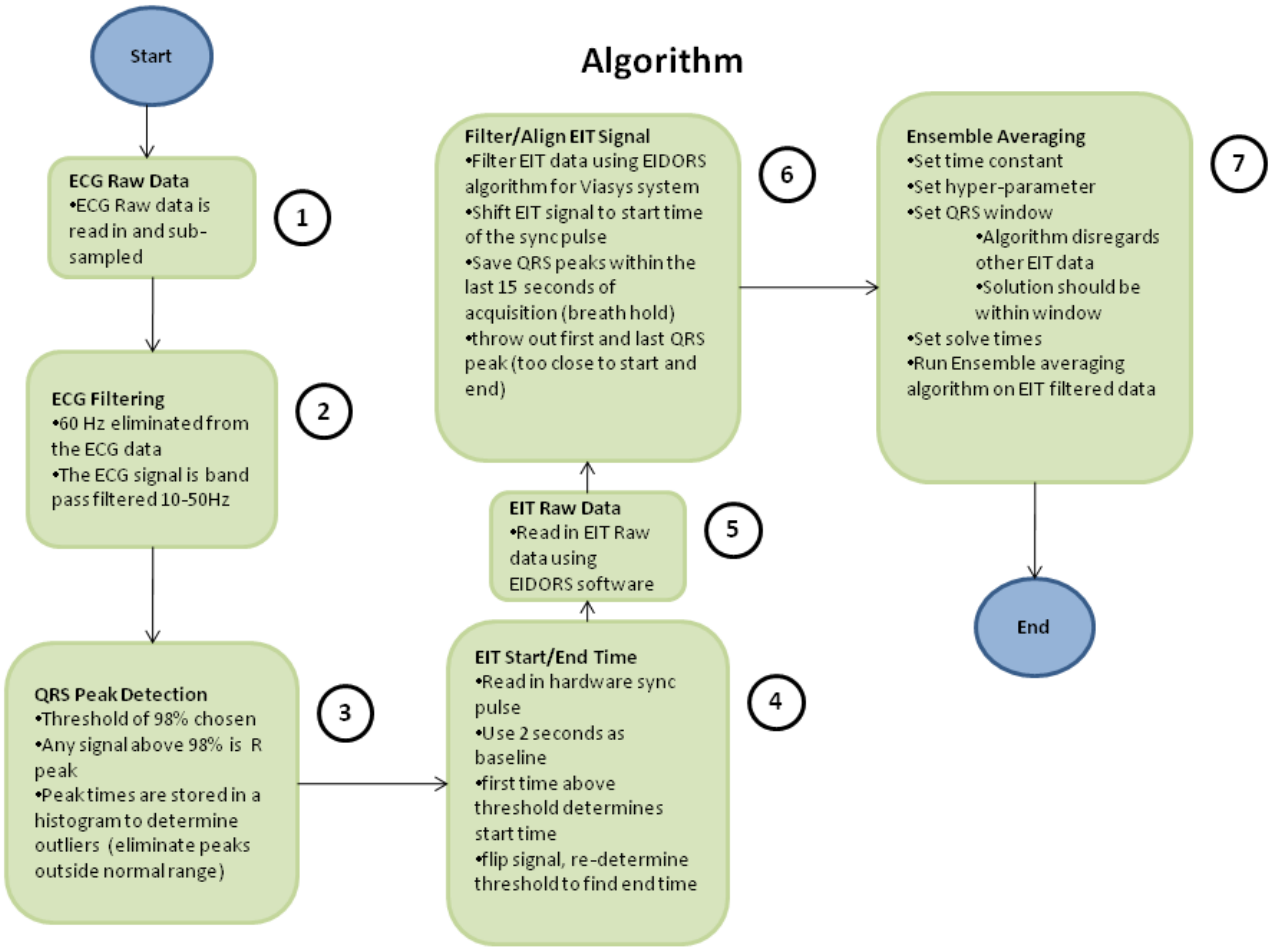
Contributions (Software Toolset)



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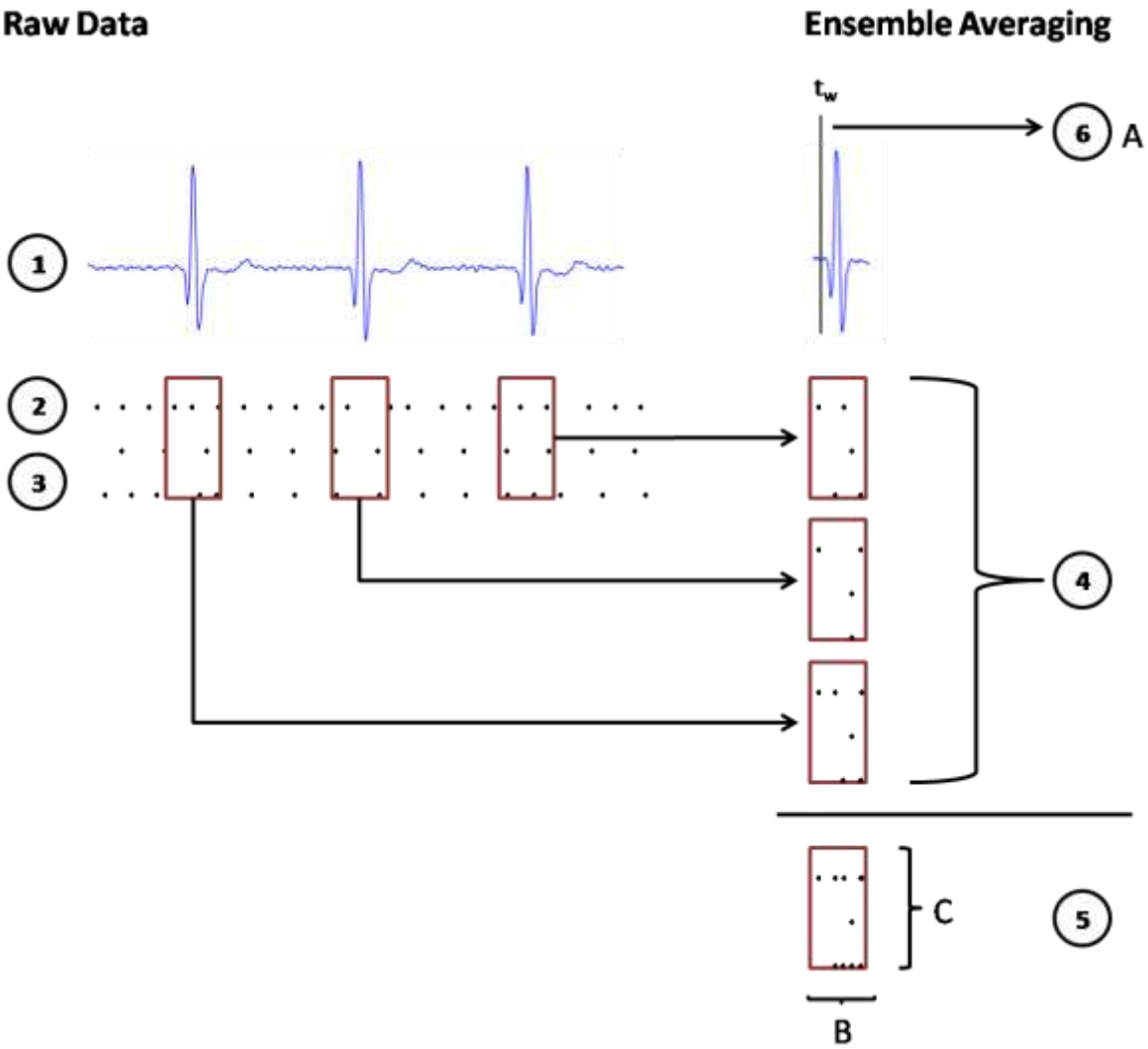
Contributions (Software Toolset) (2)



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Contributions (Software Toolset) (3)

$$x_{0,est} = \underbrace{\left[\Sigma_{\tilde{x}}\tilde{J}^t\right]_{top}}_{A}\underbrace{\left(\tilde{J}\Sigma_{\tilde{x}}\tilde{J}^t + \Sigma_{\tilde{n}}\right)^{-1}}_{B}\underbrace{\tilde{y}}_{C}$$

$$\begin{bmatrix} M \\ by \\ 1 \end{bmatrix} = \underbrace{\begin{bmatrix} M & by & N \end{bmatrix}}_{A}\underbrace{\begin{bmatrix} N & by & N \\ & & \\ & & \end{bmatrix}}_{B}\underbrace{\begin{bmatrix} 1 \\ by \\ N \end{bmatrix}}_{C}$$

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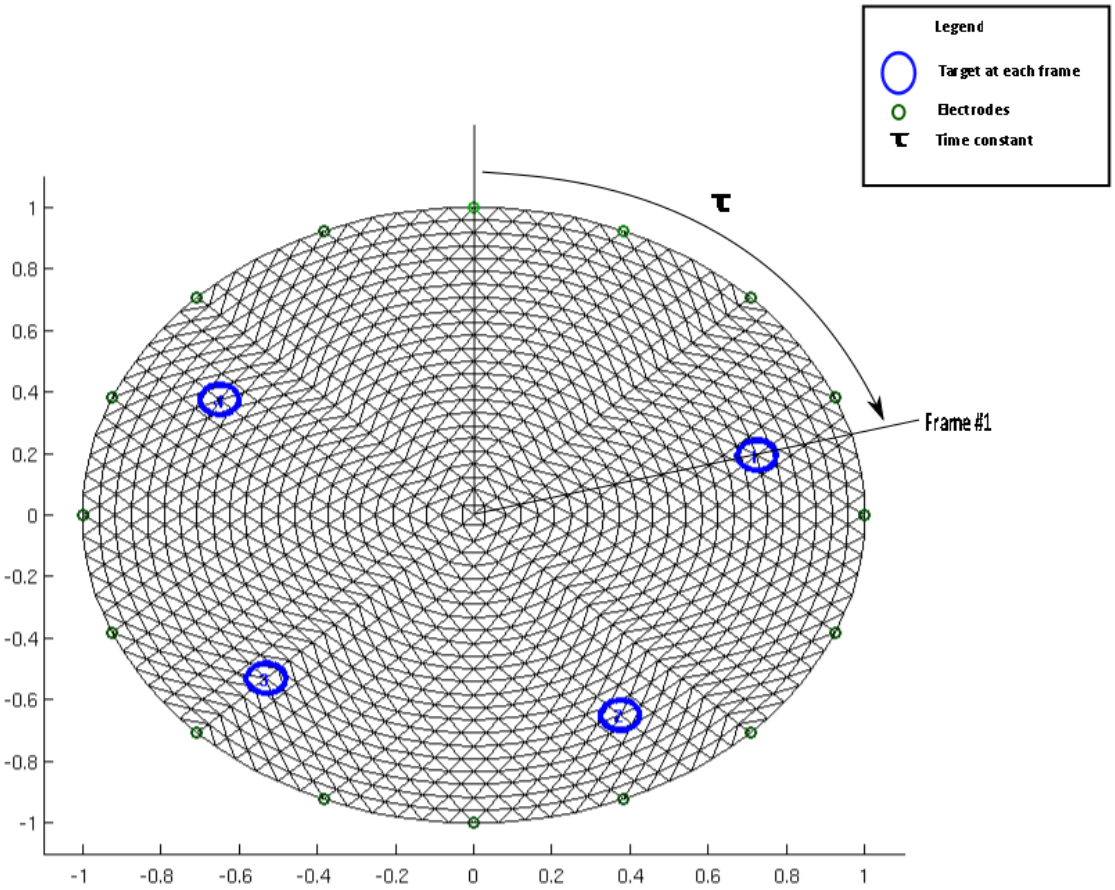
Results (Simulation)



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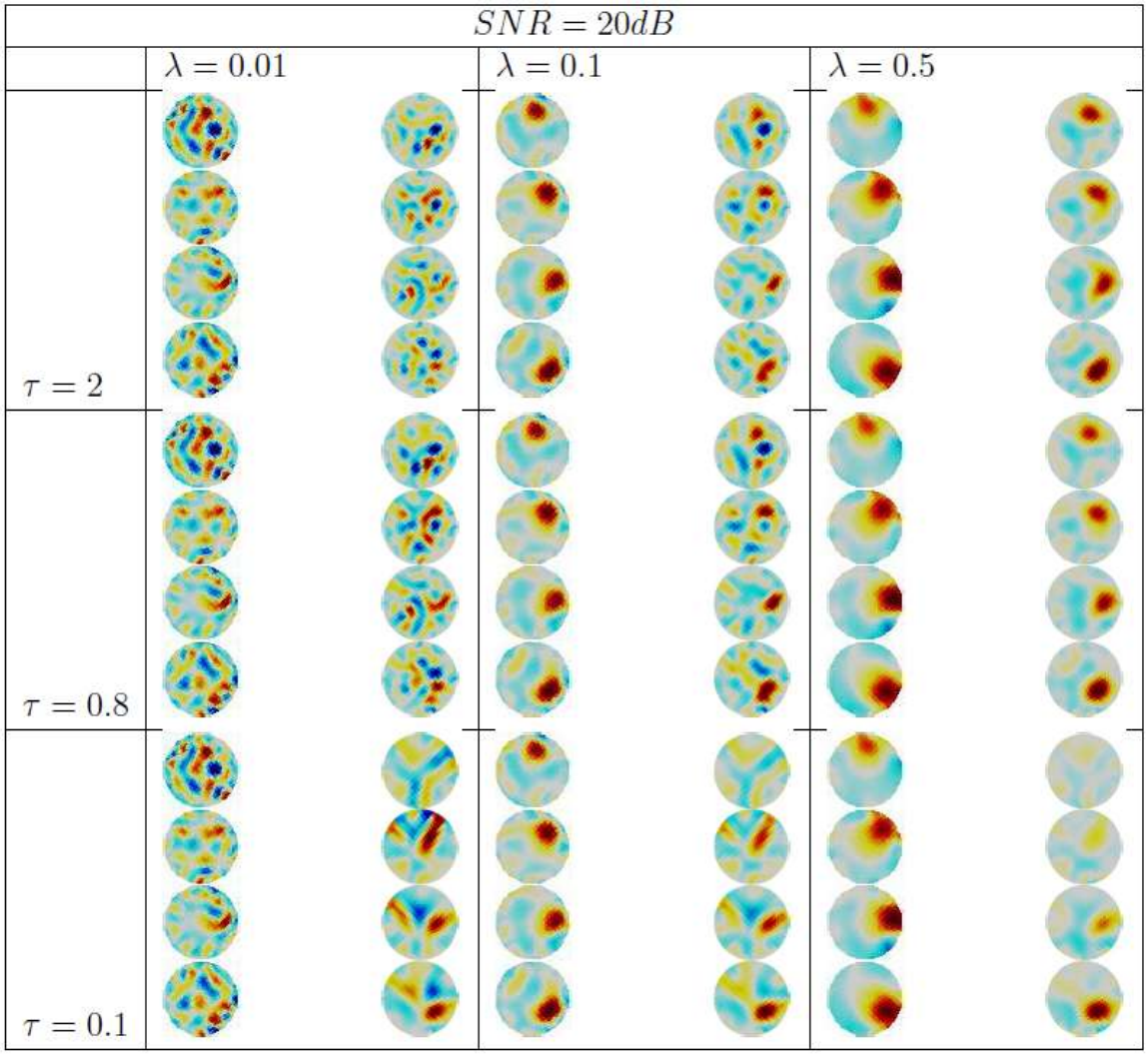
Results (Simulation) (2)



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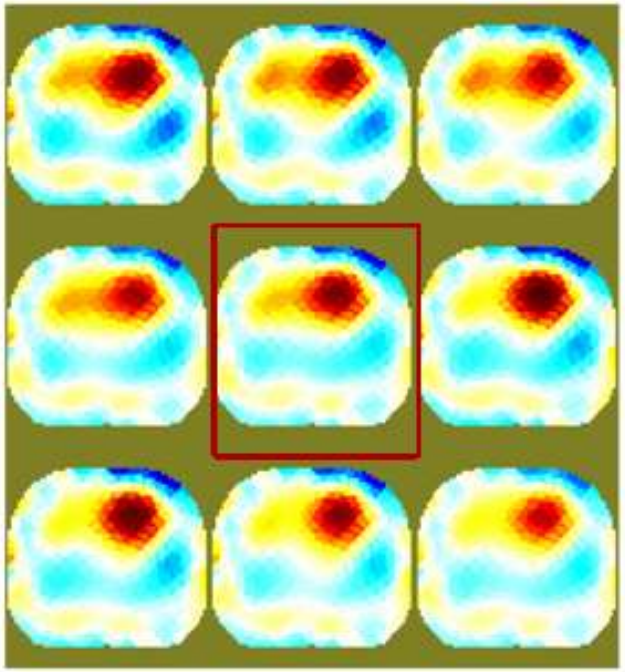
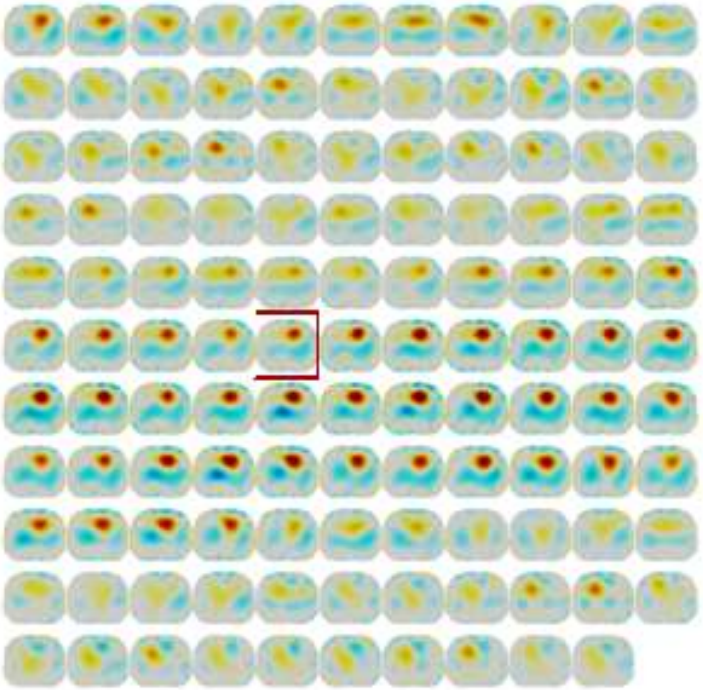
Results (Human Experiment)

- **Subject #1**





Conclusion

- Goal of this thesis was to design a toolset to enable the measurement of EIT cardiac parameters
- The results are promising
- A colleague is taking over this work

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Future Work

- Compare EIT and CT Blood flow
- Test toolset on patients at UOHI
- Tweak EIT and Software Protocol as needed
- Include other EIT methods to improve cardiac EIT imaging
- Try several EIT systems
- Increase number of patients imaged with final hardware/software toolset

Thank You

- Questions

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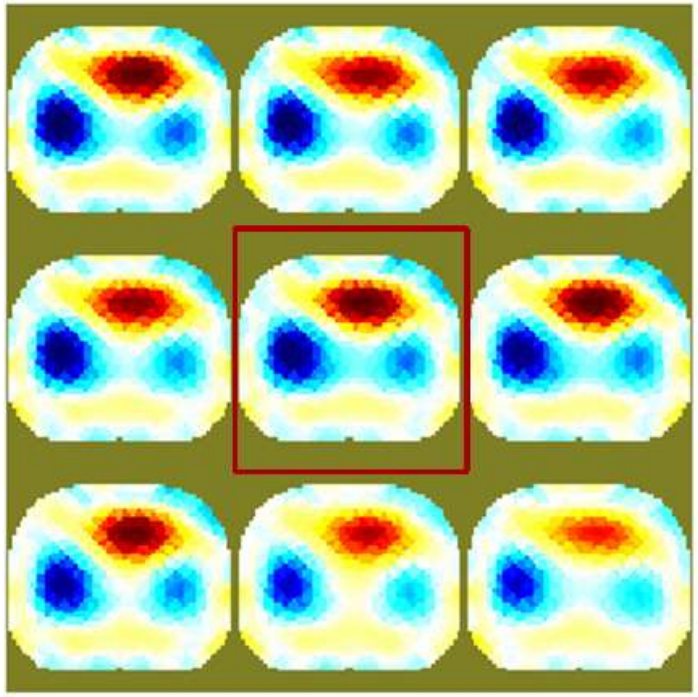
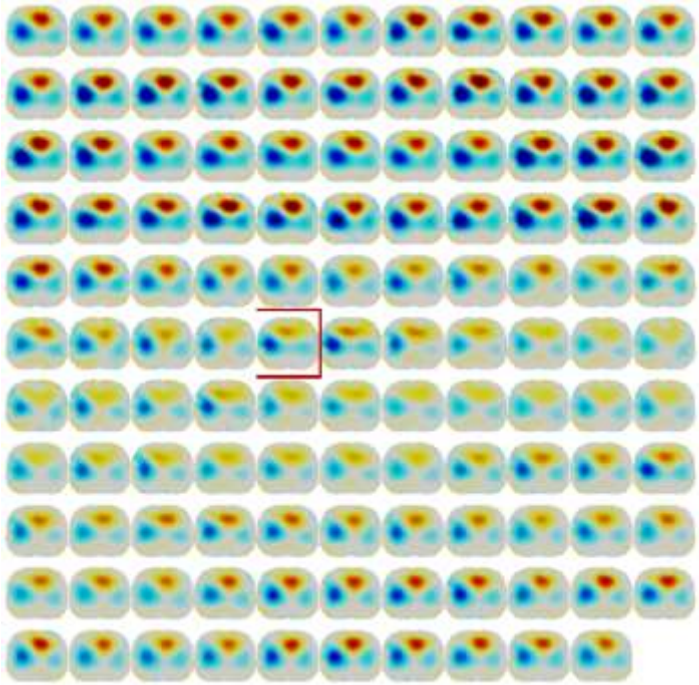
Results (Human Experiment) (2)

- **Subject #2**





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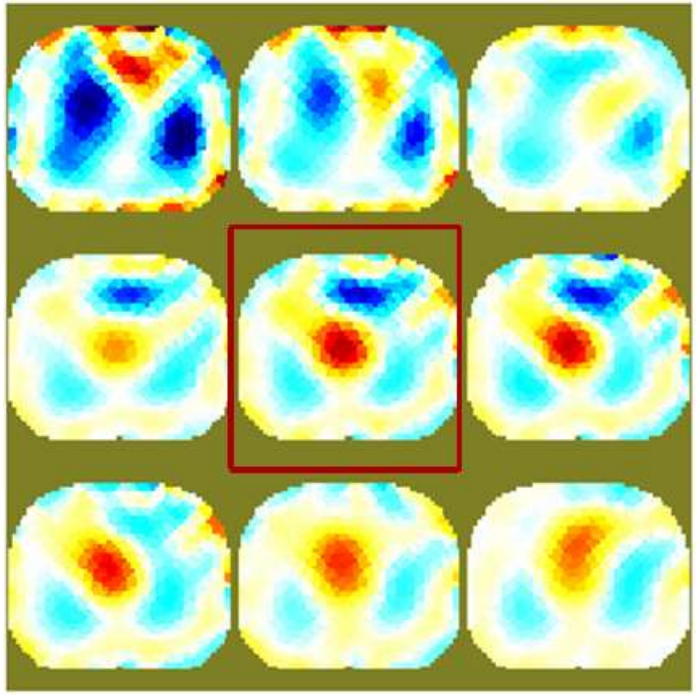
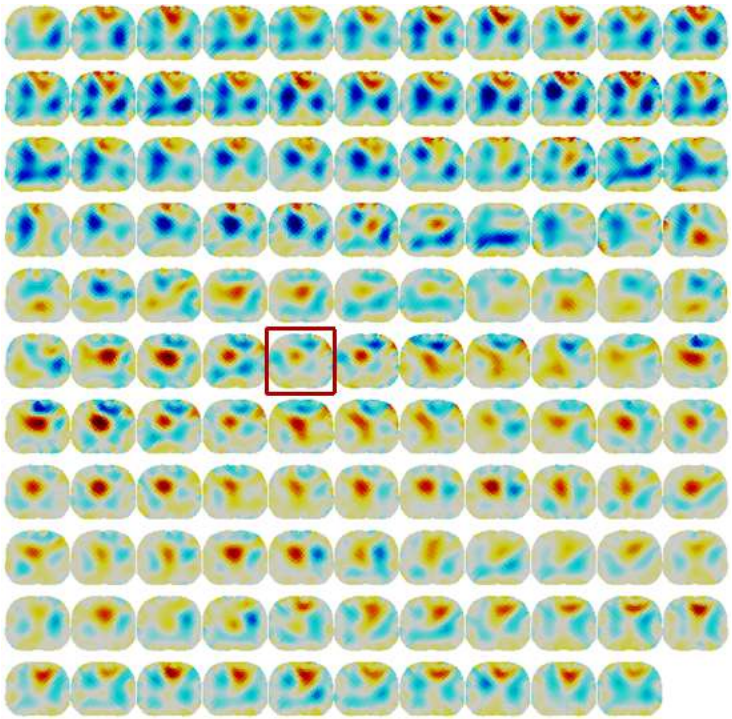
Results (Human Experiment) (3)

- **Subject #3**





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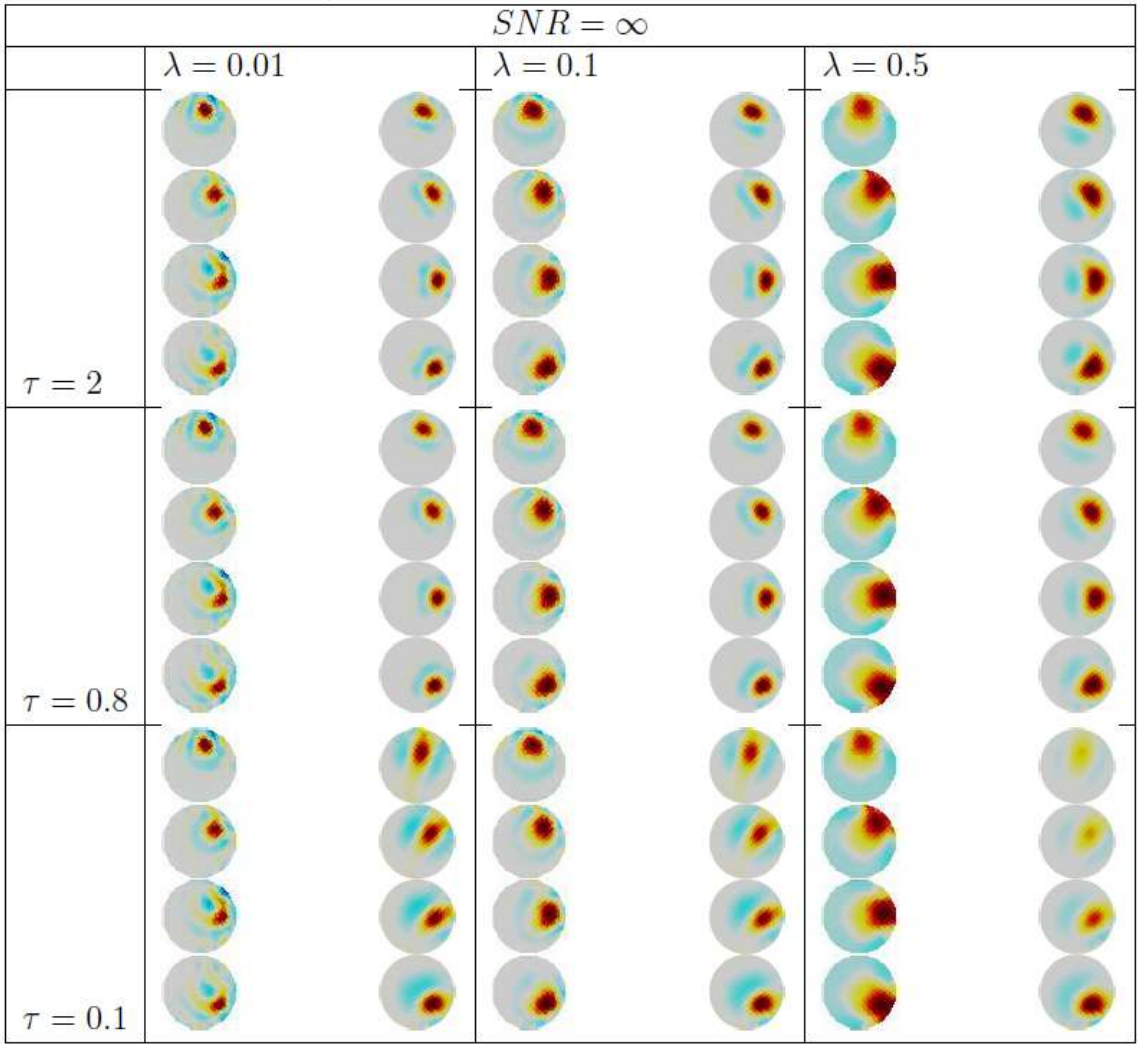
Results (Simulation) (2)



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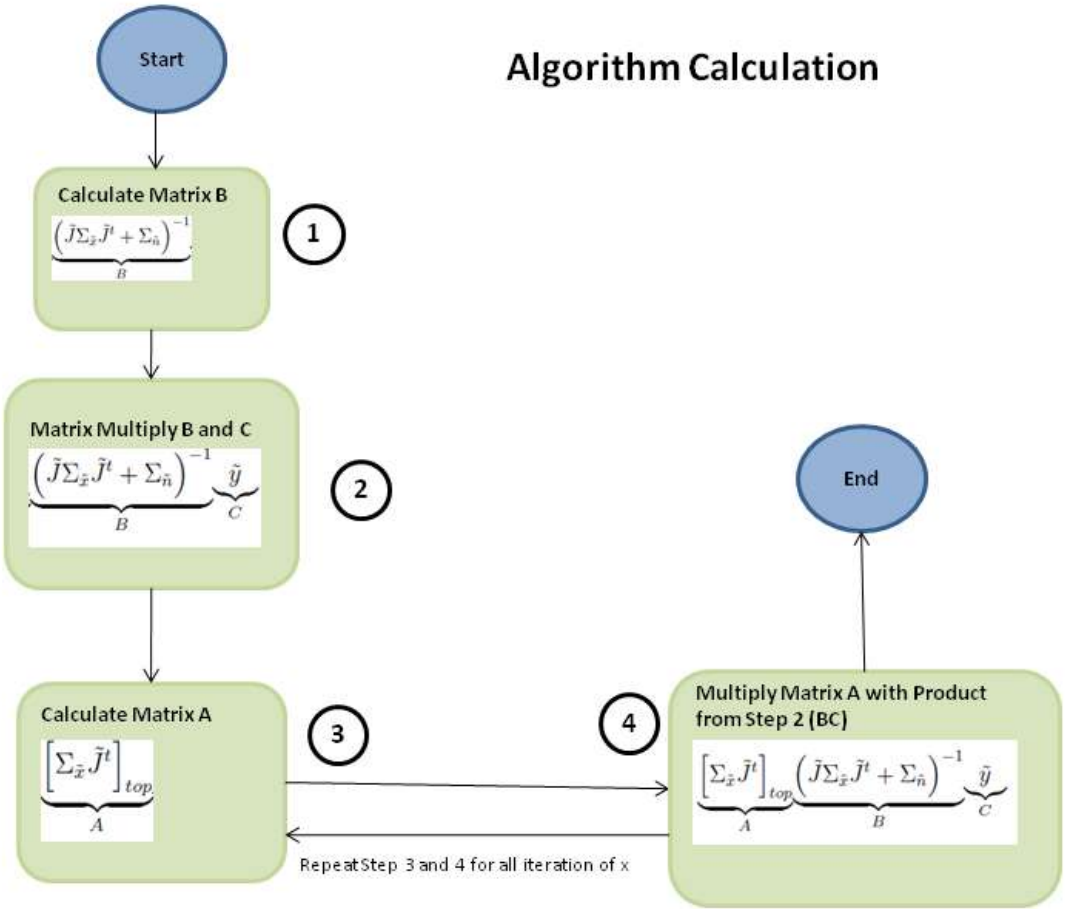
Contributions (Software Toolset) (4)



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