3D Diffuse Optical Tomographic Imaging

Rick Gaudette (NU), Dana Brooks (NU), Charles DiMarzio (NU), David Boas (MGH), Thomas Gaudette (MGH), Eric Miller (NU), Misha Kilmer (Tufts)

Goals:
- Improve reconstruction performance of diffuse optical tomography
  - better spatial localization of anomalies, especially depth
  - better optical parameter characterization

Significance:
- Applications to medical imaging
  - breast cancer detection
  - neonate brain oxygenation monitoring
  - stroke differentiation

Technical Problems:
- Challenging inverse problem
  - limited view ⇒ underdetermined problem
  - ill-posed
  - near-field
  - non-linear

Technical Approach:
- Develop a set of software tools for the community
- Examine performance of current linear model techniques
- Explore additional mathematical and physical constraints on the solution

Diffuse Optical Tomography Toolbox
- Collaboration between NU and MGH
- Based on MATLAB programming environment
- Freely available to the community
  - encourage more interaction
  - enable valid comparisons

Linear Model 3D Reconstruction Algorithm Comparison
- Looked at 2 classes of algorithms through simulations
  - algebraic techniques
    - ART, SIRT
  - subspace techniques
    - TSVD, TCG

Linear 3D Reconstruction Performance
- Looked at 2 classes of algorithms through simulations
  - algebraic techniques
    - ART, SIRT
  - subspace techniques
    - TSVD, TCG

Experimental Data Collection and Analysis
Forward Modeling Reconstruction App
Two-wavelength Constrained Imaging

- Existing requirement to collect multiple wavelengths
- How to best use information at two wavelengths to improve 3D absorption imaging?
- Absorption coefficient images at two wavelengths:
  - expected to have the same spatial structure
  - differ only by a constant scale factor
- Use constant ratio criteria to develop a constraint on the underdetermined system we have

3 Approaches

- Use the “best” information from both wavelengths in a large linear system Joint Inversion
- Apply the constraint after computing images at each wavelength Post Constrained Joint Inversion
- Integrate the constraint into the inversion process using the null space to meet the constraint Constrained Joint Inversion

2 Wavelength Reconstruction Performance

2 Wavelength Reconstruction Performance

Relationship to ERC

- Research barriers
  - Non-linear inverse problem
  - Forward modeling is too slow
  - Inhomogeneous and cluttered environment

Current Status

- Algorithm comparison results published in *Physics in Medicine and Biology*
- Presented results at OSA and SPIE conferences
- PMI Toolbox is being used and new ideas incorporated
- NSF Long-term Discovery Funding $100K

Plans and Project Evaluation

- 1 Year: Use of 2-wavelength imaging in experimental DOT
- 3 Years: Algorithms that address clutter and inhomogeneities
- 5 Years: DOT used in clinical settings with mm resolution

PI Contact Info:
Dana Brooks
Northeastern University
442 DA
360 Huntington Ave
Boston, MA 02115
voice: 617-373-3352   fax: 617-373-4189
email: brooks@ece.neu.edu
www: http://www.ece.neu.edu/Faculty/Brooks.html