Image-guided Optical Spectroscopy

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Photon scattering:
Analogy to X-ray imaging

Tromberg et al, Neoplasia, 2(1-2), (2000)
http://www.anl.gov/Media_Center/News/2006/CNM061007.html

Diffuse Optical Tomography:
Acquiring Data and Generating Images

2-d Cross section

Absorption
Hemoglobin
Oxygen Saturation
Water
Lipid
Scattering Parameters

Luminescence
Fluorescence
Phosphorescence
Bioluminescence

Multi-spectral Images at High Resolution
Imaging breast cancer

Hallmarks of Cancer
- Dense vasculature
- Hypoxic regions
- Heterogeneous blood flow

Multi-Modality Optical Imaging Systems

Tromberg et al, Med Phys, 2008
**MR-NIR System Hardware**

- Frequency Domain
- 16 laser wavelengths
- 16 sources
- 15 detectors
- 240 measurements

**Patient Interfaces – circular & compression**

Brookibly et al, PNAS 2006

**3D Segmentation & meshing**

Carpenter et al, Optics Express (2008)

**Diffusion Based Spectral Image Reconstruction (NIRFAST software)**

Mesh & mask
Diffusion model
Projection sensitivity
Map calculation

image

images
Challenge 1: Imaging in 3D

3-D Imaging is more accurate & Relevant to Clinical Imaging

3D is Computationally Intensive: BEM Approach provides a solution

Quantitative Accuracy is possible using MRI-NIRS

Srinivasan et al, Med Physics, 2007
Spectral & Spatial Priors allow accurate recovery of Hill-curve.

Clinical Results

Characterizing Healthy Adipose & FG Breast Tissue Using Six Subjects

FG Tissue: higher HbT & Water compared to Adipose tissue

<table>
<thead>
<tr>
<th>Property</th>
<th>Adipose</th>
<th>FG Tissue</th>
<th>Water</th>
<th>Mean ± SD (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HbT</td>
<td>11.8±3.5</td>
<td>15.1±3.7</td>
<td>14.7±3.5</td>
<td>14.7±3.5 (15.1)</td>
</tr>
<tr>
<td>Water</td>
<td>81.1±4.0</td>
<td>77.7±2.7</td>
<td>79.1±3.7</td>
<td>79.1±3.7 (81.2)</td>
</tr>
<tr>
<td>Mean ± SD (n=6)</td>
<td>30.3±9.0</td>
<td>34.6±2.0</td>
<td>31.6±2.3</td>
<td>31.6±2.3 (33.3)</td>
</tr>
</tbody>
</table>
Imaging Breast Cancer: Contrast in Total Hemoglobin

Challenge 2: Positioning Imaging Probe

Guidance is Necessary for Alignment of NIRS Probe

HbT in plane 1 under-estimated by a factor of 2

3D Overlay on MRI – Patient prior to neoadjuvant chemo

DCE MR subject with IDC, prior to chemotherapy. Slight enhancement of 1 main node with 3 satellite lesions, all showing increased hemoglobin.
**Subject post 1 cycle neoadjuvant chemotherapy**

![Image of medical scan](image1)


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**Hemoglobin Change during 1st cycle of Neoadjuvant Chemotherapy for pCR**

![Graph showing hemoglobin change](image2)

Jiang et al, Radiology (August 2009)

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**3007 - 2 days after Cycle 2**

![Image of medical scan](image3)


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- Off-site Collaborators

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