Ultrasound Imaging of Brain Shunts

Checkpoint Presentation
Team 1

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April 23, 2013
Overview

- Project Summary
- Deliverables
- Progress: Phantom Construction
- Progress: Imaging
- Timeline
- Milestone Validation
- Dependencies
- Reading list
Problem: Brain shunts suffers from high incidence of occlusion that the in-grown tissues block the CSF flow.

Project Goal: Use external US probe, together with photoacoustic excitation to image occlusions and brain shunts inside the skull.
Original Deliverables

- **Minimum – without skull**
  - Design and build a ultrasound friendly brain phantom and insert the shunts. *(Done)*
  - Preliminary test of US probe for reflected PA signal detection. *(Done)*
  - Collect and process the data of the occlusion with brain phantom into delayed image. *(Done)*
Original Deliverables

- **Expected – with skull**
  - Collect and process the data of the occlusion into delayed image. *(Done)*
  - Capability to distinguish shunts, tissues and fluids. **✗**
  - Demonstrate PA imaging of shunts with different levels of occlusion. *(In progress, will be done in this week.)*
Original Deliverables

- **Maximum**
  - Demonstrate real-time PA imaging through the skull of shunts with different levels of occlusion  
    - Monitor clearing of the shunt
NEW Deliverables

- Maximum
  - Visualization of fiber end point
  - Delayed monitoring (due to data collection time of DAQ)
    - Approaching of the fiber to the occlusion
    - Accumulation of occlusion
Phantom Construction

Two parts: Brain & Skull

- Brain part: model the environment of the brain
  support the shunt tube

- Skull: model the real effect of bone on US imaging
  • 3D printer not available
  • 3DP service will miss the best time to do the post-processing
Phantom Construction

What we did …

• Several simple shaped phantoms …

Pure gelatin phantom
(Very Stiff)

Gelatin and Fiber phantom
(Relatively soft, Tissue-like)
Phantom Construction

What we are using now …
Progress: Imaging

- Ultrasound generation
  - laser
- Data collection
  - Sonix Touch & DAQ
- Data processing
  - Beamform
- Image formation
Progress: Imaging

Project Summary
Deliverables
Progress: Phantom
Progress: Imaging
Milestones
Dependencies
Reading list

12
Progress: Imaging

- Test with bones of different thickness
  - Thin piece of bone (2mm)
Progress: Imaging

- Test with bones of different thickness
  - Thin piece of bone (2mm)
  - Laser energy: 0.75mJ
  - Distance: 2mm
Progress: Imaging

- Test with bones of different thickness
  - Thicker piece of bone (4mm)
  - Laser energy: 0.75mJ
  - Distance: 2mm
Progress: Imaging

- Test with distance between the fiber and the occlusion
  - Bone thickness: 4mm
  - Laser energy: 0.75mJ
  - Distance: 5mm
Progress: Imaging

- Test with distance between the fiber and the occlusion
  - Bone thickness: 4mm
  - Laser energy: 0.75mJ
  - Distance: 10mm
Progress: Imaging

- Test with different sizes of occlusion
  - Bone thickness: 4mm
  - Laser energy: 0.75mJ
  - Distance: 2mm
  - Size: previous
Progress: Imaging

- Test with different sizes of occlusion
  - Bone thickness: 4mm
  - Laser energy: 0.75mJ
  - Distance: 2mm
  - Size: twice the thickness of previous
Progress: Imaging

- Test with different sizes of occlusion
  - Bone thickness: 4mm
  - Laser energy: 0.75mJ
  - Distance: 2mm
  - Size: no occlusion
Progress: Imaging

- **Problem**
  - Bones get harder for ultrasound as time goes on.
  - Borrowed human bone is not usable.
  - Real-time monitoring is not realizable due to the hardware limitation.

- **Next step**
  - Change the position of the probe from perpendicular to aligned with the shunts
  - Inject tiny pieces of occlusion with a needle and collect the image into movie
  - Delayed monitoring
<table>
<thead>
<tr>
<th>Goals/Milestones</th>
<th>March</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week4</td>
<td>Week1</td>
<td>Week2</td>
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<tr>
<td>Milestone 1</td>
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<tr>
<td>Brain Phantom Construction (Han)</td>
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<td>System setup(Yang) Done</td>
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<td>Visualization of occlusion(Yang)</td>
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<td>Milestone Validation(Both)</td>
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<td>Skull Construction(Han)</td>
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<td>Experiment on phantom with skull(Both)</td>
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<td>Collect data from different materials(Han)</td>
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<td>Integrate MUSiiCToolkit(Both)</td>
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<td>Integrate clearing stem(Han)</td>
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<td>Visualization of clearing stem end point(Yang)</td>
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**Project Summary**

- **Deliverables**
- **Progress: Phantom**
- **Progress: Imaging**
- **Milestones**
- **Dependencies**
- **Reading list**
### Revised Timeline Version 1

#### Milestone 1
- **Goals/Milestones**
  - Brain Phantom Construction (Han)
  - System setup (Yang) Done
  - Preliminary tests (Yang) Done
  - Experiment on phantom w/o skull (Both)
  - Visualization of occlusion (Yang)
  - Milestone Validation (Both)

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<tbody>
<tr>
<td></td>
<td>Week4</td>
<td>Week1</td>
<td>Week2</td>
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</table>

#### Milestone 2
- **Goals/Milestones**
  - Skull Construction (Han)
  - Experiment on phantom with skull (Both)
  - Different levels of occlusions set in the shunts (Han)
  - Visualization of occlusion (Yang)
  - Visualization of different levels of occlusion (Yang)
  - Milestone Validation (Both)

#### Milestone 3
- **Goals/Milestones**
  - Collect data from different materials (Han)
  - Integrate MUSiiC Toolkit (Both)
  - Integrate clearing stem (Han)
  - Visualization of clearing stem end point (Yang)
  - Milestone Validation (Both)

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- **Integrate clearing stem (Han)** marked as completed.

- **Documentation (Both)**
- **Poster Making and Presentation (Both)**
## Revised Timeline Version 2

### Milestone 1
- **Goals/Milestones**
  - Brain Phantom Construction (Han)
  - System setup(Yang) Done
  - Preliminary tests(Yang) Done
  - Experiment on phantom w/o skull(Both) Done
  - Visualization of occlusion(Yang) Done
  - Milestone Validation(Both) Done

### Milestone 2
- **Goals/Milestones**
  - Skull Construction(Han)
  - Experiment on phantom with skull(Both)
  - Different levels of occlusions set in the shunts(Han)
  - Visualization of occlusion(Yang) Done
  - Visualization of different levels of occlusion(Yang)
  - Milestone Validation(Both)

### Milestone 3
- **Goals/Milestones**
  - Collect data from different materials(Han)
  - Delayed monitoring
  - Visualization of clearing stem end point(Yang)
  - Milestone Validation(Both)

### Deliverables
- Documentation(Both)
- Poster Making and Presentation(Both)

### Milestones
- March Week4
- April Week1
- April Week2
- April Week3
- April Week4
- May Week1
- May Week2
## Milestone Validations

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<th>Revised plan I</th>
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## Dependencies

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<td>Milestone I</td>
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Reading list

Phantom Construction


- Sean Jy-Shyang Chen1, Pierre Hellier2, Jean-Yves Gauvrit4,5,6, Maud Marchal3, Xavier Morandi4,5,6, and D. Louis Collins: An Anthropomorphic Polyvinyl Alcohol Triple-Modality Brain Phantom based on Colin27. McConnell Brain Imaging Centre, McGill University, Montreal, Canada


- Brian W. Pogue, Michael S. Patterson: Review of tissue simulating phantoms for optical spectroscopy, imaging and dosimetry. Journal of Biomedical Optics 11(4), 041102 (July/August 2006).


Photoacoustic and Ultrasound imaging

Limng Nie, Xin Cai, Konstantin Maslov, Alejandro Garcia-Uribe, Mark A. Anastasio, Lihong V. Wang, “Photoacoustic tomography through a whole adult human skull with a photon recycler”, Washington University, Department of Biomedical Engineering, St. Louis, Missouri 63130.


Thank you!