Seminar Presentation: Image Acquisition for Manually Scanned OCT

Amrita Gupta
Group 12
Mentor: Marcin Balicki
Intraocular OCT Imaging and Visualization

Assess the efficacy of intraoperative OCT in vitreoretinal surgery, in particular for locating epiretinal membrane edges

Simulate ERM location task in a phantom and conduct subject trials

Improve the user interface of the microsurgical assistant system by developing color-enhanced imaging and smart OCT-processing

How will we do this?
Problem Scenario

• Cross-sectional images assembled from sequential A-scans

  ![Spectrum](image1)
  ![A-Mode](image2)
  ![B-Mode](image3)

• A-scan imaging rate must be synchronized with lateral scanning of beam
  – Move beam at constant speed with respect to scan surface
  – Use a galvanometer system to track lateral scanning

• An ideal, ‘surgeon-friendly’ device would be a simple, manually-scanned probe that still presents the acquired data in the most useful form
  – Use reference markers to track tool position
  – Use acquired data to track motion of the tool

Kang et al.
Cross-correlation-based image acquisition technique for manually-scanned optical coherence tomography

Adeel Ahmad, Steven G. Adie, Eric J. Chaney, Utkarsh Sharma, and Stephen A. Boppart

http://dx.doi.org/10.1364/OE.17.008125

Biophotonics Imaging Laboratory
Beckman Institute for Advanced Science & Technology
University of Illinois at Urbana-Champaign
Relevant Goals of the Paper

<table>
<thead>
<tr>
<th>Ahmad et al.</th>
<th>Group 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discard all oversampled regions of manually-scanned images</td>
<td>Discard redundant data in manual or Steady-Hand assisted scans</td>
</tr>
<tr>
<td>Construct B-mode image from A-scans that are equally spaced in distance rather than time</td>
<td>Construct B-mode image from A-scans that are equally spaced in distance rather than time, as well as axially aligned</td>
</tr>
<tr>
<td>Test efficacy of image acquisition for synthetic phantoms as well as human tissue</td>
<td>Devise image processing that will work for both latex phantoms and retina tissue</td>
</tr>
</tbody>
</table>
Image Acquisition Algorithm

(a) Pre-processing steps
- Start from 1st A-scan
- Select this as the reference A-scan
- Calculate correlation coefficient (ρ) with the subsequent A-scans
- (ρ < threshold)
- Assemble the A-scan

(b) Correlated A-scans
- Manually scanned probe
- Uncorrelated A-scan
- Raw dataset
- Selected A-Scans
- Assembled image

Ahmad et al.
**Image Acquisition Algorithm**

- Correlation between two A-scans is given by the Pearson cross-correlation coefficient:
  \[ \rho(i,j) = \frac{\langle (I_i - \mu_i)(I_j - \mu_j) \rangle}{\sigma_i \sigma_j} \]

- Cross-correlation depends on signal-to-noise ratio, speckle pattern and sampling factor:
  \[ \zeta = \frac{f_s \Delta x}{v} \]
Selecting the Cross-Correlation Threshold

1. Select cross-correlation coefficient threshold based on sample
2. Set reference A-scan to whichever A-scan first falls below the chosen threshold
3. Append reference A-scan to OCT image

Ahmad et al.
Results: Silicone Phantom Sample

Ahmad et al.
Results: Plasticine Sample

Ahmad et al.
Results: Breast Tissue Sample

Ahmad et al.
Pros and Cons of the Paper

Pros
• Algorithm is clearly described, simple and quite effective
• Test surfaces had a variety of characteristics, such as regular vs. high scattering, uniform vs. surface irregularities, synthetic vs. organic
• Paper provides a good framework for more in-depth analysis and more complicated scenarios
• Authors suggest many areas for investigation based on these initial findings

Cons
• Important details lacking in the experimental method section
• Did not fully explain how the “optimal” threshold was selected for each surface
• Did not quantify of the match between the final assembled (reconstructed) and uniformly scanned (control) images
Further Work

- Adaptively change threshold value to compensate for gradual changes in tissue shape
- Investigate selection of threshold value for non-ideal surfaces (highly uniform, low-scattering, etc.)
- Modify correlation algorithm for vertically non-structured A-scans
- Combine with motion estimation methods to improve applicability to improve resolution of tool tip tracking
Assessment: Relevance to our Project

• Provides a simple way of comparing structured A-scans
• Provides background information into OCT image processing, such as velocity-beam diameter-sampling frequency relationship
• Provides suggestions for further work, some of which we are hoping to implement
• Success of the cross-correlation algorithm is very encouraging
Conclusions

• Useful starting point for our goal to develop smart-processing M-scans
• Algorithm is flexible enough to adapt for further work
• Paper itself could have done with more detail

Questions?