NSF Engineering Research Center for Computer Integrated Surgical Systems and Technology

Seminar Presentation: Image Acquisition for Manually Scanned OCT

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Group 12

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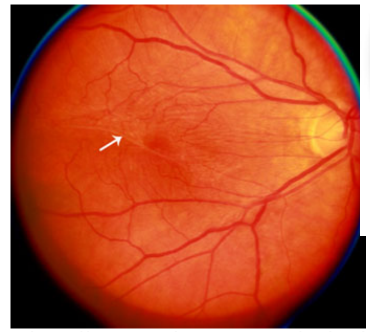
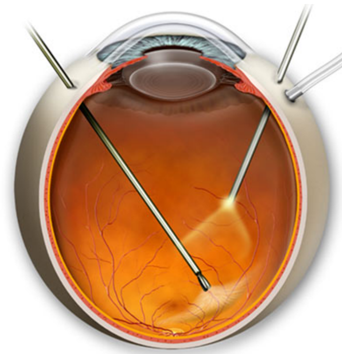
Intraocular OCT Imaging and Visualization

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



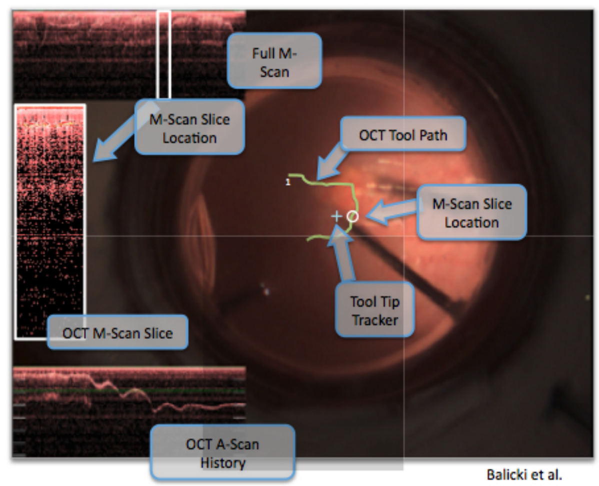


www.eyemdlink.com

http://www.retinaeye.com/epiretinalmembrane.html

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

- How will we do this?



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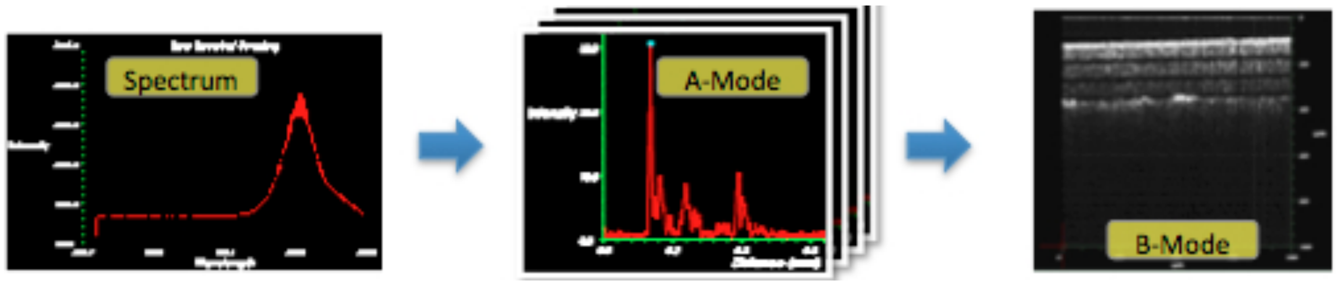
Problem Scenario

- Cross-sectional images assembled from sequential A-scans



Kang et al.

- 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

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

Optics Express, Vol. 17, Issue 10, pp. 8125-8136 (2009)
http://dx.doi.org/10.1364/OE.17.008125

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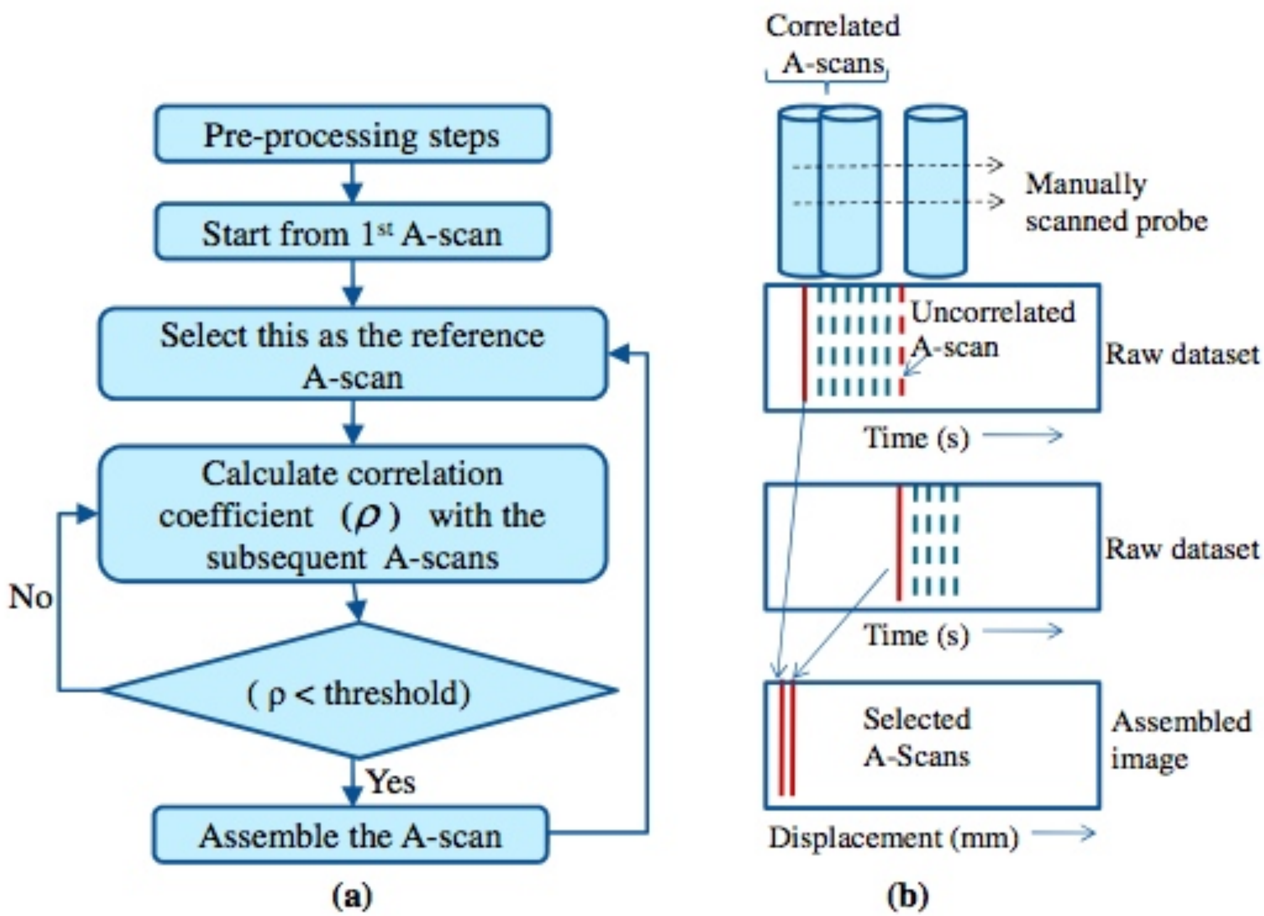
Giving surgeons superhuman abilities one micron at a time

Relevant Goals of the Paper

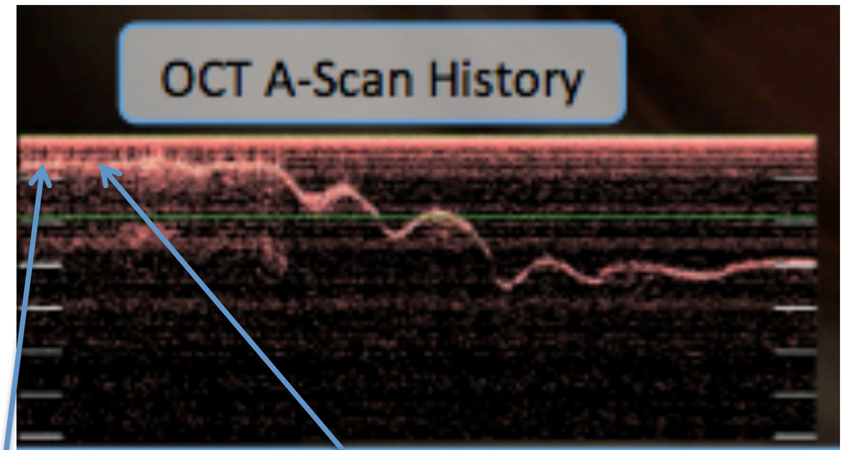
Ahmad et al.	Group 12
Discard all oversampled regions of manually-scanned images	Discard redundant data in manual or Steady-Hand assisted scans
Construct B-mode image from A-scans that are equally spaced in distance rather than time	Construct B-mode image from A-scans that are equally spaced in distance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

Image Acquisition Algorithm

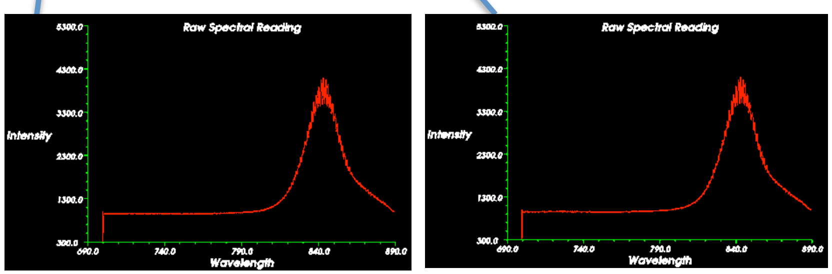


Ahmad et al.

Image Acquisition Algorithm



Balicki et al.



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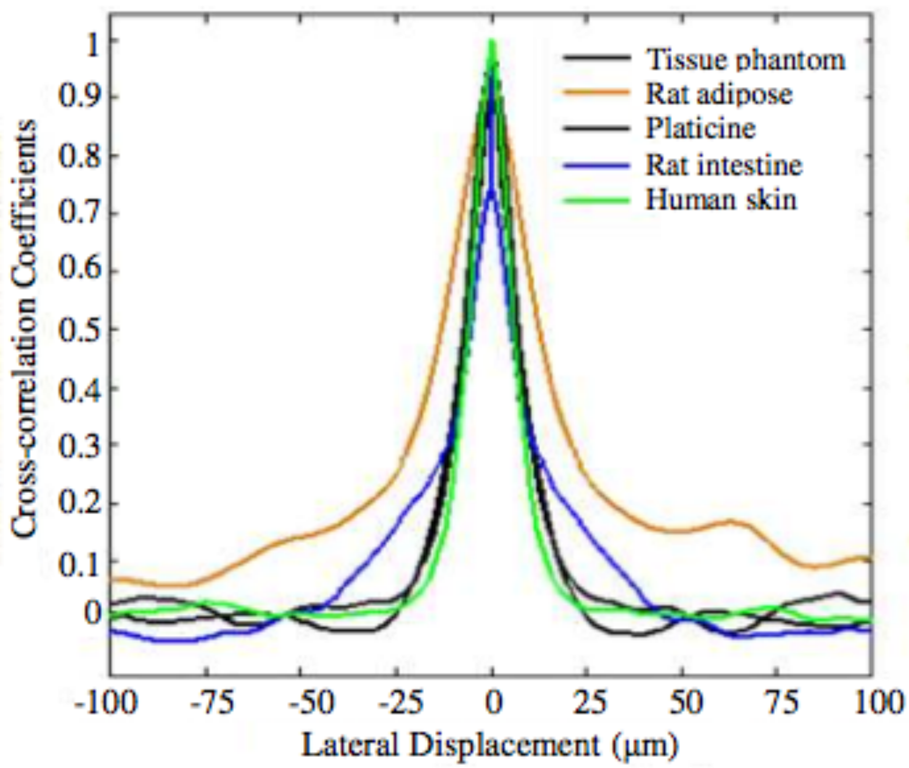
- Correlation between two A-scans is given by the Pearson cross-correlation coefficient:

$$\rho(i,j) = \frac{\langle (I_i - \mu_i)(I_j - \mu_j) \rangle}{\sigma_i \sigma_j}$$

- 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



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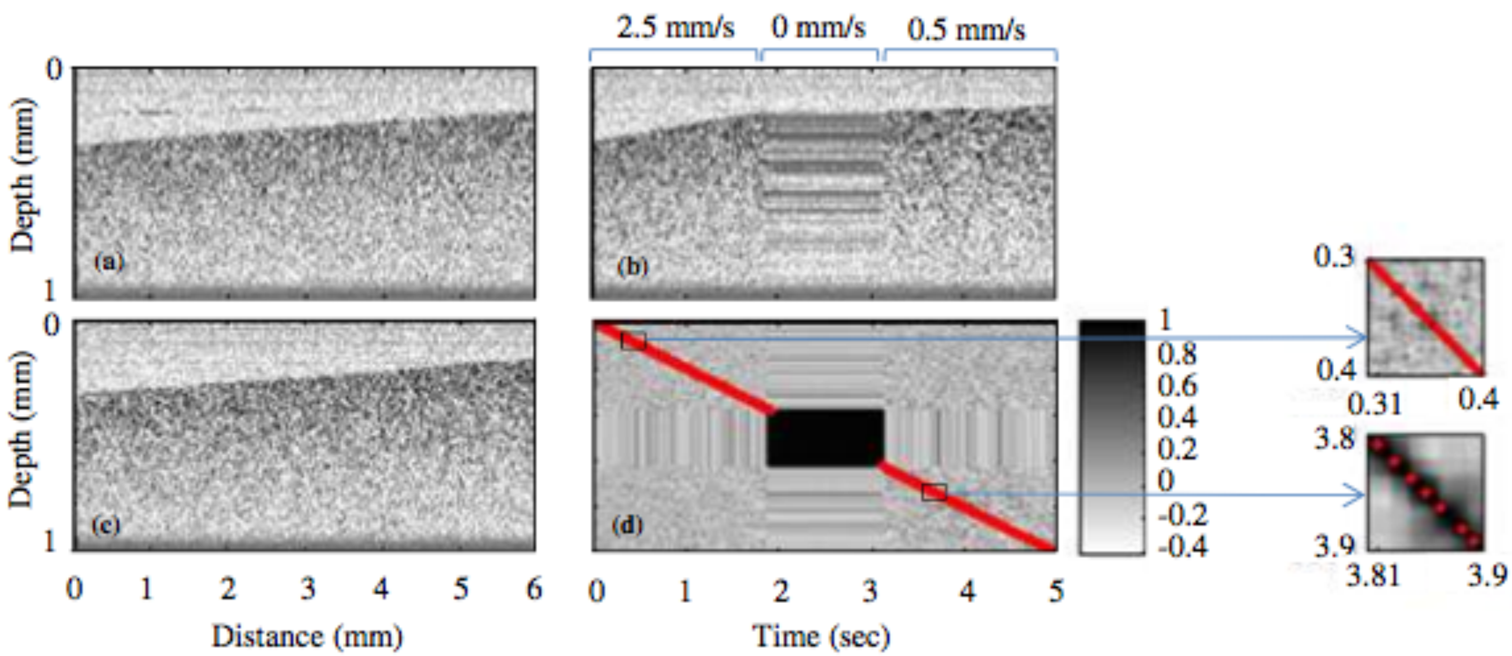
1. Select cross-correlation coefficient threshold based on sample
2. Set reference A-scan to whichever A-scan first falls below the chosen threshold
3. Append reference A-scan to OCT image

Results: Silicone Phantom Sample



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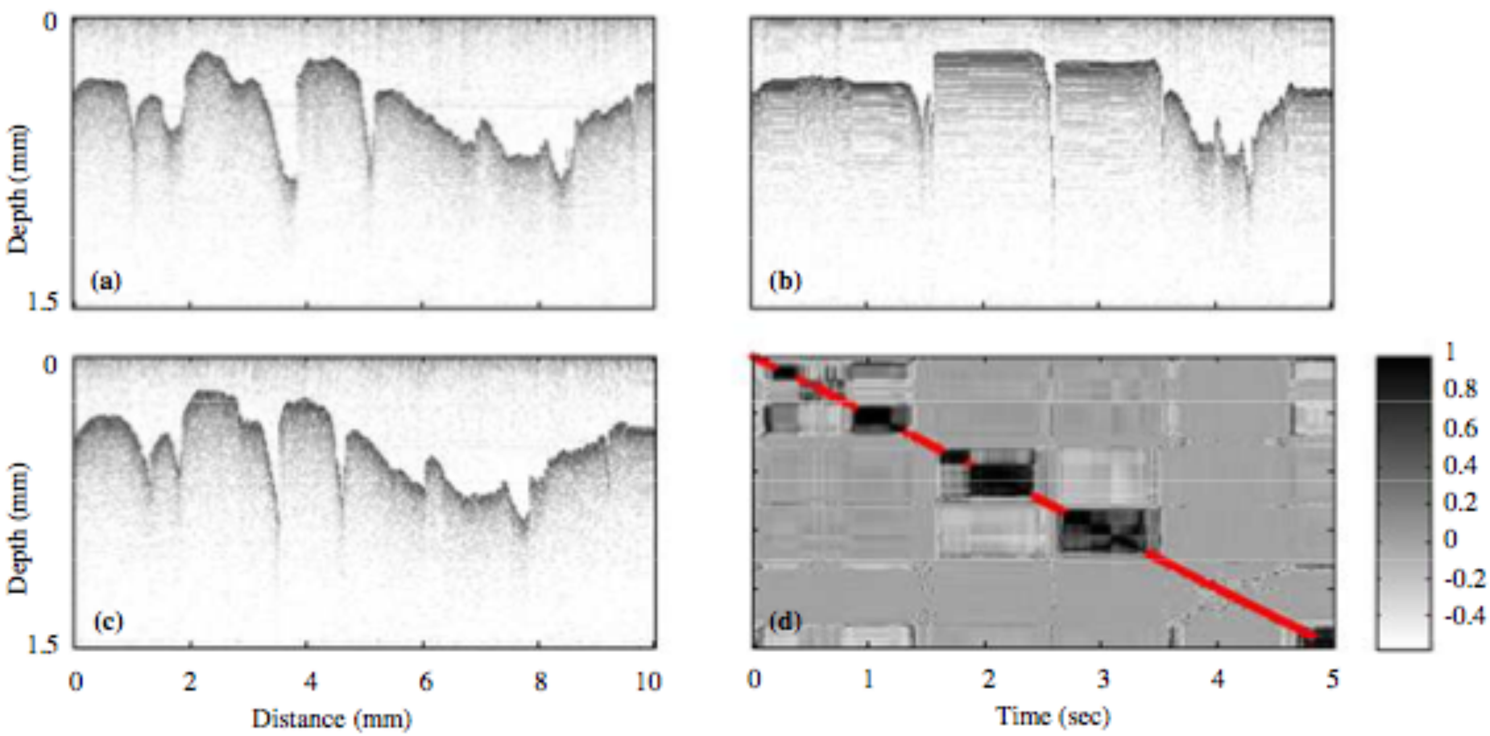
Results: Plasticine Sample



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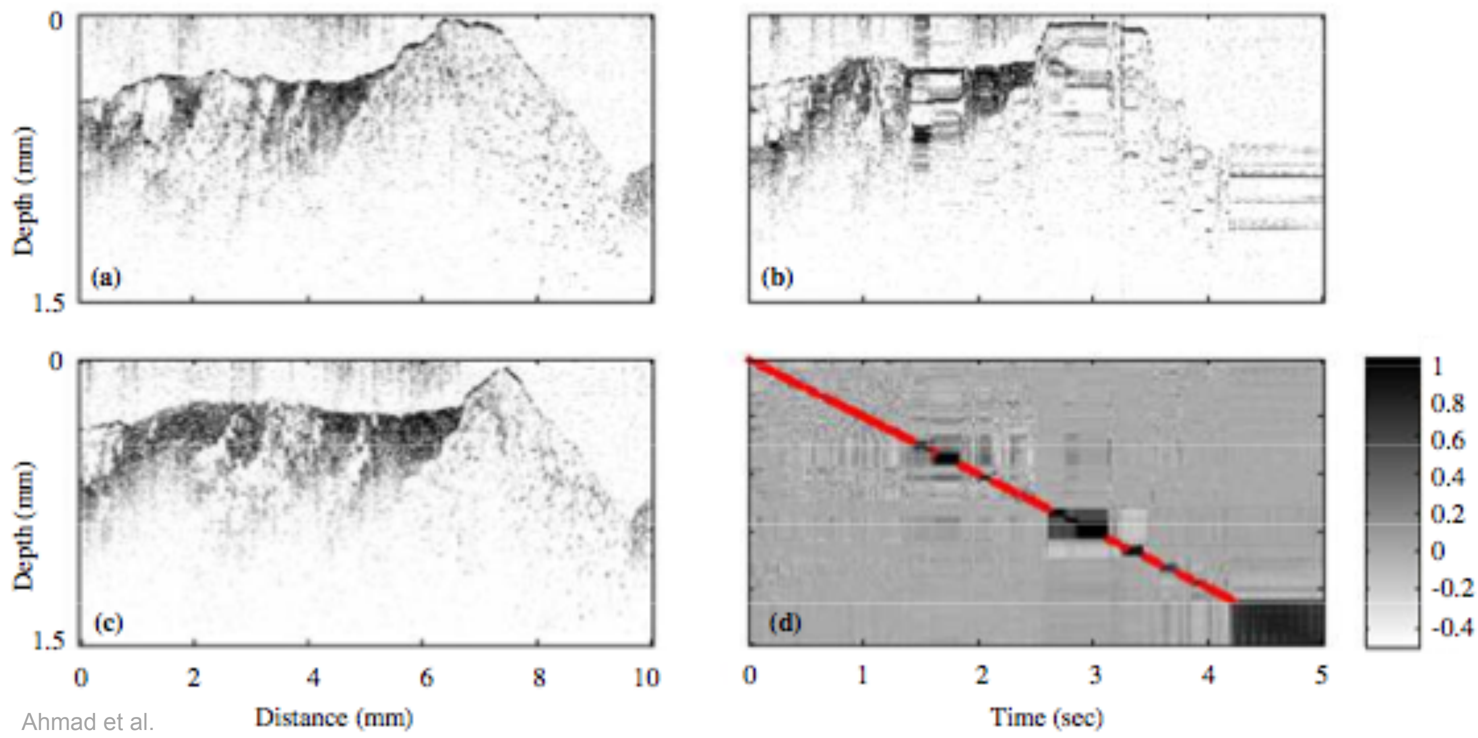
Results: Breast Tissue Sample



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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?