Project 5

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Detecting Blood-Clots Post-Operatively In Blood Vessel Anastomoses

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Dr. Nathanael Kuo

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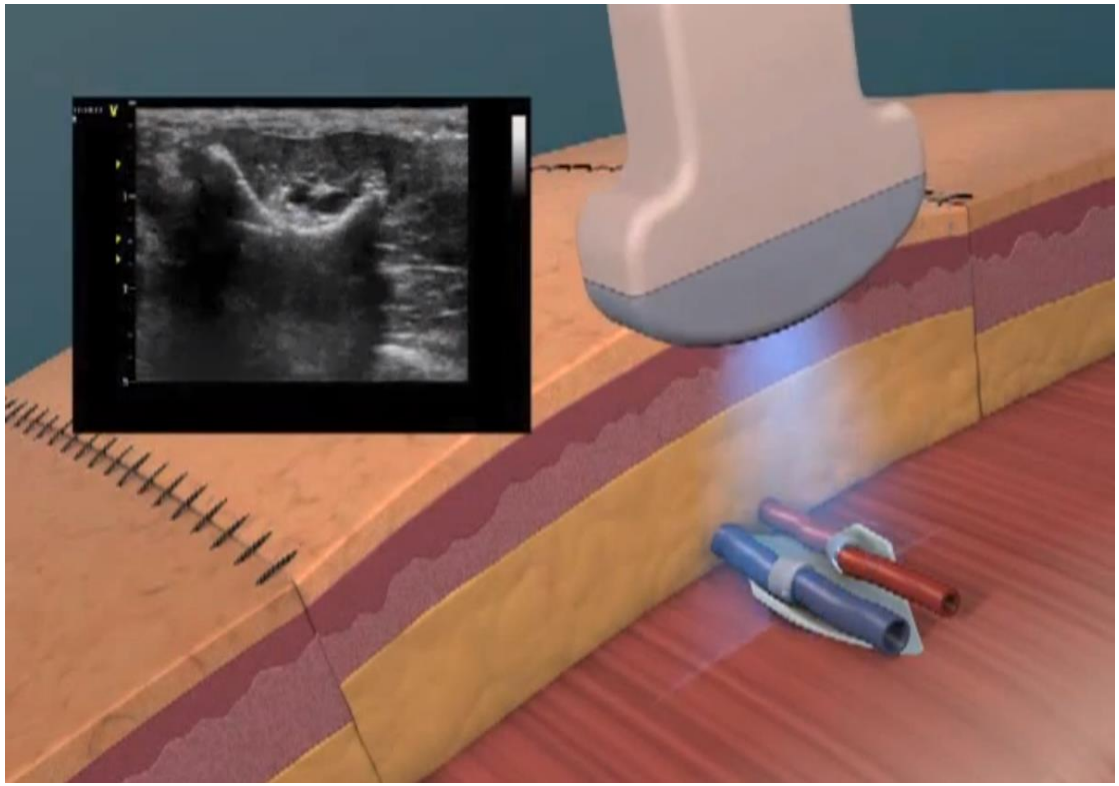
Recap of Project

Ultrasound Doppler Imaging for Tracking Changes in Blood Flow Velocity

Biodegradable Plastic Fiducial for Supplying Reliable Pose



Animation by David A. Rini

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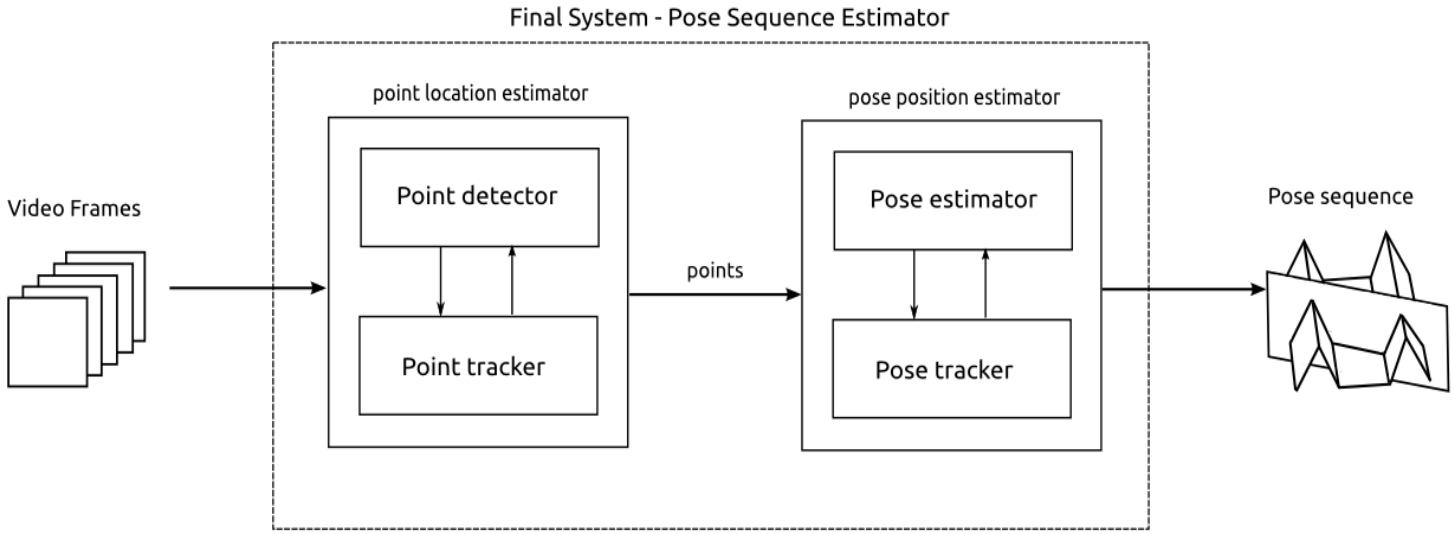
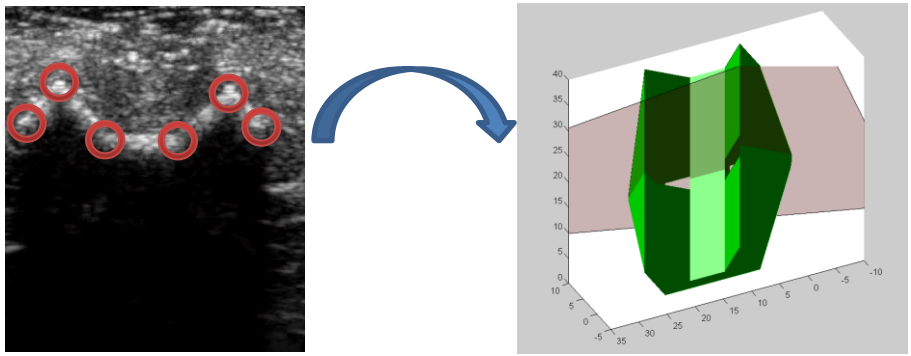
Technical Approach





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Dependencies

- Access to 3D printing for rapid prototyping
  - Wyman Basement Access with Budget Code (Project already has funding)

- Access to ultrasound machine for gathering test data
  - Dr. Boctor's MUSIIC Lab

- Access to computer for developing and testing algorithms
  - Personal Laptops; Dr. Prince's servers if necessary

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Deliverables

- Expected
  - A point location estimator system that processes ultrasound video data and returns interest points for the fiducial.
    - This system will include pure detection and point tracking. These will interact to allow for faster point detection in sequential frames.
  - Rough estimation of confidence in each detected point.

- Minimum
  - Same as expected, slower run time (not real time processing).

- Maximum
  - Statistically rigorous frameworks to optimize estimation of confidence of each detected point.
  - Pose estimator system.

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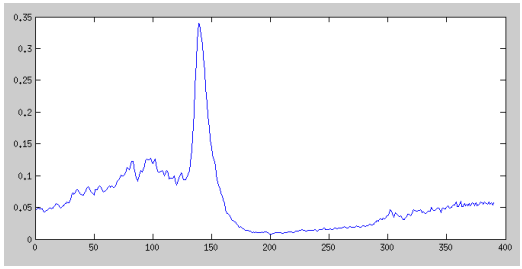
Point Location Estimator System

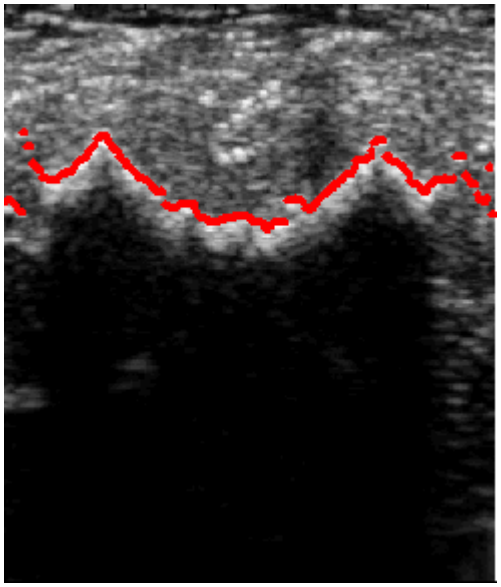
Step 1: Template Matching By Columns of Image

Original Image

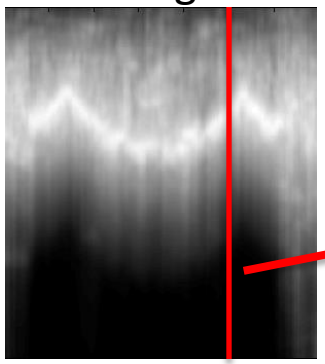
Template



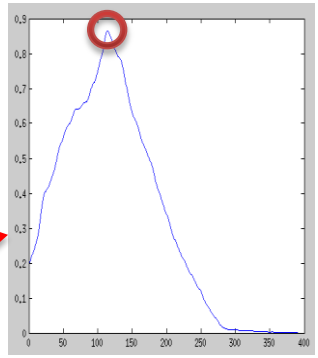
Peaks of Each Column



Correlation Image



Selected Column



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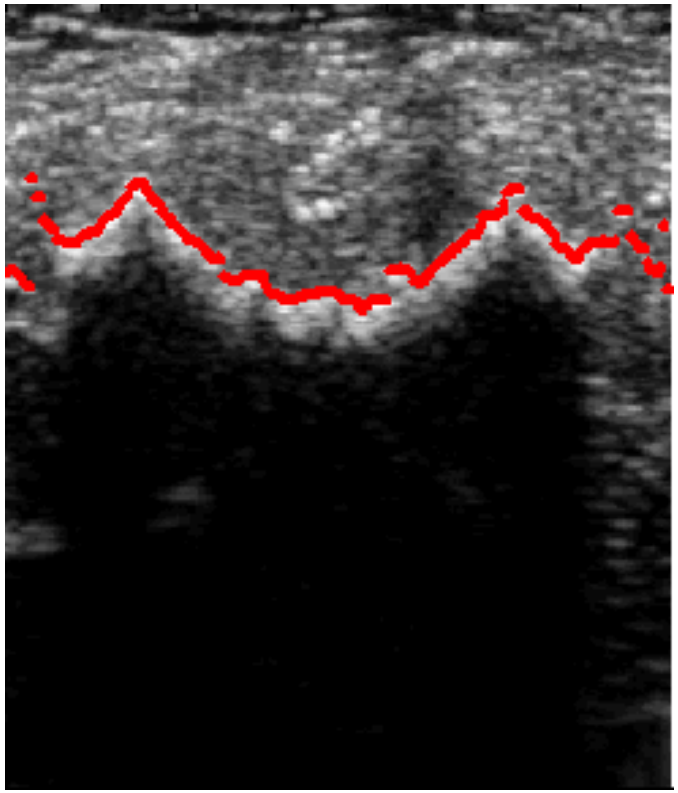
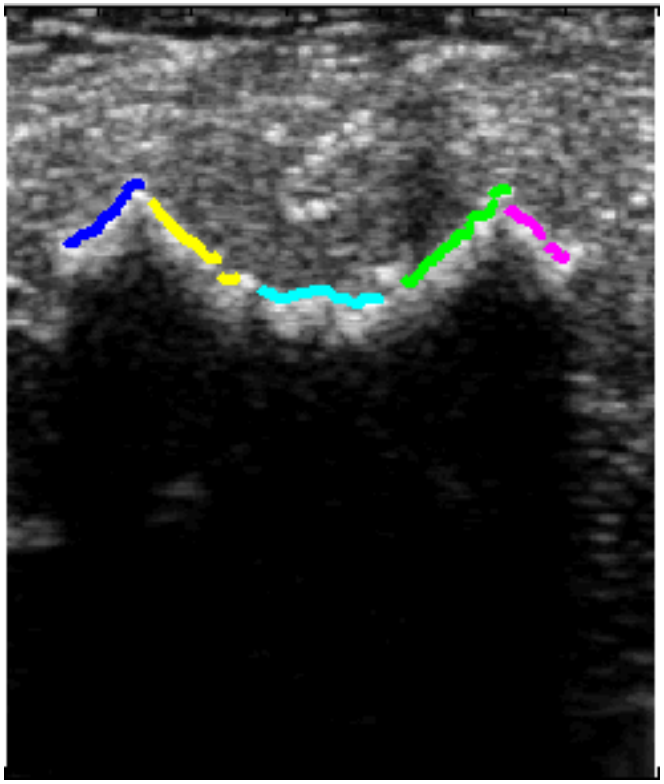
Point Location Estimator System

Step 2: Modified Multi-Line RANSAC





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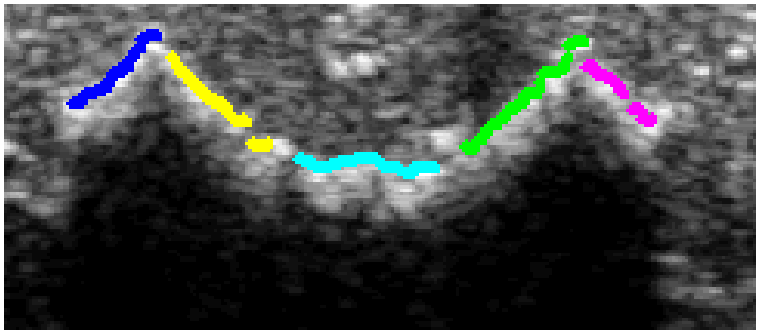
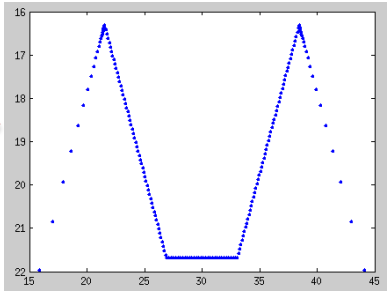
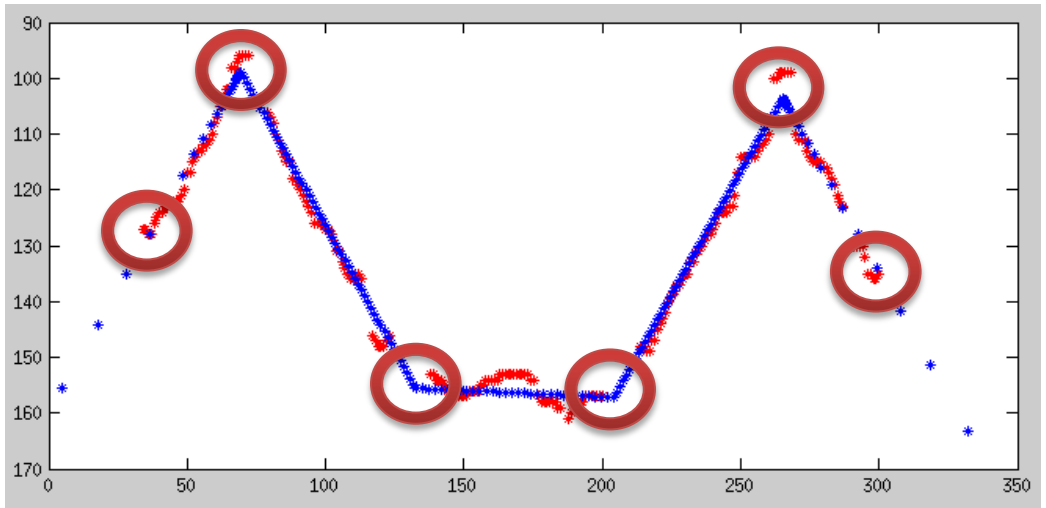
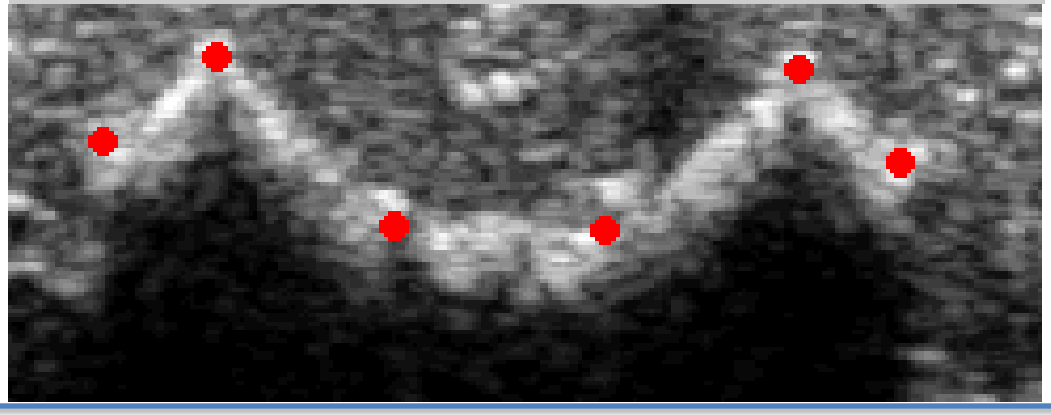
Step 3: Affine Coherent Point Drift[1]









1. A. Myronenko and X.B. Song

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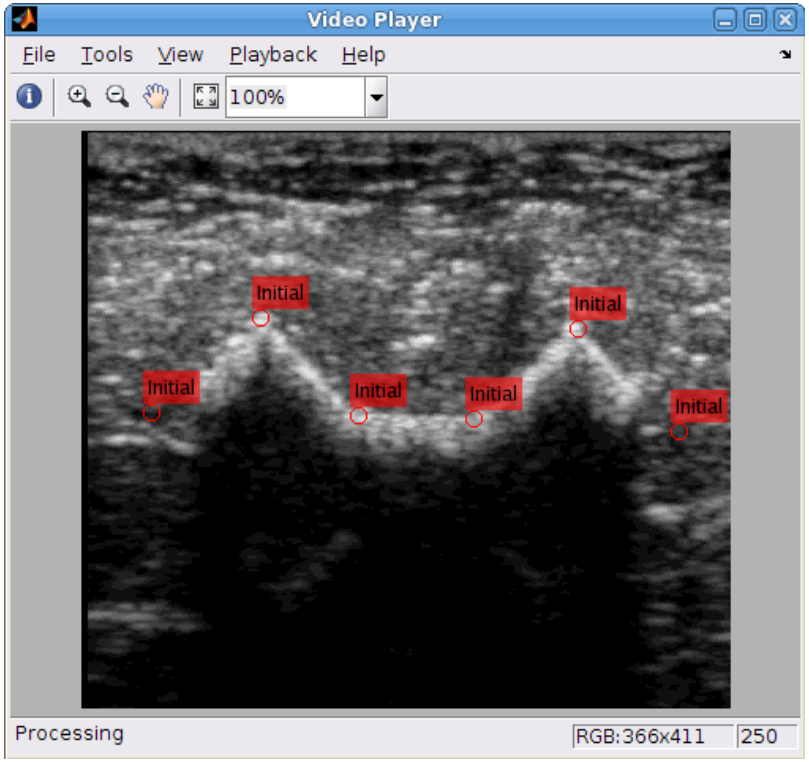
Point Location Estimator System

Total Time: .1 to .5 seconds

Usually: .2 to .35 seconds

Shape Tracking



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Until Now

- Started with using a Matlab implementation of the **Kalman Filter** to track a single point

- The Kalman Filter is an algorithm that is used in many different applications to estimate the state of a linear dynamic system
  - It has a **prediction** step based on the dynamics of the model
  - It has an **update** step based on "sensor" readings

- "Sensor" readings are given from the detection algorithm

- Currently for the dynamics we assume that the points move with constant velocity

- Works well but uses full frame detection for every frame and is slow

Upcoming

- A collaborator generated a set of acceptable poses and did PCA (Principal Component Analysis)

- We plan on using the Principal Components to improve tracking
  - Improve speed by using **normalized cross correlation** from one frame to the next (we implemented this already)
  - Project detected points on **Principal Components** to obtain a feasible pose

  FURTHER:

  - Incorporate the principal components into the Kalman Filter dynamics

  - The dynamic equation of the Kalman Filter can be designed in a way that in absence of noise the pose of the system will converge towards the feasible space define by the principal components

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  - Rough estimation of confidence in each detected ~~point~~ pose.

- Minimum
  - ✓ Same as expected, slower run time (not real time processing).
    *Not yet documented and polished

- Maximum
  - Statistically rigorous frameworks to ~~optimize estimation of confidence of each detected point~~ track fiducial shape.
  - ✗ Pose estimator system.

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Timeline: Until Now

20-27 Feb

Alessandro: Build a skeleton of the estimator system with main functions that do simple (if any) processing.

Michael: Object Detection - finding the set of points or lines to which the search of key points should be limited to.

28 Feb – 6 Mar

Michael + Alessandro: Test out RANSAC techniques. Start stringing together tracking and detection.

7-13 Mar

Alessandro: Start testing out Tracking algorithms (e.g. Optical Flow, Kernel Based, Kalman Filters) .

Michael: Start incorporating tracking info (region of interest) into detection.

21-27 Mar

Michael + Alessandro: Improve system. Try new algorithms and optimize code.

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Timeline: Upcoming

3 Apr (MIN/EXPECTED):

Working prototype (MIN vs. EXPECTED is dependent on speed and accuracy).

4 Apr – 1 May:

Michael + Alessandro:

~~**If** speed/accuracy of point location estimator is not good enough:~~

~~Work on improving detection and tracking~~

~~**Else:**~~

~~Start looking into pose estimation~~

Alessandro: Work on incorporating PCA results into Kalman Filter.

Michael: Polish and Improve working prototype.

1 May – 8 May (MAX):

Michael + Alessandro: Clean and document code. Work on poster for presentation

9 May

Poster presentation / Project Final Report

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Summary

- We are on track with our schedule.

BUT

- Originally we thought at this point we would iterate over what we had.
- Now we are pursuing a PCA based Kalman Filter approach.

Questions?


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Appendix

1. A. Myronenko and X.B. Song, Point-Set Registration: Coherent Point Drift, *IEEE Trans. Pattern Analysis and Machine Intelligence,* vol. 32, no. 12, pp. 2262-2275, Dec. 2010.