Project 5: Detecting Blood-Clots Post-Operatively In Blood Vessel Anastomoses

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Introduction

This project is to create a user guidance system that analyzes B-mode doppler images containing a cross-section of a fiducial that has been placed within tissue and determines which plane generated that cross section.

The system has three components:

Frame detection – Tracking

Pose estimation.

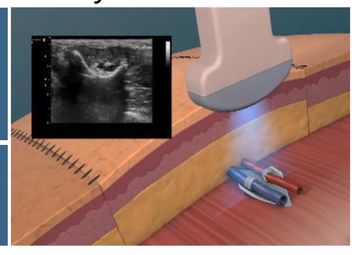
Problem

In skin flap transplant surgeries, the flap of skin is large enough to need its own blood supply; therefore a blood vessel anastomoses is required.

Current methods for detecting the clots rely on examining pulse oximetry in the flap of skin, this is an inherently delayed detection of the clot. Our approach aims to detect the clot directly.

Ultrasound Doppler Imaging for Tracking Changes in Blood Flow Velocity

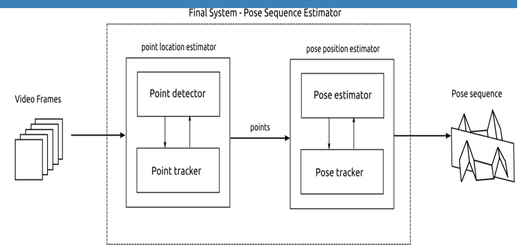
Biodegradable Plastic Fiducial for Supplying Reliable Pose



The project for the semester involves creating an intuitive and accurate user guidance system that ensures the nurse returns to the correct location each time.

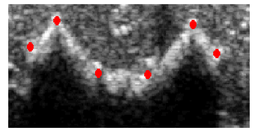
Our Solution

A system that will process the video sequence of ultrasound images, and let the user know where they are with respect to the fiducial.



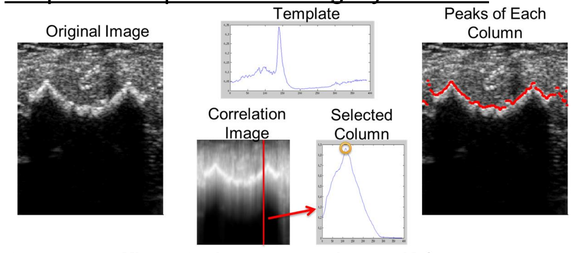
The system has three components:

- **First frame detection (Michael Ketcha)**
  - Detect 6 corner points
- **Tracking (Alessandro Asoni)**
  - Quickly detect points in next frame using local search: real time performance
  - Ensure that the points selected lie in the feasible space of the fiducial shape
- **Pose Estimation (mentor Dr. Kuo)**
  - Takes detected points and finds the plane on the model that best fits the cross-section seen in the image

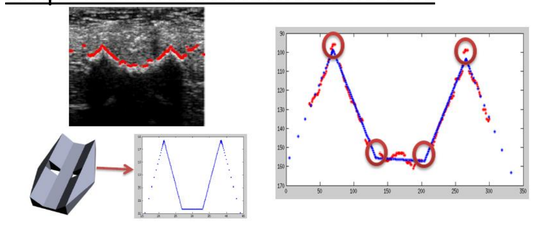


First Frame Detection

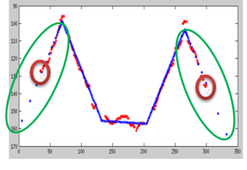
Step 1: Template Matching By Column



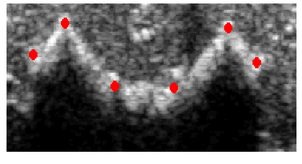
Step 2: Affine Coherent Point Drift[3]



Step 3: Line Fitting



Output:



Tracking

Tracking is based on the Kalman Filter[4]

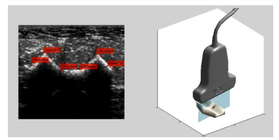
$$x_k = Ax_{k-1} + Bu_k + w_k$$
$$z_k = Hx_k + v_k$$

x_k - 12 entry vector $(x, y$ for 6 points$)$
z_k - measurements given by detections

The state space matrix *A* is obtained in the following way:

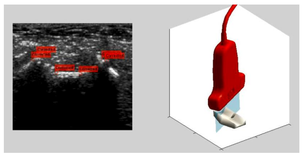
- PCA[5] is done on a large set of simulated real poses
- The eigenvectors of *A* are set equal to the principal components (PCs)
- The eigenvalues of *A* are negative and large for PCs with large coefficients (small and negative for the others)

Results



System Integration of Detection, Kalman Filter, and Pose Estimation.

Warning issued when trace of Kalman Filter state covariance is high.



Tracking by normalized cross correlation proved to be less accurate than expected. Currently the first frame detection algorithm is used at each frame.

Mean runtime: .76 seconds

Future Work

- Improving robustness of first frame detection in low-quality frames
- Developing a feature set to track with normalized cross correlation that is robust to speckle
- Convert Code to C++

Learning

- Computer vision techniques
- Engineering algorithms for specific applications
- Team management
- Never give up

Acknowledgments

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References

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