Image Processing for Video: CT Registration in Sinus Surgery

Computer Integrated Surgery II

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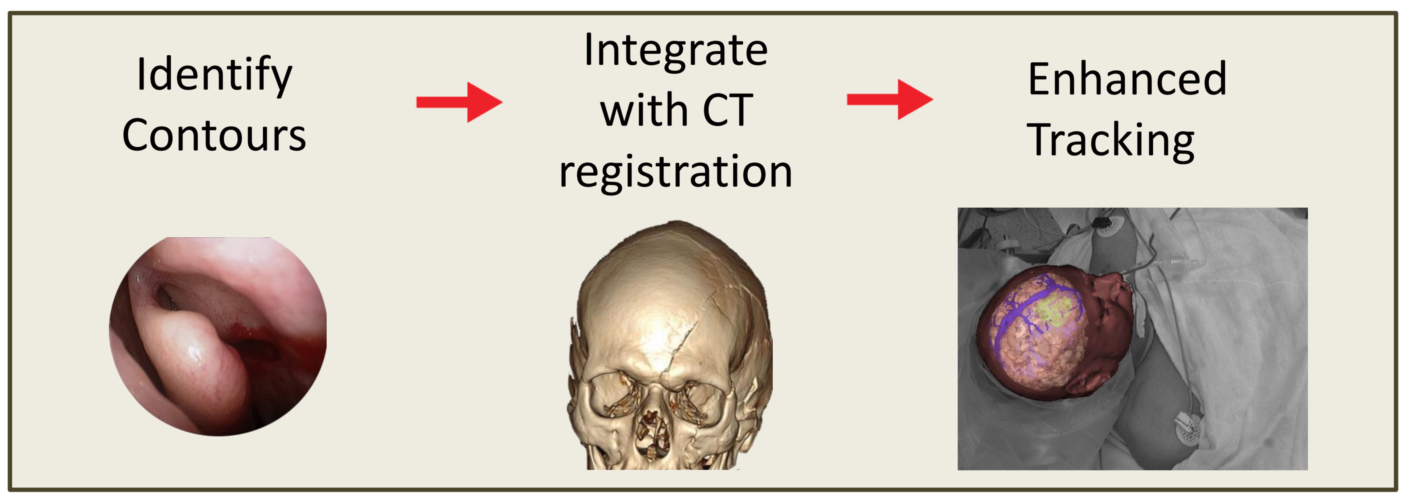
Introduction

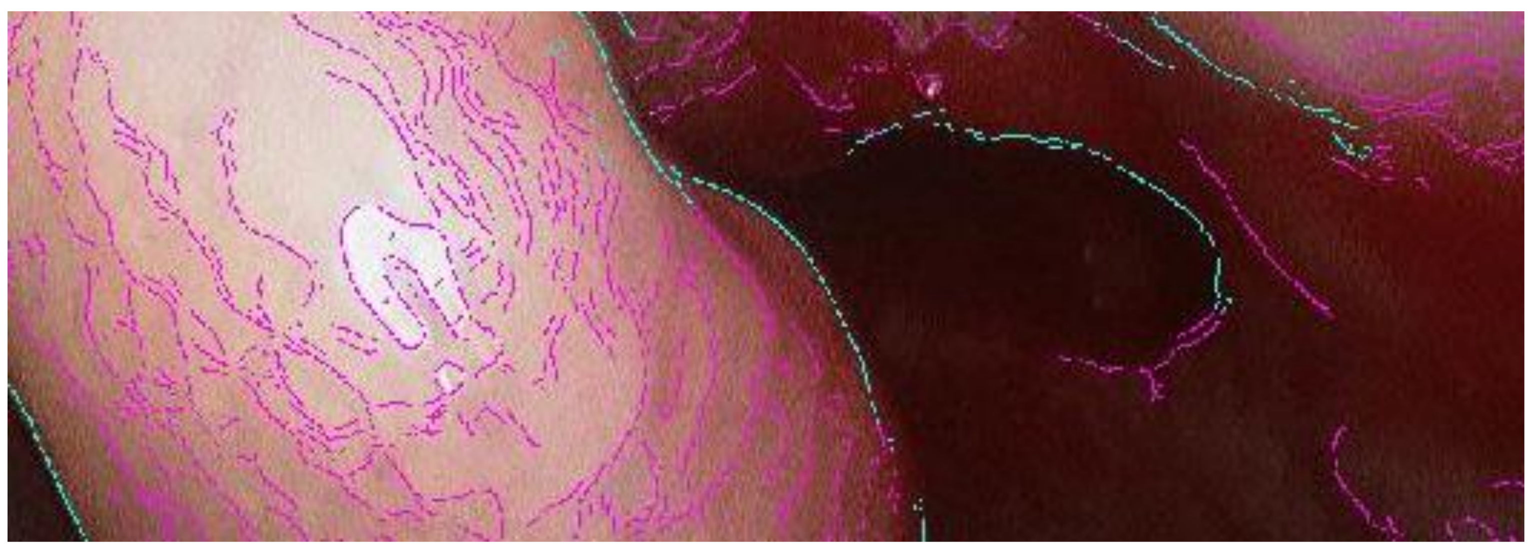
We designed and implemented an algorithm to extract occluding contours in sinus surgery endoscopic videos. Our project supports an existing registration algorithm that registers video data contours to CT image contours. With our work we aim to enhance surgical instrument electromagnetic tracking utilizing occluding contours and CT data.



The Problem

Occluding edge extraction has been a complex computer vision challenge.

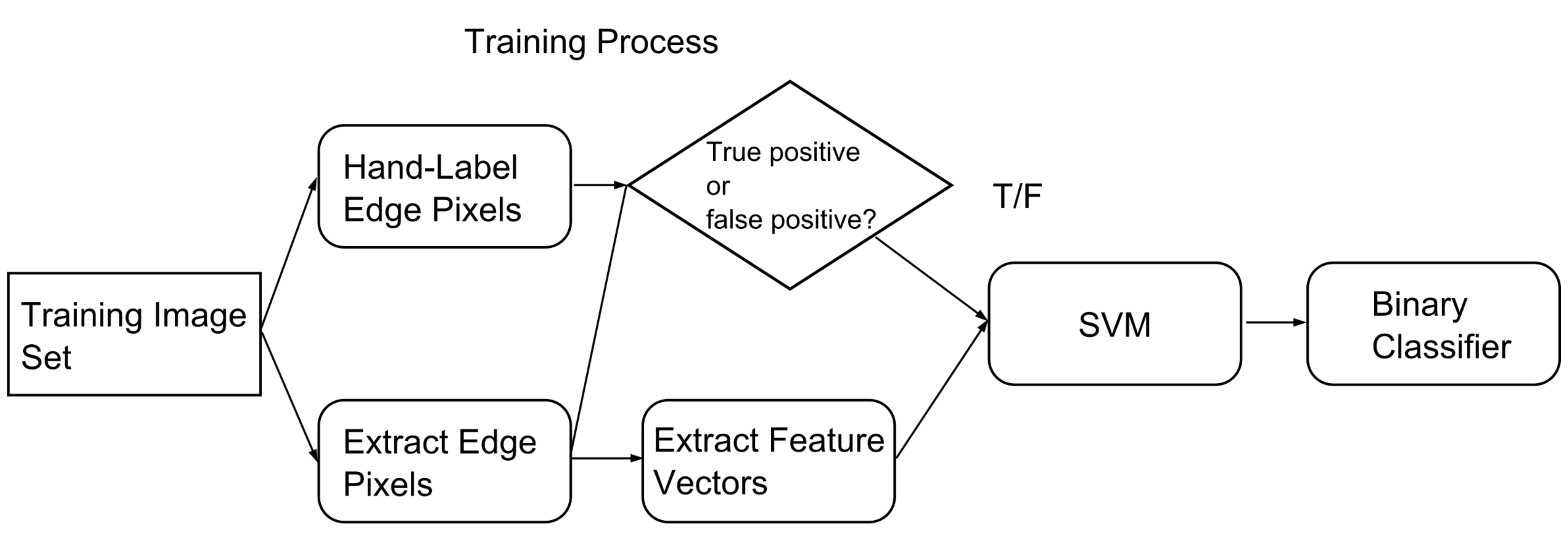
- Existing edge detection algorithms do not distinguish between contour and texture edges.
- Light artifacts can cause false edges



Existing edge detection methods. Hand labeled contour edges are in teal and texture edges are in purple

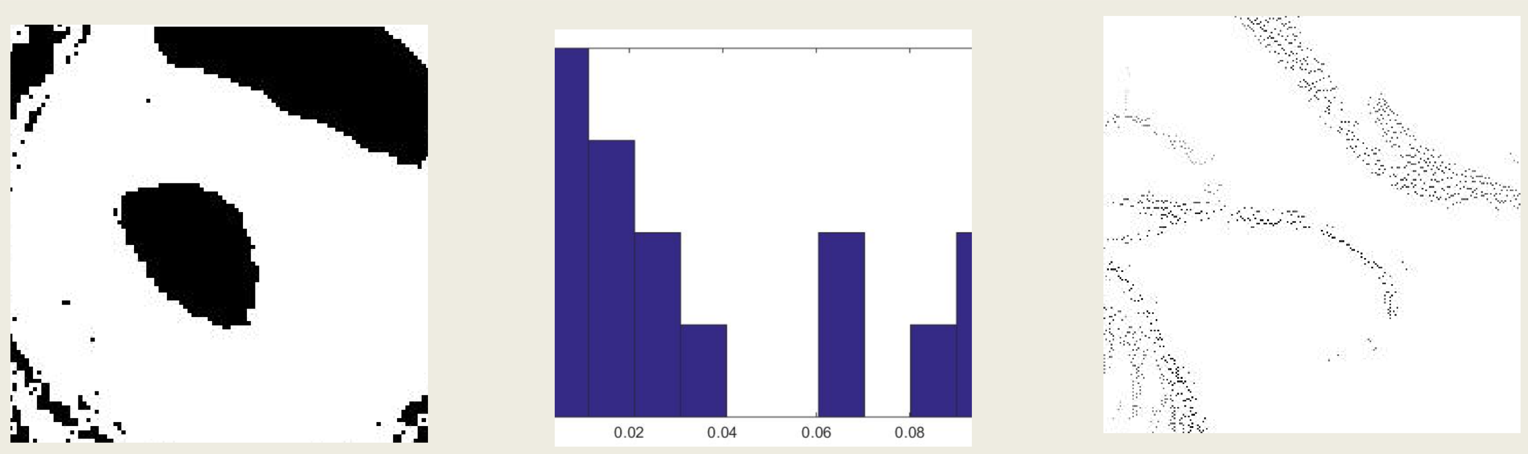
The Solution

- We used machine learning to classify detected edges
- The Support Vector Machine (SVM) was trained using 10 hand labeled ground truth images



SVM training flow diagram.

- We used 3 features for training:

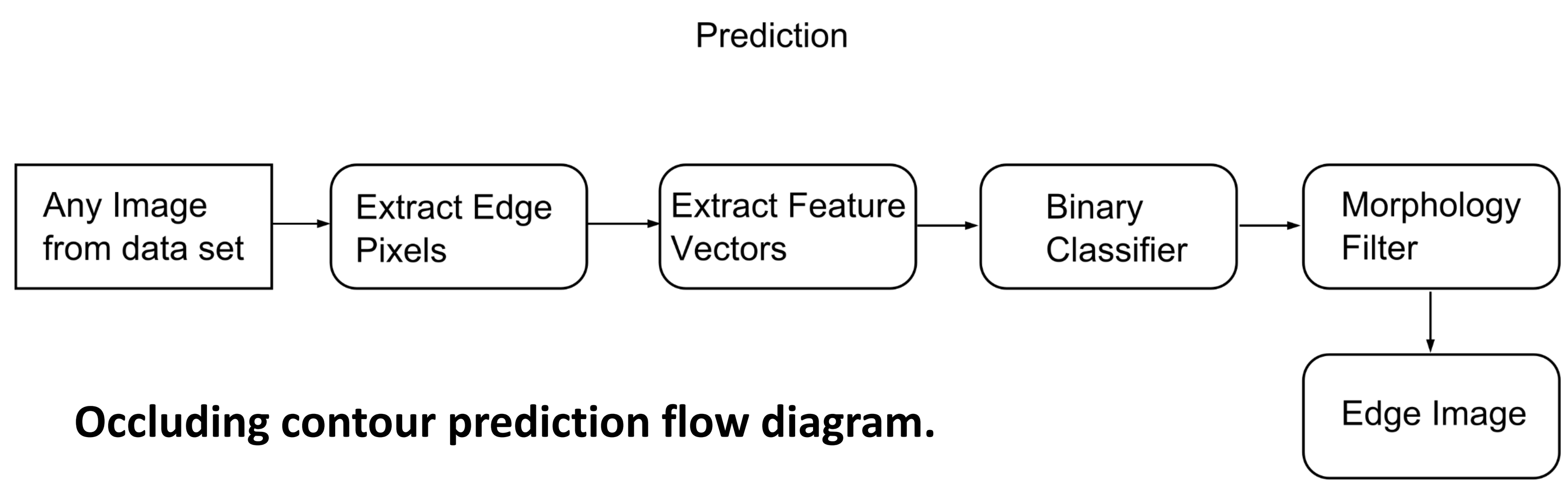


Gradients of a scaled down image

Local histograms of image values

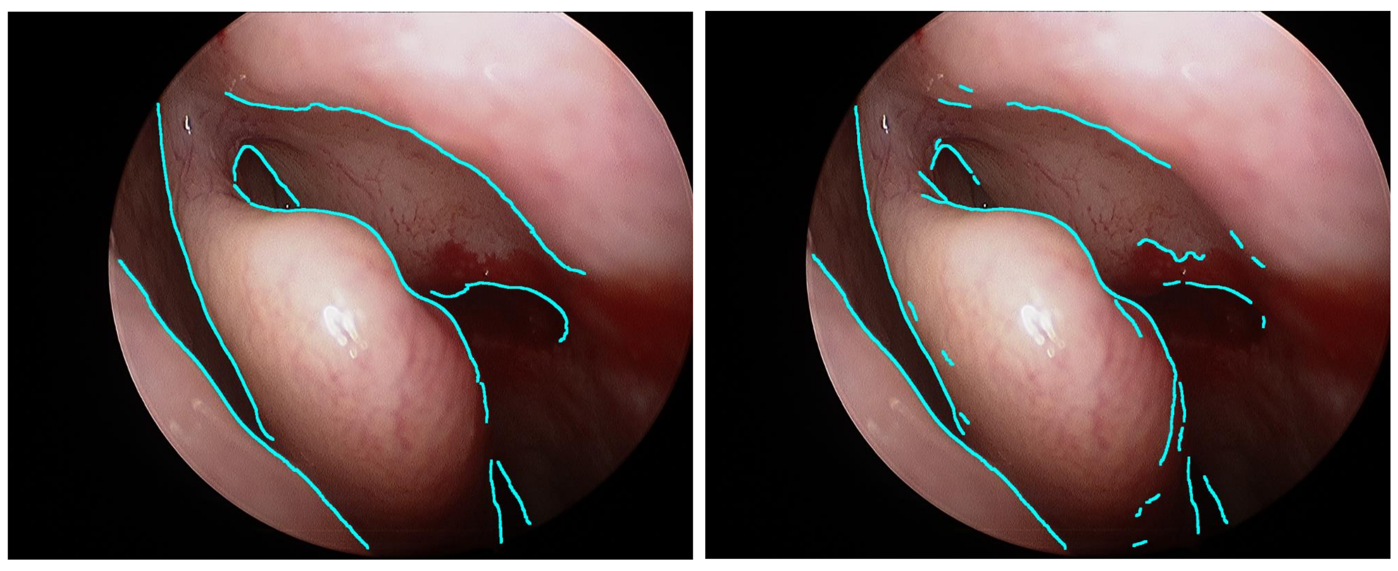
Local edge strength from histogram chi squared distance

- We then applied morphological filters to clarify edge lines
- We calculated the normal vectors for each edge pixels to be used in the registration algorithm



Occluding contour prediction flow diagram.

Outcomes and Results



	Frame 21	Frame 32	Frame 48	Frame 69
Average error per pixel	8.399	11.652	12.332	14.424
Median error per pixel	0	0	0	0

Top Left: Hand-labeled ground truth. Top Right: Edge detection result. The majority of detected points correspond to true edges. Bottom: Table of average error per edge pixel for four frames.

- We compared detected edges to hand-labeled truths and defined error as each edge pixel's distance from its corresponding ground truth.
- Our project outcome will assist in video-CT registration by providing the majority of true edges and very few false edges.
- We require that the overwhelming majority of detected points are edge points.

Future Work

- Identify other features that improve accuracy of SVM prediction
- Fully test integration with CT registration algorithm
- Create an augmented reality interface that informs surgeons of important landmarks, like nerves and other sensitive tissue

Lessons Learned

- Difficult finding the right parameters for initial edge detection
- Optical flow, which was an original metric we wanted to use, proved to be infeasible.

Credits

- John created the framework for SVM training and developed the scaled gradient feature.
- Kyle developed the intensity histogram metric, and increased efficiency of feature extraction programs.
- Calvin developed and optimized the local edge strength chi squared distance metric

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