Mixed Reality for Biopsy Site Localization

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Liam Wang (external to CIS II)

Mentors:
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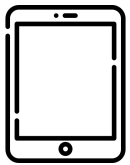
Dr. Ashley Antony
Dr. Jeffrey Scott
Dr. Kristin Bibee
Dr. Elise Ng

Project Overview

Skin biopsies are used by dermatologists to diagnose cutaneous ailments

The usual method of using photos to determine the biopsy site prior surgery is difficult, with physicians incorrectly identifying 5.9% of sites in a study [Mcginness, 2010]

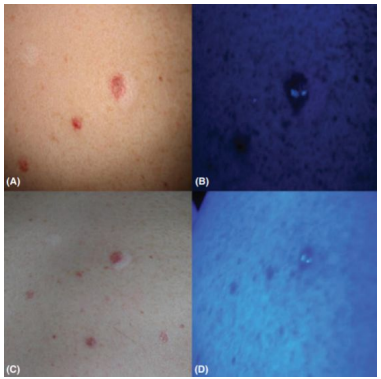


We aim to create a mobile augmented reality application that can provide dermatologists with additional guidance to locate the biopsy site

Previous Work on Biopsy Site Localization

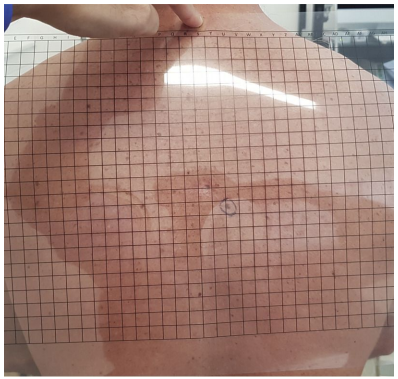
UV-Fluorescent Tattoo

Image and work: Chuang , 2011



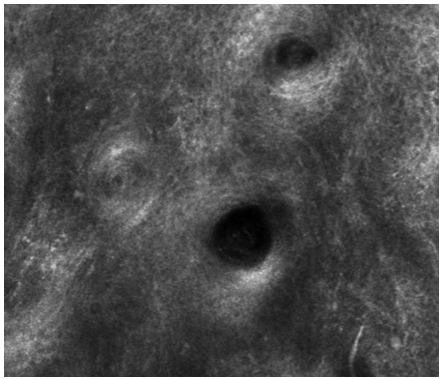
Transparent Grid

Image and work: Rajput, 2019



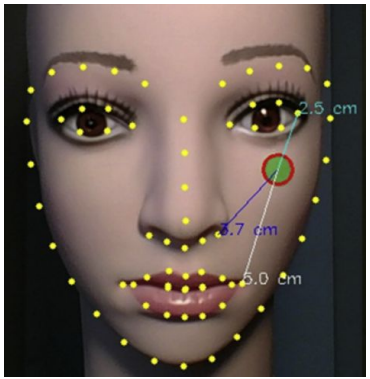
Confocal Microscopy

Image and work: Navarrete-Dechent, 2018



Facial Recognition + AR

Image and work: Timerman, 2020

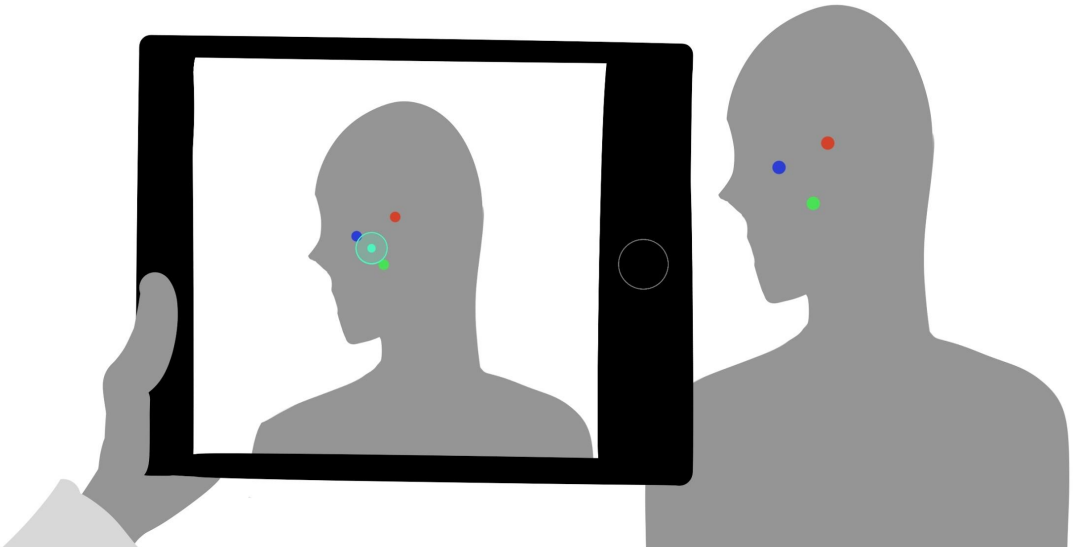


None have been incorporated into general practice yet!

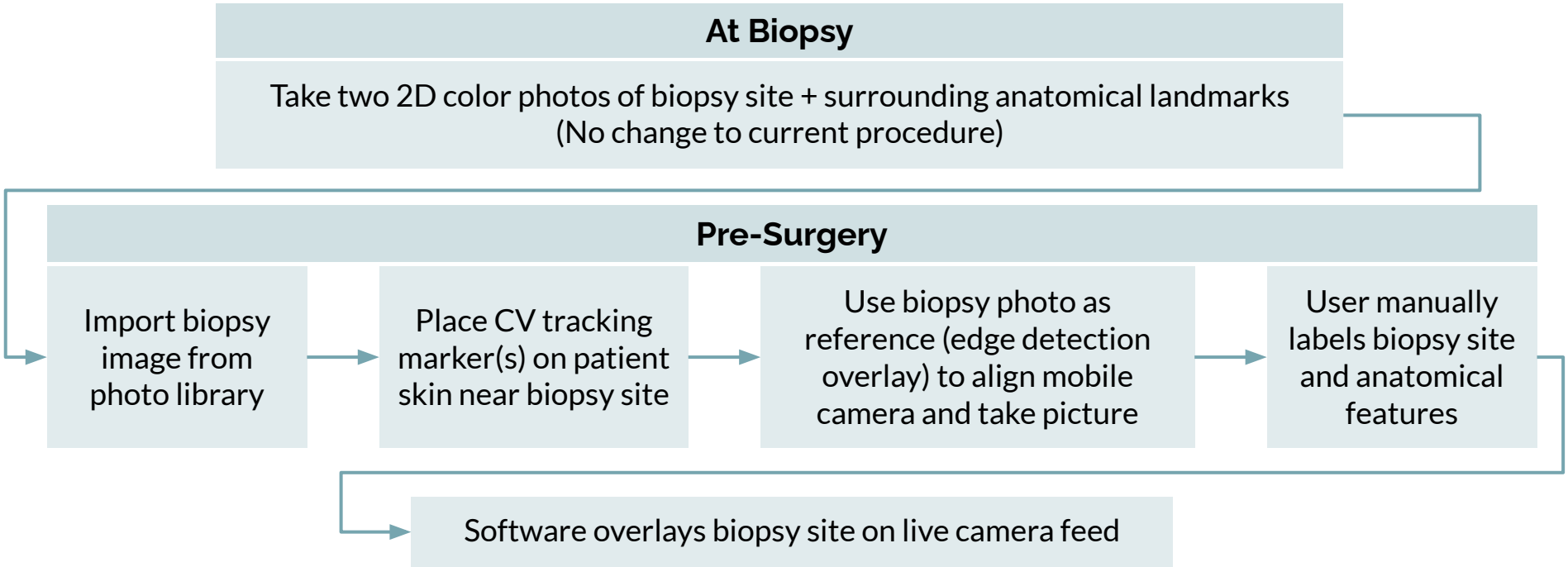
Our Goals

Create a mobile application to be deployed on a phone or tablet that can **overlay the correct site location** on a **live video** of the patient's skin

If successful, we can reduce the likelihood of incorrect site identification and thus reduce the number of or eliminate wrong-site surgeries.



UI Outline

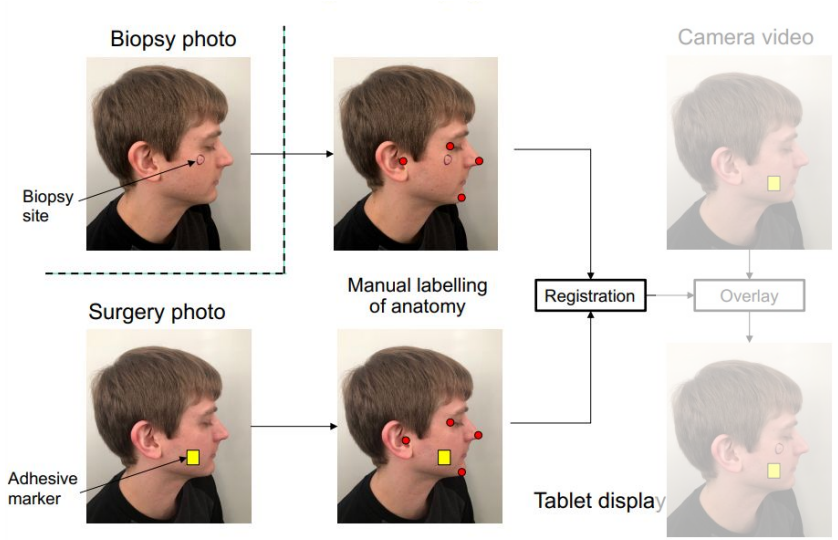

At Biopsy
Take two 2D color photos of biopsy site + surrounding anatomical landmarks
(No change to current procedure)
Pre-Surgery
Import biopsy image from photo library
Place CV tracking marker(s) on patient skin near biopsy site
Use biopsy photo as reference (edge detection overlay) to align mobile camera and take picture
User manually labels biopsy site and anatomical features
Software overlays biopsy site on live camera feed

Technical Approach - Registration Algorithm

Will implement the algorithm using Python on Windows 10 with OpenCV packages; can prototype with GRIP

- Input user clicks as pixel coordinates in both biopsy and surgery photos for biopsy site + tracking points
- Use feature detection (corners) near input points to find precise tracking points
- Find transformation using 2D-2D homography and create a circle/dot at predicted biopsy site

Testing: First register a biopsy photo to itself, check accuracy by ensuring marked position is the same as the true position, then try registration with biopsy and surgery photos at various locations



Technical Approach - Live Marker Tracking

We will use **colored stickers** as markers, which will be placed near the presumed biopsy location. This algorithm will also be implemented with OpenCV packages.

- Markers can be found using HSV thresholding
- Contours of markers can be found and filtered before being used to calculate the centroids
- The centroid points will be used to calculate the 2D transformation of the biopsy site for each frame

Calibration for lighting conditions:

- Take a picture from live feed and select a marker
- Pixel color of marker will be used to adjust HSV threshold

Technical Approach - Application Development

For an approach using XCode:

- Create Swift or Objective-C application with CocoaPods OpenCV dependency
- Use XCode storyboards and CocoaTouch for UI layout
    - Custom UIKit View for selecting points on images
- OpenCV has an iOS library that we plan to use for live AR tracking and overlay
    - Canny edge detection for helping user line up camera to take surgery photo from similar perspective as biopsy photo

Another option: Unity

- Better for cross-platform development

Deliverables

	Deliverable	Expected Completion
Min	Basic placeholder application	2/26
	Algorithm to register biopsy site photos to another photo / marked photos with documentation	3/5
Expected	Algorithm to track markers and overlay biopsy site to live video / video with tracking with documentation	4/2
	Error metrics to quantify accuracy of the live overlay	4/9
	Basic working interface with calibration overlay guidance with application documentation	4/2
Max	Completely functional mobile application with documentation	5/1
	Experimental data to quantify the geometric accuracy of our application	5/1

Dependencies

Dependency	Need	Contingency	Status	Planned Deadline	Hard Deadline
Biopsy photos from Dr. Antony	For testing the registration algorithm	Photos of ourselves	Met	2/19	2/26
Computer/internet access	For software development and communication	If technical difficulties — repair or use alternate device. Internet — mobile data.	Currently met	Continuous	Continuous
Mobile device	For testing mobile application	Use mobile device software simulators	Currently met	Continuous	Continuous
Platform to develop application	Platform that isn't specific to iOS or Android and able to develop on Windows and MacOS	If not possible for technical reasons, use XCode (MacOS dev only)	Met — Using XCode on Liam's Mac	2/26	3/5
Stickers	Markers for computer vision tracking	Print colored dots and tape them on	Met — Ruby has	3/1	3/15
Being able to load our application to an independent device	Independence would be useful for user testing, but iOS development restrictions may prevent easy deployment (may need a license or to stay plugged in to a computer)	Keep device plugged in, look for other methods of deployment, or buy license	Met — can use while unplugged	4/1	4/15

Timeline/Milestones

Registration and Tracking (Ruby)

Milestone	Expected Completion
Create basic I/O application to record user clicks on biopsy images	2/26
Finish algorithm to register biopsy site photos to another photo	3/5
Finish algorithm to track markers	3/15
Finish algorithm to overlay biopsy site to live video with marker and code documentation	4/2
Quantify accuracy of the live overlay with pixel error metrics	4/9
Acquire experimental data and quantify errors in real units	5/1

Mobile Application Development (Liam)

Milestone	Expected Completion
Create basic placeholder mobile application and determine how programs will interface	2/26
Create edge detection overlay for photography guidance and document code	3/5
Have a working UI to select points on images	3/15
Integrate photo registration and marker tracking into the mobile application	4/2
Complete and deploy final application with documentation	5/1

Team Management and Responsibilities

Students

- Ruby: Registration and live marker tracking software, wiki upkeep
- Liam: Mobile application development

Mentors

- Dr. Peter Kazanzides: Research Professor, CS
- Dr. Ashley Antony: Resident Doctor, Dermatology
- Dr. Jeffrey Scott: Assistant Professor, Dermatology
- Dr. Kristin Bibee: Assistant Professor, Dermatology
- Dr. Elise Ng: Assistant Professor, Dermatology

Will have **weekly** or **biweekly** Zoom meetings with Ruby, Liam, and Dr. Peter Kazanzides

Dr. Antony and other dermatology professors will join when available and as needed; can also email

Ruby and Liam will keep in contact over Slack

References

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