# IPHONE VIRTUAL REALITY TRAINING MODEL FOR MICROSURGICAL PRACTICE
# BME 400

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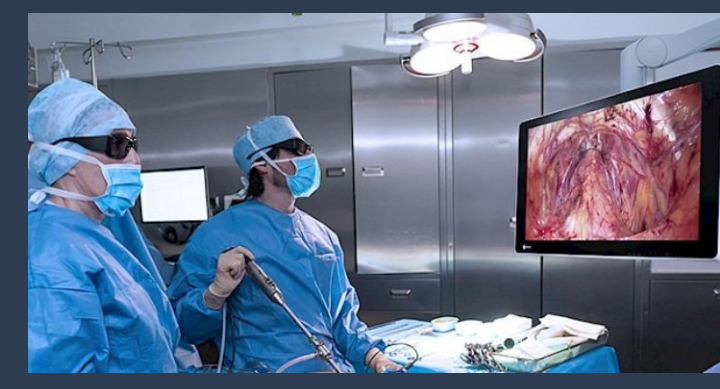**Client:** Dr. Ellen Shaffrey          **Advisor:** Dr. Willis Tompkins

## Abstract

Microsurgery is an important surgical discipline that employs the use of magnification along with specialized precision tools [1]. Due to the improvement of smartphone camera technology, smartphones have become a possible alternative to using the more expensive microsurgical magnification devices. As a result, Dr. Shaffrey and her colleagues have envisioned an application that will allow for the live streaming of a smartphone video camera image to a large monitor for microsurgical training.. The design team is currently in the process of designing an application that will efficiently and quickly live stream a smartphone video camera image and convert it to an anaglyph video for a microsurgical experience with proper depth of field.
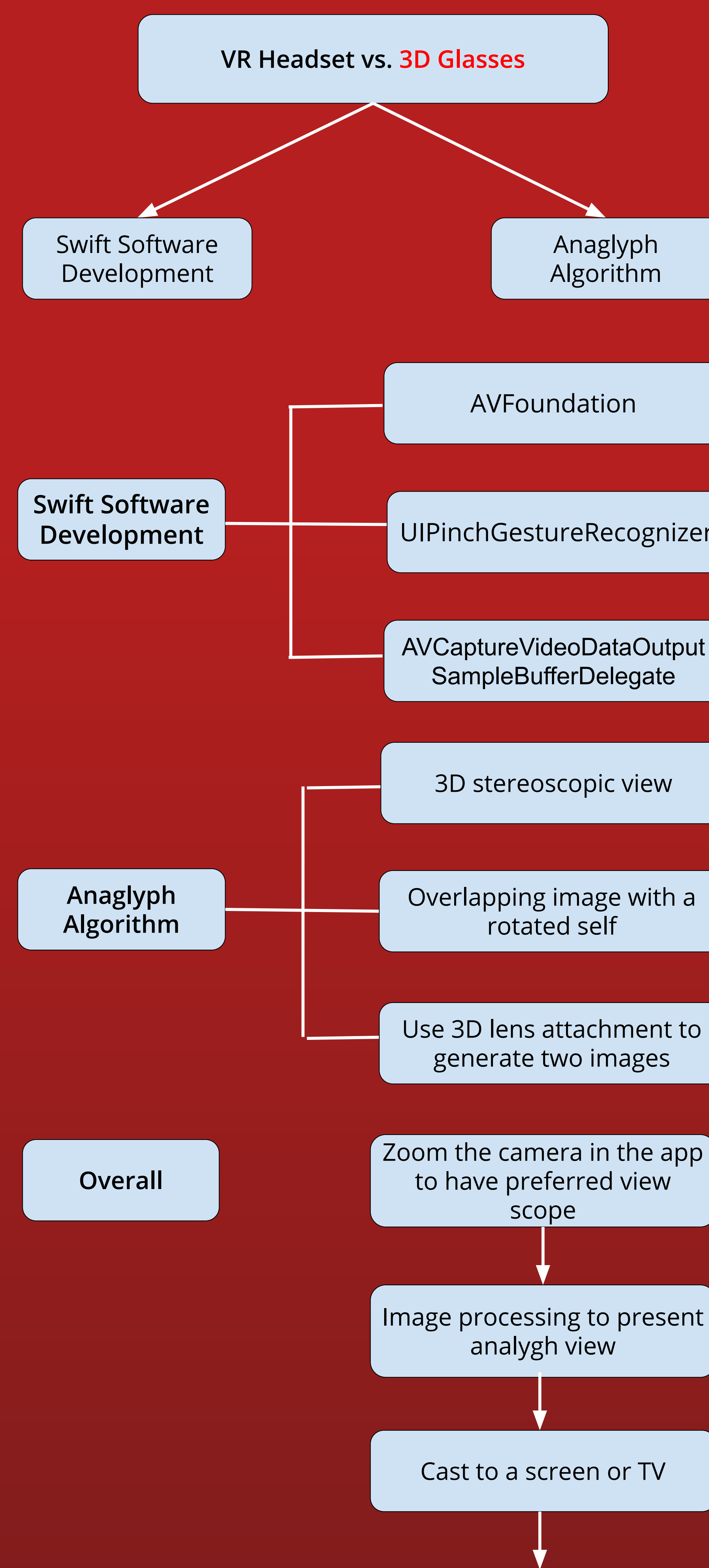
## Introduction

- Microsurgery
  - A surgical discipline that employs the use of magnification along with specialized precision tools to mainly do anastomosis on small blood vessels [1].
  - Cost of magnification devices
    - Ranges into the thousands of dollars
    - Causes financial issues when training microsurgical residents due to the limited availability of these magnification devices.
- Smartphone Cameras
  - Starting to reach the proper resolution qualities and zoom capabilities of current magnification devices
  - May be used as a training alternative to make practicing microsurgery at home cheaper and easier for residents.
- Previous Work:
  - Dr. Shaffrey and her colleagues have tested the feasibility of using an iPhone XR and iPhone 8.
  - Setup:
    - iPhone 8 and/or XR, 13" MacBook, 33" Articulating Arm Phone Mount Stand
    - Using QuickTime Player to stream live video
- Current Problems
  - The delay between the iPhone camera screen and MacBook screen can go up to 1 s of latency
  - There is a lack of depth of field

## Design Criteria

Client Requirements:
- Magnification of up to 5x
- Low latency between actual video and displayed video
  - Current Goal: < 100 ms
- Maintaining of high quality resolution
  - 4K resolution
  - 60 fps
- Depth Perception Effect
  - Anaglyph image conversion
    - The superposition of 2 images that are printed in different colors to produce a stereoscopic effect when

## Methodology



VR Headset vs. 3D Glasses

→ Swift Software Development
→ Anaglyph Algorithm

**Swift Software Development**
- AVFoundation
- UIPinchGestureRecognizer
- AVCaptureVideoDataOutputSampleBufferDelegate

**Anaglyph Algorithm**
- 3D stereoscopic view
- Overlapping image with a rotated self
- Use 3D lens attachment to generate two images

**Overall**
- Zoom the camera in the app to have preferred view scope
- Image processing to present analygh view
- Cast to a screen or TV

## Results

Successful use of anaglyph image application, how effective the 3D effect is still requires testing:



Tests using the expected video quality and a much simpler video:



The higher quality video from the iPhone resulted in a processing speed of ~2.4 frames/sec in contrast to the low quality video's native 15 fps.
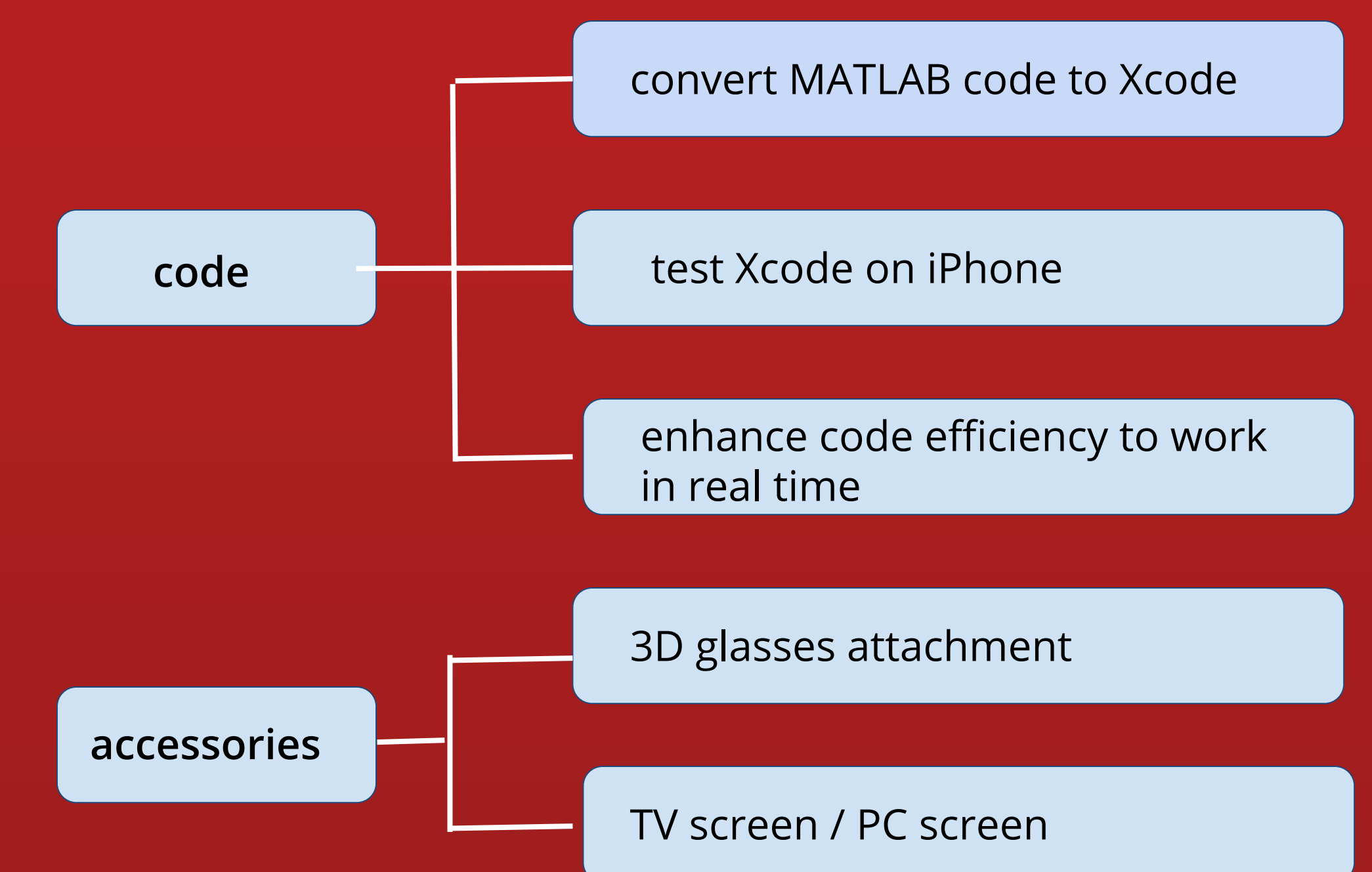
## Discussion

Camera Access Part:
- The basic camera function of the application is achieved successfully. Once installed on the application, permission will be asked to get the access of the camera.
- The user interface of the application is simply the camera view.
  - Different from the other camera applications, we do not have the bottom for take photos so that the display looks clear for 3D image.
  - However, there are two white edges on the top and bottom of the display. This might be solved by using non full screen display smartphones such as models before iPhone X.
- The users are allowed to pinch on the screen to magnify the camera view. The camera access application has the same magnification as the system's built in camera application.

Anaglyph Video Conversion:
- Anaglyph images can be easily made, and the same program is used to turn images processed from video into anaglyph.
- Higher resolution video at a higher frame rate is more difficult for both software and hardware to handle, which results in a slower processing rate for the code. Further optimization of code and more testing of computer hardware is necessary.
- For testing purposes, it is easier to use Matlab code on a computer to run the program. However, this Matlab code will need to be packaged in XCode to run on an iPhone 8/iPhone XR. Only one member of the team has a Macbook capable of programming in XCode and an iPhone 12 that can be used as a testing platform. Because of the general unfamiliarity with programming in XCode and the lack of widespread hardware, transferring the program to its target format has been taking some time.
- The testing device for the program has been a Windows 7 computer with 16.0 GB of ram and a processor running at 3.40 GHz. The iPhone 8 has 2 GB of ram as standard with a 2.39 GHz processor while the iPhone XR has 3 GB of ram with a 2.49 GHz processor. Performance in the target testing environment may differ.
- The anaglyph program can save the anaglyph images back

## Conclusion

Affordable and effective surgical microscopes have the potential to significantly improve disease detection rate in undeveloped countries where diagnostic laboratories are scarce [1].The client has an iPhone-VR model with two cell phones, VR glasses and lightning cable connection, which is unable to reach the minimum latency required by the microsurgery.
A simple streamlined iPhone-VR microsurgical scope is proposed to provide resident surgeons opportunities to improve eye-hand coordination at home. The model consists with an active 3D glass, an iPhone, and a projection screen. Compared with the VR model, this 3D glass model requires less devices and permits large screen view. An IOS app is developed to access the real-time recording from the iPhone camera and generate 3D stereoscopic videos by anaglyph algorithm.
Due to lack of hardware, the anaglyph code is developed and tested in MATLAB. The current video processing speed is 2.4 frames/sec and resolution is at 1080p.

## Future Work

**code**
- convert MATLAB code to Xcode
- test Xcode on iPhone
- enhance code efficiency to work in real time

**accessories**
- 3D glasses attachment
- TV screen / PC screen

## Acknowledgements

Dr. Willis Tompkins
Dr. Ellen Shaffrey

## Sources

Microsurgeon.org. 2020. Microsurgery Definition. [online] Available at: <https://www.microsurgeon.org/microsurgerydef#:~:text=Microsurgery%20is%20a%20surgical%20discipline,veins)%20and%20to%20coapt%20nerves.>