IPHONE VIRTUAL REALITY TRAINING MODEL FOR MICROSURGICAL PRACTICE

BME 402

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Abstract

Microsurgery is an important surgical discipline that employs the use of magnification along with specialized precision tools. Due to the improvement of smartphone camera technology, smartphones may have become an alternative to expensive microsurgical training systems. The team worked in developing an application that will will allow for the live streaming of a smartphone video camera image to a large monitor for microsurgical training. The design itself includes the live conversion of the smartphone captured video into anaglyph for depth perception elements to be visualized by the user. Using Apple's Swift software package, the team was able to produce an application that utilizes live anaglyph conversion techniques to be used in a microsurgical training setting.

Figure 1. Surgeons conducting 3D Endoscopy [3]

Introduction

- Nearly 2 billion people worldwide lack access to basic surgical services, and the burden is highest in the poorest countries of the world [1]
  - Surgical conditions treated by plastic and reconstructive surgeries make up a large portion of the global surgical burden [1]
- Availability of Magnification Devices
  - In developing countries, it is more difficult to obtain access to operational microscopes for microsurgical training [1]
- Benefits of Training
  - Offers a better understanding of texture, shape, and gentle handling of different tissues [2]
  - Enhances surgical precision and highly refined manual dexterity [2]
- Cost of Magnification Devices
  - The Olympus Orbeye, a videomicroscope, can range from $200,000 to $1 million
- 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.

Design Criteria

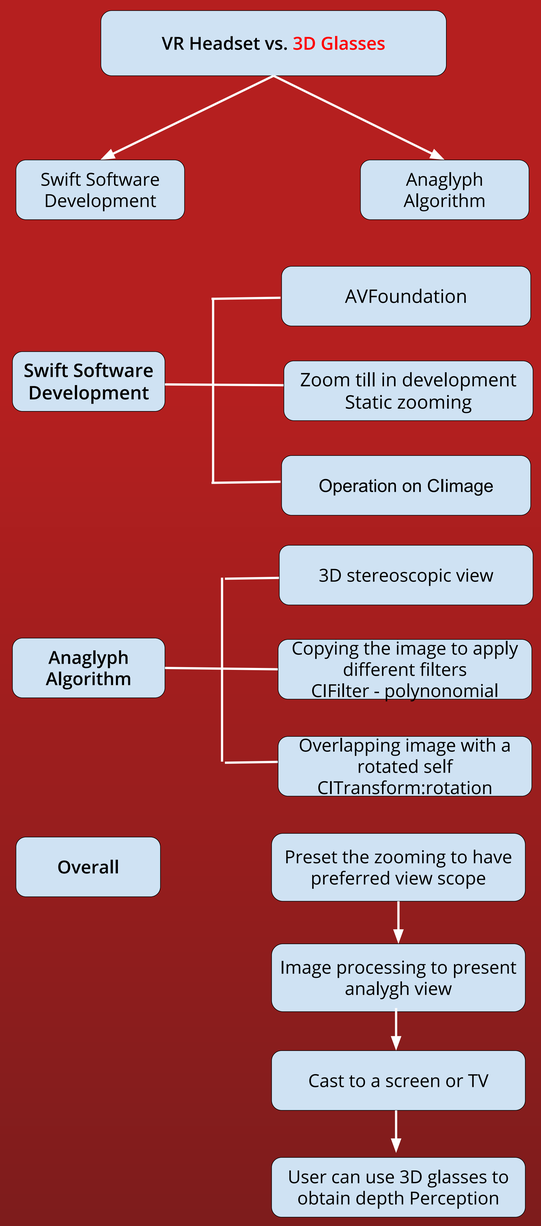
Problem Statement: The project was aimed to integrate smartphone camera technology into an easy-to-use application containing depth perception producing techniques that allow for quick and accurate microsurgical training.

Requirements:

- Magnification of up to 5x
- Low latency between actual video and displayed video
  - Achieved: 130-150 ms
- Maintaining of high quality resolution
  - 4K @ 60FPS
- Depth Perception Effect
  - Anaglyph image conversion
    - The superposition of 2 images that are printed in different colors to produce a stereoscopic effect when the photograph is viewed through specialized glasses

Methodology

Figure 2. Schematic of the two preliminary design we proposed. A) Flow diagram of the VR goggle model. B)Flow diagram of the 3D glasses model.



Results

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

Figure 3. Testing Image in Matlab(left) and Swift(right)

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

```
General Properties:
           Name: 'Jiong.avi'
           Path: 'C:\Users\User1\Documents\MATLAB'
       Duration: 2.1595
    CurrentTime: 0
      NumFrames: 63

Video Properties:
          Width: 1080
         Height: 1920
      FrameRate: 29.9700
   BitsPerPixel: 24
    VideoFormat: 'RGB24'
```

```
General Properties:
           Name: 'Rabbit.avi'
           Path: 'C:\Users\User1\Documents\MATLAB'
       Duration: 125.9407
    CurrentTime: 0
      NumFrames: <Calculating...> learn more
                 Expected: 1890 frames
Video Properties:
          Width: 320
         Height: 240
      FrameRate: 15.0000
   BitsPerPixel: 24
    VideoFormat: 'RGB24'
```

Figure 4. Matlab testing analyzing video resolution

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.

The filter has at most a very minor effect on latency, with an average of 0.15s of delay over 3 trials between what happens and what it shows compared to the camera's 0.13s of delay.

Discussion

Camera Access Part:

- Fundamental function
  - Display camera feed with permission
  - Magnification achieved, but requires optimization
    - Dynamic zooming
    - Static zooming
- Overlay of images
  - Rotation angle
  - Filter color
  - Crop region

Figure 5. Theoretical zooming after filter

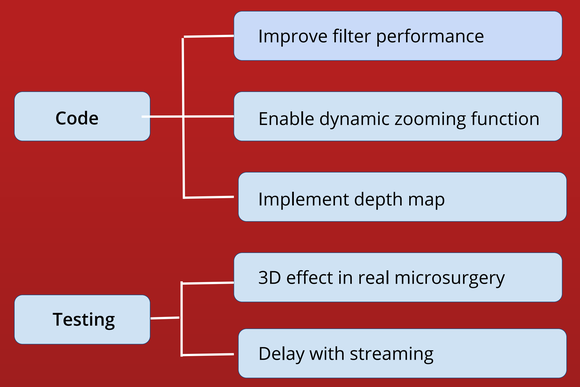
Anaglyph Video Conversion:

- First stage of testing using MATLAB
  - More powerful testing environment
  - Familiar programming language
  - Incapable of real-time processing of high resolution video
- Second stage of testing using Xcode
  - Slow development
  - Latest generation testing environment
  - Real-time video processing
    - Latency similar to natural phone camera delay
  - Still requires refinement

Conclusion

- Simple streamlined iPhone VR system is able to assist in the improvement of eye-hand coordination for microsurgery.
- Implementation of camera access
- Implementation of anaglyph algorithm to create 3D effect
  - image rotation
  - color filter
- Implementation of zooming function
- Reduced cost
- Negligible delay

Future Work



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Sources

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J. Villa, S. Amillo, and G. Vinagre, "Microsurgery Training: Does It Improve Surgical Skills?," Journal of Hand and Microsurgery, vol. 09, no. 01, pp. 047–048, 2017. [2]

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