Virtual Reality Headset for Endoscopy and Microsurgery

Team Members: Tom Geissler, Sam Peters, Sam Simon, Josh Niesen, Sam Schini, Jacob Cohn
Clients: Dr. Azam Ahmed
Advisors: Dr. Willis Tompkins

UW BME Design

ABSTRACT

The application of endoscopic techniques to endonasal skull-based surgery has become increasingly prevalent as the technology has improved. While endoscopic techniques offer many benefits over traditional methods, the surgeon does not have the same degree of immersiveness and visualization compared to traditional methods. Attempts have been made to address this by using virtual reality, however, there currently is no method for the surgeon to visualize the operating room without completely removing the headset. Our design allows the surgeon to view the operating room through external cameras on the headset that are activated when the surgeon rotates their head superiorly.

PROBLEM STATEMENT

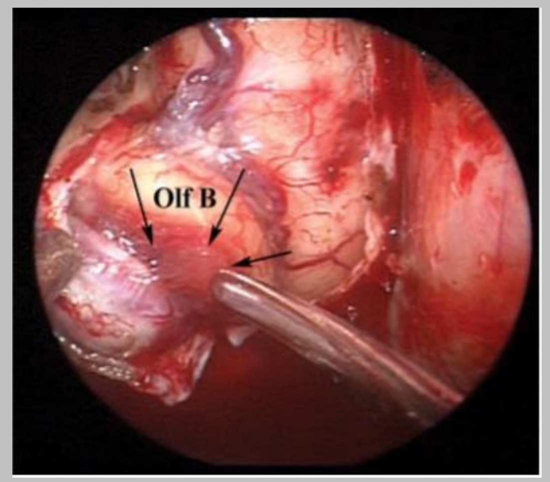
Design Motivation:

- Lack of immersiveness and visualization with existing endoscopes compared to traditional surgical loupes as stated by the client
- VR provides a superior visual platform to 2D monitors, but is not compatible with endoscopic imaging
- Surgeons must remove the headset to see their surroundings

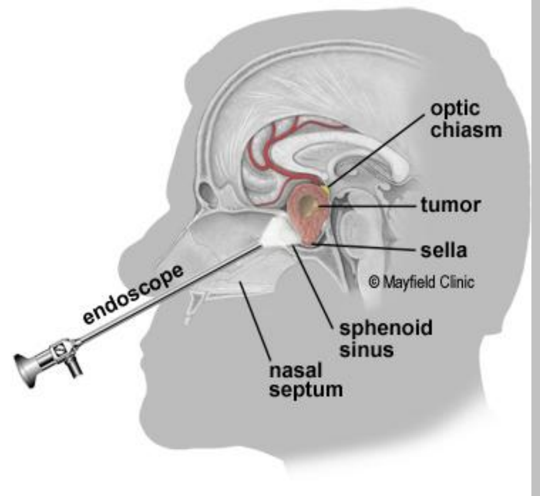
Objective:

Create a virtual reality system that will increase the immersiveness of the endoscopic visualization and will allow the surgeon to switch from the endoscopic to operative view hands free.

BACKGROUND



[Figure 1] Endoscopic View [4]



[Figure 2] Endonasal Approach [5]

- Endoscopy is a minimally invasive surgical procedure in which a thin, flexible camera is fed through a small incision in the body
- Endoscopic endonasal (EEA) surgery uses the nostril as a natural access point to skull-based tumors
- Video feed is traditionally projected onto a monitor near the surgeon, often amplifying strain on the neck over a 10+ hour procedure [1]
- Patients undergoing EEA are prone to excessive bleeding, CSF leakage, and the severing of critical neural connections [2]
  - A high level of immersiveness and low level of video lag are required to minimize complications [3]

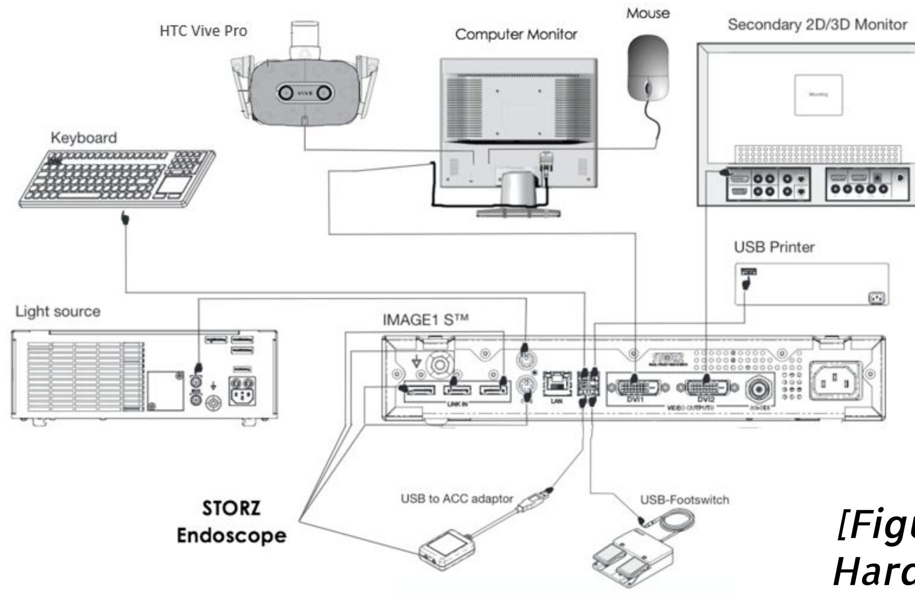
DESIGN CRITERIA

- Comfortable - surgeries are 10+ hours in duration
- Hands free and user friendly
- Reliable
- 1080p HD image quality
- Lag time less than 50 milliseconds

FINAL DESIGN

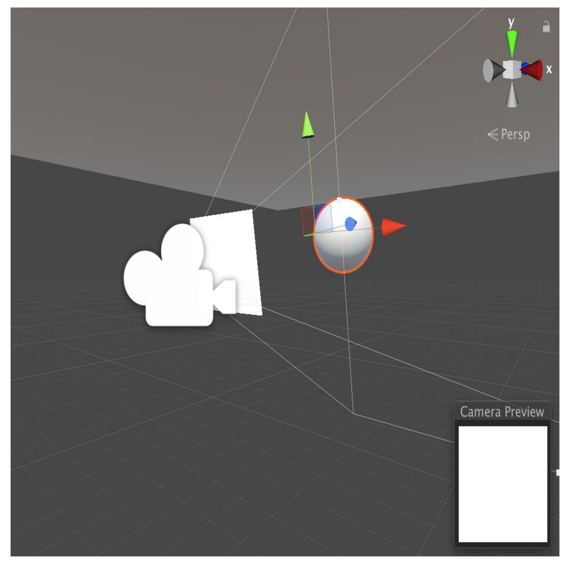
Hardware

- Modifications do not interfere with the existing setup
- A wireless headset adaptor may be purchased so the surgeon is not restricted to the vicinity of the computer

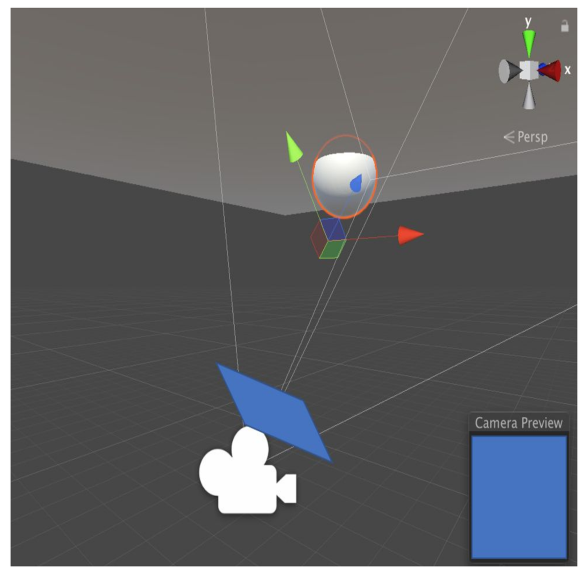


[Figure 3] Hardware Diagram

Software



[Figure 4] Pre-collision



[Figure 5] Collision changes camera

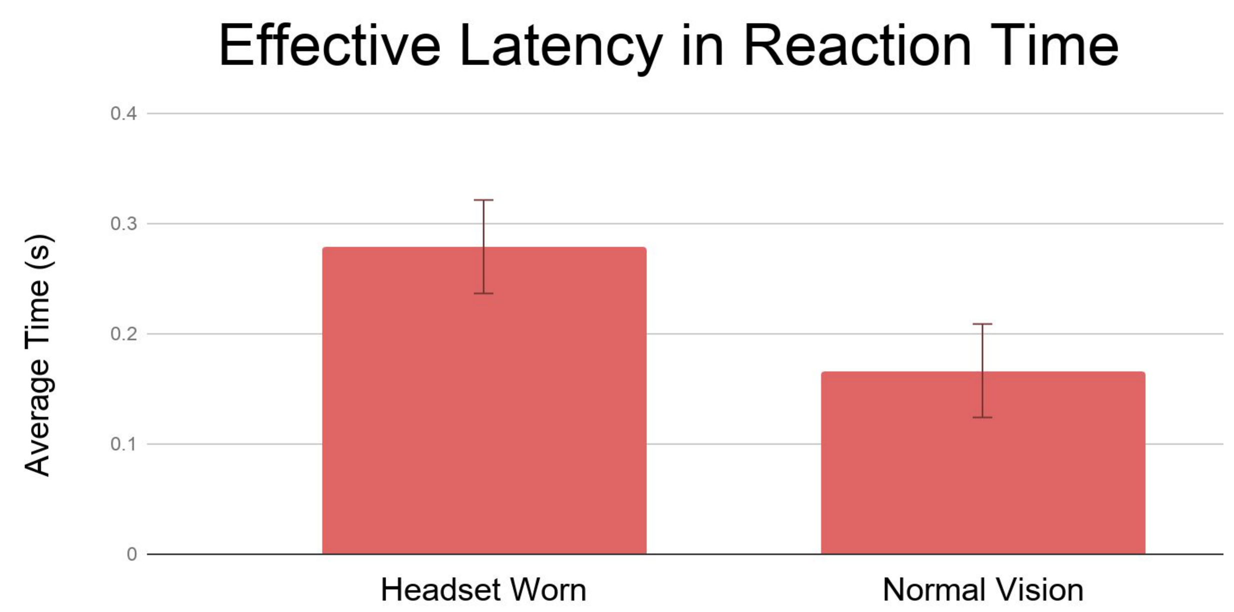
Software Tools:

- Unity
- C#

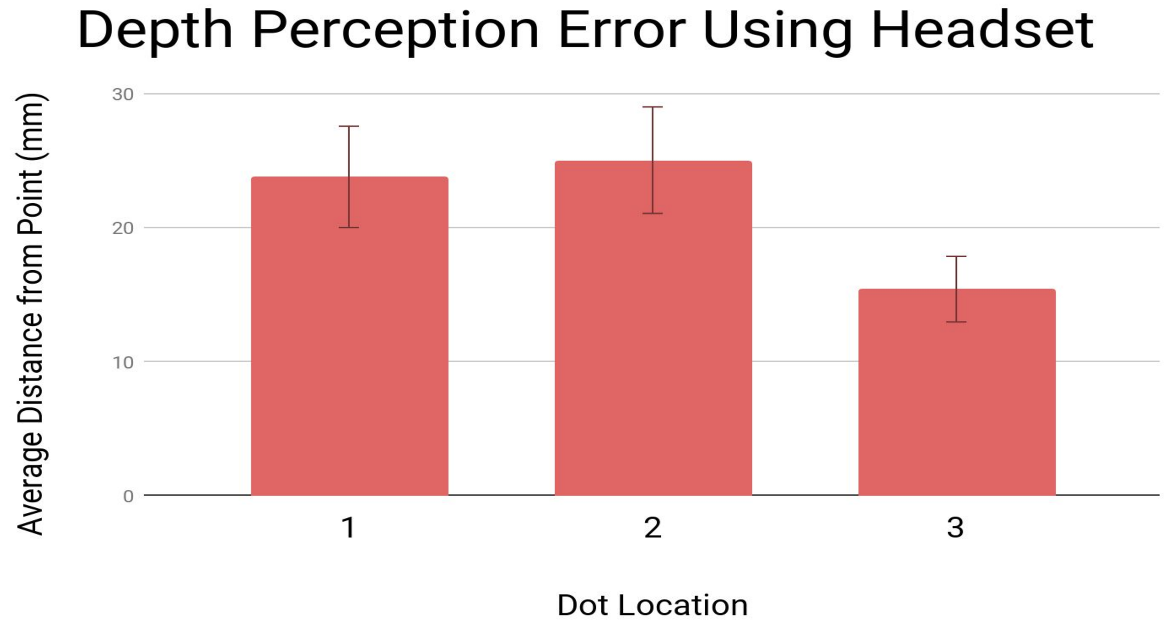
Mechanics of Program:

- Sphere attached to camera frame
- Upon sphere collision of plane, current camera is paused, alternate camera is activated

TESTING AND RESULTS



[Figure 6] Effective latency in reaction time both with and without the headset. Determined through a reflex drop test.



[Figure 7] Depth Perception per dot location. Location 1 was placed the length of elbow to hand away from the body. Each subsequent dot was 10 cm farther away distally.

[Table 1] 2 - Sample T-Test with a significance level of .05

	With Headset	Without Headset
Mean	15.4375	5.5
Variance	19.24599359	5.256410256
Observations	40	40
Pearson Correlation	-0.098785296	
Hypothesized Mean Difference	0	
df	39	
t Stat	12.21151575	
P(T<=t) one-tail	3.34612E-15	
t Critical one-tail	1.684875122	
P(T<=t) two-tail	6.69224E-15	
t Critical two-tail	2.02269092	

[Figure 8] Effective Latency Test

[Figure 9] Depth Perception Test

DISCUSSION

- Installing VR in the operating room will:
  - Eliminate bulky monitors in the operating room
  - Remove discomfort and visualization issues prevalent in traditional methods
  - Provide a highly immersive experience
- Although designed for endonasal skull-based surgery, the software can be applied to any endoscopic aided surgery
- Upon testing, questions that arose:
  - Reliability of the headset's location sensor
  - Depth perception using the dual camera HTC Vive Pro
  - Extended duration user testing

FUTURE WORK

Improvements:

•Improve depth perception and image quality
•Customizable trigger – user friendly way to customize the head movement that initiates the switch between views
•Make the system capable of handling a 3-D input
•Add a mechanism that will adjust the zoom on the endoscope hands free

Testing:

•Further validation of the system's reliability
•Ergonomics test to check practicality of wearing headset for duration of surgery

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