Executive Summary: BME Design Excellence Award, BME 301

iPhone Virtual Reality Training Model for Microsurgical Practice

There is an ever-growing need for microsurgeons, but resources available for training tend to be hard to access and expensive. It can be difficult, costly in time, and expensive to travel to a medical center where these resources are available. Especially during the COVID-19 pandemic, it has been proven that virtual training is advantageous and preferred for medical students. The team has been tasked with making it easier for microsurgery students to practice by designing a training tool that uses a smartphone lens, is capable of creating depth perception, and has a high quality resolution comparable to a surgical microscope. The team's design will try to emulate the experience of performing surgery through professional microscopes used in the surgery room but at a small fraction of the cost.

Departing from the software approach used by previous design teams, the team decided to adopt a hardware approach to effectively reduce the time lag when streaming the microsurgery training to the end user. After the initial literature research, the team proposed three designs and decided the most optimal one based on a design matrix that comprehensively evaluated the feasibility.

The team proposed a novel "splitting mirror design," in which two pairs of mirrors split the single lens on a smartphone into two identical views of the same object, mimicking the process of viewing the same object with two eyeballs to create depth perception. The team utilized MATLAB and ray tracing diagrams to determine the exact parameters in the prototypes, which includes a 3D-printed housing with laser-cut mirror pieces. The prototype can be fixed to the smartphone with rubber bands.

Prototypes were mounted to the smartphone, which was placed 20 cm away from the working station. The smartphone recorded the station, and another smartphone was inserted to Google Glass, from which the user viewed the station via Zoom meeting. The clients and all team members were asked to move five pieces of sutures from one place to another, and the time to perform the test was recorded. Then a similar test was performed with clients' microscopes. Time spent with both methods were compared, and the time lag during streaming was measured via frame-by-frame extraction of the video recorded from the attachment. More tests will be performed with the new prototypes and to evaluate the image quality. More testing protocols may be proposed, yet the current ones are sufficient to test the feasibility of the design.

The key aspect of the design requirements was to achieve depth perception in the field of view. This was achieved at the level of zoom that was hoped to be achieved. This is a vital characteristic of a microscope for practicing microsurgery. However, the field of view has some areas for improvement such as points in the field of view where edges of mirrors are visible and create blind spots on the lens. Once the housing has been created to be sturdier, the prototype will meet most of the most important requirements of the problem statement. However, some areas for improvement include the comfort of the product and the latency of the video projected to the monitor or headset.

This device will allow medical students to practice microsurgery without the need of a surgical microscope. These microscopes are very expensive and difficult to access especially in the COVID-19 pandemic. The design will eliminate both of these inconveniences as the iPhones are very commonly used. By increasing the ability to train, more microsurgeons will be ready to operate to meet the ever growing demand.