ENDOSCOPIC SPINE TRAINING SIMULATOR

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Abstract

The medical field has had recent advancements in minimally invasive spinal surgeries enabled by endoscopic cameras and tools. The ability of a surgeon to be proficient in the methods lying in the procedure prior to performing the surgery is pivotal for the success of the surgery and confidence of the surgeon. Due to decreased patient recovery time, there has been a drastic shift from general surgery to endoscopic surgery. Most neurosurgeons have not practiced the hand-eye coordination skills required for this type of procedure as current methods for this type of hand-eye coordination training are expensive. For this project, we are designing a low cost, easily translatable endoscopic spine trainer for surgeons to use to master the techniques of popping membranes, sweeping away tissue, and general camera maneuverability.

Background and Motivation

Motivation

- Hospitals with low funding do not have sufficient funds to access costly surgical trainers
- Other endoscopic simulators, such as the Spine Mentor cost upwards of $65,000 [1]
- Many countries have limited spending on health care and require lower cost training options

Anatomically correct endoscopic spine trainer [1]

Background

Cannula Placement:

- X-rays and fluoroscopy are used to guide the cannula into place
- Neurosurgeons utilize this proceed in may surgeries
- Disconnect lies within the 30° angle of the endoscopic lens
- Hand eye coordination must be fine-tuned to yield successful results

Endoscopic Spine Surgery [10].

Design Criteria

- Must be equal to or smaller than 7.5x4x11 in cardboard box
- Separate areas for each of the three tasks
- .75 diameter holes to accommodate endoscope
- Website that provides guides on how to construct the trainer
- Blog for surgeons to communicate and share results of their trials with the box
- Must not exceed 5 lbs in weight (Final weight - 0.8 lbs)
- No 3D printing allowed
- Box must last up to one year without needing replacement
- Must be able to be constructed for under $200
- Tasks must be easily replicable for each trial

Final Design

Overall design

Inside of the Sweeping Task

Sweeping Tissue Task:
The surgeon uses the sheath (large straw) to maneuver muscle tissue (cotton balls) and maneuver around bones (colored straws) on the way to a final target. They then clears as much tissue as possible from in front of the target to create a larger working space. Image registration allows user to know what percentage of the target is clear

Camera Maneuverability Task:
Tasks completed in this section include:

- Camera rotation to specific angles
- Centering the camera in terms of the target
- Adjusting distance from target while maintaining a level view

Using image registration code the user will gain feedback about what angle the camera is at as well as how far away they are from the target.

Inside of the Camera Maneuverability Task

Inside of the Popping Membrane Task

Popping Membrane Task:
For this section the surgeon uses the sheath with a needle on it to tear through the latex (third ventricle). They then need to maneuver enough of a hole to get the endoscope through. This equates to the experience and feel of the third ventricle during surgery and gives the surgeon the experience of manipulating membrane and using a tool.

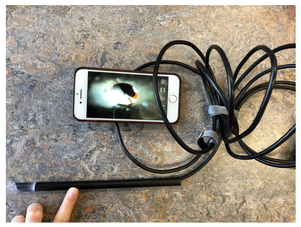
Global Applications

Our website

- Step by step video guide on how to assemble trainer
- Hard copy of step by step guide available for download

DEPSTECH Camera

- WiFi capabilities
- Can connect to any smart phone in the world
- Record video and gives live feedback



Our endoscope setup

This is an example of one of the endoscopes that might be used in surgery [9].

Testing and Results

Testing

- Client tested and timed
- Created for playback to allow for visual representations of design flaws
- Tasks were timed and recorded on our website
- All members performed 3 trial runs of the sweeping tissue task

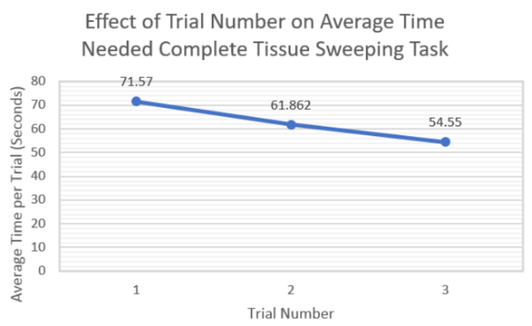
Results

After test one:

- Membrane ripping tool should be replaced with a needle.
- Simply ripping the membrane was not representative of a third ventriculoscopy
- Task needed more feedback

Brooks provided qualitative feedback:

- Resistance of various materials to mimic membrane
- The rigidness of the sheath
- Visibility of target do to lighting circumstances
- Resistance of straws compared to actual resistance of hard bone

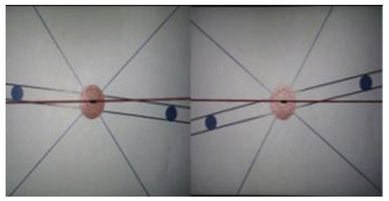


N=4, trial3/(trial1-trial3) X 100. 29.01% improvement

Future Work

Updating Code

- Update code to perform more accurately under the limited light source inside the box



Example of the software that would interpret how far the endoscope is from horizontal[8].

Finish Membrane Task.

- Format a task that would require the surgeon to maneuver a “herniated disk” through the membrane for efficient removal
- Find material that would best represent a herniated disk
- Find a better way to switch out the membrane

Overall Quality

- Extend battery life of the endoscope to allow for multiple trial runs
- Incorporate 30° angled lens discrepancy
- Obtain more feedback on precision, accuracy and convenience

Future Tasks

- Incorporate a new task which tests coordination while using sheath as a tool
- Graphite attached to the end of the sheath for the ability to write on trainer walls to test surgeon stability
- Graphite will also test surgeons ability to control pressure applied by being easily breakable

Website Creation

- Work on an interactive version of the website
- Allow users gain feedback on their own scores
- Provides a space for users of the trainer to communicate

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