Virtual Reality Simulator: Product Design Specifications

September 20, 2011

Client: Professor Robert Radwin
Team: Ashley Mulchrone, Spencer Strand, Katie Jeffris, and Patrick Hopkins
Advisor: Professor Tom Yen

Problem Statement

All surgeons, no matter what experience level, require practice in order to achieve positive outcomes when going into surgery. Currently, carpal tunnel syndrome release surgery is only performed on cadavers or live patients. As the cost of cadavers is quite expensive, especially for this simple of a surgery, a better practice method is in need. An ideal substitution would be an anatomically accurate simulator with realistic haptics. In previous semesters, a simulator was designed by interfacing a life-like hand model with computer software to display images of the inside of the hand and wrist to create the most realistic experience possible. The goal is to further this prototype by adding in special case scenarios that could possibly occur during a real surgery, in addition to furthering the current capability of the range of motion of the camera.

Design Requirements

1. Physical and Operational Characteristics
    a. *Performance requirements*: The simulation should be as life like as possible to the actual surgery. The force feedback provided by the hand model should replicate the forces experienced by the surgeon, and should increase when the blade is deployed. The endoscope images should represent the depth and angle experienced by the surgical tool, and should create a smooth transition.
    b. *Safety*: The simulation should not cause any harm to the surgeon or any of the connected devices.
    c. *Accuracy and reliability*: Signaling device should detect position within 1 mm. The tracking system should maintain accuracy of position throughout multiple simulations. The force feedback mechanism should provide a consistent amount of force in each simulation.
    d. *Life in service*: Simulator needs to withstand at least 5 years as a training tool.
    e. *Operating Environment*: The device will be used in standard conditions. It will not need to be sterilized.
    f. *Ergonomics*: All forces and components should replicate those felt when performing the actual surgery. The external circuit should also be positioned so that it does not interfere with the surgical technique.
    g. *Size*: Hand model should be life size and the incision site should be 5 mm proximal of the distal wrist crease. The carpal tunnel should be 1 cm in diameter. The transverse carpal ligament should be 5 mm thick. The ligament corrugations are 1 mm in height and thickness with 1 mm of spacing between consecutive corrugations.
    h. *Weight*: Should have the ability to be disassembled and easily transported.
    i. *Material*: Hand material has to have mechanical properties similar to carpal tunnel tissue. The force feedback mechanism should be compatible with the silicone material used in the hand model.

2. Product Characteristics
    a. *Quantity:* Ideally, two working prototypes are easy with easy manufacturability for the future.
    b. *Target Product Cost:* Around $100 for the remaining parts for the first prototype, in addition to cost needed to replicate the model.

3. Miscellaneous:
    a. *Standard and Specifications:* No specific standards because the prototype is only used in simulation as a training tool and not in actual surgery.
    b. *Customer:* The device will be used to train other surgeons to practice the endoscopic carpal tunnel release procedure. The tracking system will be incorporated with a virtual environment created by the client in Adobe Director.
    c. *Patient-Related Concerns:* None, the prototype will not be used on patients.
    d. *Competition:* A current device involving minimally invasive surgeries called TrEndo. It creates a physical connection between the tacking element and the surgical device, however, has not been applied to carpal tunnel surgery.