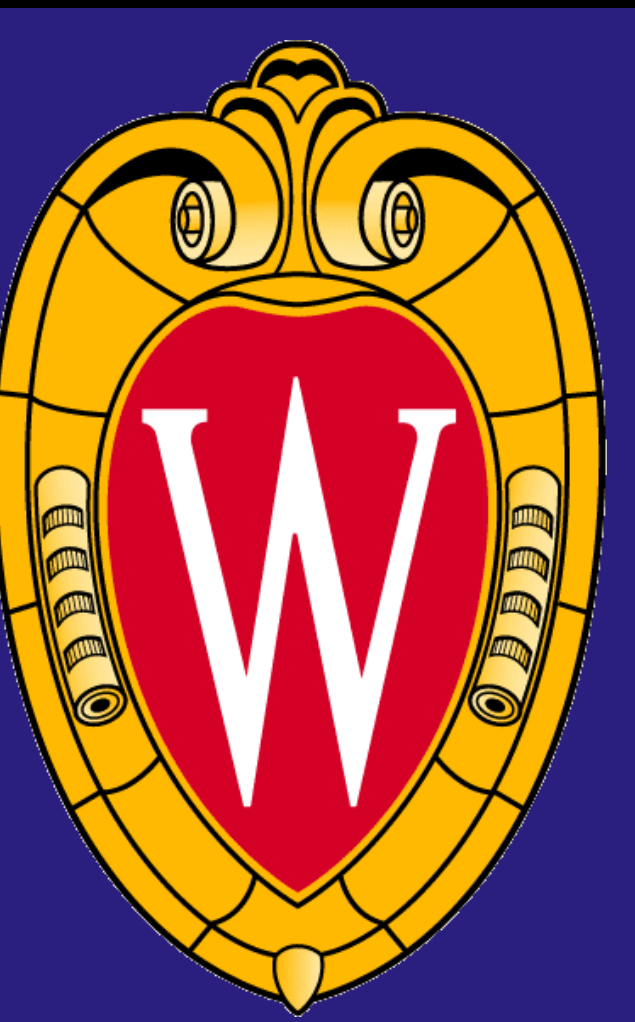


Surgical Simulator for Endoscopic Carpal Tunnel Surgery



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Clients: Dr. Robert Radwin, Dr. Benjamin Mandel

Background

Motivation

- Simulators reduce cost and increase the repeatability of training for surgeons
- Endoscopic carpal tunnel surgery is in need of a simulator to teach surgeons techniques for endoscopic carpal tunnel surgery
- This simulator would be a stepping stone for future and more complex surgeries

Surgical Background

- Endoscopic carpal tunnel release relieves symptoms of carpal tunnel syndrome, such as pain and numbness
- Endoscope with deployable blade cuts transverse carpal ligament to relieve pressure on the median nerve (Figure 1)
- Surgeons use feel of endoscope inside carpal tunnel, visualization from camera

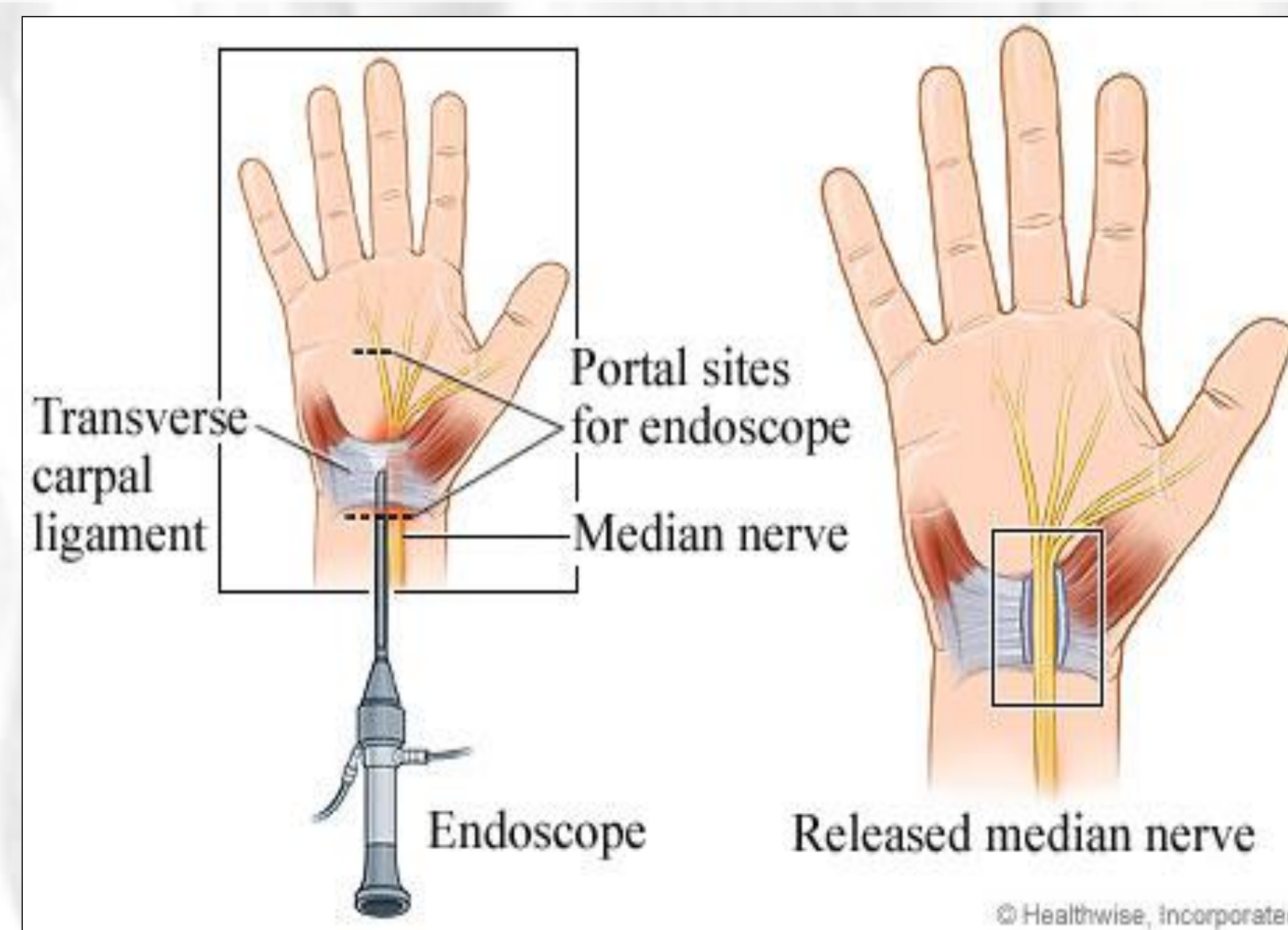


Figure 1. Carpal Tunnel Release procedure.
<http://www.health.com/health/library/mdp/0,,zm2464,00.html>

Current System

- Endoscope camera view moves through virtual environment
 - Up and down arrow keys or computer mouse
 - Series of 147 endoscope photos
- Only one degree of freedom (z axis)
- No haptic feedback or exposure to surgical instruments

Client Specifications

Hand Model

- Life-like feel/appearance
 - Realistic appearance of skin
 - Restrictive carpal tunnel
 - 1-2 cm diameter
 - Corrugations on transverse carpal ligament
 - 1 mm height by 1 mm width
- Resistance felt when ligament is "cut"
- Must withstand repeated simulations

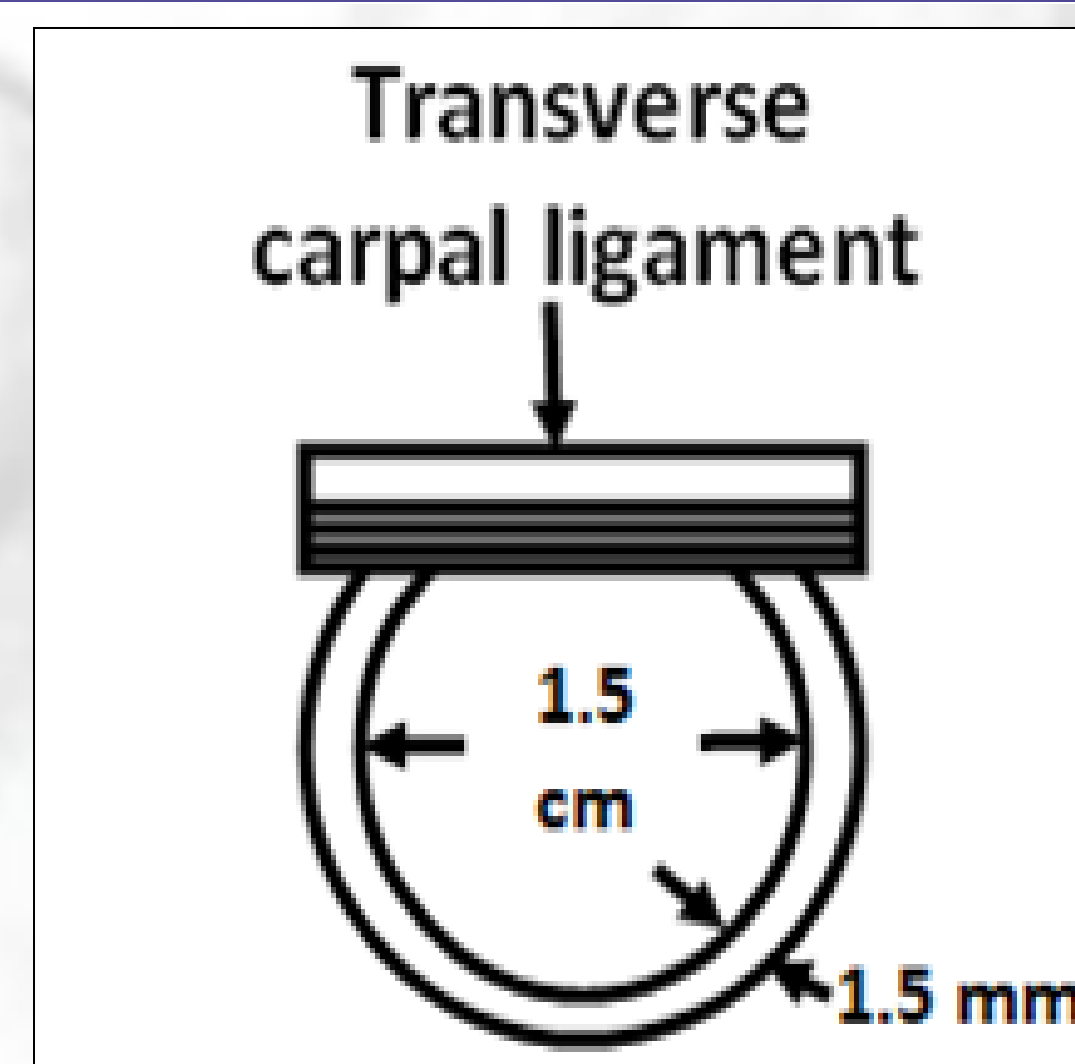


Figure 2. Carpal tunnel dimensions

Tracking Device

- 6 degrees of freedom
- 1 mm precision
- External devices must not interfere with surgical procedure
- Interface with anatomical 3D environment
 - Currently in development



Figure 3. Endoscopic camera view as seen in the virtual simulation.
<http://www.handmicrosurgery.org/services/carpaltunnelsyndrome/>

Problem Statement: to design a simulator for endoscopic carpal tunnel surgery using a life-like physical hand model that interfaces with a virtual 3-D representation of the wrist and hand.

Final Prototype

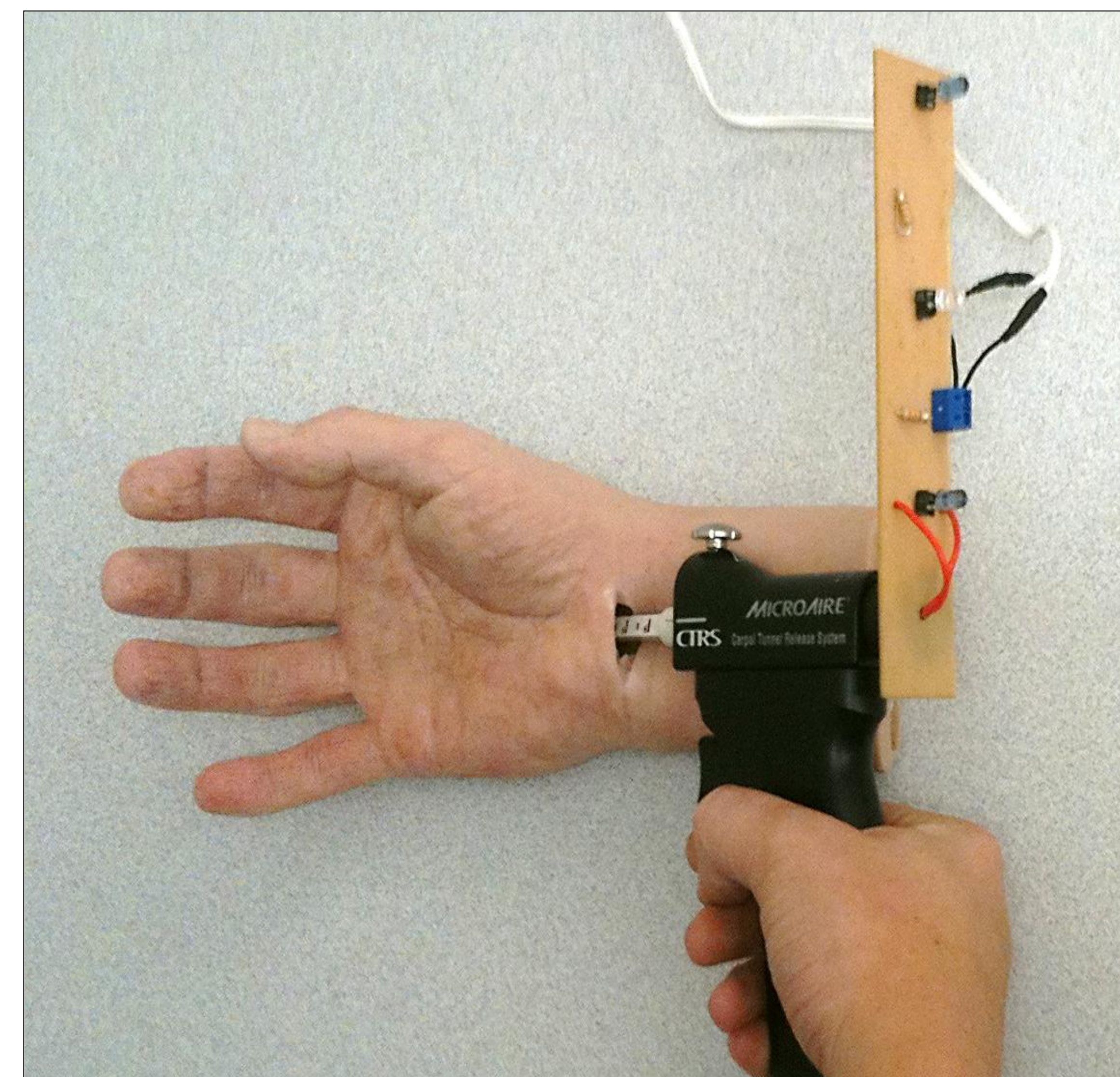


Figure 4. Silicone hand model with carpal tunnel.

Hand Model

- Silicone tube for carpal tunnel suspended in gel
- Corrugated ligament
- Silicone for skin, gel interior
- Provides resistance similar to human tissue



Switch

- Closed when trigger not activated
 - 3rd LED on
- Open when blade deployed
 - 3rd LED off

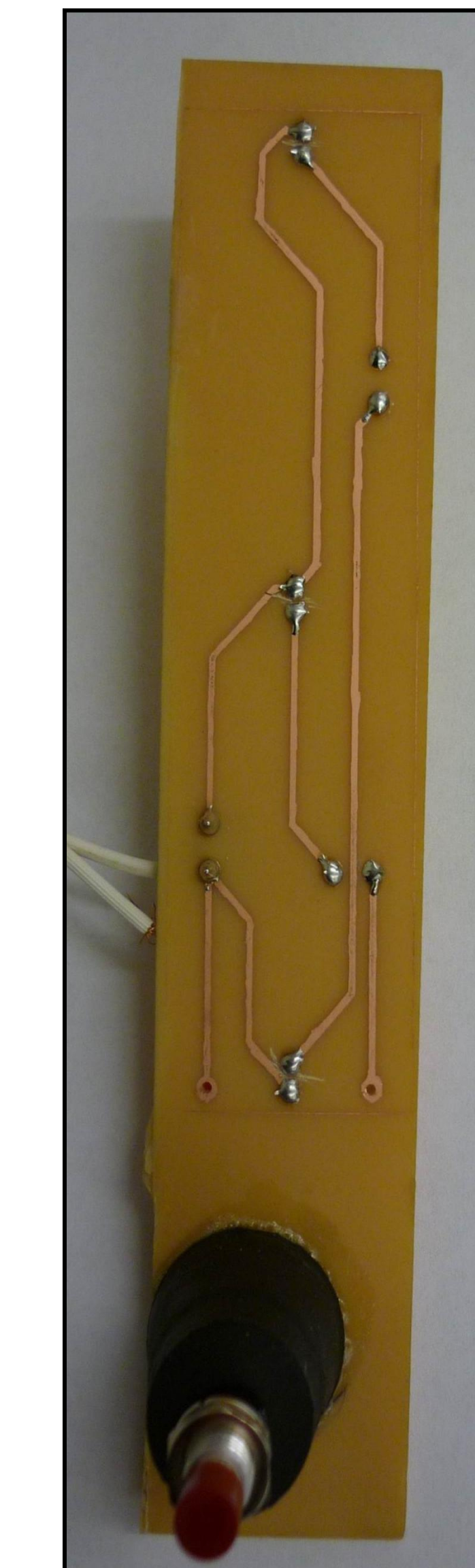


Figure 5. LED circuit board and switch.

Tracking Device

- Circuit board with 3 LEDs attaches to back of endoscope
- Wii remote infrared camera tracks LEDs
 - Translation in x-y-z and rotation about z
- Middle LED acts as trigger signal
 - Controlled by switch in endoscope shell
- Wii remote connects to computer through Bluetooth and java programming

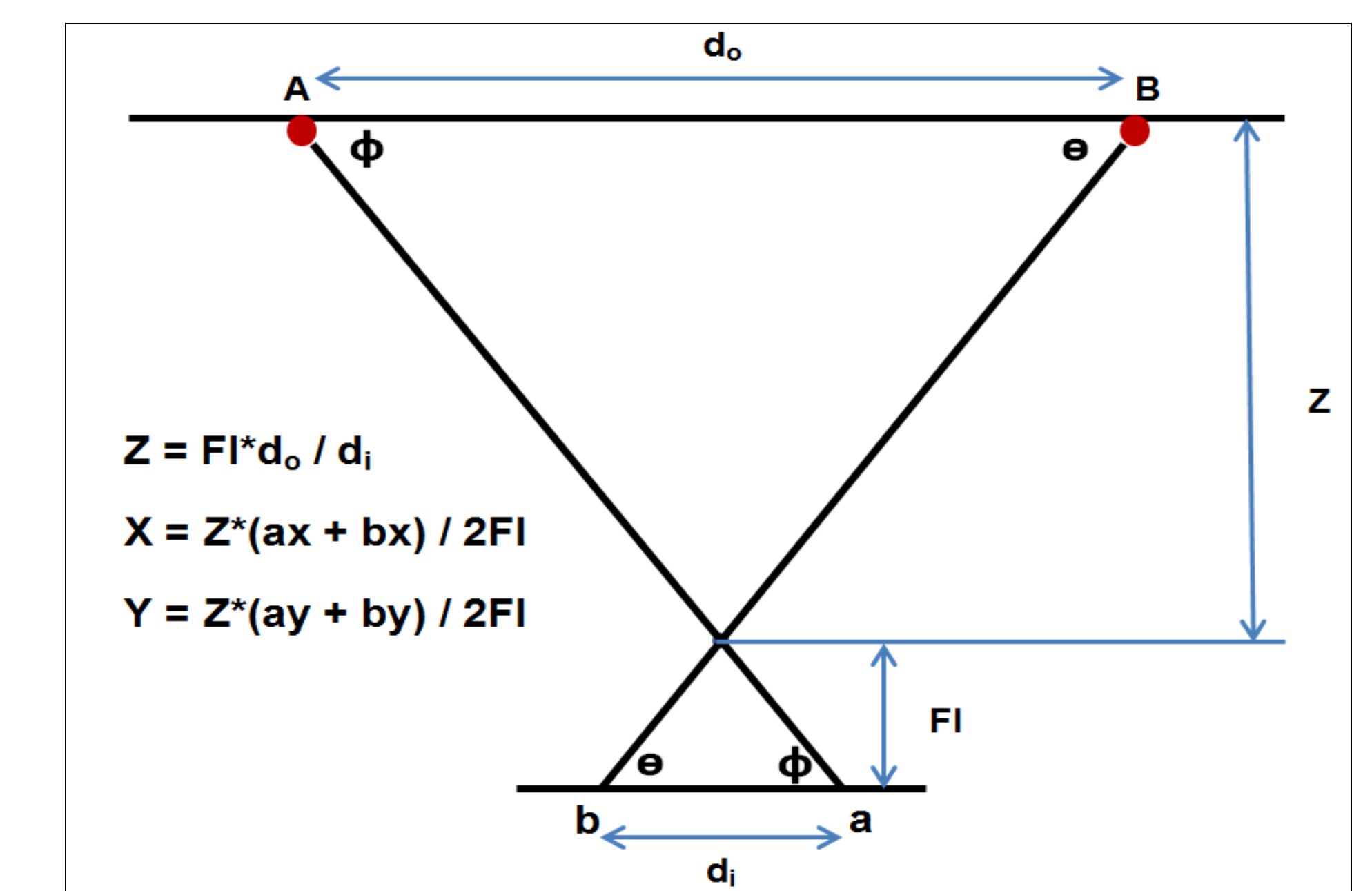


Figure 6. Trigonometric relationship of pixel coordinates.

Testing

Objective: Determine optimal distance between LEDs and Wii remote that will provide the greatest accuracy.

Methods:

- Place the Wii remote 20, 30, 40, 50, and 60 cm from LEDs
- Move LEDs backward 5 cms at 1 cm intervals, recording all distance readings
- Calculate average interval distance between readings
- Repeat 3x for each starting distance

Results: No significant difference in accuracy exists between the range of 20-60 cm.

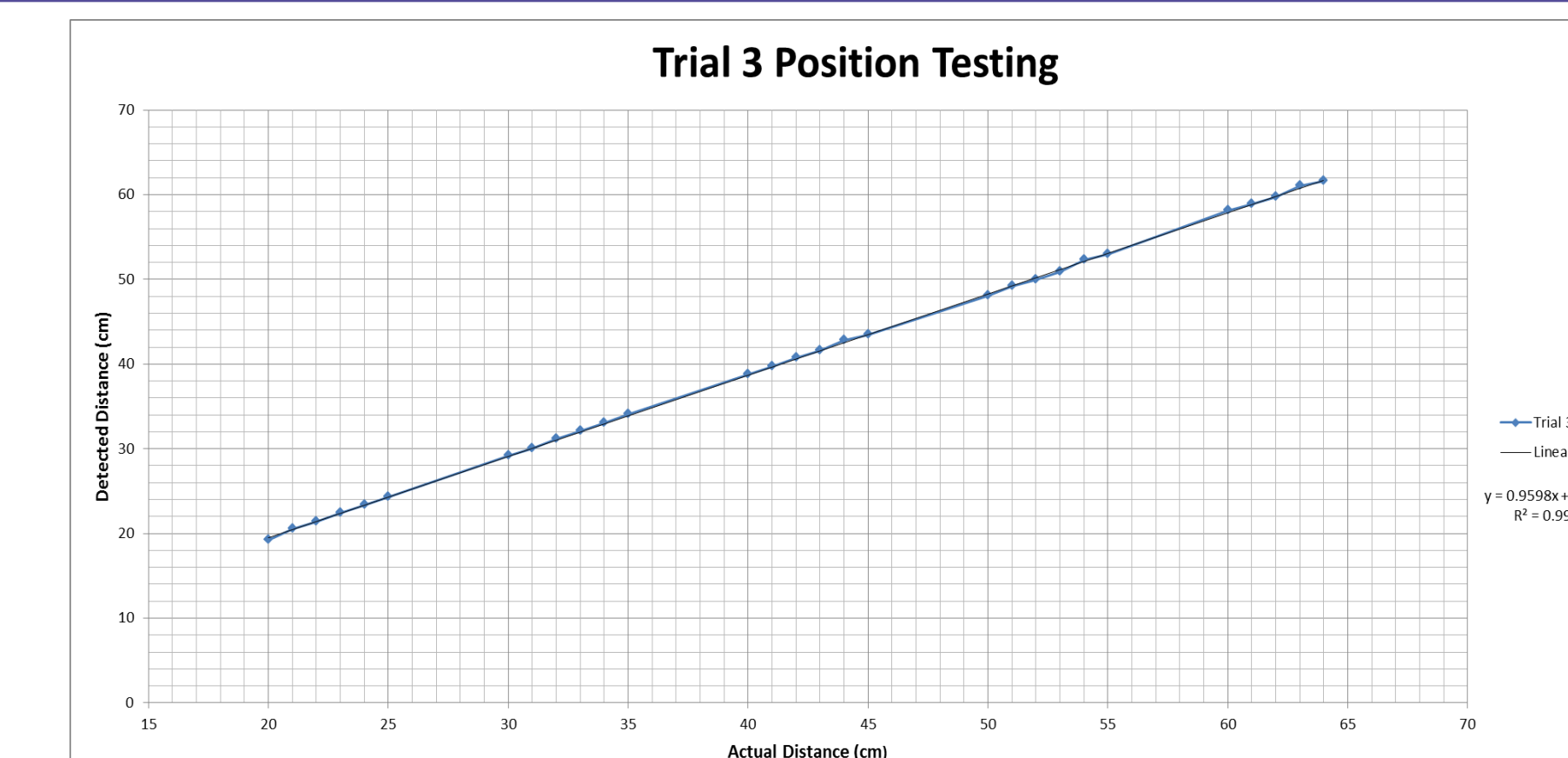


Figure 7. Data and trend line representing the third trial.

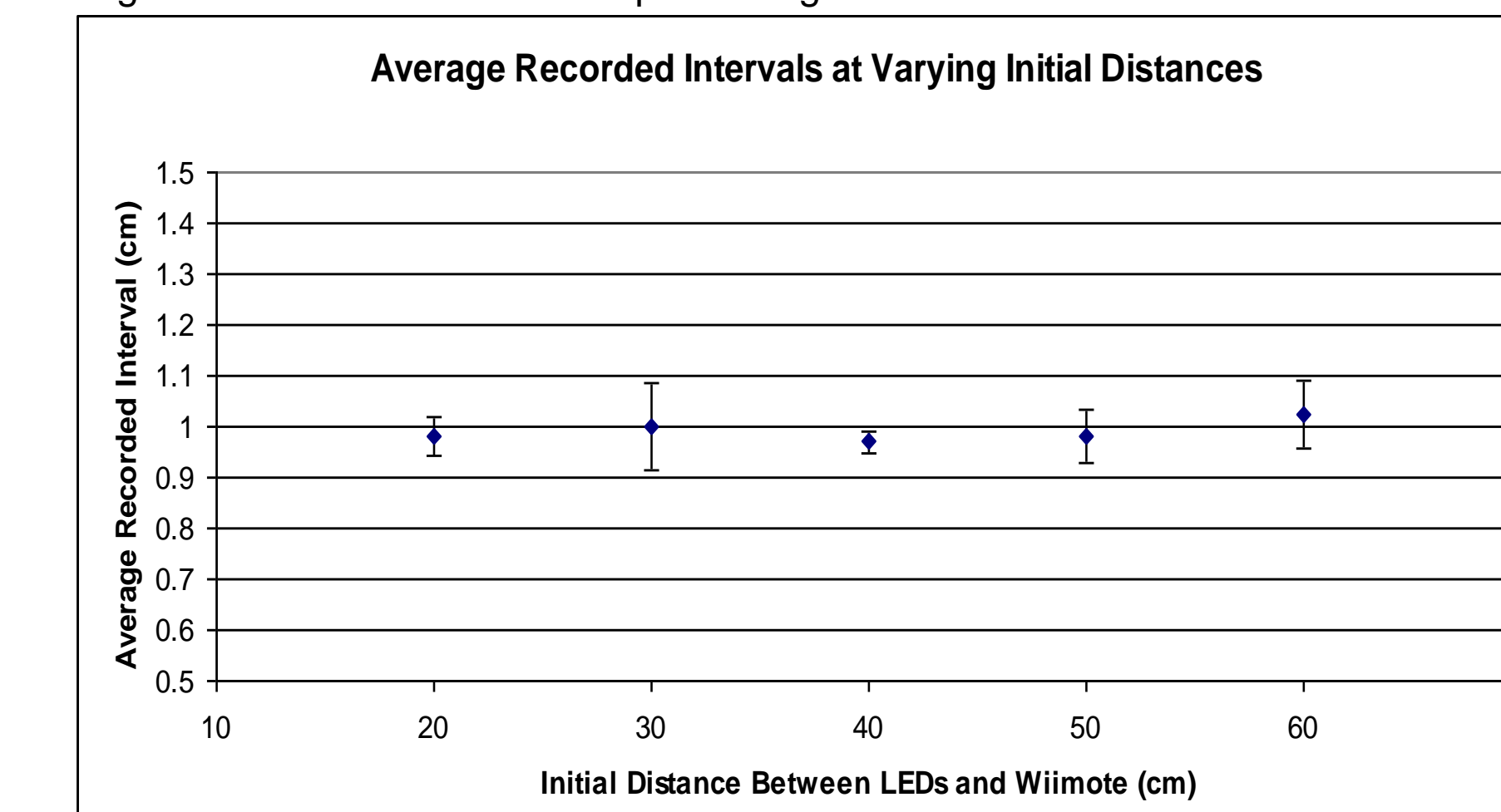


Figure 8. Average and standard deviation of interval measurements.

Future Work

- Design force feedback mechanism
- Interface tracking system with surgical simulation
- Expand simulation to incorporate the left hand
- Optimize carpal tunnel dimensions
- Perform additional testing
 - Feedback, evaluations from surgeons

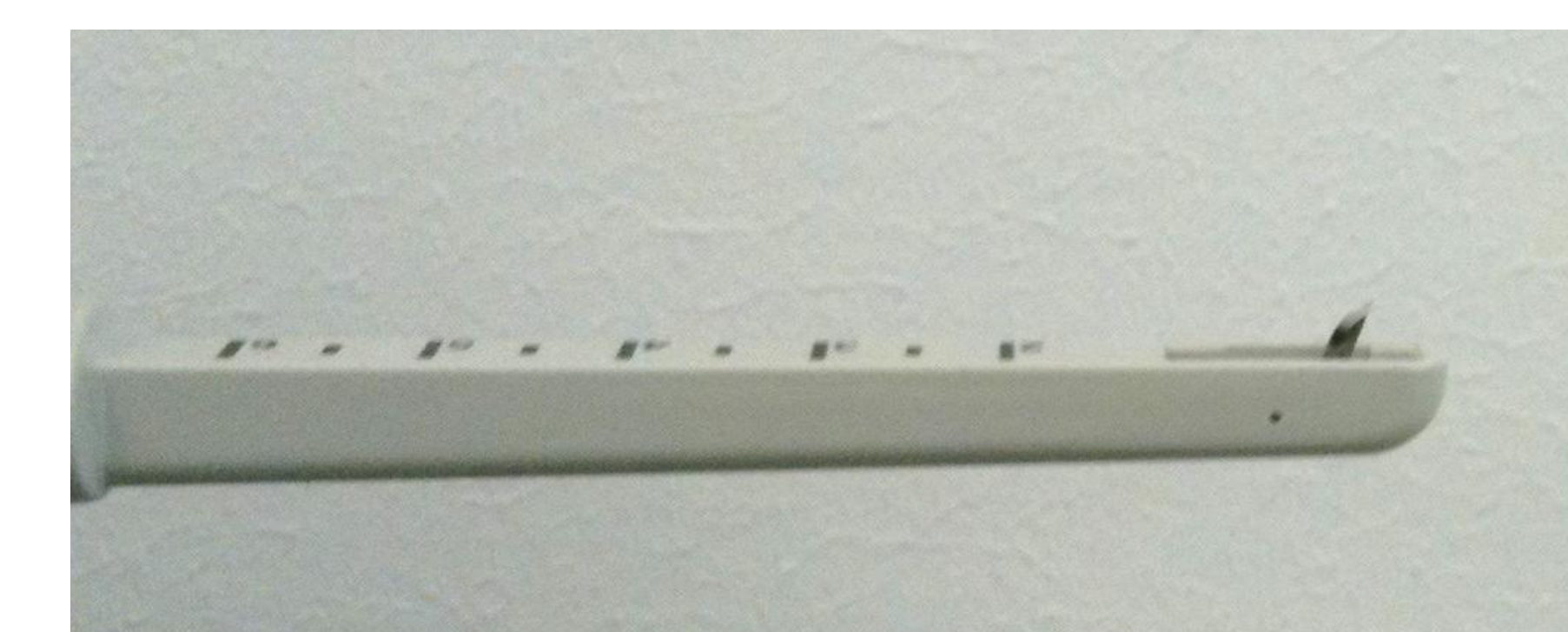


Figure 9. Displays tip of blade protruding from instrument.

Tracking Program

- Java program translates pixel coordinates to 3D position
 - Based on Motej framework
- Based on trigonometry
- Exports z position data to software
 - Updates matching camera frames

Table 1. Cost analysis

Item	Cost (\$)
Circuit parts	22.50
LED attachment parts	10.00
Hand model	300.00
Wii remote	40.00
TOTAL	372.50

References

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