Simulator for Endoscopic Carpal Tunnel Surgery

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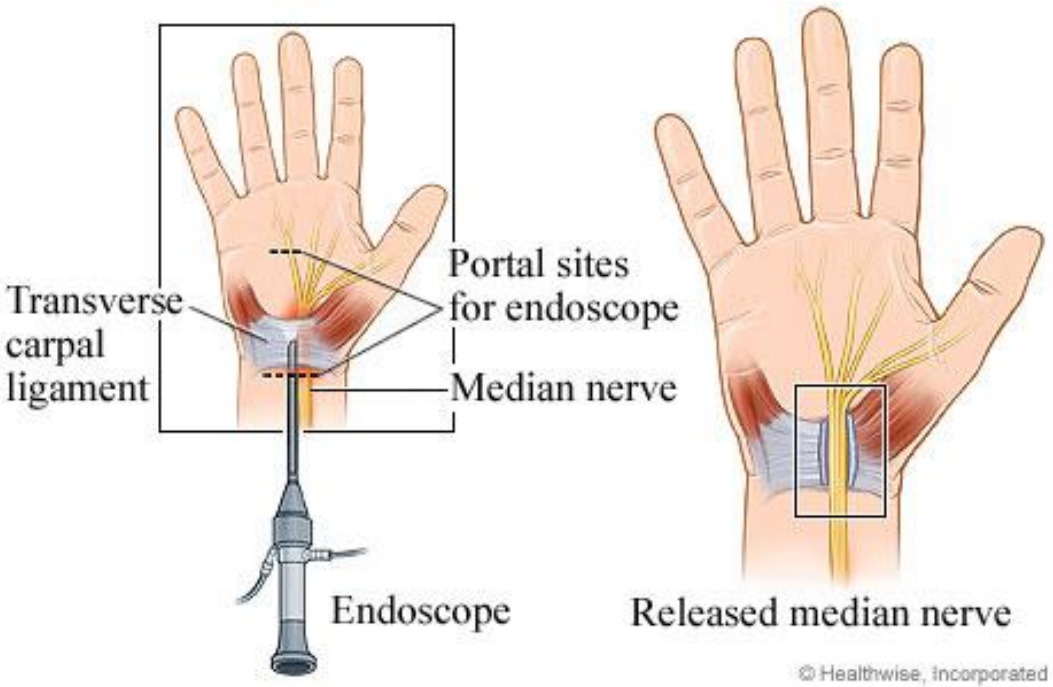
Overview

- Endoscopic Carpal Tunnel Surgery
- Problem Statement
- Client Requirements
- Current Devices
- Design Alternatives
- Design Matrices
- Testing and Future Work

Endoscopic Carpal Tunnel Surgery

- Minimally-invasive
- Relieves pressure on median nerve
  - Cuts transverse carpal ligament
- Uses optical camera and trigger activated blade
- Feel and vision used for accuracy during surgery



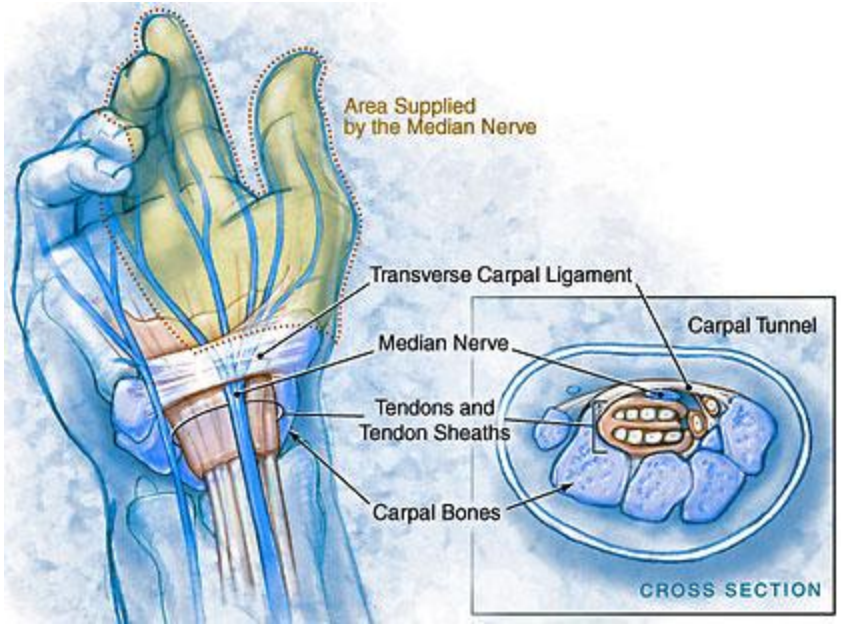
http://www.health.com/health/library/mdp/0,,zm2464,00.html

Problem Statement

- Design a simulator for endoscopic carpal tunnel release surgery
- Life-like physical hand model
- Interface to 3D anatomical software
  - Tracking device

Client Requirements–Hand Model

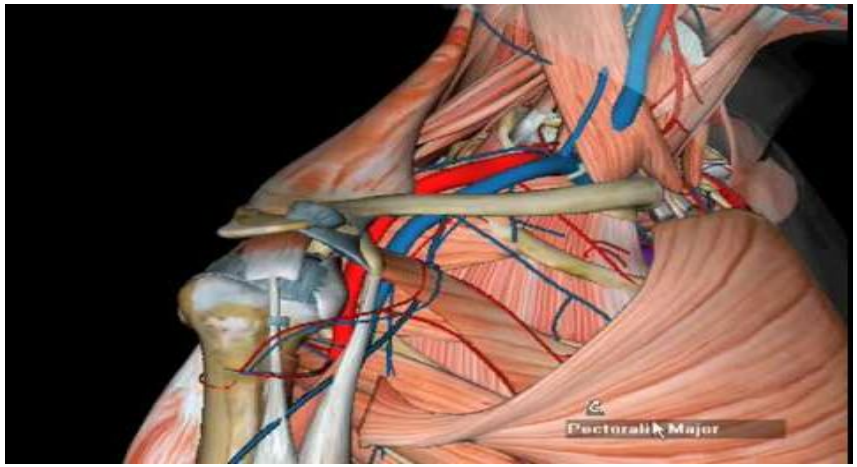
- Life-like feel/appearance
  - Skin-like exterior
  - Restrictive carpal tunnel
  - Corrugations of transverse carpal ligament
- Resistance felt when ligament is “cut”
- Robust: must withstand repeated simulations



http://www.repetitive-strain.com/ctsindex.html

Client Requirements-Tracking Device

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



http://gestalta.net/index.php?key=Elsevier

Current Devices

- Open source technology allows for haptics, visualization, real-time simulation
  - Chai 3D
- Non-lifelike models provide haptic feedback, virtual visualization
  - TrEndo
  - SIMENDO

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2211365/figure

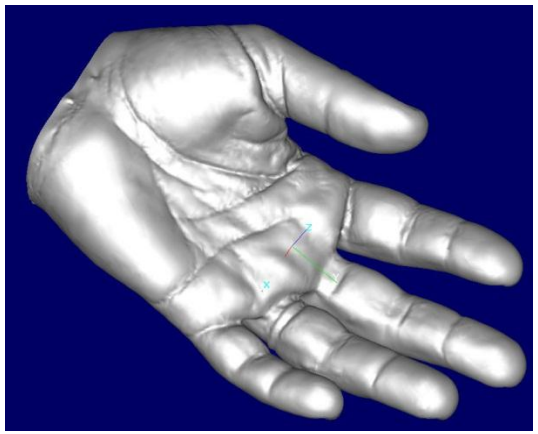
Current Devices

- Hybrid Model
  - Interaction between virtual and physical models
  - ProMIS
- Tracking Devices
  - Mechanical
  - Optical
  - Electromagnetic

www.haptica.com/promis-surgical-simulator.html

Hand Model Design 1
3D Printing

- Mold based off 3D CAD model
  - 3D model from CT scan
- High anatomical detail
- Polymers
- High cost due to complexity, size ($1500)



http://www.rhinoreverse.icapp.ch/english/gallery.html

http://www.itg.uiuc.edu/printing/3D/

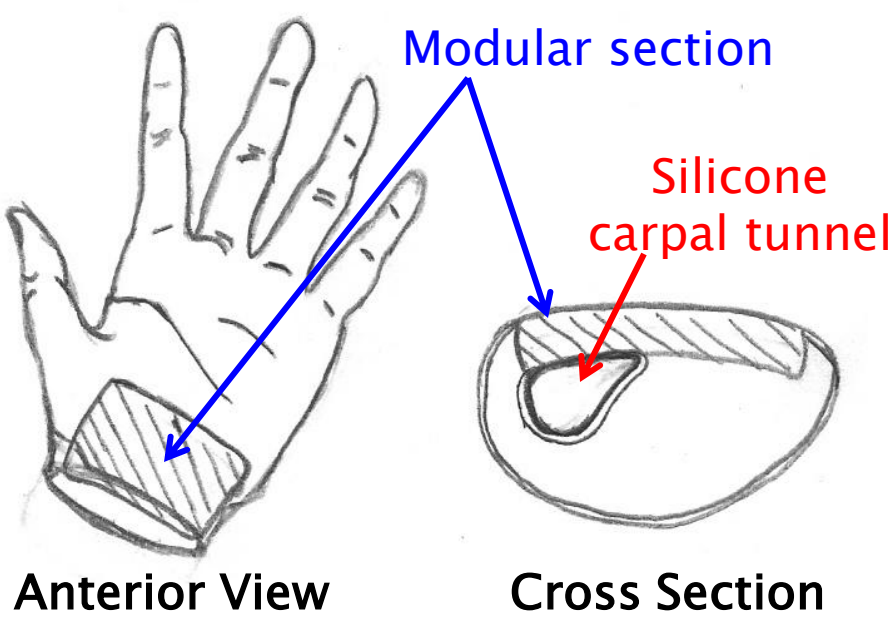
Hand Model Design 2
Alginate/Ballistics Gel

- Alginate cast of hand
- Ballistics Gel
  - Texture similar to human tissue
- Negative space for carpal tunnel
  - Can imbed carpal bones, fibers
- Cost
  - Minimal
- Reduced durability

http://www.indymogul.com/backyardfx/post/1972/build-plans-how-to-make-a-fake-hand

Hand Model Design 3
Silicone

- Silicone carpal tunnel tube suspended in gel
- Corrugated transverse carpal ligament
- High durability
  - Modular palmar section
- Greg Gion
  - Medical Art Prosthetics
  - Cost = $300



Design Matrix for Hand Models

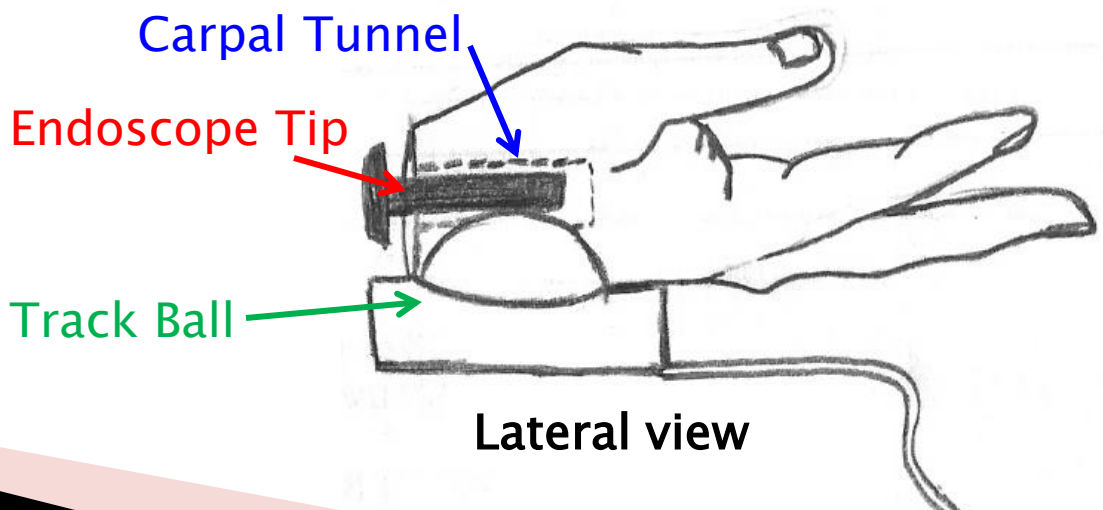
Criteria		Design Alternatives		
Category	Weight	3D Printing	Alginate/ Ballistics Gel	Silicone
Resistance / Haptics	40	30	28	35
Anatomical Accuracy	10	10	6	8
Durability	25	23	5	23
Aesthetics	15	12	8	14
Cost	10	3	10	8
Total	100	78	57	88

Tracking Device Design 1

- **Track Ball(s)**

http://www.berryreporter.com/2009/03/03/colored-trackballs-now-available-blue-purple-red-yellow-and-black/

- **Positives**
  - Direct connection to computer
  - Ease of interface with “endoscope view”
- **Negatives**
  - Limited degrees of freedom
  - Poor contact
  - Size
  - Sacrifices haptics

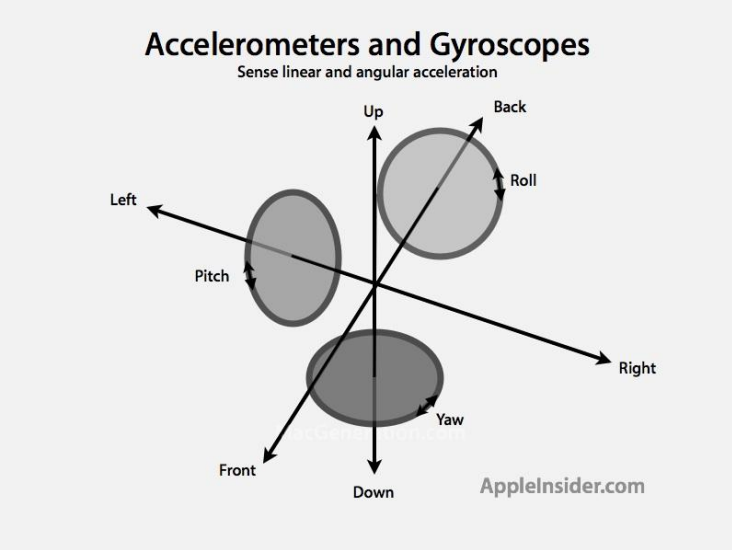


Tracking Device Design 2

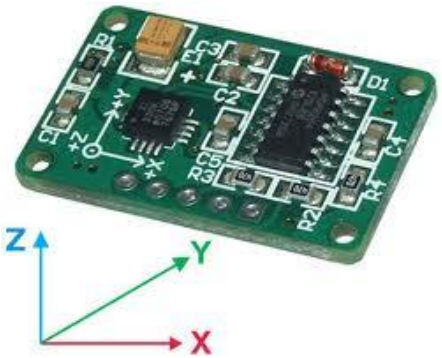
- **Accelerometer/Gyroscope**

- **Positives**
  - Provides required degrees of freedom
  - Initial size

- **Negatives**
  - Total size
  - Limited accuracy/sensitivity
  - Signal processing/connectivity



http://www.appleinsider.com/articles/10/06/16/inside_iphone_4_gyro_spins_apple_ahead_in_gaming.html&page=2



http://www.ebaheth.com/home/index2.php

http://commons.wikimedia.org/wiki/File:3D_Gyroscope-no_text.png

Tracking Device Design 3

- **Wii Remote**

- **Positives**
  - Provides required degrees of freedom
  - Completely wireless
  - Established signal processing libraries

- **Negatives**
  - Powering LED's
  - Possible obstruction

http://www.bidorbuy.co.za/item/15868570/_WOW_GENUINE_NINTENDO_Wii_REMOTE.html

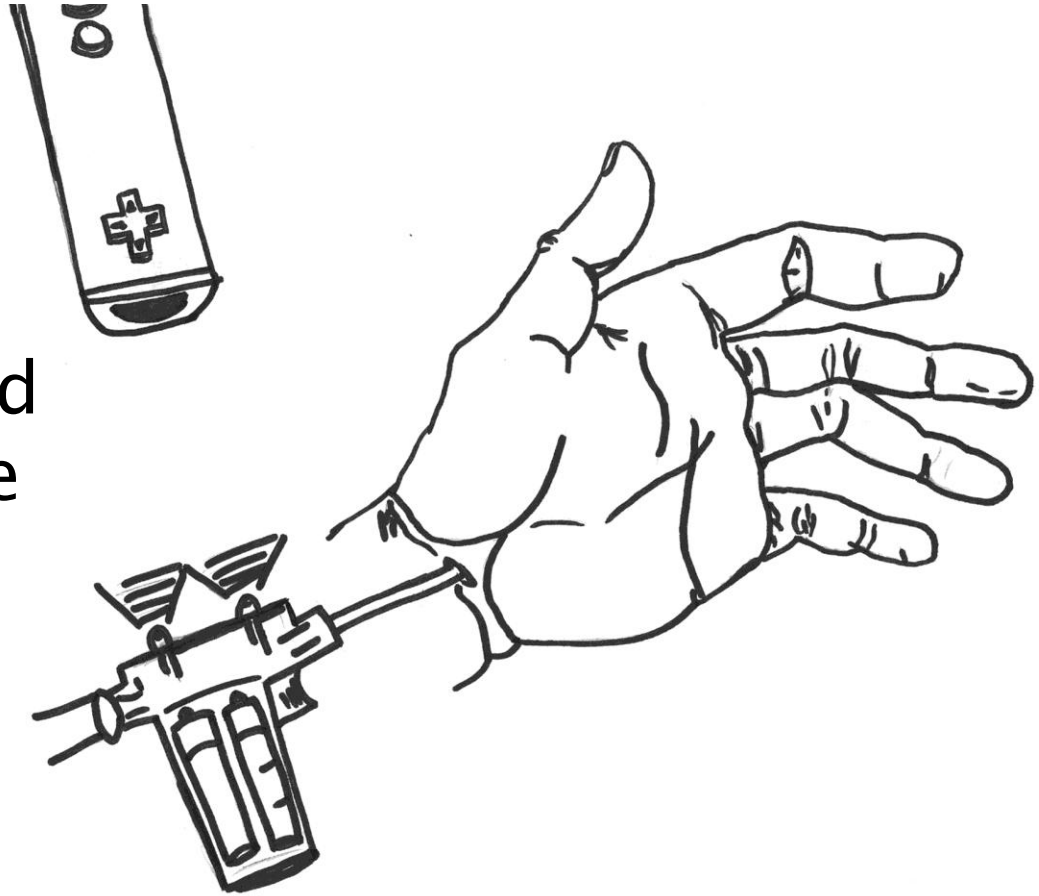
http://hpeetronics.com/hpee.html

Design Matrix for Tracking Devices

Criteria		Design Alternatives		
Considerations	Weight	Wii Remote	Accel/Gyro	Trackball
Size	22	20	12	14
Signal Processing	25	15	5	25
Degrees of Freedom	20	17	20	8
Ergonomics	28	25	14	20
Cost	5	3	3	5
Total	100	80	54	72

Final Design

- Wii remote
- LEDs attached to endoscope



Future Work

- Fabricate hand model
  - Greg Gion at Medical Art Prosthetics
- Integrate tracking device with software and endoscope
- Test position accuracy of tracking device
- Determine and create correct resistance feedback

References

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[6] www.igstk.org/IGST/img/Tracker-IJCARS-FindSubmission.pdf

Questions?