Quantification of Sensory Abnormalities

Client: Dr. Miroslav Backonja

Advisor: Prof. Mitchell Tyler

Group Members (in order of appearance):
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Presentation Overview

- I. Background Information
- II. Problem Statement
- III. Client Requirements
- IV. Data Analysis
- V. Design Alternatives
- VI. Design Matrix
- VII. Final Design and Future Work

I. Background Information

- Neuropathic Pain
  - cutaneous abnormality
  - sharp pain, tingling, burning, numbness
- Record changes in sensation
- Tracing paper currently used
- Accurate, repeatable method needed
- No commercial competition

II. Problem Statement

Dr. Miroslav Backonja, a neurologist who works in pain medicine at UW Hospital, has expressed the need for a more accurate method to measure the surface area of cutaneous sensory abnormalities. Currently, *tracing paper* is used to trace the affected area and a *plenimeter* is used to measure surface area. Dr. Backonja is looking to be able to measure surface area on contoured regions of the body in a more accurate and repeatable manner.

III. Client Requirements

Our client, Dr. Backonja, has specified the following **constraints** regarding our design prototype:

- ✓ Minimally invasive
- ✓ Accurate measurement (acceptable error rate: 5–10%)
- ✓ Cost effective
- ✓ Consistent, reproducible results
- ✓ Clinical use
- ✓ Data should be collected and displayed
- ✓ Under $1000 if possible

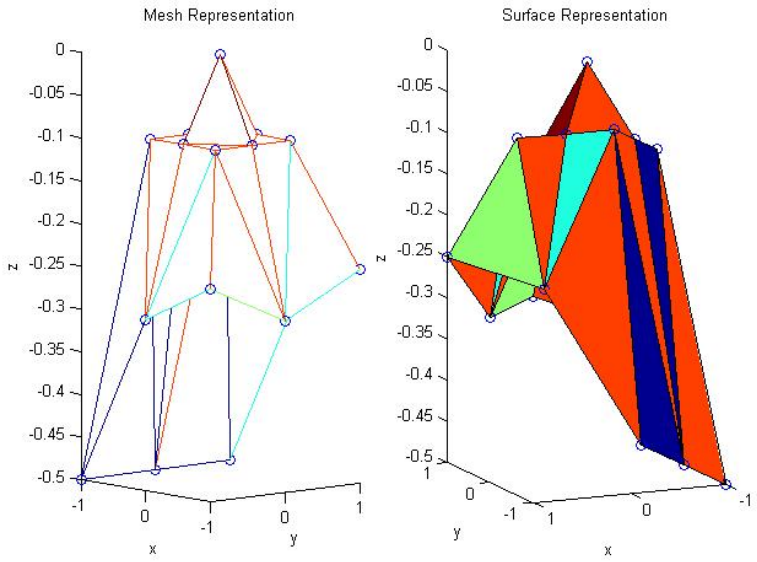
IV. Data Analysis

- Once the data is collected as **points** having three spatial dimensions (i.e. $P_i(x_i, y_i, z_i)$, for points *i=1* to *i=N*), it is sent to **MATLAB**

$$\vec{x} = [x_1 \quad x_2 \quad \cdots \quad x_N]$$
$$\vec{y} = [y_1 \quad y_2 \quad \cdots \quad y_N]$$
$$\vec{z} = [\ z_1 \quad z_2 \quad \cdots \quad z_N]$$
$$P_1 \quad P_2 \quad \cdots \quad P_N$$

(IV. Data Analysis – continued)

- The interpolated surfaces can be **visualized** using MATLAB's 3D "tri" functions (which employ the *Delaunay triangulation algorithm*)



(IV. Data Analysis – continued)

- Finally, the **surface area** is calculated using *Heron's Formula*

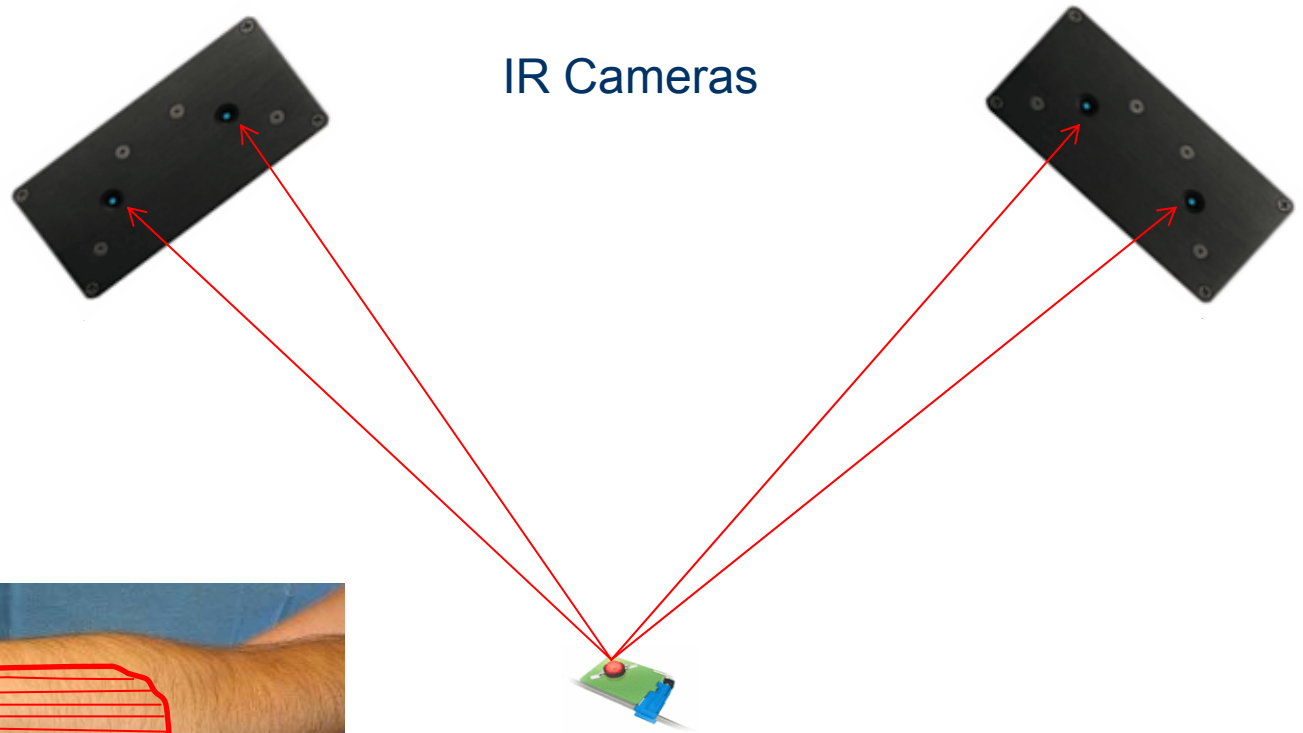
$$A = \sqrt{s\left(s - \sqrt{\sum_{i=1}^{N}(x_i - y_i)^2}\right)\left(s - \sqrt{\sum_{i=1}^{N}(y_i - z_i)^2}\right)\left(s - \sqrt{\sum_{i=1}^{N}(z_i - x_i)^2}\right)}$$

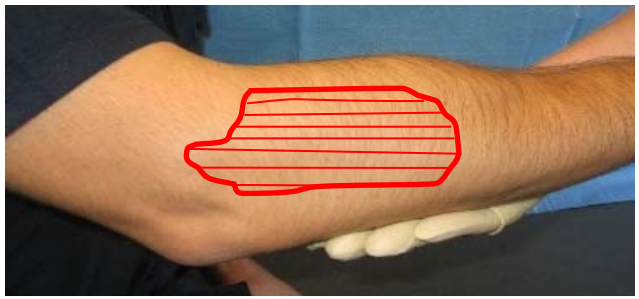
$$\text{where } s = \frac{\sqrt{\sum_{i=1}^{N}(x_i - y_i)^2} + \sqrt{\sum_{i=1}^{N}(y_i - z_i)^2} + \sqrt{\sum_{i=1}^{N}(z_i - x_i)^2}}{2}$$

V. Design Alternatives

- Active Infrared
- Passive Infrared
- Laser

Active Infrared



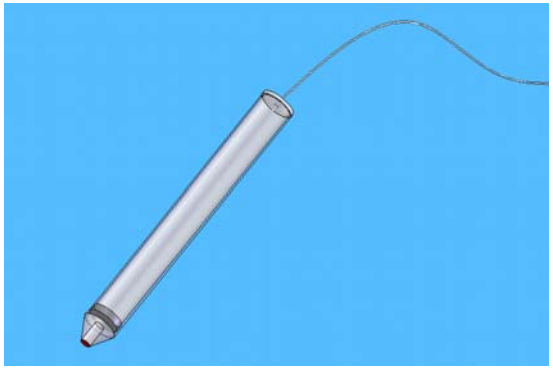


http://z.about.com/d/firstaid/1/0/e/-/-/-/Arm02.jpg

http://www.phasespace.com/productsMain.html

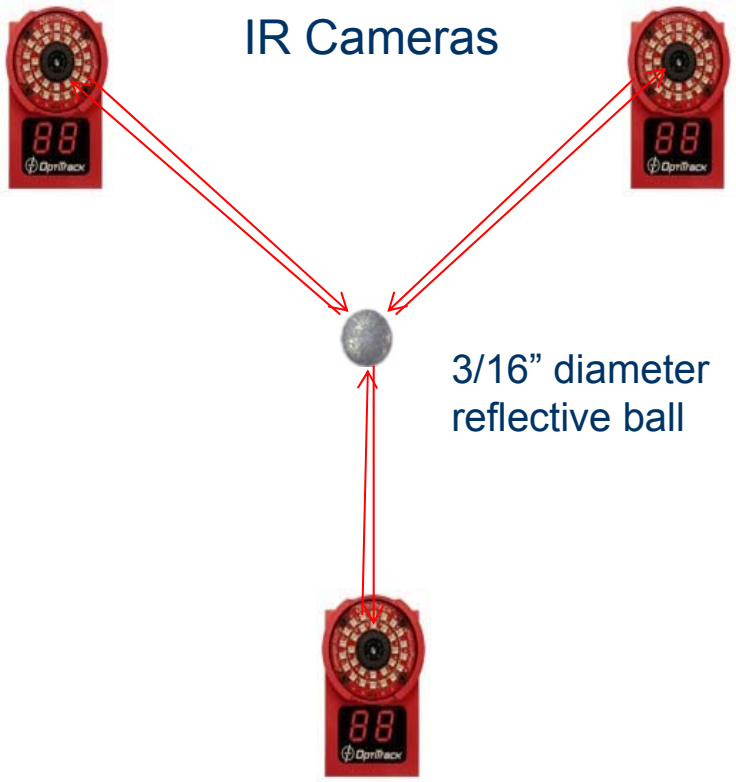
Active Infrared (continued)

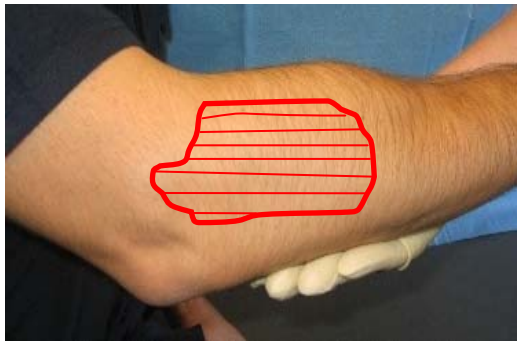
- Advantages
  - Highly Accurate (< 1mm)
  - Data capture easy and fast



- Disadvantages
  - Very high initial cost (~$20,000)
  - LED must be moved across the patient's skin
  - LED must be pointed to camera

Passive Infrared



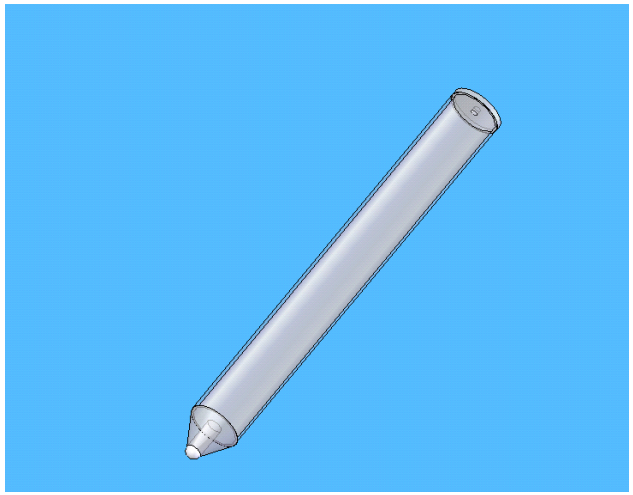


http://z.about.com/d/firstaid/1/0/e/-/-/-/Arm02.jpg

http://www.naturalpoint.com/optitrack/products/flex-v100/inthebox.html

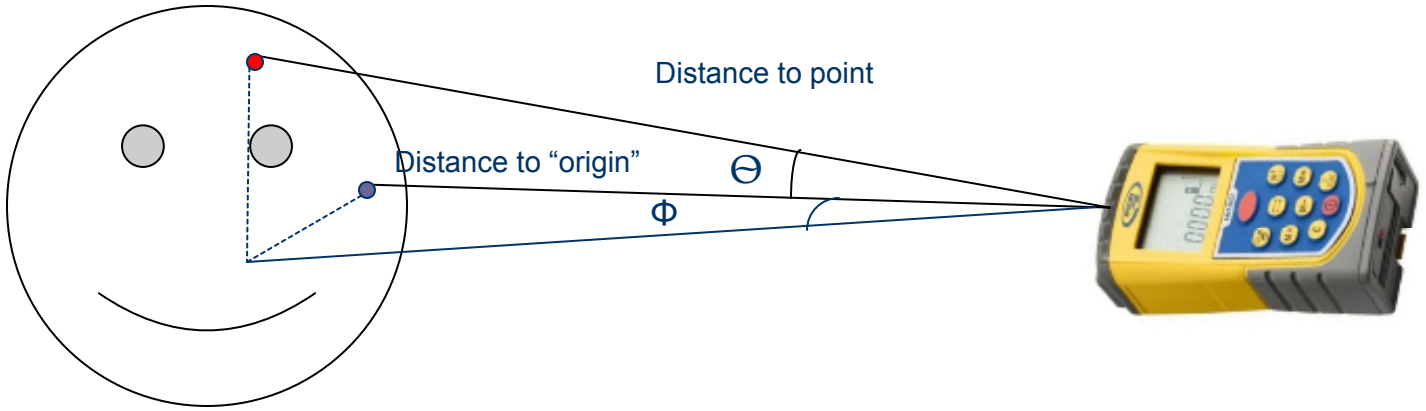
Passive Infrared (continued)

- Advantages
  - Highly Accurate
  - Data capture easy and fast
  - Cheaper than Active Infrared (~$2,000 compared to ~$20,000)
- Disadvantages
  - High initial cost
  - Reflective ball must be moved across the patient's skin



Laser

- Advantages
  - Inexpensive ($130)
  - No direct contact with patient
- Disadvantages
  - Difficult to use
  - Time consuming
  - Less Accurate (~2mm)



http://www.amazon.com/Spectra-Precision-HD50-Handheld-Distance/dp/B000Q5U9JG

VI. Design Matrix

	Possible Points	Passive IR	Active IR	Laser Meter
Accuracy	15	15	15	11
Ease of Use	10	8	7	2
Time	10	8	8	2
Cost: Initial	15	7	3	13
Repeatability	5	5	5	3
Patient Comfort	10	7	7	10
Total	**65**	**50**	**45**	**40**

VII. Future Work

- Obtain IR camera system
- Design and create pen
- Create and refine algorithms
  - Modeling “overlapped” surfaces
- Put system together
- Testing
  - Systematize the procedure

Questions?