Sensory Abnormalities

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Client: Dr. Backonja
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Abstract

Our client, Dr. Backonja, is a neurologist at the UW Hospital. He commonly works with patients that have sensory abnormalities, including lack of sensation and hypersensitivity. In order to help determine the effectiveness of treatment regimens, Dr. Backonja monitors the surface area of affected skin on his patients. A previous semesters design team developed an algorithm in MATLAB that calculated surface area using several IR cameras and an infrared LED pen. This method had significant limitations and therefore was not being utilized.

This semester, we have worked two different systems to help him track affected surface area more conveniently. Currently, our client traces the shapes of the affected area onto a sheet of graph paper and manually counts the squares to determine the area. To help with this process, we have developed an image analysis program that calculates the surface area in a bounded shape. Testing of our 2D program shows that it efficiently calculated the bounded area within 10% of the actual area in seven of eight (87.5%) trials.

We have also developed a system that calculates the surface area of a 3D shape. This method uses infrared cameras of known focal lengths, and uses two pictures to calculate 3D coordinates of several points. By connecting these points with small triangles, the program can efficiently calculate the surface area of most shapes within approximately 10% accuracy.

Introduction

Sensory abnormalities in humans include hypersensitivity, burn victims, and nerve damaged areas. Patients with sensory abnormalities are generally treated, but doctors need a reliable way to measure whether the treatment is helping the condition. One method of measurement is the surface area of the sensory abnormality. A reduction in area of the sensory abnormality can be a simple indication that the treatment plan is working effectively. Dr. Backonja currently outlines the shape of the sensory abnormality on graph paper and counts the squares to calculate surface area. Our client has asked us to develop a better surface area calculation method.

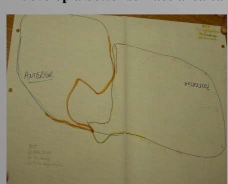


Figure 1: Sensory Abnormality Mapping
Dr. Backonja uses graph paper to map out the sensory abnormality, and then counts the squares to find the affected area.

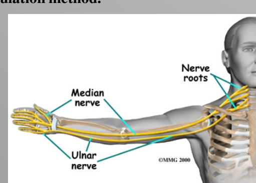


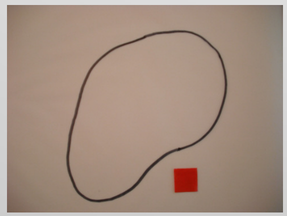
Figure 2: Sensory Abnormalities
The ulnar nerve is commonly involved in sensory abnormalities, and would be a likely area of desired surface area calculation. Neoneocon.com

Design Criteria

- **Noninvasive**
- **User friendly**
- **Affordable**
- **More efficient than current process**
- **Accurate**
- **Reliable**

Final Design

Figure 2: 2D Surface Area Calculation
The final 2D design focuses on streamlining the current process. The client takes a picture of the previously traced area, runs it through the 2D Java program, and it outputs the area inside the bounds of the shape. This program dramatically reduces the amount of time necessary to calculate the area of the sensory abnormality, and it is cost efficient, as it is written in Java.



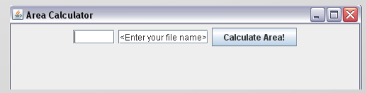
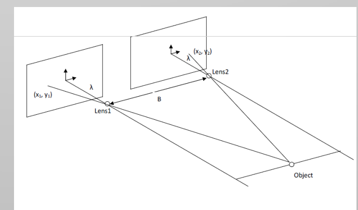


Figure 3: 2D Program Interface
The user interface for the 2D program is very simple. It contains a box where the user inputs the name of the JPEG file, a calculate button, and a box that outputs the final area calculation.

Figure 4: Stereo Imaging
If the imager size, focal length and distance between the cameras used are known, images taken by two coplanar cameras may be used to calculate the three dimensional coordinates of any point in both images.



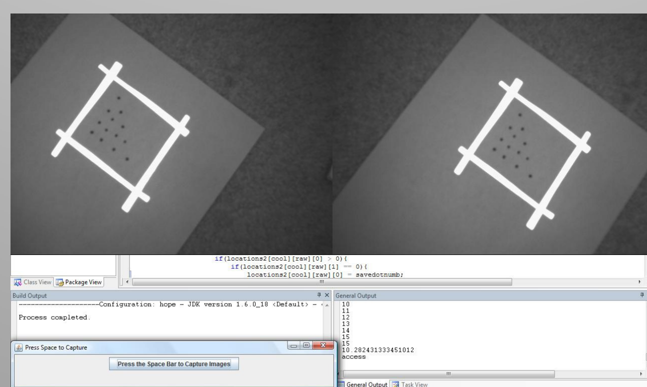


Figure 5: 3D Surface Area Calculation
The final 3D design uses stereo imaging techniques to calculate the 3D surface area of the abnormality from two images of the abnormality. The clinician must dot along the perimeter of the abnormality and then place dots within the perimeter. Then a larger perimeter consisting of retro-reflective tape must be applied, enclosing all dots. When the images are captured, the algorithm focuses on the region within the reflective tape (which appears white to the infrared cameras). It calculates the 3 dimensional coordinates of each dot within the region and then connects the dots in 3D space to determine the total area of the abnormality.

Testing

To test our final design, we used our program with several shapes of known area. We compared the area calculated with our program to the actual area to check its accuracy.

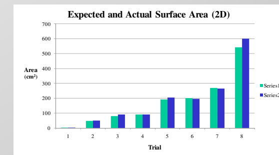


Chart 2: 3D System Testing
Testing was completed by comparing the actual area of the bounded shape (blue bar) by manual calculations, compared to the area of the shape calculated by the 2D program.

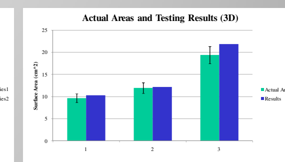


Chart 3: 3D System Testing
The green bars represent the area of each shape calculated based on planar geometry. The blue bars represent the average of the system's calculations based on images of the shapes in various three dimensional configurations. Error bars are +- 10%.

The testing of our 2D program showed that the areas of various shapes were within 10% of the actual area in seven of eight (87.5%) images. The testing of the 3D program showed similar results. It was within 10% in two of three (66.7%) trials. Although neither of the programs were able to calculate the actual area every time, each was within 15% of the actual area.

Ergonomics

Patient Ergonomics:
- No marking of patient for 2D area
- No motion restrictions

User Ergonomics:
- User Interface for easy use
- Algorithm development to minimize user input
- Integrated user interface for 2D program

Future Work

2D Program:
- **~ Algorithm development**
  - Various calibration colors
  - Complex shapes
  - More advanced GUI

3D Program:
- **~Increased reliability**
- **~Improve reflective bounding method**

Acknowledgements

- **Dr. Misha Backonja**
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References

Riversideonline.com
Neoneocon.com