Sensory Abnormality Mapping

Mid-Semester Report
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Abstract

The goal of our project this semester was to create a prototype that would accurately and reliably measure the surface area of abnormal sensory areas of patients. Examples of these abnormalities include hypersensitivity, burn victims, and nerve damaged areas. The prototype has to measure the abnormal skin's surface area in 3D; this includes the crevasses in between fingers and the various indentations/protrusions in the face. Currently, there are relatively few software programs or other devices that exist that are able to perform this task. The closest program that currently exists is the BurnCase 3D software; however, it isn't accurate enough to meet the needs of our client. In order to solve our client's problem, we first aimed to create an intermediate program that records the area from a 2D tracing of the patient's abnormal sensory surface area. Following the intermediate program we plan to create a software program that displays a 2D unfolded projection of the desirable surface area and records the area as well. This software program will effectively replace Dr. Backonja's current method of counting squares on graph paper as it is quicker and also takes into account 3D aspects of the measured area, making it more accurate as well.

Background

Our client, Dr. Miroslav Backonja, is a neurologist at the University of Wisconsin Hospital. He treats patients that have damaged nervous tissue, more commonly referred to as neuropathic pain. Symptoms from this condition include a loss of sensory ability or pain in a specific region of the body, typically occurring on the face, hands, feet, or trunk (Medicine Net, 2007).

Motivation

Dr. Backonja and his colleagues are currently studying how the sensory abnormalities respond to various treatments. In order to prove or disprove a treatment, quantifiable data is required. Therefore, the surface area of the affected region is measured during each of the patient's appointments. A reduction in area between visits provides strong evidence that a particular treatment is working. However, because the current methods to measure the surface area aren't thoroughly accurate, the strength of the evidence is reduced.

Currently the surface area is calculated by outlining the affected area on the patient's body in marker. Trace paper is then placed over the area and the region is transferred. Dr. Backonja and his staff then count the squares inside the designated region. This process is clearly not efficient nor is it accurate for all three-dimensional surfaces. Tracing on the affected area can also be painful to the patient as the area is being touched multiple times.

Problem Statement

Our client, Dr. Miroslav Backonja, has asked us to help develop a system for calculating the surface area for mapping of sensory abnormalities. Our goal is to develop a system that would allow quick, quantitative, and accurate measurement of the abnormal area for everyday use as well as clinical study applications.

Design Requirements

Since this project includes patient interaction the team's most important goal is patient safety. The product will not pose any serious threat to a patient's health, but it has the potential to cause discomfort. Patients suffering from neuropathic pain experience painful sensations in the affected area. Therefore, it is imperative that the product/procedure has minimal contact with the patient's skin. The product should also not cause discomfort or harm to the operator or bystanders.

The skin surface calculating procedure must take less time than the current square counting method. The final product should be able to analyze 3-5 samples in under 10 minutes.

This also means that the product must be user friendly. In order have fast results; the procedure must be nearly automatic. This will require an easy-to-operate user interface, as well as minimizing the number of settings that require adjustment prior to each measurement.
Product performance is another important aspect to this design. The product should be able to calculate the surface area within 10% of the actual area. This should give the team an adequate barometer for making conclusions about the effectiveness of the product. The device should also have 10% repeatability between trials.

Existing Technology

The idea of computing the surface area of a traced area on the human body is relatively novel; there aren't many existing products that can provide this function. The most relevant technology is a software program called BurnCase 3D. This software provides a virtual model of the human body. A physician can then estimate the areas to be measured on the patient and trace those areas on the virtual model (BurnCase 3D, 2010). A virtual model with part of the chest area is shown along with an actual burn patient in Figure 1. This is not sufficient as the estimation of the area along with having to use a computer mouse to trace the area is going to cause errors. Furthermore, the virtual model can't be custom designed to completely match the dimensions of the patient and therefore won't be completely accurate. In conclusion, BurnCase 3D doesn't provide enough accuracy necessary to be considered a solution to our client's problem.

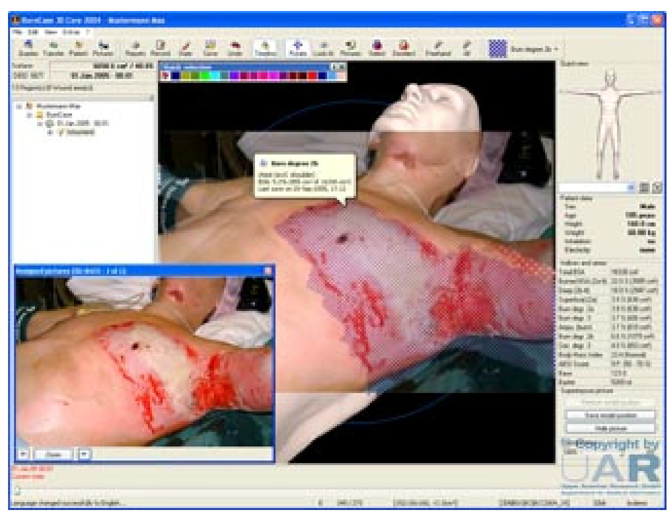

Figure 1: BurnsCase 3D Image
Shown in the lower left is an actual burn patient. Shown behind the patient and to the upper right is the virtual model plus shading of the desired area to be measured (http://www.burncase.at/index.php?page=software).

While most of the other existing technology researched didn't come nearly as close to the BurnCase 3D software in meeting Dr. Backonja's needs we felt it was important to mention a couple of these technologies for the sake of completeness. Another software that was researched was called Make 3D. Its primary function was to convert any picture taken into a 3D image based on shadows within the picture and the angle the picture was taken at (Saxena, 2007). However, this software had no capabilities of measuring pixels or surface area once the picture was converted. Furthermore, the some aspects of the pictures would be distorted due to misinterpretation of a shadow. Other technology besides software that was considered included reflector-less laser measurement technology. This technology is implemented in products similar to range finders. The thought was that this technology would be able to determine various "hills" and "valleys" on the patient's skin. However, no technology exists that can measure discrete changes, only relatively large changes (+/- 1 meter in accuracy) and therefore also isn't suitable for our client.

Preliminary Work

Due to the programming based nature of this project and immediate availability of all the components necessary to begin programming, we have been able to make significant progress toward our final goals prior to the mid-semester mark. Accounting for the complexity of the image analysis required to meet the client's specifications and the lack of programming experience within the group, a sensible initial step in our design process was the development of an intermediate program in a familiar language. That is, a MATLAB program which calculated simple two dimensional areas. This first step not only produced a system which, when converted to java, would provide the client with a time saving solution but also highlighted and solved several issues which we would have encountered in the final design. These issues include detection of the boarder of the area of interest, which was addressed by standardizing the colors used to delineate this boarder, and variation in the size of the area of interest with various camera perspectives, which was addressed with the use of a calibration unit of known area.

A second option we have already begun to explore is the use of stereo imaging. However, because stereo imaging requires the use of two cameras and our budget prohibits us from purchasing even a single camera, exploring this option required the use of the OptiTrack cameras from the previous semester's design. Unfortunately, the cameras did not include software for viewing or saving the images they captured. Instead, the OptiTrack website provides a free Component Object Model (COM) based Software Development Kit (SDK) with which the user of the cameras must program their own camera interface. The COM allows for the use of the SDK in any programming language and because the only language with which we had any familiarity, aside from MATLAB, was java, we decided to interface with the cameras through java. While this decision eased the basic programming aspects of the interface and will ultimately lead to a better Graphical User Interface (GUI) in our final program, it also introduced several complications. The first of these complications resulted from java's inability to directly access the COM elements of the SDK. This was overcome with the use of JACOB, a free, downloadable JAva COm Bridge and the "wrapping" of all COM based code components in JACOB syntax. Java's inability to retrieve the handle of windows it creates posed another complication since the OptiTrack SDK requires window handles to display images captured by the cameras. Although handle retrieval is not possible in java, it constitutes only a few steps in C++. Therefore, the necessary C++ code was written to a Dynamic Link Library (DLL) and this DLL was accessed from java using another free, downloadable tool known as Java Native Access (JNA). Although it requires some fine tuning and a GUI, we currently have a java program which accesses two OptiTrack cameras through JACOB, displays a stream of captured grayscale or infrared images from both cameras using the C++ DLL, freezes both streams when the spacebar is pressed and saves the images which were frozen on the screen.

Previous Design

The first design alternative merely continues the work contributed to this project during a past semester. During this past semester a design based on motion capture was implemented. Three OptiTrack FLEX: V100 infrared motion capture cameras were purchased and a system was devised to allow these cameras to track the position of an infrared LED on the tip of a stylus as it was traced over and around the affected area. The LED position was sampled periodically to produce three dimensional coordinates which were later connected to form polygons. The areas of these polygons were summed to produce the desired surface area.

Figure 2: Previous Semester's Design

Ultimately, our first design alternative would involve streamlining, refining and general salvaging of this non-ideal design. The following section outlines why this would not constitute a productive use of our time.

Decision About Previous Design

Although a significant amount of time and resources was invested in this project in previous semesters, our group has come to the conclusion that the most prudent course of action is to discard this prior work and move forward in a different direction. Careful consideration of the faults in the prior work was necessary in reaching this conclusion. The first consideration involved the ergonomics of the system, that is, how easily the client could begin its implementation. We noticed that, as the system now stands, the three infrared cameras must be repositioned and recalibrated, relatively randomly, after every session of use. This is not ideal, nor is it very scientific. To truly get the most out of the cameras would require careful deliberation and calculation as to where exactly to position them in order to obtain a maximum viewing area. Following determination of camera position, time and resources would be required to devise a mounting system, so as to achieve repeatability and sustained calibration. This mounting system would also require significant space somewhere within the clinic. Even with the mounting system in place, recalibration of the cameras might become necessary due to the fact that fairly small changes in camera position require a recalibration of the entire system.

Furthermore, even with the cameras positioned in such a way that their viewing area is maximized, the nature of the system creates significant blind spots such as areas on an appendage facing away from the cameras. These spots not only limit the types of areas the client may measure with the system but also cause loss of data since any interruption of the signal detected by the cameras causes data collection to cease. In other words, if the LED tip of the marking stylus leaves the view of even one of the three cameras for even a short time, the data collection will halt and any subsequent motion of the stylus will not be captured. Therefore, the client must spend time positioning the patient such that no area of interest faces away from the cameras and such that all areas of interest fall within the viewing area of all cameras.

A similar concern with the current system is immobilization of the patient during mapping. The patient must be immobilized throughout the mapping process because and movement of the area of interest will cause spurious readings by the cameras. Due to the spatial nature of the current system, very small movements of the area of interest can add up to significant inaccuracies in the final area calculation. Similarly, the clinician performing the mapping must do so with extreme care to avoid errors due to an unsteady hand such as the application of inconsistent pressure to the skin with the stylus, accidently removing the stylus from contact with the skin and so on.

Finally, the software components of the current system require a great deal of further refinement. For instance, the current algorithm used to calculate the area of the mapped skin frequently connects points which should remain unconnected and which are commonly far away from one another. This creates a large amount of area which does not reflect the true area of the mapped skin and this causes the calculated area to be much larger than the actual area. In addition, the software used to collect the data is distinct from that used to compile and analyze the data and in a final design a third distinct software would be required as the user interface. This gives the system a very steep learning curve and makes even simple measurements into unnecessary ordeals. To salvage the current system, we would have to consolidate the software and correct the known and unknown eccentricities of the area calculation algorithm. Such a task would not be easy for someone familiar with the software and algorithm but for those unfamiliar with either, such as our group, it would become nearly impossible.

We believe that the limitations of the current design are insurmountable and therefore we will have more success in meeting our client's needs by letting go of prior work and pursuing a novel design.

Stereo Imaging

Using an image captured by a camera of known focal length and sensor area, it is possible to determine the two dimensional, real-world coordinates, of any point on the image, with respect to a coordinate system originating from the center of the camera's sensor. These two dimensional coordinates define the position of the point in the plane of the image. In order to determine the third dimension, or depth, of the point, two images, captured by cameras of known focal length and sensor area and separated by a known distance, are required. The process of determining three dimensional coordinates from two two dimensional images is known as stereo imaging. Figure 3 illustrates how this process is carried out. As figure 3 demonstrates, the geometry behind stereo imaging is not complex. The complexity of the process lies in the correlation of points on both images. That is, the algorithm must determine which point on the second image corresponds to any given point on the first image. In addition, this correlation must be performed for every point of which the three dimensional coordinates are desired since the relative position of a second point does not follow from the relative position of the first.

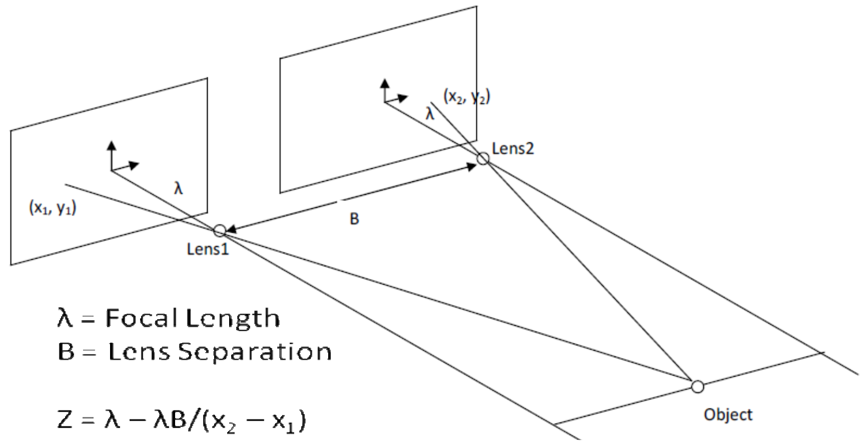

Figure 3: Stereo Imaging Geometry

The second design alternative employs stereo imaging techniques to determine the three dimensional coordinates of many points within the affected area. These points are then connected to form polygons and the areas of these polygons are summed to produce a good approximation of the surface area of interest.

This design is very theoretically sound. In theory, nearly every pixel in one image may be correlated to a pixel in the other. Therefore, the design has the potential to generate an enormous number of three dimensional coordinates which, when connected will generate a similarly large number of polygons, the areas of which, when summed, will generate a very accurate surface area. However, in practice, the correlation of this many pixels, will require a fairly large amount of computing power due to the large number of pixels which must be compared during the correlation of each single pixel.

Ergonomically, this design is also quite sound. Because it must work just as well with grayscale images as with color images, the design does not require special markers with which to outline the affected area on the patient. This reduces any anxiety and cosmetic concerns associated with undergoing the procedure. In addition, the design allows for a fairly unrestrictive working environment for the clinician due to the small size of the required device and the point and shoot nature of the cameras and associated GUI. Finally, the positioning of the cameras does not factor into any calculations required by this design as all scaling is accounted for using the focal length of the cameras and the area of the cameras' sensors and as only relative positions are required for point connection.

The bottom line however, is simply that much of this designs implementation remains speculative. The correlation algorithm has yet to be determined, the housing required to fix the cameras' relative positions has yet to be designed and much of the area calculation algorithm is based on the previous semester's design which is known to have issues. While this design appears attractive on paper, it may not be the most feasible to move forward with.

2D Projection Method

The third and final design alternative utilizes the same principles as a Mercator projection map of the world. This means that the objective is to model a three dimensional space in a two dimensional picture. This method would require the client to first map the sensory abnormality with a marker of some kind. The user would then have to divide the area into several appropriate sub sections, the size of which would be determined by the contours of the surface being modeled, as well as preliminary testing. Using some sort of different marker, whether it be several dots in line, of an actual line, the user will designate the different sub sections. The user will then take pictures of every sub section designated in the previous steps, normal to the middle of the face of each sub section. After taking the necessary pictures of all of the sub sections, the pictures would be uploaded into a certain folder (depending on the interface of our program) and run through our Java program.

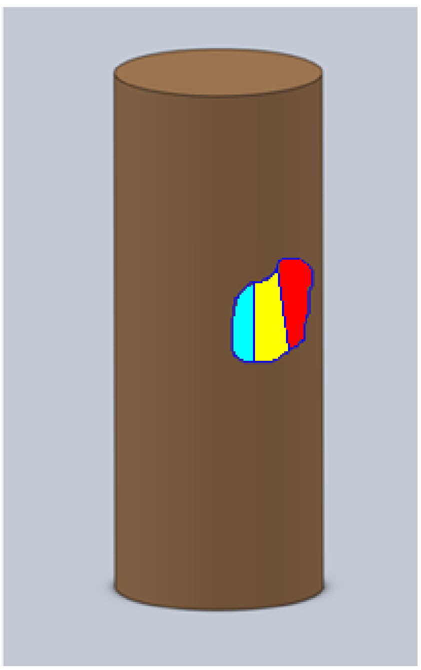

Figure 4: Sub Sections of Example Area
The figure shows an example which has been divided into three separate sub sections (coloring for demonstration only). This shape would require three separate pictures by the user.

The program would then take all of the pictures and make modifications to each one of them individually. It would first identify the boundaries for each of the sub sections and splice the pictures removing any area that is outside the sub section area. The program would then reassemble the sub sections, forming one two dimensional master image (Figure 4). The area of the two dimensional master image would then be readily calculated with methods already proven in our preliminary Matlab work. This design would allow for great maneuverability around an entire surface, as it is not limited by the viewing of stationary cameras. This design would also be incredibly cost efficient, as it would be limited to the cost of digital cameras, which are readily available and very cost efficient. This design would possibly have future capabilities for a mobile phone application, as it does not require a special camera, or camera configuration. The downside of this design is the unfamiliarity with the in depth Java programming necessary to complete it in the time available to us.

The accuracy of this design has yet to be proven and this is also cause for concern. There is no doubt that in theory it has capabilities to be extremely accurate, but it is unknown how many sub sections will be required to ensure a surface area calculation within the allotted error of 10 percent. The more sub sections that are made, the more accurate the surface area calculation will be. Figure 5 is an example showing several sub section methods and how the surface area of a cylindrical three dimensional object (circular cross section) would be more accurate with more sub sections. If four sub sections were chosen, the approximation would resemble the surface area of a similar rectangle. If eight sub sections were chosen, the surface area is modeled by a three dimensional shape with an octagonal cross section, allowing for a much more accurate representation of a cylinder. As the number of sub sections approaches infinity, the model of the cylinder would become the cylinder with no error. This is not a feasible solution, and it will be a balancing act of the accuracy required and the amount of time spent sub sectioning the area on the patient.

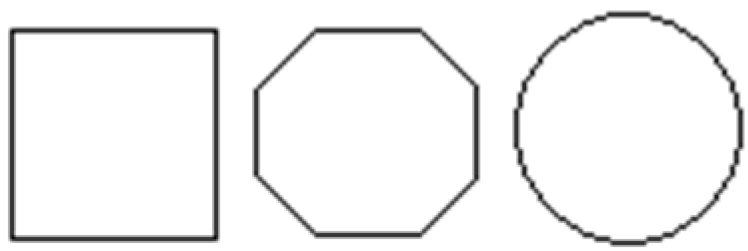

Figure 5: Surface Area Approximations
It is easy to see from the figure that the larger the number of sub section photographed used, the better the surface area approximation for the circular cross section shown.

There were several ergonomics considerations for this design. The capability for one to use any camera versus using a specific camera makes this design very easy on the user. We also hope to eventually integrate the programming into a mobile phone application, which would allow for extremely easy use for everyone who has ever downloaded a simple application for their cell phone. We have also been trying to develop a marking method that does not leave any permanent (ie washable) markings on the patient which would also add to the ergonomics for this design.

Design Matrix

In order to quantitatively compare the design alternatives formulated, a design matrix was employed. This allowed for the comparison based on several design criteria specified by our client. Feasibility, Accuracy, Ease of Use, Ergonomics and Cost were all considered in the comparison of the three designs. Each of the criteria was given an individual weight, based on the importance of each of the factors to the success of the overall design.

Design	Feasibility (15)	Accuracy (20)	Ease of Use (30)	Ergonomics (25)	Cost (10)	Total (100)
Old Design	13	10	10	20	3	56
3D Coordinates	5	15	15	20	5	60
2D Projection	5	15	25	15	10	70

Table 1: Design Matrix
The design matrix shows that the biggest difference came in the ease of use, which is a measure of the ability of our client to actually implement the design.

Feasibility

Feasibility was a measure of the knowledge, familiarity and previous exposure that we have had to the components required for the success of each design. Progress to date was also incorporated in this criterion. The feasibility of the three alternatives was important so we didn't take a more difficult route to a similar result. However, we did not want to simply pick a design that was the "easiest" specifically for that reason, and that is why we gave feasibility a relatively low weight. The previous design had the highest ranking because of the work done by the previous group, which would save us a lot of time. The other two alternatives scored lower because of the relative inexperience as a team working with Java and the limited progress to date on each design.

Accuracy

The accuracy of each design was a measure of the repeatability (within 10% specified by client) of data acquisition, as well as the accuracy (within 10% of actual area) of the final surface area calculation. Accuracy is important to our client so he can reliably use it his studies with confidence that his results are correct. For this reason it is weighted fairly high in our design matrix. The previous design required the patient to remain motionless throughout data acquisition, and required a steady hand to map out the area on the patient effectively. For these reasons the repeatability was severely lacking for the previous design. The accuracy of the algorithm was limited as well, as it often formed surfaces that did not exist and therefore overestimated the area of the surface.

The stereo imaging and 2D projection design alternatives fared slightly better for accuracy. Both designs have better repeatability because they don't rely on having a steady hand or a steady patient, just the ability to take a picture. The accuracy of the stereo imaging design is not flawless as it requires perfect meshing of the data from each camera to create coordinates for the photograph. This is similar to the 2D projection method, which requires perfect reassembly of the sub section pictures to create a perfect master image.

Ease of Use

The ease of use for each design was analyzed with respect to the client using the design. We wanted to formulate criteria that captured the likelihood that our client would integrate the system into his day to day work, and for this reason ease of use was given the highest weight in our matrix. The previous design has some glaring problems when evaluated from this perspective. The system is bulky and requires extensive calibration procedures before every use. The system is also limited to one "hemisphere" of the surface, as described in detail previously, requiring our client to move everything and make several runs to obtain necessary information about the surface area on the backside of an object.

The stereo imaging design is still relatively bulky as it requires a setup of known dimensions for proper function. The 2D projection method was by far the best in this category, as it only requires the knowledge of the use of a digital camera. The client can simply walk around and snap a few photos up close to the area and data acquisition is complete.

Ergonomics

The evaluation of the three designs for the ergonomics criterion was a means of measuring the ergonomics of the design with respect to the patient. Ergonomics was given a high weight in our design matrix, mostly because it is important to us and our client that the patients that the design is used on are capable of being measured effectively, and are willing to use it again. The previous design scored fairly well, as it does not mark the patient in any way shape or form. This is very beneficial as sensory abnormalities often reside on the face, and patients would likely prefer a method that does not require marking of the face. The previous design does require the patent to hold (whatever is being modeled) still for the entire mapping process which generally takes around 30 seconds.

The stereo imaging design requires the marking of the perimeter of the surface area to be found, but it doesn't require the patient to remain motionless, aside for the brief moment that the photographs are taken. The 2D projection method requires extensive marking of the patient, for the outer perimeter of the surface area, as well as the sub sectioning of the area. For this reason, the stereo imaging and previous designs scored slightly higher in ergonomics.

Cost

Cost is a measure of the cost of the overall design for our client, as well as the cost to others that were to use our design in the future. Cost was given a relatively low weight because we believe that the ability to perform should be weighted higher than the cost of the design. The previous design requires the purchase of three infrared motion capture cameras, which in this case was over $2,000. The stereo imaging design requires two cameras (do not have to be infrared) of known focal length. The 2D projection design simply requires the use of a digital camera, possibly even one found in a mobile phone. This means the cost of the 2D projection method is significantly less than the stereo imaging design, which is significantly less than the previous design. All designs would require an algorithm so the cost (if any) difference for this aspect of the cost comparison is negligible.

Final Design(s)

As the design matrix indicates the final design that will be pursued is the 2D projection program, however it won't be the only program that our client receives. After first meeting with Dr. Backonja a short-term goal was created to develop a prototype that at the very least replaces the process of counting squares, but doesn't necessarily solve the problem of determining the surface area of a 3D object. The purpose of this goal was to ensure that our client would receive a product that he could benefit from, even if it doesn't satisfy every single one of his needs. Of course, while the short-term goal nears completion we will continue to pursue and develop the 2D projection program.

Intermediate Program

The intermediate program that is currently in development is to be used as an automation method for counting the squares inside the enclosed area of a shape traced onto graph paper. The program is not any more accurate in determining the surface area in terms of 3D, but should be just as accurate when compared to the counting squares method. The first step of the program is to place a calibration unit on the graph paper somewhere near the traced shape. The calibration unit can arbitrarily be any size; we chose a unit that is two square centimeters. A digital picture is then taken of the graph paper and the calibration unit and is loaded into our developed program. The user would then indicate the size of the calibration unit and the program would then output the area inside the traced shape on the graph paper.

The theory behind the program relies on the RGB (red, green, blue) color model, shown in Figure 6. The digital picture that is inserted into the program is made up of several pixels. Each pixel consists of three values, which are integers between 0 and 255. One value corresponds to the color red, one to the color green, and the final value is for the color blue. All three of these values combined contribute to the overall color of the pixel. Therefore, the program is made to recognize certain threshold values in the RGB matrix that correspond to a specific color. The program is currently being designed to recognize the color of a blue marker commonly used by Dr. Backonja. The program will be able to recognize the color of the marker and view it as the outline of the shape traced on the graph paper.

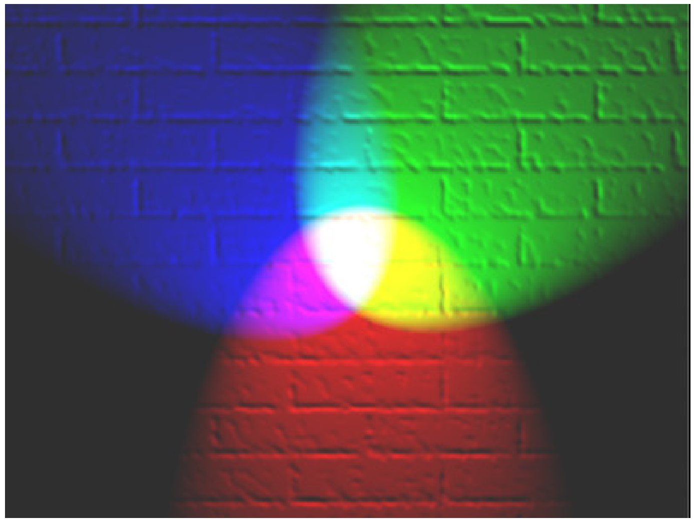

Figure 6: RGB Color Model
Shown in the figure how the different amounts of the colors red, green, and blue yield different overall colors (http://en.wikipedia.org/wiki/File:RGB_illumination.jpg).

Once the program determines the outline it counts every pixel within it, but not the pixels of the actual outline. The calibration unit is what is used to convert the number of pixels into an actual identifiable area. The program is also made to recognize the color of the calibration unit and record the number of pixels the calibration unit makes up as well. This determines the pixel to area ratio. Using this ratio the program can then convert the number of pixels inside the outline into an area. From testing (shown below in Figure 7) on a rough version of the program the area given was only off by roughly 0.5 cm^2 (about a 2.5% error).

This program is beneficial in several ways. First, it saves our client time from having to count hundreds of squares. It also serves as a stepping stone between methods. Having our client first use this program will ease the transition from graph paper to image analyzing. As long as the program continues to provide accurate results, the trust of our client will build and he will be more likely to accept the final 2D projection program.

2D Projection Method

This final program will be a more complex version of the intermediate program. Its function as previously indicated will be to read several inputted pictures, splice and combine the pictures, and output the area of the new Mercator projection-like picture. The main steps the user must perform in order to use this project are to first enclose the area being measured (either with reflective tape, or a reflective marker). Second, calibration units must be also be placed on the patient in such a way that two calibration units are completely visible at any angle. Third, the appropriate amount of pictures are taken in order to view every area in question. Finally, the pictures are loaded into the program where the rest of the process will be automated.

The goal of the program is for it to be able to recognize certain calibration units and combine those units in an overlapping manner when combining pictures together. The resulting picture should indeed be a 2D representation of the surface area on of the 3D surface. Reflective material was chosen instead of marker because it is more universal on all skin tones, where as certain marker colors made be hard for the program to recognize when applied to various skin pigments. Testing of reflective material is shown in Figure 7. By incorporating a flash, the reflective material should appear white on a digital image. This indicates that all the RGB values will be 255. Therefore, any pixel with the values near 255 will be considered part of the outline of the shape. Theoretically, the pixels that are counted inside the outline and the converting factor from the several calibration units should yield the proper surface area of the traced area. The desired output of the program will consist of both the measured area (cm^2) and the resulting combined picture.

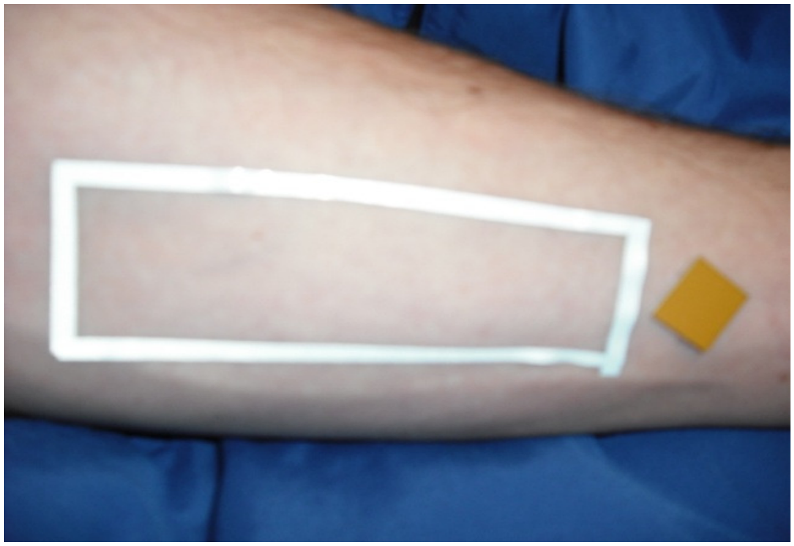

Figure 7: Testing of Reflective Material/Intermediate Program
The left rectangle is enclose with reflective tape. The right yellow diamond was used as a calibration square. Testing showed that the reflective tape was more distinguishable than colored markers on skin.

There are a few challenges that need to be overcome in order to successfully complete this program. The first challenge will be incorporating a method to accurately combine and overlap the pictures. This is important because if the pictures aren't combined properly the area that the program yields won't be accurate or relevant. The second major challenge will be converting pixels into an area. Images of the calibration units will be taken at a couple different angles and not at the same distance. This means when combining the areas, certain parts of the picture maybe more distorted than others, yielding a different pixel to area ratio than other areas of the picture. Therefore, a proper way to normalize the calibration squares on each picture taken is needed.

Estimated Budget

The budget for this semester is very limited, as the previous semester used the entirety of the funds allocated to this project. The method chosen to complete this project therefore is very cost effective. All programming software that will be used to finalize the program can be obtained for free. The programming that will need to be completed will solely be accomplished by us and therefore won't cost anything. The only materials that might require purchasing are either some reflective tape or reflective markers and the poster for the end of semester poster presentation. Therefore, this project has an estimated budget of no more than $60.00.

Future Work

The rest of the semester, much like most of the preliminary work, will consist of programming. Immediate work will include finalizing the intermediate program in Java. Currently the program is written in MATLAB, which is not that commonly used in terms of software programs. The conversion of the program into Java will allow the program to be used much more universally. Once this is completed the program will be tested on various shapes drawn on graph paper. As soon as testing confirms that the program is accurate and reliable it will be delivered to Dr. Backonja.

While a couple of our group members finalize this intermediate project, the rest will get a jump start on programming the 2D projection program. The main focus will be on overcoming the challenges previously mentioned. Again, as the program nears completion it will be tested for its accuracy and reliability by mapping out various surface areas on the body (specifically in the hand region). Accuracy will be determined by comparing program area calculations of a shape with the predetermined area values. Once the program meets our standards we will do further testing with Dr. Backonja to make sure it meets his standards and to ensure that he has a clear understanding of the program.

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Product Design Specifications

Sensory Mapping

Group Members: Mason Jellings, Justin Gearing, Jamon Opgenorth, Daniel Miller

Advisor: Prof. Nimunkar

Client: Dr. Miroslav Backonja

Function:

Our client, Dr. Miroslav Backonja, has asked us to help develop a system for calculating the surface area for mapping of sensory abnormalities. Currently, doctors manually trace sensory abnormalities on graph paper, and measure the area by counting squares inside the traced area. We would like to develop a system that would allow quantitative and accurate measurement of the abnormal area for everyday use as well as clinical study applications. Ideally, the system would accurately calculate the surface area of a 3D surface, but a first step in the process would be to develop a system that accurately calculates the area of a traced shape on a 2D surface.

Client Requirements:

- The final product should be noninvasive
- Must be user friendly
- Must be compatible with different samples without modification
- Must calculate surface areas within ten percent repeatability between trials (10% precision)
- Must yield accurate data (10% accuracy)
- Must take less time to use than the current square counting system
- Must not harm patient or medical personnel

1. Physical and Operational Characteristics

a.) Performance Requirements: The system should measure surface areas more efficiently than the current system.

b.) Safety Requirements: The final design should not come in significant contact to the patient. Some patients experience hypersensitivity, or open wounds that require the least amount of contact possible. Any type of area or perimeter marker used must not harm the patient in any way, and should be able to be easily removed.

c.) Accuracy and Reliability: The accuracy of this system should be within 10% of the actual known area for a given surface. The precision should also be within 10% between measurements.

d.) Life in Service: If the final design is a computer program, it should last as long as technology permits.

e.) Shelf Life: Long periods of inactivity should have no effect on the performance the system.

f.) Operating Environment: The device will function in an clinical environment. This suggests it will not encounter extreme temperatures or humidity. There should be no significant problems due to environmental conditions.

g.) Ergonomics: The device should be easy to use for any physician with minimal programming background. It will be user friendly such that someone that is familiar with a digital camera and uploading pictures could use it.

h.) Size: The device will be used in an exam room, so for this reason the entire system should be easy to transport and store in a cupboard or office.

i.) Weight: The entire system should be easy to handle by one person.

j.) Materials: Any materials are welcome, provided they are safe for use in a hospital exam room.

k.) Aesthetics: Aesthetics should not affect any aspect of our design as our client prefers function over appearance.

2. Production Characteristics

a.) Quantity: One complete prototype will be fabricated.

b.) Target Cost: Firm guidelines for cost have yet to be established, but we expect the budget to be around $200.00.