September 18, 2004

Dr. Andrew Rawicz  
School of Engineering Science  
Simon Fraser University  
Burnaby, British Columbia  
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Re: ENSC 340 Project Proposal for a Tactile Vision Glove for The Blind  

Dear Dr. Rawicz:

The attached document, Proposal for a Tactile Vision Glove for The Blind, outlines our project for ENSC 340 (Special Project Course). Our objective is to design and implement a glove that would inform a visually impaired person, via tactile feedback, of the existence and shape of nearby obstacles.

The purpose of this proposal is to provide an overview of our product and motivate its need within the blind community, review the design considerations and the existing alternative solutions. Additionally, this document manifests our understanding of the project requirements through a tentative schedule and timeline, an estimated budget and funding plan and the role of each group member towards our goal.

S3 Technologies consists of three motivated, enthusiastic, hard working and talented four-year engineering students: Shaun Marlatt (CEO), Sina Afrooze (COO) and Mahmoud-Sam Zahed (CFO). Should you have any questions or concerns about our proposal, please do not hesitate to contact us at S3-Tech@sfu.ca.

Sincerely,

Shaun Marlatt  
Shaun Marlatt  
President and CEO  
S3 Technologies

Enclosure: Proposal for a Tactile Vision Glove for The Blind
Proposal for a
Tactile Vision Glove for the Blind

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Executive Summary

In 2002, a study by the Canadian National Institute for the Blind (CNIB), reported that there are 104,187 visually impaired, blind, and deafblind persons in Canada, with 11,000 new members in 2002 alone. Since visual impairment is most often related to age related diseases, as the average population of Canadians increases, the total number of members of the CNIB is only expected to grow.

At S3 technologies, we are committed to meeting the special needs of the increasing number of visually impaired persons in Canada. We believe that the continuing advances in integrated circuit technology and engineering materials should be applied to increase the mobility and independence of those who are visually impaired.

In this proposal, we outline our plans to develop an inexpensive assistive device to aid blind persons in day to day tasks such as navigation. The device, a glove which senses the proximity of nearby obstacles and provides detailed tactile feedback to the wearer about the distance and form of the object, would allow blind persons to navigate in complex environments where the layout of obstacles, such as people, is constantly shifting and moving. We also believe that tactile feedback is the appropriate choice, since it has been shown that the tactile acuity in blind persons is higher than that of sighted persons (Daniel et al., 2003; Van Boven et al., 2000).

Our goal is to design the tactile sensory glove to be both intuitive and user friendly. Unlike many other specialized assistive devices for the handicapped, the device will also be affordable, with a development cost of less than $200 for the research model. Considering economies of scale, we predict that a production ready version would cost less than $100.

With three excellent engineers having previous experience in sensor design, haptics and embedded programming, S3 technologies is well equipped to tackle the design and development of the tactile vision glove.
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1. Introduction

With over 100,000 blind persons in Canada and more than 10,000 new blind persons per year, the need for assistive technologies that help increase the mobility and independence of the blind is only increasing.

Blind people have few choices when it comes to assistive devices that help them walk safely and avoid potentially hazardous objects around them. These choices range from using conventional walking sticks to guide dogs, to a recently developed laser ranging walking stick or even electronic eyes; the expense of the latter two making them inaccessible to the majority of the visually disabled.

The goal of this project is to build a device that can detect objects around a blind person, measure their distance, approximate the shape and convey this information to the blind person through tactile signals. The device is called Tactile Vision Glove and as the name indicates, is a glove equipped with distance measurement sensors and transducers that provide tactile feedback.

Using the Tactile Vision Glove, a blind person not only will be able to locate the objects and obstacles and their distance from him/her, but will also sense the rough shape of the object, as if he/she was actually touching it. Similar technological devices available to help the blind in walking are either not very safe or not very helpful. Many of these devices use audio tones to communicate with the blind. In many situations, audio tones can pose a danger to the blind person because they serve as a distraction from other sounds in the environment.

One of the major problems that blind people face is finding a specific object in the room. They cannot use their stick because it may hit fragile objects and break them. They need to move around the walls with their hand and touch every single object to find what they are looking for, possibly touching a hot or sharp object. A device that can give the blind information about the shape and distance of objects around them, without the need for direct contact, would be very useful. The Tactile Vision Glove will be the first to provide this type of assistance.

In the remainder of this proposal we discuss several possible design alternatives, along with their limitations and drawbacks, the proposed design solution for the Tactile Vision Glove, the estimated project cost and sources of funding and a development schedule outlining critical milestones and target completion dates.
2. System Overview

The diagram in Figure 2.1 illustrates the Tactile Vision Glove system overview. The distance measuring sensors mounted on the glove would relay the distance of potential obstacles in the form of analog output, which would be subsequently processed by the digital signal processor. The processor would analyze the distance data and provide the wearer with tactile feedback through vibrators (Figure 2.2).

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**Figure 2.1: Block Diagram of the Product System**

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**Figure 2.2: Illustrated use of Tactile Vision Glove**
3. Existing Devices for Assisting the Blind in Walking

There are several methods and devices available to assist blind people in detecting obstacles or specific objects of interest. Conventional walking sticks, guide dogs, laser equipped walking sticks, and the recent electronic eyes are some examples of the devices and methods that have been developed so far. In the following section we discuss some of their drawbacks.

3.1 Walking Sticks

Walking stick is probably the first assistive tool that was used by the blind. There are many problems associated with them, which are listed below:

1. When blind person is walking, the stick may hit other people in their path and cause trouble.
2. It is very difficult to find objects using the stick. Often the blind person resorts to using their hands to feel for the object.
3. If the stick hits a fragile object it may break it. Also if it hits a liquid container, it may spill the liquid.

3.2 Guide dogs

Although guide dogs can help blind person to pass through obstacles, there is the potential for attack from other dogs, which harms the dog and possibly blind person in some cases. In a survey done in 1999 by Guide Dogs for the Blind Inc. it was determined that about %31 of the dogs trained in that institute had been attacked by other dogs in the past three years (Don, Guide Dogs for The Blind). In addition, many people have allergies to dogs, or are not comfortable around them.

3.3 Laser Equipped Walking Sticks

The laser walking stick uses a low power laser beam to detect obstacles up to 12 feet from the blind person and provides several different audio tones depending on the distance between the person and the obstacle (Associated Press, 2003). One of the disadvantages of this device is its price; it sells for about US$3000 commercially. Besides being expensive, it takes time for the person to get used to audio tones. It is also easy to mistake audio signals in a noisy environment.
3.4 Electronic Eye

Still under research and development, electronic eyes have been tested with some success since year 2000 (BBC, 2000). They are very expensive and also contain some risks because a number of electrodes must be implanted in brain. One major disadvantage of this device is that it can only be used for people who were not born blind, but were instead blinded in an accident. This is because the brain of people who have been born blind can not interpret the visual signals, even though the brain may ‘see’ them. Even for the people who are not born blind, this device does not provide full vision capability (only in limited distance and limited area). Therefore, although it is a very powerful device, it is not yet suitable for many blind people both in financial and limitations aspects.

3.5 Navigation Device for The Blind

There have been several devices developed commercially and non-commercially that assist blind persons in navigating by either generating audible tones or speaking to the blind person (e.g. 400 feet straight or turn left) (Associated Press, 2004). These devices do not provide any information on obstacles on the way, so the person still requires some kind of assisting tool when using a navigation device (Walking Stick, etc.).

3.6 Similar Devices to the Tactile Vision Glove

We could only find one project that had the same objective as ours, i.e. converting distance to tactile signals. This product is only in prototype stage and it’s called CyArm, developed in Japan (Okamoto et al., 2004). It uses only one ultrasonic distance measurement sensor and an electrical motor controlled strap that is attached to the person’s body. The strap is used to apply a pulling force proportional to the distance measured. The research model was not very accurate. In testing to detect a white wall from distance of about 1.5 m, the device failed to recognize the wall in %10 of the time. This error is very significant considering the fact that a flat white wall is supposed to be the easiest object to detect. They also use only one sensor; therefore it can not detect the shape of the object. Overall, we do not think that this device is very successful, at least at this stage of the project.
4. Proposed Design Solution

Our proposed design solution is composed of four distance measurement sensors and four tactile transducers (e.g. vibrators) mounted on palm of a glove. Each of the transducers makes a tactile signal proportional to the distance measured by its associated sensor. Therefore blind person would be able to sense not only that there is and object at a certain distance, but also the rough shape of the object and the location of its edges. If used with ultrasonic distance measurement sensors, it can also be used by a normal person in situations where the vision is limited by smoke or dust, e.g. firemen can possibly use it in excess of smoke to sense obstacles in their way.

The Tactile Vision Glove is an innovative idea that has not yet been produced commercially. Although there have been other mobility assisting tools for the blind, there have not been any devices that could map the distance into tactile feedback that allows a blind person to sense the shape of objects from a distance.

The major constraint for us in this project is time and funding. We have a twelve week time limit and our budget is limited to about $200. These two constraints force us to limit our research to simple design solutions and only use low cost components. This is beneficial in the sense that it will keep the price of an eventual market prototype in the affordable $100 range. We will only focus on building the Tactile Vision Glove with four (or three) infrared distance sensors and four (or three) transducers that produce intensity controlled vibrations.

Having more time and financial resources, we could build the Tactile Vision Glove using smaller sensors and transducers so that more elements could be fit on palm of the hand, therefore creating a more realistic feeling of the shape of the object. We could also do extended research on using ultrasonic distance measurement sensors for use in excessive dust and smoke, extending the range of applications for the Tactile Vision Glove.
5. Sources of Information

For general research and design issues we will draw primarily on knowledge gained from previous courses, course textbooks and resources in the SFU library.

The internet, particularly pages maintained by robotics hobbyists, will also be a good reference for programming and interfacing sensors and components to the Pic microcontroller. Of course, component data sheets and application notes will also be extensively used, as well as the user manuals for the Pic microcontrollers.

In researching alternative solutions to tactile rendering, our main source of information will be the internet, as well as journal and conference papers on tactile (haptic) rendering.

Our primary research sources on blindness and needs of the visually impaired will be from journal papers and various internet sources dedicated to providing information on blindness, particularly the Canadian National Institute for the Blind. We also plan to make use of the SFU Center for Students with Disabilities to attempt to contact students with severe visual impairment, who are attending the university, and are interested in answering questions that will help us better define the functional specifications for our device.

Finally, we will draw on our CEO’s extensive expertise in infrared sensors and microcontroller interfacing issues, and knowledge of haptics gained through his current research activities.
6. Budget and Funding

6.1 Budget

Table 6.1 outlines the estimated budget for our project. To estimate the budget we considered the prices of equipment listed in the table at Digi-key electronics and used the maximum price for the components that meet our preliminary design needs as our cost. For example, the IR distance sensors listed in the Digi-key catalog ranged in price from $15-25 dollars. The total cost for the sensors was determined by multiplying the maximum price by the number of sensors (three) that we intend to use in the project. The same procedure was used to estimate the price of other equipment. We have also grouped the price of extraneous parts and connectors required for supporting or interfacing the sensors, microcontroller and transducers.

We also plan to avoid the cost of a programmer for our microcontroller by using a Pic microcontroller chips in our project, for which SFU already has several programmers for. From past experience, we have also allocated a portion of the budget to the cost of replacing parts that are accidentally damaged or destroyed during project development. The cost of shipping has also been included in our estimate, calculated as 3 separate orders from Digi-key over the semester, at a cost of $8 shipping per order.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR Distance Sensors</td>
<td>$25x3</td>
</tr>
<tr>
<td>Microcontroller</td>
<td>$15</td>
</tr>
<tr>
<td>Transducers</td>
<td>$10x3</td>
</tr>
<tr>
<td>Misc. Parts/Connectors</td>
<td>$25</td>
</tr>
<tr>
<td>Replacement Parts</td>
<td>$25</td>
</tr>
<tr>
<td>Shipping Costs</td>
<td>$24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$194</strong></td>
</tr>
</tbody>
</table>

6.2 Sources of Funding

Our plan is to make use of the Engineering Science Student Endowment Fund, and the Wighton Development Fund to provide the funding required for our project. If additional funding is required, we will attempt to contact institutions such as the Canadian National Institute for the blind for financial donations. In the case that we are unable to raise enough
capital to cover our costs, the company members are prepared to absorb costs of the project that could not be covered.
7. Schedule

The Gantt chart for the timeline of our project is depicted in Table 7.1. Estimated time to be spent on different tasks is shown for major deliverables as well as key stages of the development cycle.

Table 7.1: Gantt chart

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Sep '04</th>
<th>Oct '04</th>
<th>Nov '04</th>
<th>Dec '04</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Research</td>
<td>29</td>
<td>12</td>
<td>19</td>
<td>16</td>
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<tr>
<td>2</td>
<td>Proposal</td>
<td>10</td>
<td>17</td>
<td>24</td>
<td>5</td>
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<tr>
<td>3</td>
<td>Component Selection and Purchasing</td>
<td>17</td>
<td>14</td>
<td>21</td>
<td>5</td>
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<tr>
<td>4</td>
<td>Functional Specifications</td>
<td>10</td>
<td>7</td>
<td>14</td>
<td>5</td>
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<tr>
<td>5</td>
<td>Design Specifications</td>
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<td>14</td>
<td>21</td>
<td>5</td>
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<td>6</td>
<td>Integration</td>
<td>10</td>
<td>7</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Testing and Debugging</td>
<td>17</td>
<td>14</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Documentation</td>
<td>14</td>
<td>11</td>
<td>18</td>
<td>5</td>
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<tr>
<td>9</td>
<td>Oral Progress Report</td>
<td>21</td>
<td>18</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

The expected completion time of the expected tasks are summarized in Figure 7.1 the Milestone figure.

Figure 7.1: Project Milestone Chart
8. Team Organization

S3 Technologies is comprised of three hard working engineering students at Simon Fraser University. Each member is motivated and determined to achieve our goal and even extend the scope of our project beyond ENSC340. The different experience and background of each member makes our team ideally suited to tackle every single aspect of the development of the Tactile Vision Glove.

The duties are designated based on the corporate structure of the company. Shaun Marlatt, Chief Executive Officer (CEO), is the team leader and assures that the overall progress of the project is as expected. Mahmoud-Sam Zahed, Chief Financial Officer (CFO), is responsible for financial planning and budget management. Sina Afrooze, Chief Operational Officer (COO), will manage and solve the technical problems encountered along the way. Since there are only three members in the group, the member duties are not confined to the titles and each member will be involved in other aspects as needed. Members are also aware of their strengths and weaknesses and will eagerly try to help each other.

The daily schedule and course load of the team members are very similar and they spend most of their time together. However, there are two formal meetings per week where the detail status of the project as well as any difficulty or problem will be discussed and solutions will be evaluated. There are also some break times for members to accommodate the demands of other courses. Mr. Marlatt is working on his undergraduate thesis and other group members are involved in high level engineering courses, which will occupy the remainder of their time outside of the project.
9. Company Profile

Shaun Marlatt – Chief Executive Officer (CEO)

I am a 5th year systems engineering student at Simon Fraser University with previous experience in system integration and design. In pre-university life, I received numerous awards, including one from the Canadian Council of professional engineers, for a science fair project in which a partner and I developed a six-legged autonomous walking robot capable of relaying gathered sensory information back to a computer base station. This project required the use and interfacing of distance measuring sensors, microcontrollers and actuators. Currently, I am actively involved in research to develop a virtual reality minimally invasive surgery simulation and training system; a multidisciplinary project which requires an expert understanding of biological soft tissues, high-performance numerical modeling codes, computer architecture, computer graphics and haptic rendering.

Mahmoud-Sam Zahed- Chief Financial Officer (CFO)

I am a 4th year electronics engineering student at Simon Fraser University where I was able to obtain various invaluable skills including software programming and hardware design. Through different demanding projects, I have developed excellent programming skills in Java, C, VHDL and assembly language. I am also experienced with various microprocessors including Motorola’s HC11/12 and DSP microprocessors. I have also taken coursework in analog and digital circuit design and communication systems analysis. In addition, my acquired organizational skills and business protocol enable me to assist S3 Technologies towards our target.

Sina Afrooze-Chief Operational Officer (COO)

I am a 4th year Systems Engineering student at Simon Fraser University with four previous co-op term experiences. Out of these four co-op terms, three have been in Creo Inc., the largest high-tech company in British Columbia. I have programming experience in Object Oriented Design with Java and C++ languages. I have also built several windows applications using Visual Basics. I have also done real time programming in QNX environment. I am familiar with many electronics lab equipments, as well as different types of electro-optical sensors, I am experienced with many image processing algorithms and techniques such as edge finding, sharpening, smoothing etc. Working in the large environment of Creo, I have also gained a lot of team-work skills.
10. Conclusion

S3 Technologies is using latest technology in electronics to build the Tactile Vision Glove. This product is an innovative idea that has not yet been developed commercially and has the potential to greatly assist the blind in their daily activities by helping them in walking and locating objects.

The Tactile Vision Glove will enable the blind not only to detect objects around them and estimate their distance through the intensity of tactile feedback, but will also sense the rough shape of the object as if the person is actually touching the object itself. Our product can be used in combination with other blind navigation systems that have already been built to fully empower the blind to walk to any place they need. Other devices such as walking sticks, and even laser sticks, have drawbacks that are not inherent in the Tactile Vision Glove.

Our scheduling with the Gantt and Milestone charts demonstrates how this project will be completed in the allotted time frame. Our sources of information and finance are clearly highlighted and we have proposed a reasonable strategy to achieve our objectives.
11. References


