GroZi Shopping Assistant

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ABSTRACT

There are approximately 10 million blind and visually impaired people in the United States. A remarkable 2 million of these people use computers regularly. There is also an increasing rate of people in the blind community who are willing to learn and train to use canes and guide dogs. These are sure signs of the demand to be more independent from physical human assistance. As technology improves, the blind community will want to become more and more independent in hope that one day, they will be as normal as a person with no visual problems. One typical problem that the visually impaired have thus far is being able to shop at their own convenience and privacy. The GroZi Shopping Assistant is our solution to this problem. It is the next step towards being able to locate objects by the use of computer vision. Using a haptic (touch) feedback device placed on the user's hand, the blind person can feel exactly where to locate the item he/she desires. Since the computer software is still under development, a substitute called the Remote Sighted Guide (RSG) will guide the user by giving haptic and audio commands to the blind person through the view of a camera placed on the blind user to mimic the "sight" of the blind individual. With the right computer code and an advanced computer object recognition system, the blind community will be able to "see" and locate anything they desire.

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EXECUTIVE SUMMARY

The GroZi shopping assistant project is a joint mission between the California Institute of Telecommunications and Information Technology (CalIT^2) and UCSD's Computer Science and Engineering departments, overseen by computer science professor Serge Belongie. The long term goal of the project is to eventually allow the blind and visually impaired to independently locate any distinct items in any given area. By utilizing the use of advanced computer vision technology, the computer will serve as the blind and visually impaired persons' eyes. Once the computer system has located the item desired, a device will provide touch sensory feedback to the user and indicate to him/her the whereabouts of the item. As a beginning step towards this mission, the project has selected a grocery store as a typical place where such a technology could be utilized. The blind or visually impaired individual would enter the grocery store and the GroZi shopping assistant would guide him/her to the items that he/she has on a grocery list. The project has been split into three primary parts that are working concurrently to complete the project. One part will develop a blind-accessible website which allows the blind user to create a grocery list of all the items he/she wants from the grocery store at the convenience of their own homes. The second part is developing the computer vision software which will enable item identification through a camera based on object recognition algorithms. The final part is responsible for creating an innovative portable device that can synchronize the information given from the blind-accessible website, execute the object recognition algorithms from the advanced computer vision software, and output the results by means of haptic feedback. The MAE156B team has been assembled to develop this portable hardware for the project that the user will interface with. The portable unit should be easy to use, nonintrusive, and ergonomically pleasing to the user. The MAE156B team has provided the project with a unique perspective at how the user will be able to interact with the computer to locate items that he/she cannot visually see. A glove unit will become the enclosure for the haptic feedback mechanism. Placed inside the glove are vibrating motors that will enable the user to feel four direction orientations on his hand (up, down, left, and right). These four orientations indicate to the user where the object is in relation to his/her hand in real time. Mounted on the area between the index finger and the thumb of the glove is an advanced camera typically used in security systems. This camera is the computer's vision; all object recognition algorithms are determined by the pixilation and resolution of the camera. The power supply for the device is located as a belt battery pack to store all the necessary components that cannot fit onto the glove. A speakerphone will also be included into the device for audio feedback that may be too difficult to adhere to with touch. As the user's hand moves, the camera will pick up images and act as the blind user's eyes. When pointed at an aisle, the portable unit will indicate to the user, using preprogrammed voice commands, the components of that aisle as an indicator of where he/she is in the grocery store. Next, the haptic system will guide the blind user to the desired item and an audio confirmation button has been included on the glove to tell the user what item he/she has selected. Since the hardware team worked in congruence with the computer vision team, the computer vision software cannot be utilized to test the product. In substitute of the computer vision, the MAE156B team has configured an alternative method of vision called the Remote Sighted Guide (RSG). The RSG is a person who has a screen viewing of what the camera on the blind user's glove sees and a control box to provide the audio and haptic feedback that the computer would provide if it were available. Using a Bluetooth headset and a control box developed by the MAE156B team, the RSG can simulate the actions of the computer by looking at the camera view through a laptop computer from afar. Numerous risk reduction analysis and experimental results show that this design is efficient and robust.

PROJECT DESCRIPTION

BACKGROUND

The project began late summer of 2006 when Dr. Serge Belongie, a professor in the computer vision department of UCSD, proposed a research interest in aiding the visually impaired locate items through computer vision in any environment. The first research step he took was in grocery shopping assistance. The initial concept consisted of an online grocery shopping list that the user can visit to create a list of items he/she wishes to purchase at the store. The list is then downloaded onto a device loosely titled "MoZi" box, which contains servo motors to guide the blind person around the aisles (Figure 1). A camera within the MoZi box can read random words in the viewing panel and attempt to associate locations of the words with items on the shopping list. However, this MoZi box was only a concept that had no real working parts. The project required a team of Mechanical Engineers to develop a prototype device that will serve as the model to build around the software. The goal of this MAE 156B project is to create a device apt for allowing a blind individual to pan the camera view and to create a haptic system that guides the user to the item he/she wishes through application of pressure. At the conclusion of the MAE 156B project, the Mechanical Engineers will have created a physical model that encompasses the research project mission.

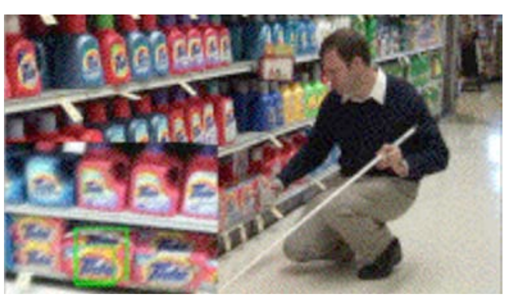

Figure1: Blind User using MoZi

EXISTING DESIGN SOLUTIONS

The idea of aiding the visually impaired has been an ongoing process for many years. However, the addition of computer vision is an idea that has not been perused till within the past couple of years. Many projects have tried to implement Braille machines into allow haptic sensory and provide a written language to help the blind. However, statistically, only a very small percentage of the blind population is apt enough to use Braille. Others have attempted to use sonar detection (Figure 2), but many items become undetected through sonar if the frequencies are incorrect. The most popular form of computer aided blind guidance is through Radio Frequency Identification tags (RFID) like the ones in Figure 3. However, this is not an efficient method because a system needs to be created and placed on every item in order for the item to be accessible by the computer.

Figure 2: Oxford Design

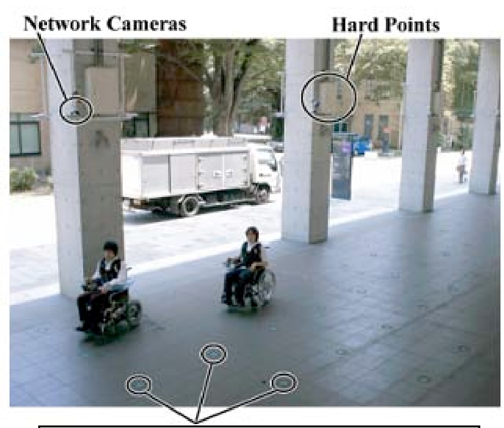

Figure3: Haptic Mechanisms

STATEMENT OF REQUIREMENTS

The device must be able to direct a visually impaired person around a grocery store with minimum audio feedback given to the user. The user interface will be interrupt-based, with the user prompting a remote sighted guide for direction in the form of haptic feedback. The device must also be user-friendly, inasmuch as it must be comfortable, relatively easy to use and be unobtrusive to the user. All in all, the primary requirement is to utilize the touch sensory as the primary mechanism for feedback.

DELIVERABLES

The deliverables of this project are simple compared to the testing and design decisions that must be made throughout the development due to basic research trial and error. A blind or visually-impaired user is assumed to have the ability to navigate through the store and position himself/herself in front of an aisle sign and push a button on the glove. There needs to be a remotely-located person read the aisle signs from a wireless camera feed and speak the words into a phone headset worn by the user. The user will then navigate down the aisle and wave the camera past the shelves. We must be able to pick out the desired product on the shelf and direct the user's hand to grab it using mainly haptic, tactile, feedback to the user. It is beyond the scope of this project to have a solution for holding the cane, shopping basket, and product at the same time, though we have taken that situation into consideration with our design.

DEFINITIONS OF PROJECT USE

The project itself is designed to be used in a typical grocery store. The prototype of the final design built is fully functional within a 60 ft radius of the camera receiver, which is about six aisles, thus limiting our product to small to medium size grocery stores. This constraint can be diffused with a better camera, but since we are the first ones working on this project, our main intentions were to just make sure that the device we build would work. In later variations of the product, a better camera with a stronger receiver and better visual clarity would be used.

The product is used by the user in a very simple manner. First, the user enters the store and navigates himself/herself through the store aisle with his walking stick. The camera itself is positioned on the glove which would allow it to read the aisle signs. This is relayed to the user via audio feedback through a headset. Next, the user changes the positioning on the camera and moves it forward until the camera makes a clicking noise, indicating that the camera has reached its ideal position for scanning items on the shelf. The user would then walk through the aisle, stop, and then scan on both sides of the aisle by pointing the camera towards the product. This scanning motion needs to be done very slowly, thus allowing the RSG to view the products and determine if the user specified product is in the visual field. If the user scans through the products too quickly, the RSG would send audio feedback telling the user to slow down due to a blurry field of vision. Once the product is recognized by the RSG, the user is sent haptic feedback by the RSG to help navigate his/her hand and pick out the product. If the item is not in the visual field, no haptic feedback is given, and the user continues to walk and scan through the aisles, until the desired item is found. A flowchart of the idea can be found in Figure 4.

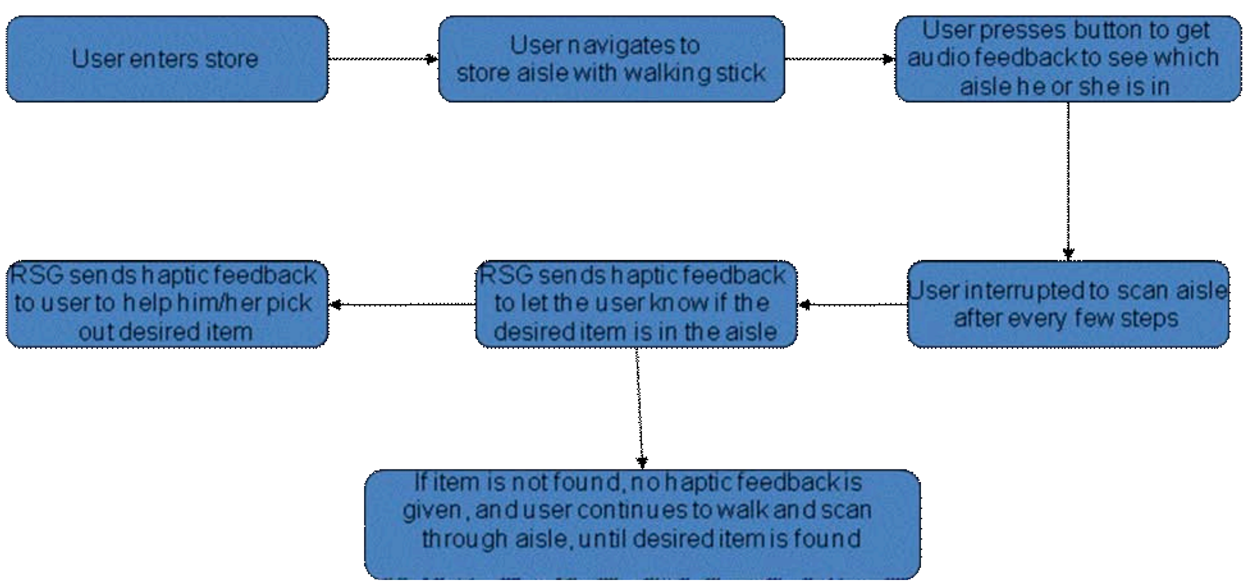

Figure 4: Design Flowchart

DESIGN SOLUTIONS CONSIDERED

PRIMARY DEISGN CONSIDERATIONS

One primary focus when considering designs was the study of rehabilitation engineering. Many research institutions, primarily universities, performed extensive research on ways to aid the blind and visually impaired. Some research projects were original; others were in depth, while some were just outrageous and impractical due to the funding needed for such ideas to work. Three primary research designs were studied for rehabilitation engineering. The first comes from the University of Oxford. The researchers at Oxford mounted cameras and sonar detection devices onto a utility backpack and harness in which the user wore. Whenever an object was displaced from the ground plane, either the sonar or visual would detect the object in the person's path and notify the person of the obstruction. Although, the device was large and cumbersome, the identification of objects was very clever and precise. The second research idea studied comes from Massachusetts Institute of Technology where researchers there studied the "vision" of the blind. Using an expensive laser called the Scanning Laser Opthalmoscope (SLO), blind members claimed to have seen images that were inputted into their retina through this laser. This was a very fascinating discover, though more tests need to be conducted to see if images could really be implanted into those who cannot see. There was one instance in which a blind user was implanted an image of a stairway and using this image she was able to walk down the steps. The final rehabilitation engineering research that was studied comes from the University of Tokyo. In this design, a part of the university was labeled with Radio Frequency Identification Tags (RFID) all over the ground. Each blind individual has vibrating pulse wires connected to each of their fingers except the thumbs. As blind individuals, using wheelchairs, crossed over one of the RFID tags, a wireless network would send signals to the devices on the user's hands and send Braille through vibrations to the user of his/her location. We extrapolated many ideas from these three research studies to come up with our own rehabilitating engineering design (Table 1).

Research into the role of audio feedback in blind navigation revealed that current off the shelf solutions generally do not use audio feedback unless the user queries the device. This is a common theme in devices aimed at blind navigation, as the visually-impaired rely on their sense of hearing to make sense of their surroundings. Because of this, devices that use a great deal of audio feedback will generally do more to hinder than help their users.

	Pros	Cons
University of Oxford	Camera resolution, human rotation feedback control, multiple object tracking	Placement of devices, number of devices, aesthetics
MIT	"previewing" images	Impractical, exclusively available
Tokyo University	Haptic feedback, use of Braille, RFID utilization, GPS	Limited environment, impractical use of GPS, number of parts

Table 1: Existing Design Pros/Cons

Many ideas were considered as a method for providing haptic, tactile, feedback to the user in hopes of finding an "out of the box" idea. The most difficult ones to rationalize were temperature changes, small electric shocks, pressure, and positioning the neck so the user would be able to sense where to put his hand. These methods are very invasive, and the users would not want to experience these sensations for very long, so without interest from the user, there would be no market for this product. The ideas that made the most sense were vibration and position or displacement. Both methods have been used extensively in applications that are used every day, so we had to choose the best for our application.

RISK REDUCTION EFFORT

From understanding the previous designs, it was noticeably clear that each research study included a rigorous set of guidelines for the computer to follow in aiding the blind person to his/her desired location. For us to further understand the complications in identifying and locating objects that we cannot see, an extensive risk reduction was performed to improve and make the command list of our system to be simple and easy to use. One team member was blindfolded and was guided around using various guidance tools such as tapping (Figure 5), constant pressure, angular voice commands, and variations. A compilation of dozens of tests concluded that there was a simple and efficient way to implement haptic feedback and limit the need for voice commands.

Figure 5: Blind User Risk Reduction

Another potential problem with the design is that the RSG must be able to clearly read text at both a great distance (as when making sense of aisle numbers and descriptions), as well as at a close range (as when the used reaches for an item on a store shelf). As our cameras cannot change focus dynamically via a remote, they must have a predetermined focus. Risk reduction efforts were made to determine if one camera would be sufficient for our requirements, or if two cameras would be required. The camera was first set to a focus that enabled 4" tall letters to be read at a distance of 20 feet. The camera was found at this range to have enough contrast to read many common product boxes at a distance of 6". The camera's focus was then set to be able to read newsprint at a distance of 3". It was determined that, at this focus, it was impossible to read the 4" letters at anything more than a few feet. This test indicated that an additional camera would not be required.

A critical decision that we had to make was the camera and its placement on the body. In regards to camera selection, we needed the camera to be small, wireless, and have a good enough resolution to recognize the products on the aisle. After doing some research we chose a security camera made by a company called SWAN. It is a wireless camera, the size of a ping-pong ball and provides good video feedback in a 60ft radius from the receiver, thus limiting our product to be only used in small to medium grocery stores. Several ideas were brought up during our discussion sessions with our sponsors in regards to where the camera should be placed. (i.e. on the head, neck, chest, or the hand). Placing the camera on the head or neck seemed too invasive and would not make our product discreet. We initially agreed to place the camera on the chest and mounting it onto the user's shirt through a clip, but that idea fell through after a few risk reduction tests. The chest mounted camera posed a problem when the user would try to read the aisle signs, as he/she would have to lean back tremendously to get the aisle signs in the visual field of the camera thus allowing the RSG to send the appropriate audio feedback. After doing a few more risk reduction tests, we chose to put the camera on the hand.

JUSTIFICATION OF DESIGN CHOICE

Compared to existing designs, the command list we have fabricated for the Remote Sighted Guide is rather simple. Although most blind and visually impaired personnel have a high school diploma, they may not be so adept in learning a large list of commands and operations to go along with the device. Later in our research and

interviewing, we discovered that the blind actually have a great sense of direction and seldom run into objects ahead of them. However, they can still not locate specific items such as a certain item at a grocery store. Therefore, we changed our parameters and limited our command to simply a two dimensional plane in which the items are located in a grocery store. This simplified our concise command list even further leaving us with a final design consisting of four direction movements (up, down, left, right), one correction movement (step back, the camera is blurry), and two confirmation commands detailing the individual's aisle location and item obtained. Our findings were detailed onto a sample soundboard to simulate a computer or RSG talking to the user (Figure 6). Through extensive risk reduction analysis, we concluded that a total of seven commands are sufficient enough to navigate a blind person through a grocery store to obtain his/her items.

Through our risk reduction tests at the grocery store, we attempted to simulate the glove design. This showed that either design would work for guiding a person, but we had to make an actual model to determine the best for us. We constructed a glove with vibrating motors (Figure 7) glued to it, and it worked great. We were going to try to use solenoids as pressure or position devices, but to design it so that a person could feel four of them at the same time through a glove were not worth the effort. We were also concerned that the vibration might get annoying to the user, but it will only be used when the user is trying to get his hand on a specific product, which is a relatively short time. The user can easily feel the vibration through the glove, and can determine the command given by the location of the vibration.

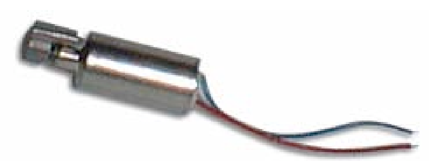

Figure 7: Vibrating Motor

In regards to the placement of the camera, we decided that placing the camera on the hand made our product very discrete and also gave the user more degrees of freedom in regards to the movement of the camera (Figure 8). The user could move the camera freely by just moving his arm. The camera itself is going to be mounted on the glove through a slide and lock mount mechanism. Placement of the camera on the glove would integrate all of our separate devices into a singular working field, thus making our product very discreet.

Figure 8: Risk Reduction Test

The camera risk reduction consisted of setting the camera focus to make products readable when placed three inches in front of the camera (Figure 9), and then determining the maximum range at which four inch tall letters could be read. Predictably, this focus failed miserably, with the four inch letter being practically unreadable when 2 feet from the camera. Next, the focus was set to be able to read those same four inch letters at a distance of 25 feet, and then determining at what point the small letters would become unreadable. Surprisingly, setting the camera focus to this length still allowed print almost as small as newsprint to be read at distances as close as four inches. Using engineering intuition, we discovered the allowable resolution of the camera to work under not only an RSG, but also for computer identification. These risk reduction results qualify as justification for the use of one camera, focused at a long focal length.

Figure 8: haptic risk reduction

Figure 9: Camera and Receiver

DESCRIPTION OF FINAL DESIGN

ASSUMPTIONS

Assuming that the users of the device will go through a training program before operating the unit allows the design to be more feasible. For the purposes of the MAE156B deliverable, it is also assumed that the blind person has the ability to navigate to the grocery store and understand how to get around areas without causing havoc. Through some analysis of blind persons' motor skills, it can be assumed that they are able to navigate on their own from place to place, thus eliminating the concern to guide the blind individual from the grocery store entrance to the item location. Instead, the project can now focus on navigating the blind person only on a two dimensional plane that is the shelf where the items are located.

FINAL DESIGN SUMMARY

The final design consists of four vibrating motors embedded into a glove, as shown in Figure 10. These motors are connected through a circuit board and wired wirelessly to a remote control used by the RSG. Mounted on the rim between the index finger and the thumb is a camera mount where the camera can alternate rotations about two axes for correctional purposes. The camera, which reads the items, in turn is located atop the camera mount. At the thumb position of the glove, there is also a prompt button that allows the user to prompt for audio feedback from the RSG for aisle sign reading and item confirmation. Due to the amount of battery required to power the system, a battery pack will be used that is attached to the belt wired by two cat-5e cables.

Figure 10: User's Glove (left hand) Assembly

COMPONENTS

The primary components in the design are:

1. Swann security camera and mount(1)
2. Vibrating motors (4)
3. Battery pack (1)
4. RSG controls and commands

The Swann is a security camera, as shown in Figure 11, about the size of a thumb. This small camera has a large enough resolution to identify items clearly from 20 feet away. There is a focal length can be adjusted for far and close regions to allow visibility from a distance as well as up close. This camera is mounted onto our mount designed from light weight acrylic. The mount allows the camera to tilt about two axes to account for error in hand orientations as the hand reaches for objects versus when the hand is holding an object to a person's side such as a cane. From several risk analyses of the camera, the effectiveness of the camera for reading labels was determined. Also, the difficulty in viewing items when the hand orientation is changed sparked the need for a mount that can tilt to adjust for this error.

Figure 11: Swann Camera

The vibrating motors can be found in many cellular phones and pagers. These are simple cylindrical tubes with a rotational end that causes vibration when they tubes rub against each other. When the RSG notifies the user a direction, the motor will start to vibrate indication the direction the user should move his/her hand. These little motors were perfect for fitting into a glove discreetly. There was a problem with the motors having very low stall torque, so a protective aluminum tube was placed around it to reduce error in motor start and stop. As discussed previously, a pressure transducer was considered as opposed to the vibrating motors. However, the vibration motors proved to be more cost effect and smaller, thus saving weight and stress on the hand.

The battery pack is a case, as shown in Figure 12, will clip onto the user's body to relieve the stress that the weight of the batteries may cause. By using the battery pack, it allows the glove to be less bulky as well as make the glove design more robust since the circuit will no longer need to be on the glove. Hence, there is less chance for any circuitry breaks because the wiring remains stationary rather than moving with the arm. All of the electrical components can be encompassed using two cat-5e wires. These wires are very durable and can be seen in all Ethernet internet connections. This will relieve any strain on from the arm motion to the battery pack as these wires do not break easily.

Figure 12: Battery Pack (open)

The RSG commands and controls are the temporary substitution to the computer vision program that will later replace this design. In the mean time, a remote control, as shown in Figure 13, was developed to allow the RSG to input the four directional haptic movements of the motors as well as the on-call button from the user and any audio commands that the RSG needs to make to correct the camera angle and focus. To help simulate anonymous voicing of a computer, a computerized sound board was created for audio feedback rather than the live human RSG. Human voice tends to be subjective through the tones of a person’s voice. For that reason, a computer voice was generated to reduce error of providing hints through human tone. The controls and the audio are wireless operated to ensure that the RSG is far away from the user to simulate how the actual computer would operate.

Figure 13: RSG’s Wireless Control Box

ANALYSIS OF PERFORMANCE

Due to the nature of the project, there was more qualitative analysis than quantitative analysis. Through various risk reduction tests and experimental examinations of trial and error, the final design was obtained. Risk reduction analysis included simulation of a blind individual, camera resolution correction, haptic feedback operations, command list control optimization, and optimal camera positioning. These tests allowed us to design a product that is suitable for the project and its deliverables.

The quantitative data that does exist was derived from testing a user's ability to effectively use the device to aquire assorted objects of varying size. These tests assumed the user to have already received a higher-order command indicating that they should turn to face the product shelf. The time in which the user acquired an object of 8"x8", 4"x4", 2"x2" or 1"x2" front cross-sectional area were recorded, with the intent being to determine the minimum threshold size the glove could accurately guide the user to. As seen in the following chart, there is a learning curve associated with the use of the device. Initially, the user found it difficult to make sense of the RSG's input, but after a small period of acclimation, the user could find objects with great accuracy. Notice, however, that there is a threshold size indicated by the miss rate (percentage of attempts which resulted in grasping wrong object). As indicated by the data, it is difficult to guide the user ! to small objects (smaller than 2"x2" frontal cross section) with our current camera configuration. Attempts to rectify this by altering the positition of the camera on the glove were unsuccessful.

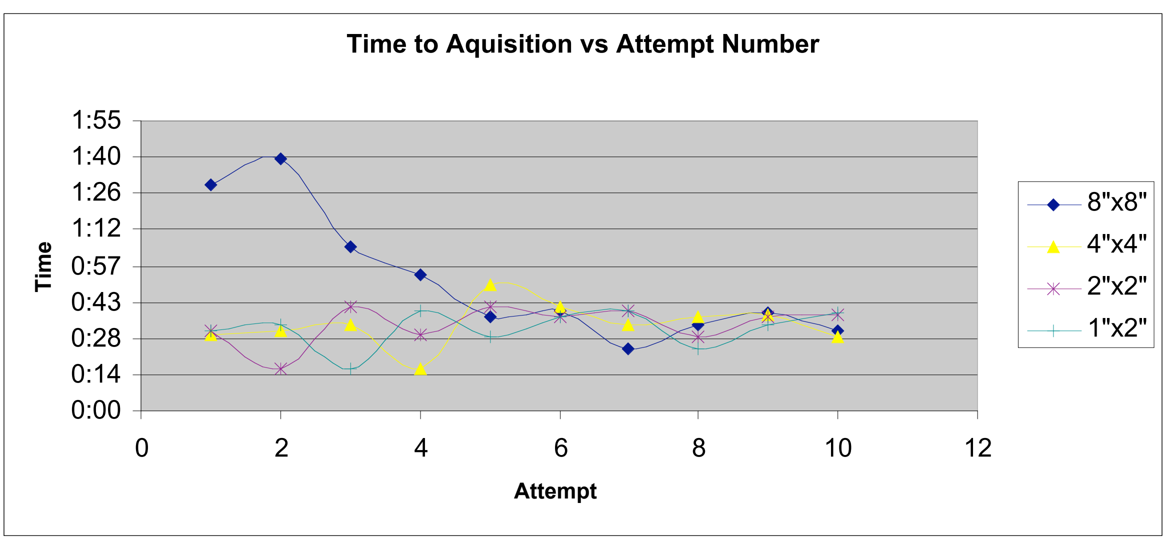

Figure 14: Time to Acquisition vs. Attempt Number

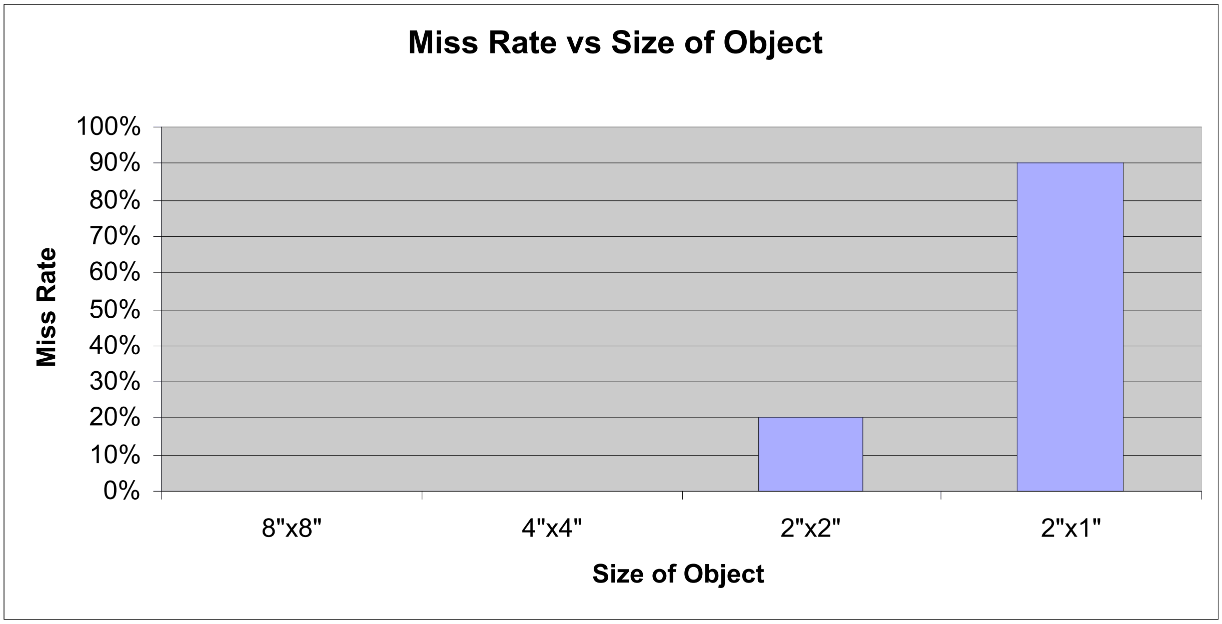

Figure 15: Miss Rate vs. Size of Object

FABRICATION PROCESS

The fabrication process was fairly simple for our product. First we had to come up with the circuitry to make our device work. We used a circuit board from a toy RC car that had operations to move up, down, left, and right. These four directions would correspond to the four motors placed inside the glove to give haptic feedback to the user. The glove that we have selected is dual layered thus allowing us to enclose the motors in between the two layers, hence making it very discrete. A Bluetooth earpiece is used to give the user audio feedback.

The next phase was to build the mount for the camera that is also going to be placed on the glove. We chose to use acrylic because it was easily available and fairly light. The mount was designed in a way to give it a prescribed range of motion that would be ideal for the user. Screws and bolts were used to constrain the range of motion of the camera.

Our device was powered by two double AA batteries and two 9V batteries that are enclosed in a box that the user will have attached to his belt. We used CAT 5 cable to connect the four motors; the cable would run along the user's arm and connect to the battery pack on his belt.

TESTING/EVALUATION

Testing and evaluation of our ideas were performed from the first week of the project in an effort to understand how to go about solving the problem presented to the group. Throughout the design and construction of prototypes tests were performed in actual grocery stores to determine how well the group's ideas and designs were accomplishing the purpose of guiding a visually impaired person to the product they want. The following chart was constructed to organize the flow of information between the user and the RSG.

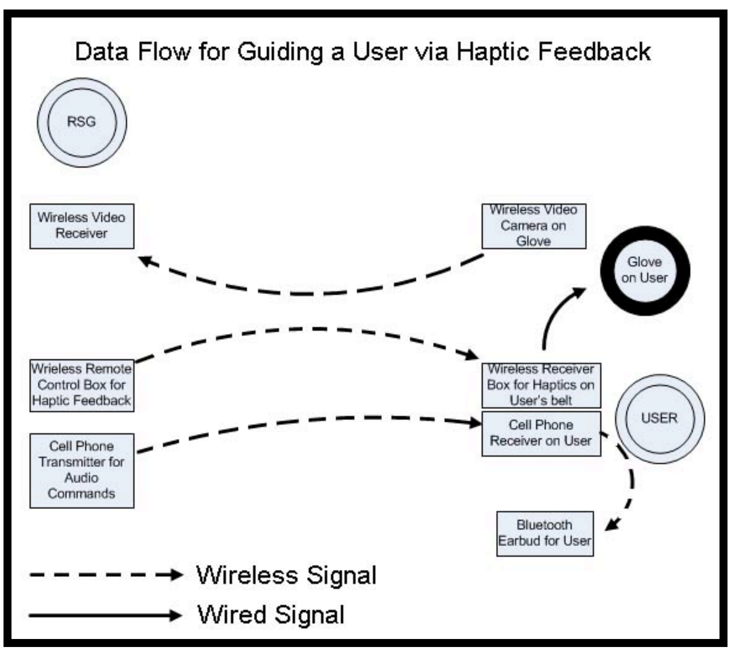

Figure 16: Data Flow for Guiding a User via Haptic Feedback.

PROTOTYPE TO PRODUCTION DESIGN

The project is completely a prototype design, so there are many simple improvements that can be made to the glove in aesthetics, size, and weight. These weren't a concern for this project because the purpose was only to determine the logic of guiding a visually impaired user to demonstrate that concept. On a production/manufacturing floor, the battery pack and mount assembly could easily be created through injection molding of cheap plastic. The circuitry could be preassembled and inserted into the battery pack. Aside from the necessary mechanical and electrical operations, the assembly onto a fabric such as a glove is necessary for each individual component.

COSTS ANALYSIS

To produce the prototype, the materials cost a total of $188 with a camera that costs $200. With a budget of $1000, this is easily feasible. Since much of the parts aside from the camera are parts of other assemblies or parts that may be purchased on a large scale such as batteries and wiring, the cost of this product can easily be reduced from in half. The cables, buttons, circuit boards, and batteries can all be purchased in large quantities for cheap costs. The easy manufacturability of this design provides the sponsor an efficient product.

SAFETY/IMPACT ON SOCIETY

By aiding the visually impaired, there is a positive reaction by society. This product has the potential of having a direct relation to the increase in independence of the visually impaired. This prototype design will be a great stepping stone to achieve GroZi's ultimate goal in computer vision recognition. The concept is designed for the blind, but this project can easily be extended into future areas where computer vision recognition and haptic sensory are needed. These methods can be implemented into future products to enhance quality of life for not just the blind, but for the elderly and practically anyone who requires computer guidance. One safety factor to consider for the blind users is the chance that this device will disable their perception and cause damage in markets as they crash into items while searching for their groceries. This problem can easily be corrected through a training program that is to be assumed the user will be required to take.

RSG's and USER'S OPERATION MANUAL

Both the RSG control box and the glove to be worn by the user were designed with ease of use in mind. Although the devices are simple to use, they do require a few hours of training to ensure that both the RSG and the user know the procedure of scanning the isles in the grocery store. The scanning methodology used might seem overly complicated to a sighted person at first, but becomes second nature to a visually impaired user with a few hours of use.

Before operation, the control box and the receiver box must be opened to connect the batteries and re-closed with provided screws. The RSG should adjust the control box to orient the "UP" direction with the way the user holds his hand. When the user enters the store, he will be sufficiently skilled at navigating with a white cane to find the entrance to the first isle. Standing at the isle entrance, the user will point the camera on his glove toward the ceiling at the isle sign and will receive audio feedback from the RSG reading the words on the signs. The user will then make a decision to go to the next isle or continue down the current isle. If he continues down the current isle, he will take a few steps, pause, and slowly scan both sides of the vertical shelves until notified of an item on his list by a pulse of vibration from the RSG via his glove.

He will turn toward the location he just scanned with the camera and slowly scan the shelf again to allow the RSG to determine a specific item to direct him to grab. The RSG will then use up, down, left, and right commands through different vibration regions of the glove to guide the user's hand to the target item. From experience, the user will know how to point his hand toward the item and advance toward it as necessary to grab it. If the RSG loses sight of the target item on the camera he will instruct the user to step back from the shelf using an audio command and will repeat the guiding process toward the desired item. Once the user's hand is on the target item, the RSG will give an audio cue confirming the exact product that the user has just grabbed. The user will then carry the product in his hand or basket. The user will then determine the next action to take, either to continue down the isle, move to a new isle, or proceed to the checkout counter. Future developments will include dollar bill denomination recognition to confirm the payment of the user. There is no maintenance needed for any of the components used. The system is not weatherproof, and is for indoor use only.

CONCLUSION

In order to help provide a better lifestyle for those with visual disabilities, the GroZi team was formed. By utilizing mechanical engineering fundamentals integrated with future computer technologies, the blind and visually impaired will soon have the opportunity to become as independent as a normal human being. The haptic mechanical design provides the stepping stones to directional sensory for those with seeing problems. This mechanical innovation also allows a collaboration of mechanical engineering with computer science and electronics. The MAE156B team has created the guidelines in which future electrical and computer engineers will follow in improving the design using their special expertise.

ACKNOWLEDGEMENTS

National Federation of the Blind – http://www.nfb.org/

American Foundation for the Blind – http://www.afb.org/

The Braille Institute – http://www.brailleinstitute.org/

Professor Serge Belongie

Dr. Eric Jayson

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Grozi Mozi project: http://grozi.calit2.net/

Rehabilitation: http://www.cs.wright.edu/bie/rehabengr/services/frames_deafandblind.htm

Oxford U: http://www.eng.ox.ac.uk/research/icv.html?group=sonar

MIT computer vision: http://groups.csail.mit.edu/vision/welcome/index.php

RFID: http://www.aimglobal.org/members/news/templates/podcast.asp?articleid=1847&zoneid

APPENDIX

PROJECT MANAGEMENT

Landon was the liaison between the team and the sponsor and organized the meetings, deadlines, etc. He designed and fabricated the circuits from cheap, mass-produced remote control cars. He headed the haptic device decision and implementation into the glove. He also helped with the testing throughout the project.

Daniel identified the commands and controls needed to guide the visually impaired user around a grocery store. He headed the initial testing of the logic to guide a human around a store. He also designed and maintained team website.

Satendra analyzed the camera positioning on the user and the logic needed to direct a human to point the camera where the RSG would need to see. He was the blind community coordinator and interviewed visually impaired people in the community to find their opinion about our project and specific designs.

Matthew analyzed the mixture of audio commands and haptic cues needed in specific situations. He designed and constructed the camera mount and installed the haptic sensors in the glove. He also interviewed people from the blind community.

RISK REDUCTION

Simulation of a blind individual – allowed realization of the difficulty of locating items as a blind individual

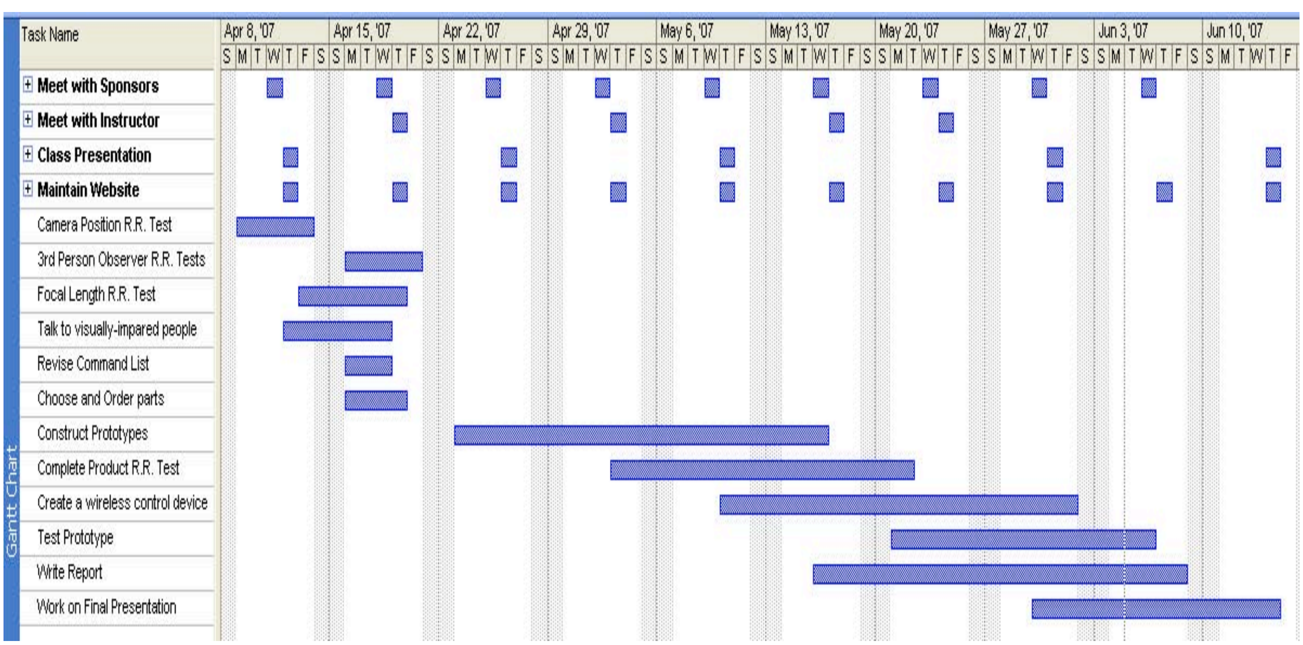
Camera resolution correction – allows the RSG and computer (future) to be less likely out of focus in the resolution, thus causing false item identifications

Haptic feedback operations – eliminated poor methods of haptic feedback and optimized the best solution for the problem

Command list control optimization – limit the amount of commands that the user needs to understand, thus making the design more user friendly

Optimal camera positioning – reduces chance that the hand may disorient and cause the RSG/computer to be unable to view the items desired

INTERMEDIATE DEADLINES



CALCULATIONS

There were not very many practical calculations to use for this project because most of the design consisted of logic and practicality decisions. One simple calculation performed was to determine the useable time of the battery for the electronics used in each component of the design. The Swann Mini-Cam can last for up to 6 hours on a single 9V battery, so that might need to be changed every few trips to the grocery store or use a larger battery for less maintenance. The cell phone and Bluetooth electronics are capable of lasting a few days, so they aren't a concern. The remote controlled car controllers have enough batteries to control the cars under normal continuous use for many hours, so the RSG control batteries would have sufficient battery power to control the haptic glove for many times longer if it is only used intermittently. The circuits of the remote controlled cars that were used usually had very small batteries to power them and lasted about 15 minutes. The battery capacity of each receiver was increased at least 10 times more than when purchased and the devices will only be used intermittently, so they will be able to last for over 10 hours.

BUDGET

STORE	ITEM DETAILS	STORE TOTAL
Golemine electronics	Vibrator Motors	$30
	Buttons	
Radioshack	Batteries	$85
	Cables & Jacks	
	Project Boxes	
	Buttons	
	Velcro	
	Misc. Electronics	
Mouser	AND Logic Chip	$12
KB toys	Remote Controlled Car	$12
Matt	Remote Controlled Car	$30
	Glove	
Landon	Remote Controlled Car	$15
Ralphs	Batteries	$4
	TOTAL COST	**$188**