GroZi: Grocery Shopping Assistant

National Federation of the Blind

Final Report
Winter 2008

Thursday, March 20, 2008
Marvin Tu (mmtu@ucsd.edu)
Phil Thai (philthai@gmail.com)
Ryan Ferrel (Feralryan@gmail.com)
Hannah Brock (hrbrock@gmail.com)
Kaivalya Shah (kaivalyas@gmail.com)
Franco Guadarrama(stims88@aol.com)
Hourieh Fakourfar (hfakourf@ucsd.edu)

Advisor: Serge Belongie (sjb@cs.ucsd.edu)
TIES Student Advisor: Elisabeth Kain (ekain@ucsd.edu)
NFB Representative: John Miller (j8miller@soe.ucsd.edu)

University of California, San Diego
Teams in Engineering Service

Executive Summary

There are currently 1.3 million legally blind people living in the United States who face daily obstacles with routine tasks, especially in regards to their experiences within supermarkets and stores. Developing assistive technologies and handheld devices allows for the possibility of increasing independence for those who have low vision. Currently, many grocery stores treat those that are blind as "high cost" customers, and dramatically undersell to this market, neglecting to take their needs into consideration. The use of computational vision can be advantageous in helping these blind customers, as restrictions such as the limited ability of guide dogs, frequently changing store layouts, and existing resources do not allow for a completely independent shopping experience. Using technologies such as object recognition, sign reading, and text-to-speech notification could allow for a greater autonomous solution to the growing problem.

In conjunction with Calit[2], UCSD's Computer Vision Lab, and TIES, the GroZi project is working to develop a portable handheld device that can "see", helping the visually impaired navigate more efficiently within difficult environments as well as better locate objects and locations of interest. GroZi's primary research is focused on the development of a navigational feedback device that combines a mobile visual object recognition system with haptic feedback. Although still in its early stages of development, when complete, the GroZi system will allow a shopper to navigate the supermarket, find a specific aisle, read aisle labels, and use a camera to then scan the aisle for objects that look like products on the shopper's list (compiled online and downloaded onto the handheld device prior to going into the store).

Under the direction of our advisor Serge Belongie, for the past two quarters we have been researching the creation of a usable, blind-accessible web interface to allow users to prepare their shopping list before downloading it to the MoZi digital assistant. The website not only provides blind users with a convenient interface for compiling their shopping list, but also provides the digital assistant with a set of current product images (pulled from sources such as Amazon Groceries, Safeway.com and user-contributions) in order to improve accuracy of object detection at the store. While we are currently using UCSD's Sunshine Store as a training prototype, we would like to extend this on a broader scale to larger local grocery stores and eventually in the future adapt this technology for use in a wide range of settings.

This quarter we have continued to meet actively with our client, Dr. John Miller, and continue development and testing of the prototype. We have particularly focused on ensuring the continuity of our project and preparing our prototype for outside feedback. The following document will serve as a description of what we have accomplished thus far, what we have learned and overcome, and the processes involved in designing and implementing a usable and accessible interface for the blind to assist future members of TIES GroZi team.

Table of Contents

The Accomplishments of winter 2008

<u>Research:</u>

In the beginning, our team did not see the current prototype as efficient and we did some research in order to replace the prototype with a more self-sufficient device. The first step we took to improve the prototype was to create a better interface that could offer video communication and data transfer. We wanted to choose our prototype in a way that it could have the possibility of data transfer via internet for object recognition purposes in the future. Thus, we thought of Apple Inc. products. They are all Bluetooth enabled devices and they can all communicate within each other. This system allows us to test the prototype via human control while offering a lot of technical capabilities for future development.

<u>Product Development:</u>

This quarter, we pursued different haptic options and we developed a system that would replace the glove with a more self-sufficient device. We introduced a new interface and prototype design that would integrate more functionality. In the process of developing this device, we decided upon a microprocessor that allows us to receive data transmitted from the RF / Client/Server and to process the data using a micro-controller in order to control numerous motors. The board was made with the intention of expansion and to be able to give us a good starting point on a prototype and it would offer a better setting for testing purposes. Hence, the board offers new flexibility in terms of design and future development. For the purpose of this design, we needed to also implement a simple net based server which is written in Python. Basically, the server/client allows the data streaming via WiFi. We also implemented a 'Navigator' which takes coordinate information with mouse interaction and send it to the client/server. It also integrates Apple's speech engine, which is a computer generated voice command used for audio feedback.

The other main aspect of the prototype design was the physical prototype. We replaced the glove with a semi-wireless prototype. This semi-wireless prototype consists of two wristbands each holding two motors for orientation guidance. In addition to the wristband we also worked on improving on camera functionalities. We changed the location of the camera from top of the user's hand to his shoulder. To make the camera mounting more stable we employed iflex cable which is flexible and stiff enough to hold the camera stable and in any direction that we desire. Furthermore, we mounted an external lens to the camera in order to add a greater field of view.

In short, we managed to construct a semi-wireless device that adds more self-sufficiency and functionalities for the blind user.

Challenges and Obstacles we have faced

This quarter, our biggest challenge was to implement everything without knowing how would this effect the client. We had to put ourselves in the client's shoes and consider his needs without getting much feedback from him. So our design started off primarily with no feedback from Mr. Miller. The aspects of the project became less challenging once we received his inputs.

The choice of right haptic feedback was also a challenge. We came up with various protocols. We discussed different functionalities such as vibration intensities, number of motors, motors location and orientation. Once we decided on the kind of haptic feedback to use, the next step was to position the camera in the most optimal location. Since we were using video feedback to direct the user to aim at the right object, the camera positioning was the most significant issue and it needed to be resolved before we move on. The position of the camera and its field of view became more critical as we proceeded with the project.
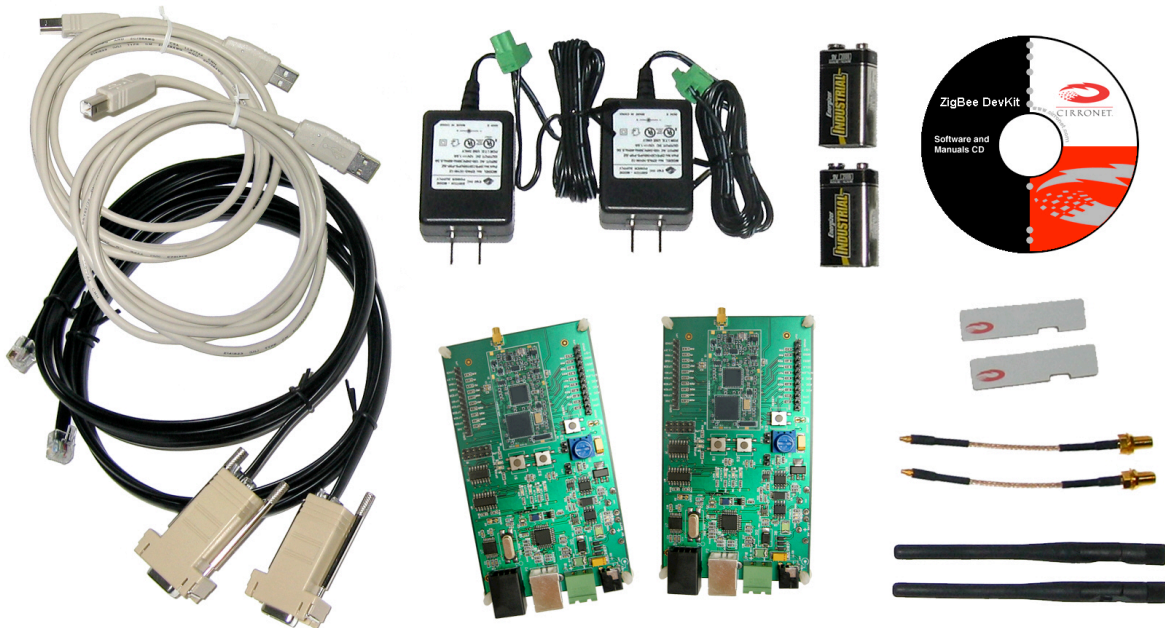
The least significant challenge was budgeting. While designing the prototype we had to keep in mind, if the user will be able to afford our proposed product. So we needed to examine the variety of options for everything that is being purchased and we had to choose among different options based on both their functionalities and price.

Implementation of the Micro-controller

The Board: The board basically has two main purposes. First, to receive data transmitted from the RF Client/Server and second, to process the data using a micro-controller in order to control numerous motors. The board was made with the intention of expansion and to be able to give us a good starting point on a prototype that we can get real answers from. The board uses a Texas Instruments micro-controller called the MSP430, and it gives us new flexibility in terms of design. It runs between 6-18 volts and provides 3.3 and 5 volts of regulated power. The motors are controlled with high current capable P Channel FETs. Currently there are eight mounted on the board but we are only using four.

The board has two UART engines which allow us to communicate with external devices such as the Xtend RF Transmitter. These engines transmit at 9600 Baud 1 stop bit no parity. The Xtend RF transmitter runs at 5 Volts and transmits up to 40 miles. There are over 20 unused ports brought out onto multiple connectors one the MSP430 allowing future additions to the project.

The MSP runs off of 2 external crystals which allow processing speeds of up to 4 MHZ. In addition to this the MSP has several timers which have also been brought out in order to give us precision control via Pulse width modulation of the motors. This has yet to be implemented and will be a future revision in code.
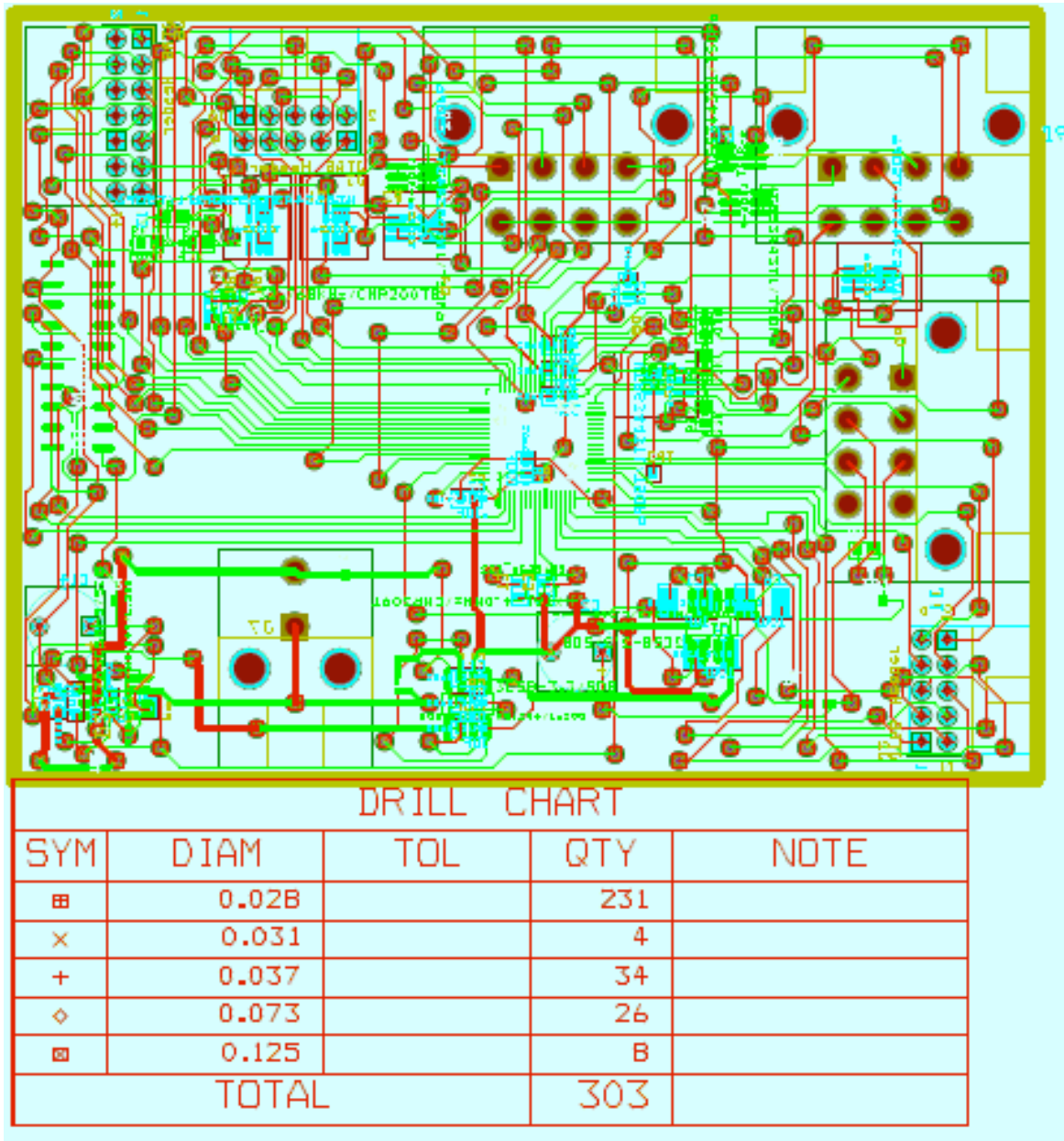
GroZi RF Board Schematic

GroZi Board (PCB) Layout

SYM	DIAM	TOL	QTY	NOTE
⊞	0.028		231	
×	0.031		4	
+	0.037		34	
◇	0.073		26	
⊡	0.125		8	
TOTAL			303	

DRILL CHART

Server/Client Configuration

The server client is a simple net based server written in python. The base code for this part is borrowed from the web. If you go on Google and search for "Python client server", the links where you can find the corresponding base codes should be among the very first links. The client server is capable of sending and buffering streams of data via WiFi. The only restrictions come into play when dealing with router settings. As of now it can only work when both parties share the same network. This is something we just picked up for this project and is still relatively new to me so changing it will take some time. The server client speaks directly to the serial ports on the Mac and is transmitted with the Xtend RF demo board.

The Navigator

The navigator is a gui program designed on xcode. We also borrowed a portion of this code from online resources in order to get started. The navigator acts in two parts:
1. It takes coordinate information with mouse interaction and sends it to the client/server.
2. The second part involves Apple's speech engine which activates when text is typed in the text field. The Apple Speech engine is scripted directly to the client.

Vibrator Motors

For this project, we used four vibrator motors to remotely guide the users hand to the product. To guide him more effectively, we chose to place the motors such that the user feels the vibrations on his wrist. We used two wristbands where each contained two motors. One of the wristbands is used for top/bottom orientation and the other one for left/right orientation. Since the motors had to be placed on the wrist, they had to be small and thin but with high amplitude of vibrations.

We choose a motor from this website: http://www.vibratormotor.com/cyl-table.htm. The model number of the motor is C1026B300F. The motors' most important specifications are as follows:

Motor Dia (mm)	Motor Thickness (mm)	Rated voltage (v)	Operating voltage (v)	Rated current (ma)max	Rated speed (rpm)
10.0	2.6	3.0	2.7~3.3	90	9000

This motor has few qualities that made it ideal for our project
1. Size: it is small and thin
2. Has high amplitude of vibration.
3. Also the voltage at which it operated was easily achievable.
4. Besides that, the motor wasn't very expensive. Each motor cost $3.
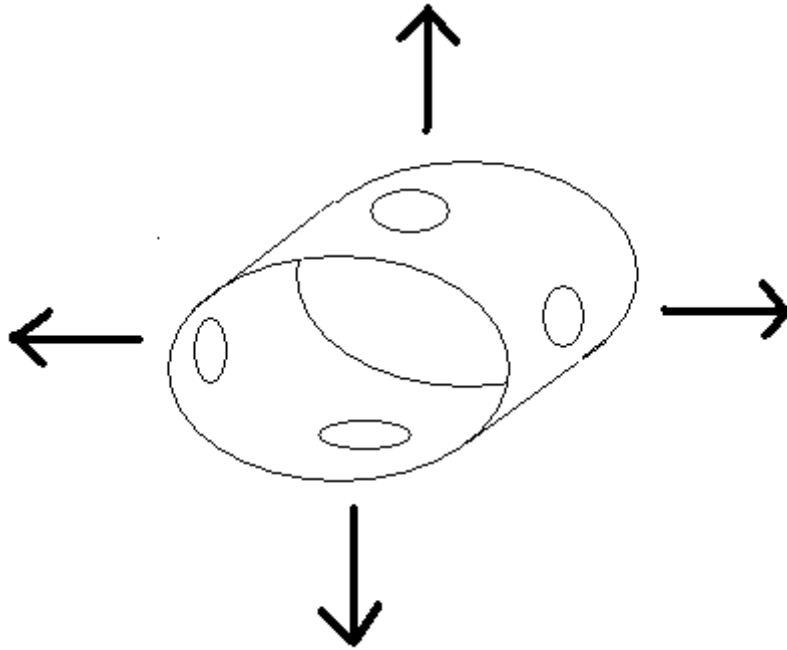

Motor Placement & the Wristbands

We decided to place the motors on a sport wristband which will then fit any wrist and it will be easy to reposition them for the future testing purposes.
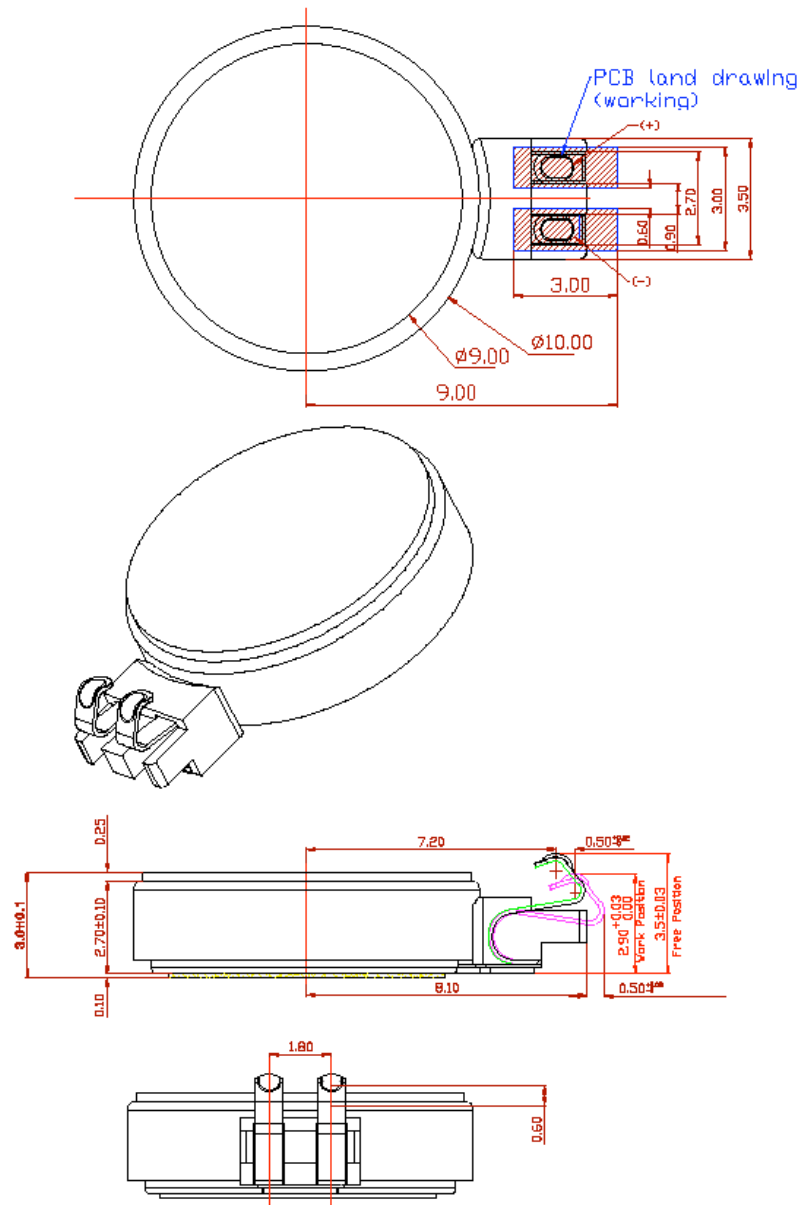
The idea is to "sewn" the motors on the inside of the sweatband as being displayed in the diagram below:

Also, for each individual motors, we soldered the metal wire with extension wire so it's easier to make any testing and mountings.
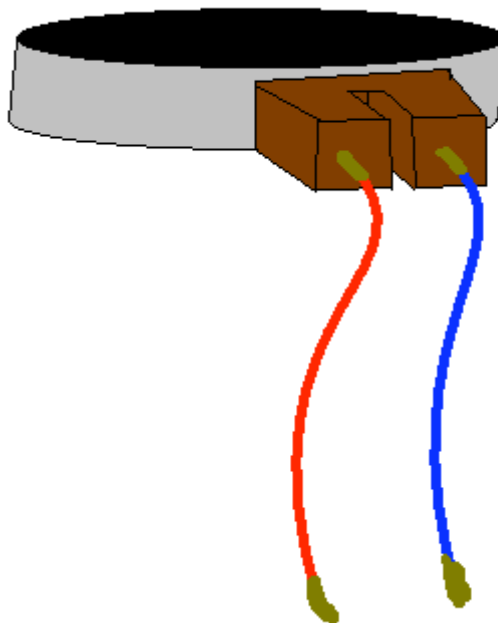
Schematic Diagram of the Motor

Motors Detailed Specification

1) Operating condition

Item		Specification
1	Rated voltage	3.0 V DC
2	Operating voltage	2.7 ~ 3.3V DC
3	Rotation	CW (clockwise) or CCW (contrary clockwise)
4	Operating environment	-20°C ~+60°C ,Ordinary Humidity
5	Storage environment	-30°C ~+70°C ,Ordinary Humidity

2) Electrical initial characteristics

Item		Specification	Condition
1	Rated speed	9,000rpm Min	At rated voltage
2	Rated current	90 mA Max	
3	Starting current	120 mA Max	Motor is rotating at min starting voltage.
4	Starting voltage	2.3 V DC Max	
5	Insulation resistance	10 MΩ Min	At DC 100V between lead wire and case.
6	Terminal resistance	31 Ω ± 15% (sigle posture) 59 Ω ± 15% (double posture)	25°C At 25°C

Camera View and Properties

Apple's iSight is a 50mm webcam that lists a 54.3 degree field of view. The field of view was too narrow for use on the head (the hand kept escaping the visible range) and does not offer a full vertical view of the shelves when standing arms length away in the grocery store. Attaching a .5x wide angle conversion lens gives a wide enough field of view to reveal the entire vertical extent of the shelves. The physical area imaged with a wide angle lens is about 2.2 times as large. The wide angle conversion lens does make chromatic aberrations around high contrast edges more extreme and very visible. Purchasing a .7x wide angle conversion lens (about the same price) should reduce chromatic aberrations, but will also reduce viewing angle.

A 37mm thread size (to fit the iSight) .5x wide angle conversion lens can be purchsed from http://www.adorama.com/ for $21.95, although a higher quality lens may be desirable. The lens used for this group was purchased as a set of two lenses from RitzCamera for around $45. John reported that polarizers can help with reflection in the grocery store and aid text recognition. A circular polarizer that fits a 37mm thread size conversion lens is $17.95 from Adorama. Shipping for the lot is $5.

These boxes are drawn to scale to represent the view of the iSight and iSight with a wide angle lens attached.

Wide Angle Lens
Viewing 1.92m away:
Height: 2.21m
Width: 1.92m
Total Area: 4.25m

iSight only
Viewing 1.92m away:
Height: 1.26m
Width: 1.54m
Total Area: 1.94
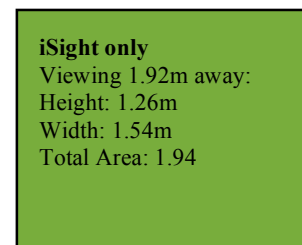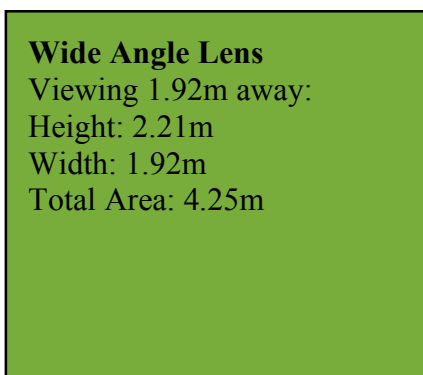
IFLEX

Camera mounting, previously, was done by just taping the camera on the backpack strap using scotch tape and the fire wire cable running into the backpack. This obviously was not the optimal solution. So we decided to use a mount that would ease the change in the direction or position of the camera.

After some research, we found IFLEX. It is basically an all rigid gooseneck 6 Pin - 6 Pin firewire cable meant for i-sight camera.

iFlex was bought from http://www.mac-pro.com/ for $14.99 + shipping.

Project Planning - Future Directions

In the upcoming quarter we hope to continue building upon the prototype we have established and work toward returning to the challenges we identified in our first quarter:

- While we began research into the idea, we hope to begin implementation/create a user log-in system to make our prototype more interactive, and allow for a favorites list to streamline the shopping list creation experience.

- Continue development on adding a display for product images on the Item Records page - possibly collaborating with Steve Davis.
- Determining how to best export finished shopping lists to the MoZi box and for our users.

- Further extending our current database to contain more details such as item prices and weight, quantity options for the user, and the ability to check for product abbreviations and spelling mistakes in search queries.

- Choose a more secure camera Location to add stability

- Possibly come up with a smaller camera, better lenses, and rotation capabilities.

- Implement wireless capabilities between the camera and the server/client control

- Replace the human controlled server/client control with an automated system

- Improve the current interface to make it more appealing for the market

Team Organization and Contact

Winter 2008 TIES Team:

Phil Thai - Team Leader/Head Programmer
Email: philthai@gmail.com
Phone: (909) 348-3138

Kaivalya Shah - Motor Adjustments
Email: kaivalyas@gmail.com
Phone: (408) 317-8661

Ryan Ferrel - Camera View & Properties
Email: Feralryan@gmail.com
Phone: (858) 336-6174

Hourieh Fakourfar - Camera Positioning & Adjustment
Email: hfakourf@ucsd.edu
Phone: (714) 457-4852

Marvin Tu- RF Design/ Wireless System
Email: mmtu@ucsd.edu
Phone: (626) 223-6006

Franco Guadarrama - Community Client Liaison
Email: stims88@aol.com
Phone: (909) 208-8532

Hannah Brock- Human Resources/ Programming Assistant
Email: hrbrock@gmail.com
Phone: (970) 618-0734

TIES Student Advisor:

Elisabeth Kain - Teacher Assistance
Email: ekain@ucsd.edu
Phone: (858) 243-8501

Faculty Advisor:

    Serge Belongie
    Email: `sjb@cs.ucsd.edu`
    Phone: (858) 822-5163

NFB Representative

    John Miller
    Email: `j8miller@soe.ucsd.edu`
    Phone: (858) 967-2666

Resources and References

PRODUCT INQUIRY

1. Micro-Controller: http://digikey.com/ OR   http://www.newark.com/
2. Vibrator Motors: http://www.vibratormotor.com/cyl-table.htm
3. Wide Angel Lens: http://www.adorama.com/

EXAMPLES OF WELL-FORMATTED NFB-APPROVED WEBSITES

4. National Federation of the Blind: www.nfb.org
5. National Center for Blind Youth in Science: http://www.blindscience.org
6. Zigzag forms: http://rescue.calit2.net/zigzag/feedback/feedbackcopy.html
7. NFB Mentor form: http://grozi.calit2.net/webinterface/ties/mentorform.php
8. Blind Programming: http://www.blindprogramming.com/

USABILITY IN THE NEWS

9. NFB Sues Target (September 2006):
http://www.nfb.org/nfb/Target_Sept_Release.asp?SnID=1856320445
10. Our Working Prototype: http://www.r-infinite.com/grozi/
11. Permanent Location: http://grozi.calit2.net/webinterface/
12. GroZi Project Homepage: http://grozi.calit2.net/
13. GroZi TIES Wiki:
http://vision.ucsd.edu/collaborate/index.php/Grocery_Shopping_Assistant

OTHER USEFUL LINKS

14. JAWS Screen Reader for Windows: http://www.freedomscientific.com
15. JAWS windows shortcut keys:
http://www.rnib.org.uk/xpedio/groups/public/documents/PublicWebsite/public_rnib
003398.hcsp
16. Keyboard Shortcuts for JAWS:
http://www.webaim.org/resources/shortcuts/jaws.php

ESSENTIAL GROZI TIES LINKS

17. Prototype location (temporary until July 1, 2007): http://www.r-infinite.com/grozi/
18. Permanent location: http://grozi.calit2.net/webinterface/
19. Project Management: https://tiesgroziwebteam.projectpath.com/
20. NFB blindtlk mailing list: http://www.nfbnet.org/mailman/listinfo/blindtlk

COMPUTER-VISION RESEARCH LINKS

21. Improving Web-based Image Search via Content Based Clustering:
http://www.cs.ucsd.edu/~sjb/slam06.pdf
22. Recognizing Groceries in situ Using in vitro Training Data:
http://grozi.calit2.net/files/grozi_slam.pdf