POST-MORTEM for **NOW I SEE**

A Travel Aid for the Visually Impaired

Project Team: Anita Kadkhodayan
Steven Lee
Darya Namvar

Contact person: Anita Kadkhodayan
akadkhod@sfu.ca

Submitted to: Dr. Andrew Rawicz – ENSC 440W
Dr. Steve Whitmore – ENSC 305W
School of Engineering Science
Simon Fraser University
April 11th, 2014

Table of Contents

1. INTRODUCTION

Now I See is a travel aid designed for the visually impaired to assist them towards a more independent lifestyle. The ability to live independently is a significant and desirable quality for the visually impaired; however, moving around without direct help from another individual can be a difficult feat. **Now I See** scans and detects obstacles in the user's surroundings and alerts them through a vibratory user interface worn on the user's forehead. An illustration overviewing the system is shown below.

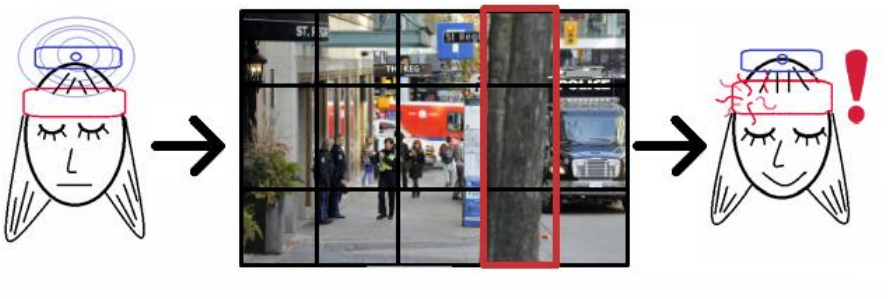

Figure 1: System Operation Illustration

The **Now I See** travel aid consists of a hardware device and software package. The hardware device includes a depth camera, an accelerometer, a central processor, a microcontroller, a set of vibration motors, a power supply module, a wearable device mount and UI headband. The depth camera will provide the depth image of the frontal FOV, which will be examined in the processor, and appropriate alerts will be delivered to the user interface through the microcontroller. Most of device, excluding the processor and the battery, will be mounted on the user's head, and a battery will be used to power the device for mobility. The user interface consists of a 3x5 array of vibration motors that are implanted into a comfortable head band. The observed view of the surrounding is split into 15 subsections (3 horizontal, 5 vertical) and the presence of obstacles in each subsection is reported to the user at the corresponding location on the UI.

Over the past 13 weeks, the engineers of **VisuAid** have been working vigorously to produce a proof-of-concept (POC) system. In this document, a summary of the process and results of creating this POC device is presented. The difficulties and learning experiences our members faced are also included herein, with reviews of our project's budget and schedule. All of us at VisuAid would like to thank our Technical Advisor Dr. Kamal Gupta for giving us the initial idea for this project.

2. CURRENT STATUS OF THE DEVICE

A POC device was constructed based on our previous documents submitted for the **Now I See** device. Most of the requirements designated for the POC device and some of those for the production model were implemented in our finalised device. In this section of the document, the current status of our POC device is discussed.

2.1. Core Electronic Hardware

As described in the previous documents, the Microsoft Kinect for Xbox 360 was chosen for the depth camera and the accelerometer, a generic laptop for the central processor, and an Arduino Uno board for the Microprocessor. As planned, the Kinect camera was slightly modified and installed on a mounting apparatus as planned, and the Arduino Uno board was placed in an enclosure with other circuits. The laptop prepared as the central processor was placed in a backpack with the battery. All communication connections were achieved via USB.

2.2. Device Mount and User Interface

A bicycle helmet was chosen as the device mount for our POC device and the Kinect sensor and the enclosure encasing the rest of electronics were fastened thereon. In placing of these components, the weight distribution was taken into consideration to stabilize the device as much as possible, as the whole device is somewhat heavy.

The user interface control circuitry (UICC) was placed inside the enclosure above and a detachable intermediate connection was prepared for ease of equipping. The user interface was created in a form of a head band as planned, with adjustable sizing for optimal contact pressure of the module onto the user's forehead. While the POC device only required a 3-by-3 matrix for interfacing, we went ahead and developed a 3-by-5 matrix of motors, which was planned for the production model, with promising results. The UI protocol was developed for three levels: off, "blinking", and on, to represent states of clear, warning, and danger.

2.3. Power Supply Unit

The power supply unit (PSU) of our POC was prepared, comprising of: a rechargeable lead-acid battery too serve as the main power source for all electronic parts except the central processor, and a voltage regulating circuitry to create required voltage for the vibration motors in the UI. The battery was placed in the back pack as specified, and leads and power switches were

prepared correspondingly. The actual circuitry was placed in the enclosure with other electronics and placed on the device mount.

2.4. Software Package

The laptop we secured to serve as the central processor was prepared with Ubuntu Linux and Robot Operating System (ROS) as planned. We were able to interface and tune the software packages to work together as a single package.

Using the drivers and application interfaces provided in ROS packages available for the Kinect device, we obtained the raw depth image and acceleration data from the Kinect sensor. These raw data were processed in a series of nodes to create corresponding UI protocols to be sent to the microprocessor. The depth image was corrected with respect to the orientation of the camera, ground was detected, subsections were divided and examined, and presence of obstacles was tested. A serial connection is then created to send this result to the Arduino board, which controlled the motors according to that input.

3. CHALLENGES AND DEVIATION OF THE SYSTEM

Unfortunately, some compromises had to be made for a number of reasons in making of our POC device. In this section of the document, each aspect of our POC device is examined with respect to its designs at various stages along the creation process, illustrating the challenges we faced and the solutions and compromises we came up with to overcome them.

3.1. Central Processor

One of the biggest issues we faced during creation of the POC device was with the central processor. Initially during the conception of the project and in the proposal phase, a microprocessor board, such as a Raspberry PI board, was considered to serve as our central processor, which would allow us to achieve a compact design. Fortunately, even during these stages, it was unclear if this implementation was possible based on our research, thereby enabling us to separate the central processor and the microcontroller early in our device design. We went ahead with the initial plan, but with further research and in attempts to make this design work, it was found that this implementation indeed was not possible, due to the processor architecture of the microprocessor boards in respect to the Kinect sensor. A compromise was made to use a laptop with fully supported architecture, which diminished the

compactness and mobility of our device, but the implementation was successful. However, we already had purchased the microprocessor board at this point, and we had to cover the cost, and another issue of locating a laptop was created.

Due to the fact that a new operating system had to be installed, it was not easy to find an idle laptop, especially with the end of the semester nearby. The requirement for a good battery life was also an obstacle. Without incurring any further costs, we could only locate one laptop, which was a Chromebook. There was a significant effort required to prepare this laptop due to the nature of Chromebooks and the unstable nature of the solution we found. After all however, we were able to make it work for our project.

3.2. Kinect Sensor

The Kinect Sensor was chosen as our main sensor, and it was very important, if not necessary, that we used this specific device, as other alternatives would foreshadowed various issues including largely increased implementation efforts, logistics and availability, and cost. While using this device allowed our project to work, it brought with other issues including the central processor issue discussed above.

The sensor had a base stand that interfered with mounting. Removal of this portion of the device was necessary and required a considerable amount of effort. The device also has a proprietary connector and requires a 12V DC power. This meant that an adaptor had to be separately purchased and modified to meet our needs.

3.3. Circuitry Work and Wiring

While the scheduling was done at the proposal phase, the circuitry design of the UICC went through major changes, increasing the volume of circuitry and wiring work significantly. This increase finally caught up as we followed our schedule and we ended up spending a lot more time on building the circuit than we expected. The change arose from the need for the actual UICC, which we did not anticipate in the proposal phase. These changes included a switching circuit, a protection circuit, and extended wiring for each of 15 motors.

3.4. Obstacle Detection on the Ground

During implementation of the software components, we realized that the detection the holes on the ground would require a much more stable sensor and a lot more complicated algorithm. The simplest of the solutions we thought of, already requires modeling of the environment and

keeping track of it, which would involve mapping and other complicated algorithms. Given the stage of the project when this issue was discovered, we decided that we cannot afford to pursue these options. In addition, the lack of precise specifications for the camera (Microsoft only published limited amount of specs and reverse engineering data available only were not enough) made it very hard to correctly measure and estimate the ground to the precision we need to detect the ground. As a result, this feature was removed from our POC device.

4. BUDGET

The table below shows our initially estimated budget and our actual costs. With some design changes and utilizing some second hand components, we were able to bring the cost down. As we were funded $350 by ESSEF, we decided to re-budget our project to this amount.

Component	Part	Est. Cost	Actual Cost
Depth Camera	XBOX 360 Kinect Sensor	$130	$56
Microcontroller	Arduino Uno, REV 3	$35	-
Processor	Raspberry Pi- Model A	$40	-
Vibration Motors	Vibration Motor, Flat Coin	$85	$63
Accelerometer	IC Accelerometer, XY AXIS	$10	-
Mount Apparatus	Bike Helmet	$35	-
UI Mount	Head Band	$10	-
Breadboard		$10	-
Prototype Board		$10	$3
Electronic Comp.	Various	$35	$226
Battery		$50	$13
Additional Parts, Overhead, Shipping, etc.		$50	$25
	Total	**$500**	**$386**

Table 1: Budget overview - comparison between planned and actual costs

As shown in the table above, we were slightly over the new budget of $350 by about 10%. We realized that we significantly underestimated the amount of electronic components required for our project. This is due to the major re-design of the UICC that took place after the budget was prepared. It should be noted that our actual cost also includes some parts that were not used for the final design but does not include the Raspberry PI board's cost. Also there were no shipping charges, as we bought everything in person and this bill also includes costs for tools such as a heater and a glue gun.

5. SCHEDULE

The figure below illustrates a comparison between the initially planned schedule and the actual.

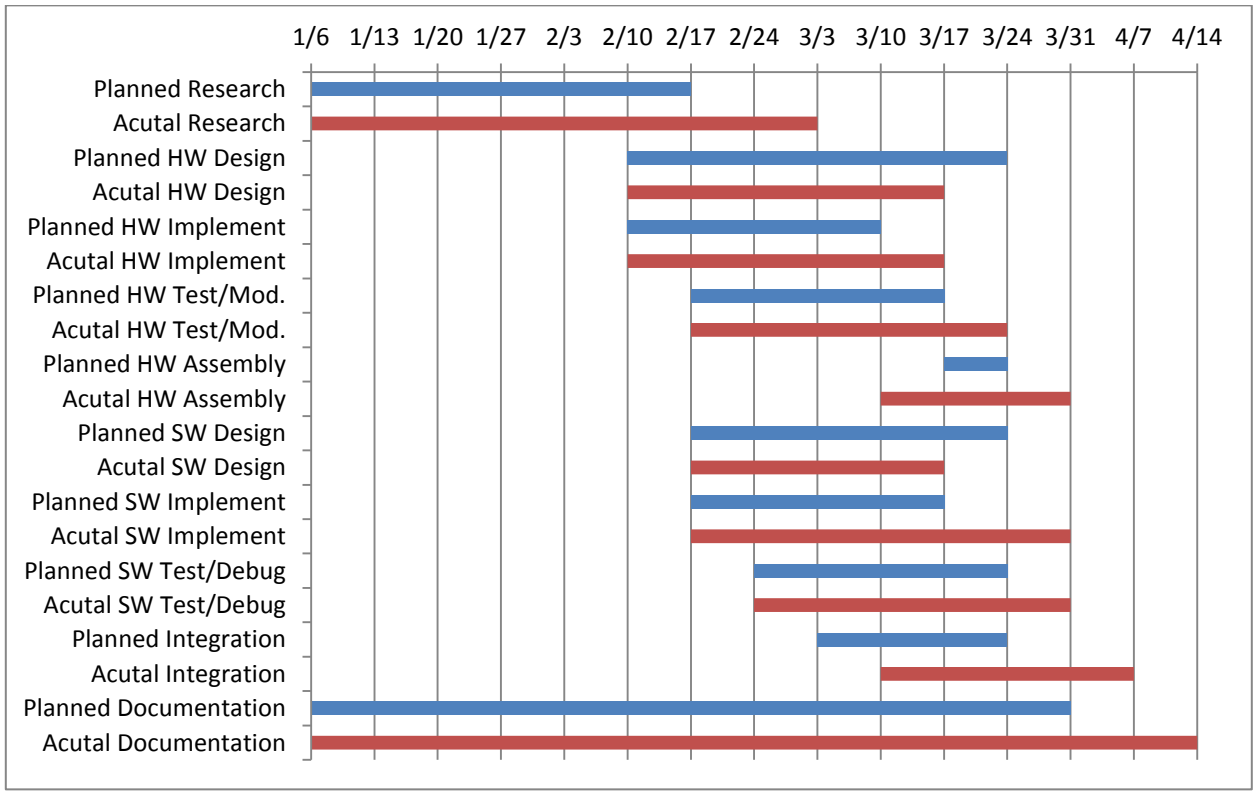

Figure 2: Schedule Comparison Gantt Charts

Due to the challenges we faced during the implementation, we were unable to meet the initial schedule set for completion of implementation, missing the scheduled date by two weeks. As the proposed schedule was created during the proposal phase, we were unaware of our

demonstration date which turned out to be two weeks later than our expected date. As a result, we were able to finish our project by utilising this extra time.

6. INTERPERSONAL AND TECHNICAL EXPERIENCES

6.1. Workload Distribution

The table below illustrates the workload and responsibility distribution during our project. "XX" denotes primary responsibility and "X" the secondary.

Task	Anita	Daria	Steven
Hardware Design	X	X	XX
Hardware Modification			XX
PSU Design		X	XX
PSU Implementation		X	XX
Software Design	XX	X	X
HW-SW Communication	XX		X
Image Processing	XX	X	X
Software Implementation	XX	X	X
Linux/ROS	X		XX
UI/UICC Design	X	XX	X
UI Implementation	X	XX	
UICC Implementation	X	X	XX
Arduino Programming	X	XX	
Parts Acquisition	X	X	X
Administrative	X	XX	
Documentation	X	X	X

Table 2: Responsibility Distribution Table

6.2. Anita Kadkhodayan

In this Project I was mostly involved with the software design, however I helped with other aspects of the project as required. I have had experience with image processing and C++ programming but in this project we also use Robotic Operating System which was totally new to me. Steve had more experience with ROS and therefore we collaborated for software. I am really glad that I learned this operating system as I will be using it in future for my thesis. I am

very interested in image processing and in my coop experience I gained a lot of software and embedded system experience. I could apply most of these skills for coming up with algorithms needed for processing the raw data captured by the camera.

I didn't have much hands-on experience like soldering and building prototype circuits. My other coworkers thought me many good tips and I took a more supporting role rather than leading for those tasks.

I really liked how we communicated and I believe this was because we knew each other well enough. I happened to live very close by Darya and that gave us the opportunity to work together for most of the parts. Then we would discuss the outcomes with Steve and coordinate everything.

I really enjoyed working with my coworkers at VisuAid. I practiced group work and organization skills by making meeting schedules and keeping track of our progress. This course made me be more organized and prioritize my work load so I can be successful in my other courses as well. Nonetheless, this task proved to be more deficult than I thought, as we fell behind in some cases. I'm happy that in the end with a little bit more endeavour we managed to finish on time.

I also believe we practiced a lot of problem solving skills. There were many fundamental things that I was worried it might go wrong. We tired our best to come up with back up plans for most of these. The only thing that I would do differently in future endeavours would be doing more extensive research before starting the project. In this project since we were short for time we couldn't research all aspects of the project to the fullest extent. But we should have in mind that this was only a proof of concept product and there is room for improvement.

6.3. Dara Namvar

My group mates for this course were Anita, my best friend, and Steven. We took a lot of courses together so we decided to take capstone as a team. Steven had already come up with a project idea, approved by Dr. Gupta, that was interesting for all of us and the good thing about our group was that we had different strengths. I remember when Dr. Whitmore talked about group dynamic and how this course has made some friends never want to talk to each other, I got very nervous because my group mates are very special and important to me and I didn't want to lose them. It is the end of the semester and I can proudly say that we are closer than ever and we survived. Our team did not have conflicts and we worked well together so it was a pleasant personal experience.

One of the biggest challenges I faced with our project was to build everything from scratch and find different specifications. When taking courses, for the labs the specifications and the outline was always given and we just needed to follow the lab manual. This course taught me how to be independent in that matter which I think is very important in becoming a successful engineer. The advantage of our team, even though it was a small team, was that we were organized and the project was distributed evenly as each of us was more comfortable with parts of the project. For our project, VisuAid, Steven had decided to focus more on the hardware design and Anita and I focused more on the UI design and software. We used Arduino to program our control circuit. In my first co-op semester working with Dr. Menon I learned how to program with Arduino so I had a good idea how to make the vibrating motors by Arduino. I had also done some control circuit design that was helpful for our project. Anita and I had some difficulties designing the UI and it has some room for improvement as future work.
I had seven courses this semester so it was nice to know I could do time management. It would get hard at times and as Dr. Whitmore mentioned the first day of classes we suffer to learn but at the end when the project worked it was all worth it. It was also rewarding to see that the ENSC courses we took helped with our project especially the electrical and circuit courses. Overall, it was a unique experience and I think I needed a course like this to make me realize why I chose engineering in the first place.

6.4. Steven YM Lee

I was in a meeting with Dr. Kamal Gupta to discuss about my thesis topic last semester. I told him that I will be doing the Capstone project with my thesis proposal and asked him if he has any interesting ideas. He told me about this device found online, Kinecthesia, which became a related work for our project. My group members, Anita and Daria, and I had taken a number of courses together so we knew each other well and had already decided to form a group even before the term started. So I started planning a project out for this Capstone course, and with approval from my group mates, **VisuAid** was created.

At **VisuAid**, I was in charge for most of the hardware design and the operating system environment. As a team, I believe we worked well with each other without any conflicts, and each of us had a part of this project that we were comfortable working with. I always enjoyed working with my hands and building things, so I took over the hardware aspects. I assembled the hardware components together to build the physical device, and transferred the UICC design and the PSU module onto create the circuit board. Throughout this course, it was quite

rewarding to apply the various aspects I learned over the course of ENSC program, to design, plan, and build something physical and functional.

While I was doing my second co-op term working in Dr. Gupta's lab in 2012 summer, I used the Kinect sensor to perform object detection using ROS under Linux OS. My experience during that co-op term proved quite valuable throughout this project. As a result, I handled transferring of the SW codes and building software framework. Personally, this project has been a great opportunity to revisit and strengthen my proficiency with ROS and Linux OS environment, which would prove invaluable in my future career.

To reflect on something that I or we could have been improved, I would chose the planning and researching involved with the projects. While we were mostly on par with our schedule, we missed to update our plan according to the specifications of our device that changed overtime with more research and actual implementation, leaving us behind schedule in the end.

7. CONCLUSION

This documentation sums up the POC device project for the **Now I See** travel aid device. We had contacted CNIB (formerly known as Canadian National Institute for the Blind) asking for any interest in our project, but never heard back. As a result, at this point, there are no further plans to pursue this project. However, some possible improvements are: more compact design, a camera with vertically wider field of view, better battery performance, pit detection, and other lower priority requirements listed in previous documents.

NOW I SEE

Agenda

January 6, 2014
4:00 PM-6:00 PM

Purpose of the meeting: To discuss about what we want to do for the project, the scope of the project and to get to know each individual's skill sets.

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Discussed the topic of the project**: Steven had discussed about the topic with Dr Gupta, and he informed us of the generality of the project. We agreed we want to make some device that helps visually impaired patients to navigate.
- **Discussed possible design**: We all discussed various aspects of the design. Compared to commercially available designs. We discussed possibility of each design and its advantages and disadvantages. In particular the UI was discussed and we came up with various models but we chose the vibrating panel on the forehead as the best idea as of now.
- **Discussed each person's strength and interest**: We all discussed as a team about our interest and strength to divide the project work accordingly. Steven has had experience with Kinect, he also says he would like to work with hardware. Daria says that she has worked with Arduino in her Coop experience and she is comfortable with designing circuits. Anita has had experience with programming she has experience coding in python and C++.

NOW I SEE

Agenda

January 14, 2014
6:00 PM-8:00 PM

Purpose of the meeting: To discuss about the name of the company as well as the product name. More detail discussion of the outline of all aspects of the project

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Discussion for picking the company name and product name**: Brainstormed various company names and logos, once we reached a unanimous decision Daria is assigned to draw the logo
- **Discussion of project components**: We chose Kinect as depth camera, and raspberry pi for processor and Arduino as a microcontroller and 3X5 panel of vibrating linear motors as UI, helmet as a mount. These decisions have been made based on our familiarity and the specifications of the products with respect to our requirements.
- **Discussion of the cost**: Researched and estimated the cost of each piece. The total cost was estimated to be $500.
- **Discussion of work division for Project Proposal**: Each member picked a part to work on and research on for the documentation

NOW I SEE

Agenda

January 18, 2014
2:00 PM-4:00 PM

Purpose of the meeting: To discuss about proposal documentation and synchronizing each member's part.

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Information for project proposal was gathered:** Each member of the group shared their written part for the documentation and the report flow was finalized
- **Discussion for fund application**: The only option for receiving fund is through the ESSS or the Wighton fund. ESSS will provide us with the main amount of the cost and if it did not cover all we can apply for Wighton for the rest.
- **Work division for funding presentation**: Anita and Daria will fill out the form and each member picked a part they were comfortable to explain for presentation. Anita will explain the related works and some back ground. Daria will explain the cost and Steven will explain the project description.

NOW I SEE

Agenda

January 27, 2014
5:00 PM-6:30 PM

Purpose of the meeting: To discuss about the funding presentation and practice

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Discussion for preparation for funding presentation**: Practiced the presentation together and timed it to make sure it is reasonable
- **Discussion of the parts and ordering**: Some of the parts can be bought from Lee's electronic store and the camera was found to be on EB game store. We called and inquired for the cost

NOW I SEE

Agenda

February 1, 2014
5:00 PM-6:30 PM

Purpose of the meeting: To discuss about work division for the functional spec documentation

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Work division for functional spec documentation**: Each person picked a part to complete for the documentation
- **Update on ordering parts:** We bought the camera already before receiving the fund because we thought we would need to modify the camera so we cannot use from the library

NOW I SEE

Agenda

February 15, 2014
3:00 PM-4:00 PM

Purpose of the meeting: To gather information and discuss for the functional spec documentation

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Discussion for completion of the Functional Spec documentation**: Gathered information from each person and finalized the report flow
- **Problems discussed**: one of the problems we had was that the amount of current for the vibrating motor was not enough from Arduino. As a team we discussed to use transistors to solve the problem.
  Anita had a question about how to communicate to Arduino from ROS and Steven and Daria helped find a solution by research. For communication between raspberry pi and Arduino, there is a ROS package that can be set up to exchange msgs and it can manage serial ports to the Arduino as well.

NOW I SEE

Agenda

February 25, 2014
4:00 PM-6:00 PM

Purpose of the meeting: Practice for Oral Progress report

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Discussion on oral progress report**: Discussed the progress of the report. At this point we were behind on software. We have done designs for control circuit of the UI. Research took longer than we expected. Cost is on par with the estimated cost that we said originally. we discussed some of the problems that we might encounter:
  - The vibration sensation might be overwhelming and as a solution we thought we can use different body parts but then this will not be as intuitive as we wanted it to be
  - Power supply might drain too fast in that case we said that we would use the power source in which case the project will not be mobile anymore

NOW I SEE

Agenda

March 3, 2014
4:00 PM-6:00 PM

Purpose of the meeting: TA meeting for design spec document and functional spec document, and to update team on current stage of the project

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Discussion with our TA about both Functional spec document and design spec documentation:** Went over our mark for the functional spec documentation. We also discussed improvements for the next document. TA mentioned we need to add solid works of the design of our project.

- **Team discussion for work division on Design spec documentation:** Each member picked a part to work on for the documentation of the design spec

- **Discussion of existing problems (raspberry pi):** Problem: raspberry pi runs on ARM architecture so it could not handle ROS and arduino connections. We decided to eliminate raspberry pi and use a laptop instead.

NOW I SEE

Agenda

March 15, 2014
5:00 PM-8:30 PM

Purpose of the meeting: to discuss possible problems that we encountered to update the other group members of the current stage of the project

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Update on hardware**: Steven has modified the camera to fit on the helmet. He finished mounting the camera on the helmet. He has done some work for control circuit PCB board
- **Updates on UI**: Anita and Darya worked on making the UI. However it still needs improvements and it has to be tested
- **Discussion of problems encountered**: the wires for UI were not long enough and they were not flexible so it was hard to implement the UI. We discussed if we have time we can use different material if possible.

NOW I SEE

Agenda

March 28, 2014
4:30 PM-6:00 PM

Purpose of the meeting: to discuss and meet with the TA and seek feedback for the current stage of the project. Discuss possible changes that we can incorporate

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- **Meeting with our TA** : Jamal saw the hardware design done and he told us as an improvement we can drill the Kinect to the helmet if time allowed
- **Team meeting for update on hardware (done):** Hardware is completely done
- **Team meeting for update on software (transfer to laptop):** Arduino code is completed. At this point ROS is programmed on our PC. In future we need to transfer this to laptop.

NOW I SEE

Agenda

April 6, 2014
4:30 PM-6:00 PM

Purpose of the meeting: to discuss progress on software and to synchronize parts of the code and to discuss problems that we encountered

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- Discussion of software progress: after putting together the code and fixing the existing bugs the Software is all done and we performed preliminary testing for UI.
- Discussion of problems encountered: Steven's laptop had problems installing the linux environment because it uses different architecture.
  We looked into buying a used laptop but we didn't want to add to our costs. We also asked other friends for spare laptop but no one had. After some research and inquiry we are now able to transfer everything to the laptop.

NOW I SEE

Agenda

April 12, 2014
4:00 PM-6:00 PM

Purpose of the meeting: to do a final test and to discuss about final demo and presentation

Present: Daria Namvar, Steven Lee, Anita Kadkhodayan

Minutes:

- Final tests are finished. Some tweaking was done on the spot
- List of recordings and photos to be taken is created.
- Logistics of creating the slides and creating post-mortem documents are set – Daria will start, Anita does hw, steven does sw, and daria to finish.
- Need to make the business case slides - steven
- Need to finalize budget - daria
- Need to create schedule talbe - anita