University of Waterloo

Faculty of Engineering
Department of Computer and Electrical Engineering

Initial Prototype Demonstration and Progress Report

Voice - Device to Enable Real-time Sign Language to Speech Translation

Group 2017.037

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Consultant: Prof. Dana Kulić
July 26, 2016

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1 Overview of the Project

1.1 Revised Project Abstract

There are 375,000 culturally deaf people in Canada, and in-person communication barriers between the native sign language speakers and the general populous still remain high. Many people do not understand sign language, and communicating through a text medium is arduous and impersonal. The goal of this project is to design a device to translate sign language to speech in real-time, allowing the deaf or mute to communicate naturally even with those who do not know sign language. Voice uses custom-made ergonomic gloves equipped with various sensors and an onboard microcontroller to track and stream data on a user's hand positions and motions to a Bluetooth-connected mobile application. The application connects to a quorum of pre-trained machine learning models to predict the given sign and speak it aloud, mimicking true speech. Our system can match tens of American Sign Language signs, in addition to signs for the Japanese manual syllabary. Voice is portable and unobtrusive compared to current computer vision variants - requiring the minimum of hardware - giving users a voice that they never had.

1.2 Original Project Timeline

Given that all four team members are working in downtown Toronto for the Fall 2016 term, the team can continue working on the project at a highly reduced intensity (approximately one to two hours per week, on average). As such, the project timeline will span the co-op term in addition to both 4A and 4B academic terms.

The project is broken down into two major phases and four major tasks. Phase one of the project will be done throughout the 4A term and phase two of the project will be carried out during the final co-op term and 4B. Figure 1 and Figure 2 illustrate our timeline during the two phases along with the time allocated to each group of tasks. Time allocated to designing and building the external subsystem prototype is in red. Any time allocated towards machine learning tasks are in green, and any tasks related to the companion mobile application are in yellow. Finally, other miscellaneous tasks are shown in blue.

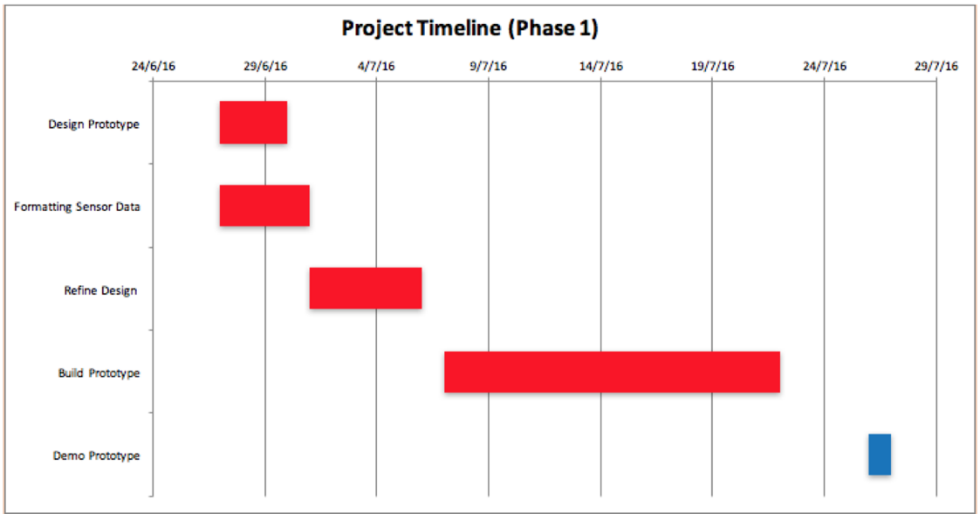

Figure 1: Phase One Gantt Chart (June 27th to July 27th)

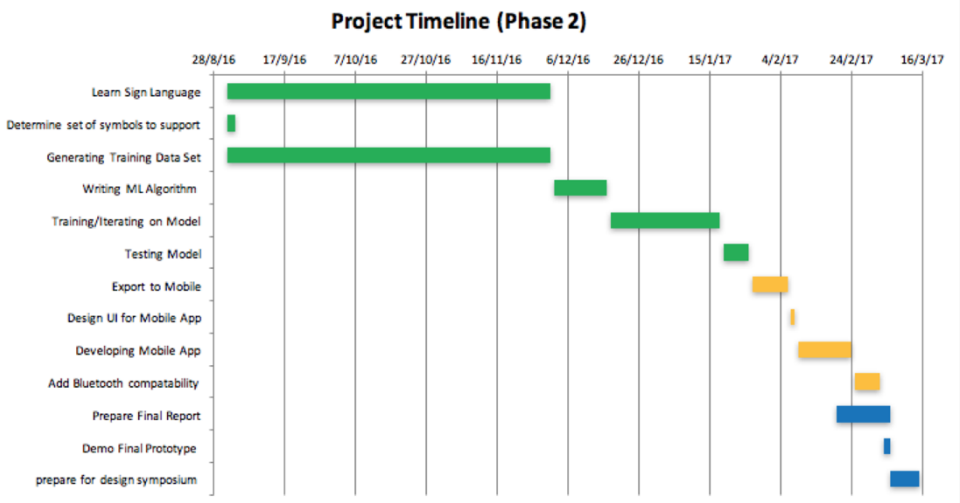

Figure 2: Phase Two Gantt Chart (September 1st to March 15th)

2 Current Status of the Project

2.1 Prototype Completion

The group has completed approximately 70% of the entire project. Our initial glove prototype is now able to gather relevant data when a user is making a sign and transmit this data through an Arduino, and further, to an Android application using a Bluetooth adapter. This application forwards this data to a Python backend which has incorporated a Machine Learning model that has been trained offline for two signs - “Hello” and “Bye”. The backend responds with the predicted sign, based on its classification of the the user’s motion/finger position, etc. as the input data. The Android application receives this prediction, updates the transcript, and speaks the sign aloud, completing the entire flow through all of Voice’s subsystems.

All of the subsystems work independently of each other, and work together when integrated. The largest next step is for the team members to create/gather hand motion/position data for the signs Voice has been specified to support. This data will be used to re-train the models. We will also be working on refining the overall design of the glove, and powering it using an external battery pack.

2.2 Student Hours

Table 1. Hours worked by students (Appendix A)

Student	Hours
Akshay Budhkar	107
Eliot Chan	88.75
Biraj Kapadia	93.75

Amish Patel	103
Total Hours	392.5

The total number of hours spent on the project was 392.5 (Table 1). It was difficult in the first few weeks to work on the hardware components as we were waiting for parts to arrive in the mail. Because of this, we were blocked on some portions of the other subsystems, and as such, the majority of the work was completed in July.

Despite spending less time than the recommended number of hours, the project is still well on its way and the team is quite confident in its completion by the Design Symposium.

3 Discussion

The group is quite confident that we can complete all essential specifications except perhaps the number of signs supported. Since all of the individual subsystems have been tested as working while integrated, the majority of the remaining work is related to training the machine learning models to support more signs, and to predict them more accurately.

If we find that our models are unable to predict the number of signs correctly or accurately, we can reduce the number of signs in scope. The team has worked quite well together so far, and there are no doubts about our continued ability to function and contribute to the project.

4 Appendix A: Student Logs

Name: Amish Patel	**Group: 037**	**Signature:**			
By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.					
Date	**Task**	**Time (hours)**	**Start Time**	**End Time**	**Running Total**
5/11/2016	Brainstorming Ideas	3.5	1:00 PM	4:30 PM	3.5
5/12/2016	Researching Ideas	2.5	12:00 PM	2:30 PM	6
5/14/2016	Finalizing Abstract draft and researching on potential consultants	4	8:00 PM	12:00 AM	10
5/17/2016	Meeting with Potential Consultants	1.5	2:00 PM	3:30 PM	11.5
5/18/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	13
5/25/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	14.5
5/26/2016	Brainstorming Project Specifications and coming up with block diagram draft	2	7:10 PM	9:10 PM	16.5
5/27/2016	Apply for the Engineers for Trust Scholarship	1	8:30 PM	9:30 PM	17.5
5/29/2016	Finalize Project Specifications and Risk Management Document	4	4:45 PM	8:45 PM	21.5
6/1/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	23
6/7/2016	Getting the project timeline	2.5	5:45 PM	8:15 PM	25.5
6/8/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	27
6/8/2016	Finalizing on the Baylis Pitch	1.75	9:45 PM	10:30 PM	28.75
6/9/2016	Coming up with answers to potential questions for Baylis Pitch	1.5	2:45 PM	4:15 PM	30.25
6/9/2016	Refining the pitch+potential questions after Prof. Dana's review	0.5	6:30 PM	7:00 PM	30.75
6/15/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	32.25
6/16/2016	Experimenting and looking up with sensors	2	1:15 PM	3:15 PM	34.25
6/19/2016	Learning Machine Learning - Day 1	1.5	3:00 PM	4:30 PM	35.75
6/22/2016	Experimenting with Accelometer/Gyroscope Sensor + Arduino	1.75	6:30 PM	8:15 PM	37.5
6/22/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	39
6/23/2016	Reading Flora sensor data + looking on tutorials for Android-Arduino communication	2.5	1:30 PM	4:00 PM	41.5
6/25/2016	Started working on detailed design + gathering data from sensors	4	2:15 PM	6:15 PM	45.5
6/25/2016	Gathering data from flex sensors and accelerometer/gyroscope	4	7:15 PM	11:15 PM	49.5
6/26/2016	Working on the detailed design	5.25	2:15 PM	7:15 PM	54.75

6/26/2016	Working on the detailed design	2	8:00 PM	10:00 PM	56.75
6/28/2016	Fix up the detail design report based on Prof. Kulić's feedback	4	5:00 PM	9:00 PM	60.75
6/29/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	62.25
7/6/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	63.75
7/10/2016	Planning on what tasks need to be done by the demo date	1	12:15 PM	1:15 PM	64.75
7/10/2016	Create and initialize android application repository	0.5	4:00 PM	4:30 PM	65.25
7/10/2016	Android Development: Implemented the UI portion of the application	3	5:00 PM	8:00 PM	68.25
7/13/2016	Android Development: Incorporate TextToSpeech module to the application	2	3:30 PM	5:30 PM	70.25
7/13/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	71.75
7/14/2016	Android Development: Implement the Export to txt option + UI Listeners and Initialization	4	11:00 PM	3:00 PM	75.75
7/15/2016	Designing the Glove: Stitching pockets on them for flex sensors - Helping my Mother with directions	2	4:00 PM	6:00 PM	77.75
7/16/2016	Android Development: Implement Simulation where a stream of data is sent to the transcript	3	9:00 PM	12:00 PM	80.75
7/18/2016	Bluetooth Integration: Making sure we get "Hello World" running for Android-Arduino communication	2.5	2:15 PM	4:45 PM	83.25
7/18/2016	Bluetooth Integration: Getting data from arduino through bluetooth	1.75	6:00 PM	7:45 PM	85
7/20/2016	Android Development: Working on client-server communication through sockets	2	5:30 PM	7:30 PM	87
7/20/2016	Weekly Team Meeting	1.5	8:00 PM	9:30 PM	88.5
7/22/2016	Soldering sensors+arduino for the first glove	3.5	11:30 AM	3:00 PM	92
7/22/2016	Soldering sensors+arduino for the first glove	3	3:40 PM	6:40 PM	95
7/23/2016	Assembling the Gloves	2.5	9:00 PM	11:30 PM	97.5
7/24/2016	Android Development: Bridging the Arduino code with server	3.5	2:00 PM	5:00 PM	101
7/25/2016	Demo	1	11:30 AM	12:30 PM	102
7/25/2016	Work on the Progress Report	1	8:40 PM	9:40 PM	103

ECE498A: Student Log

Name: Biraj Kapadia **Group: 037**

Signature: B Kapadia

By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.

Task	Date	Start time	Finish time	Hours	Running total of hours
Brainstorming Ideas	May 11	01:00 PM	04:30 PM	3.5	3.5
Research/Narrowing Ideas	May 12	12:00 PM	02:30 PM	2.5	6
Research Consultant/Finish Abstract	May 14	08:00 PM	12:00 PM	2	8
Talk to Consultants	May 16	01:00 PM	02:45 PM	1.75	9.75
Finalize Consultants	May 17	04:00 PM	04:15 PM	0.25	10
Team Meeting	May 18	08:00 PM	09:30 PM	1.5	11.5
Apply for Baylis medical award	May 20	11:15 AM	11:45 AM	0.5	12
Discuss and write specs	May 24	05:30 PM	07:30 PM	2	14
Team Meeting	May 25	08:00 PM	09:00 PM	1.5	15.5
Prepare info for other award applications	May 28	09:15 PM	10:00 PM	0.75	16.25
Finish Award Application and Specs Document	May 29	04:00 PM	06:45 PM	2.75	19
Team Meeting	June 1	08:00 PM	09:30 PM	1.5	20.5
Discuss goals for first iteration	June 7	05:45 PM	08:15 PM	2.5	23
Team Meeting	June 8	08:00 PM	09:30 PM	1.5	24.5
Discuss the pitch for Baylis award	June 8	09:30 PM	11:30 PM	2	26.5
Discuss the design	June 9	02:30 PM	04:00 PM	1.5	28
Get parts for prototyping	June 10	01:00 PM	01:15 PM	0.25	28.25
Testing parts	June 11	03:00 PM	04:00 PM	1	29.25
Team Meeting	June 15	08:00 PM	09:30 PM	1.5	30.75

Arduino Test	June 22	06:30 PM	08:00 PM	1.5	32.25
Team Meeting	June 22	08:00 PM	09:30 PM	1.5	33.75
Arduino Test	June 23	01:30 PM	04:00 PM	2.5	36.25
Detailed Design	June 25	02:30 PM	06:30 PM	4	40.25
Arduino Test	June 25	07:15 PM	11:15 PM	4	44.25
Detailed Design	June 26	02:00 PM	07:00 PM	5	49.25
Detailed Design	June 26	08:00 PM	10:00 PM	2	51.25
Detailed Design	June 29	02:30 PM	04:00 PM	1.5	52.75
Weekly Team Meeting	June 29	08:00 PM	09:30 PM	1.5	54.75
Detailed Design	June 29	09:30 PM	11:00 PM	1.5	55.75
Weekly Team Meeting	July 6	08:00 PM	09:30 PM	1.5	57.25
Discuss Parts to we need for the initial prototype	July 10	12:30 PM	01:30 PM	1	58.25
Team Meeting	July 13	08:00 PM	09:30 PM	1.5	59.75
Help debug issues with parsing the data used to generate the ML model	July 15	02:15 PM	04:15 PM	2	61.75
Work on Arduino and research missing parts for next week	July 16	01:30 PM	05:15 PM	3.75	65.5
Research on how to send data from Arduino HC-06 to Android devices via Bluetooth	July 16	06:00 PM	07:00 PM	1	66.5
Implement sending data from Arduino to Android phone	July 18	02:15 PM	04:45 PM	2.5	69
Getting android to read Bluetooth data within the Application itself	July 18	06:00 PM	07:45 PM	1.75	70.75
Team Meeting	July 20	08:00 PM	09:30 PM	1.5	72.25
Implement the communication between HC-05 and HC-06	July 21	05:30 PM	08:45 PM	3.25	75.5
Implement the communication between HC-05 and HC-06	July 21	09:30 PM	11:59 PM	2.5	78

Implement the communication between HC-05 and HC-06	July 22	12:00 AM	02:00 AM	2	80
Soldering sensors + Arduino for the first glove	July 22	11:30 AM	03:00 PM	3.5	83.5
Soldering sensors + Arduino for the first glove	July 22	03:40 PM	06:40 PM	3	86.5
Assembling and test the first glove	July 23	09:00 PM	11:30 PM	2.5	89
Integration Testing for the Demo	July 24	01:00 PM	03:45 PM	2.75	91.75
Demo the initial prototype	July 25	11:30 PM	12:30 PM	1	92.75
Work of Progress Report	July 25	08:40 PM	09:40 PM	1	93.75

ECE498A: Student Log

Name: Akshay Budhkar **Group: 037**

Signature:

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Task	Date	Start time	Finish time	Hours	Running total of hours
Brainstorming Ideas	May 10	01:00 PM	04:45 PM	3.75	3.75
Researching Ideas	May 11	1:00 PM	4:30 PM	3.5	7.25
Research/Narrowing Ideas	May 12	12:00 PM	02:30 PM	2.5	9.75
Research Consultant/Finish Abstract	May 14	08:00 PM	12:00 PM	2	11.75
Talk to Consultants	May 16	01:00 PM	02:45 PM	1.75	13.5
Finalize Consultants	May 17	04:00 PM	04:15 PM	0.25	13.75
Weekly Team Meeting	May 18	8:00PM	9:30 PM	1.5	15.25
Apply for Baylis medical award	May 20	11:15 AM	11:45 AM	0.5	15.75
Discuss and write specs	May 24	05:30 PM	07:30 PM	2	17.75
Weekly Team Meeting	May 25	8:00PM	9:30 PM	1.5	19.25

Prepare info for other award applications	May 28	09:15 PM	10:00 PM	0.75	20
Finish Award Application and Specs Document	May 29	04:00 PM	06:45 PM	2.75	22.75
Weekly Team Meeting	June 1	8:00PM	9:30 PM	1.5	24.25
Discuss goals for first iteration	June 7	05:45 PM	08:15 PM	2.5	26.75
Weekly Team Meeting	June 8	8:00PM	9:30 PM	1.5	28.25
Discuss the pitch for Baylis award	June 8	09:30 PM	11:00 PM	1.5	29.75
Discuss the design	June 9	02:30 PM	04:00 PM	1.5	31.25
Get parts for prototyping	June 10	01:00 PM	01:15 PM	0.25	31.5
Testing parts	June 11	03:00 PM	04:00 PM	1	32.5
Weekly Team Meeting	June 15	8:00PM	9:30 PM	1.5	34
Arduino Test	June 22	06:30 PM	08:00 PM	1.5	35.5
Weekly Team Meeting	June 22	8:00PM	9:30 PM	1.5	37
Arduino Test	June 23	01:30 PM	04:00 PM	2.5	39.5
Detailed Design	June 25	02:30 PM	06:30 PM	4	43.5
Arduino Test	June 25	07:15 PM	11:15 PM	4	47.5
Detailed Design	June 26	01:00 PM	07:00 PM	6	53.5
Detailed Design	June 26	08:00 PM	10:00 PM	2	55.5
Detailed Design	June 29	12:30 PM	04:00 PM	4.5	60
Weekly Team Meeting	June 29	8:00PM	9:30 PM	1.5	61.5
Weekly Team Meeting	July 6	8:00PM	9:30 PM	1.5	63
Initial Prototype	July 10	12:00	1:30	1.5	64.5
Weekly Team Meeting	July 13	8:00PM	9:30 PM	1.5	66
ML-Initial Prototype	July 14	12:00	5:00 PM	5	71
ML-Initial Prototype	July 15	12:00	6:00	6	77

ML- Preprocessing	July 16	1:00	7:30	6.5	83.5
ML – Preprocessing	July 17	1:00	3:30	2.5	86
ML – Model building	July 18	3:00	9:00	6	92
ML – Backend setup	July 19	3:00	5:30	2.5	94.5
Weekly Team Meeting	July 20	8:00PM	9:30 PM	1.5	96
ML – Backend Preprocessing	July 21	10:00	2:30	4.5	100.5
Integration	July 22	12:00	1:30	1.5	102
Integration	July 24	2:00	5:00	3	105
Demo	July 25	11:30	12:30	1	106
Progress Report	July 25	8:40	9:40	1	107

ECE498A: Student Log

Name: Eliot Chan Group: 037

_____ Signature: _____

By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.

Task	Date	Start time	Finish time	Hours	Running total of hours
Brainstorming Ideas	May 10	1:00 PM	4:45 PM	3.75	3.75
Research/Narrowing Ideas	May 12	12:00 PM	2:30 PM	2.5	6.25
Begin Abstract Draft	May 13	8:00 PM	8:30 PM	0.5	6.75
Research Consultants/Finish Abstract	May 14	8:00 PM	10:00 PM	2	8.75
Talk to Consultants	May 16	1:00 PM	2:45 PM	1.75	10.5
Finalize Consultant	May 17	4:00 PM	4:15 PM	0.25	10.75

Weekly Meeting	May 18	8:00 PM	9:30 PM	1.5	12.25
Discuss and Write Specs	May 24	5:30 PM	7:30 PM	2	14.25
Weekly Meeting	May 25	8:00 PM	9:30 PM	1.5	15.75
Prepare Information for Award Application	May 28	9:00 PM	9:45 PM	0.75	16.5
Finish Award Application and Specs Doc	May 29	4:00 PM	6:45 PM	2.75	19.25
Weekly Meeting	June 1	8:00 PM	9:30 PM	1.5	20.75
Discuss Goals for First Iteration and Write Pitch for Baylis	June 7	6:00 PM	8:15 PM	2.25	23
Continue to Write Pitch for Baylis	June 8	2:00 PM	2:30 PM	0.5	23.5
Weekly Meeting	June 8	8:00 PM	9:30 PM	1.5	25
Continue to Write Pitch for Baylis	June 8	9:30 PM	11:15 PM	1.75	26.75
Research how to Power Arduino with Batteries, Finish Baylis Pitch	June 9	2:30 PM	4:45 PM	2.25	29
Modify Pitch to be One Slide	June 9	11:00 PM	11:30 PM	0.5	29.5
Practice and Present Baylis Pitch	June 10	12:30 PM	1:30 PM	1	30.5
Buy Parts and Start Preliminary Arduino Testing	June 10	3:30 PM	4:30 PM	1	31.5
Weekly Meeting	June 15	8:00 PM	9:30 PM	1.5	33
Testing Parts, Figuring Out Other Parts to Buy	June 16	1:00 PM	3:15 PM	2.25	35.25
Attempting to Read from Flora Sensor	June 22	6:00 PM	7:45 PM	1.75	37
Weekly Meeting	June 22	8:00 PM	9:30 PM	1.5	38.5
Actually Managing to Read from Flora Sensor	June 23	1:30 PM	4:00 PM	2.5	41

Working on Detailed Design Doc	June 25	1:15 PM	6:15 PM	5	46
Gathering Data for Design Doc and Working Out How to Fulfill Specs	June 25	7:15 PM	12:15 AM	5	51
Working on Detailed Design Doc	June 26	2:15 PM	7:15 PM	5	56
Working on Detailed Design Doc	June 26	8:00 PM	12:00 AM	4	60
Polishing 9DOF Explanation in Design Doc	June 29	4:00 PM	6:30 PM	2.5	62.5
Weekly Meeting	June 29	8:00 PM	9:30 PM	1.5	64
Weekly Meeting	July 6	8:00 PM	9:30 PM	1.5	63.5
Researching Time Sync, Creating Demo Script	July 16	3:30 PM	7:00 PM	3.5	67
Practice Sign Language	July 17	9:30 PM	10:00 PM	0.5	67.5
Get Socket-IO Python Base Application Running on Heroku	July 18	3:30 PM	5:00 PM	1.5	69
Apply to Norman Esch Award	July 18	8:05 PM	8:20 PM	0.25	69.25
Practice Sign Language	July 19	8:00 PM	9:30 PM	0.5	69.75
Get socket communication working between Android app and backend	July 20	3:30 PM	7:30 PM	4	74.75
Weekly Meeting	July 20	8:00 PM	9:30 PM	1.5	76.25
Practice Sign Language	July 21	10:00 AM	10:30 AM	0.5	76.75
Ensure backend is using sockets and not HTTP, miscellaneous hardware help for actual glove	July 22	11:30 AM	3:30 PM	4	80.75
Practice Sign Language	July 23	2:15 PM	2:45 PM	0.5	81.25

Researching multiple Bluetooth slave connections, shooting part of demo video	July 23	10:00 PM	11:00 PM	1	81.25
Miscellaneous glove help	July 24	2:00 PM	4:30 PM	3.5	85.75
Demo	July 25	11:30 AM	12:30 PM	1	86.75
Final Progress Report	July 25	8:15 PM	10:15 PM	2	88.75