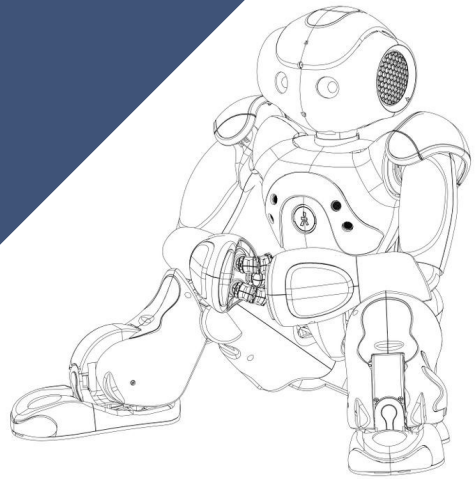
Visual and Aural Telepresence via NAO Robot



Chelsea Cantone (CoE), Theresa Pham (CoE), Daniel Ponsini (EE)

Advisor: Dr. Seung-yun Kim

December 6th, 2017

TCNJ THE COLLEGE OF NEW JERSEY

Overview

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- Humanoid Robot Background
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- Team Breakdown

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- Task Breakdown

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- Budget
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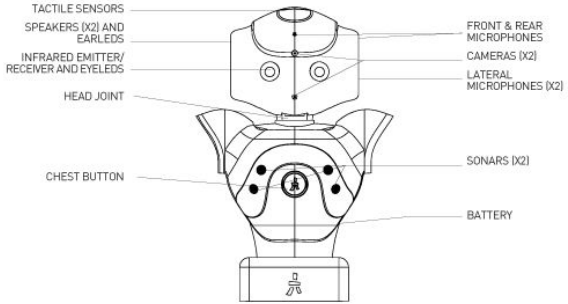
- Current Status
- Senior Project II Plans

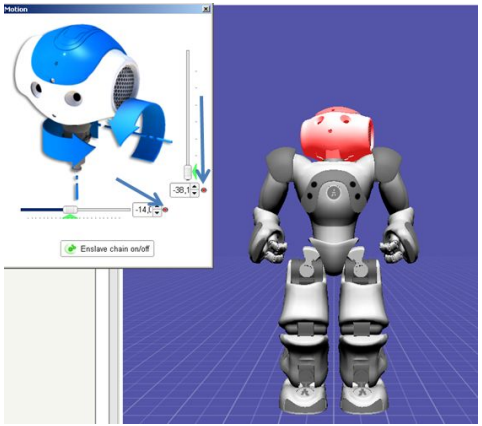
Problem Definition & Need Identification

- Applications for **telepresence/teleoperation devices**
  - Remote in to lectures, classes, conferences
  - Navigate dangerous terrain
  - Work remotely as tour guides, security, consultants, etc.
- Will allow people in far away places or people with disabilities to **immerse** themselves and physically **interact** in a **remote environment**

Humanoid Teleoperated Robot

- SoftBank Robotics NAO Robot
- Ideal for HRI (human robot interaction)
  - 23 inches (58 centimeters)
  - 25 Degrees of freedom to mimic human motion
  - Microphones (x 4) and speakers (x 2)
  - Cameras (x 2)





Project Goals

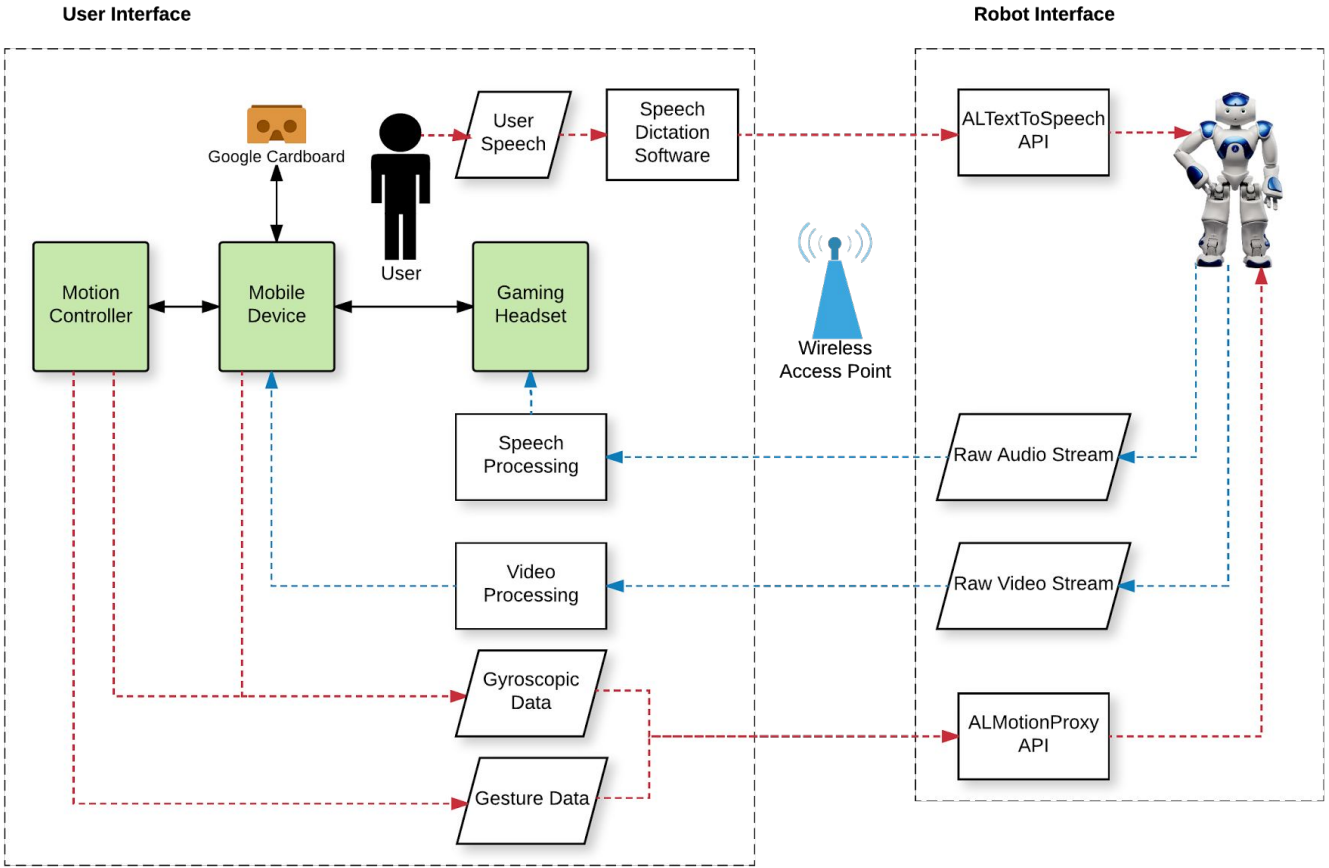
- To **aurally** and **visually** engage the user and audience using the NAO robot
- To develop **wireless communication** between the NAO and a user wearable headset
  - connecting movement using **gyroscope** data
- To develop a **web/mobile application** which receives a **live video and audio stream** from NAO
- To incorporate *Motion-Based Humanoid Robot Controller* project

Team Breakdown

Team Member	Work
Chelsea Cantone	To implement audio streaming and speech processing between the NAO and its operator
Theresa Pham	To work on video processing and develop the web/ mobile application for video streaming to the operator
Daniel Ponsini	To work on controlling NAO movement based on sensor information and establish wireless communication between the NAO and headset

High-Level Look at the System

Detailed Block Diagram



Legend

Robot Interface Source → Process

User Interface Source → Data (I/O)

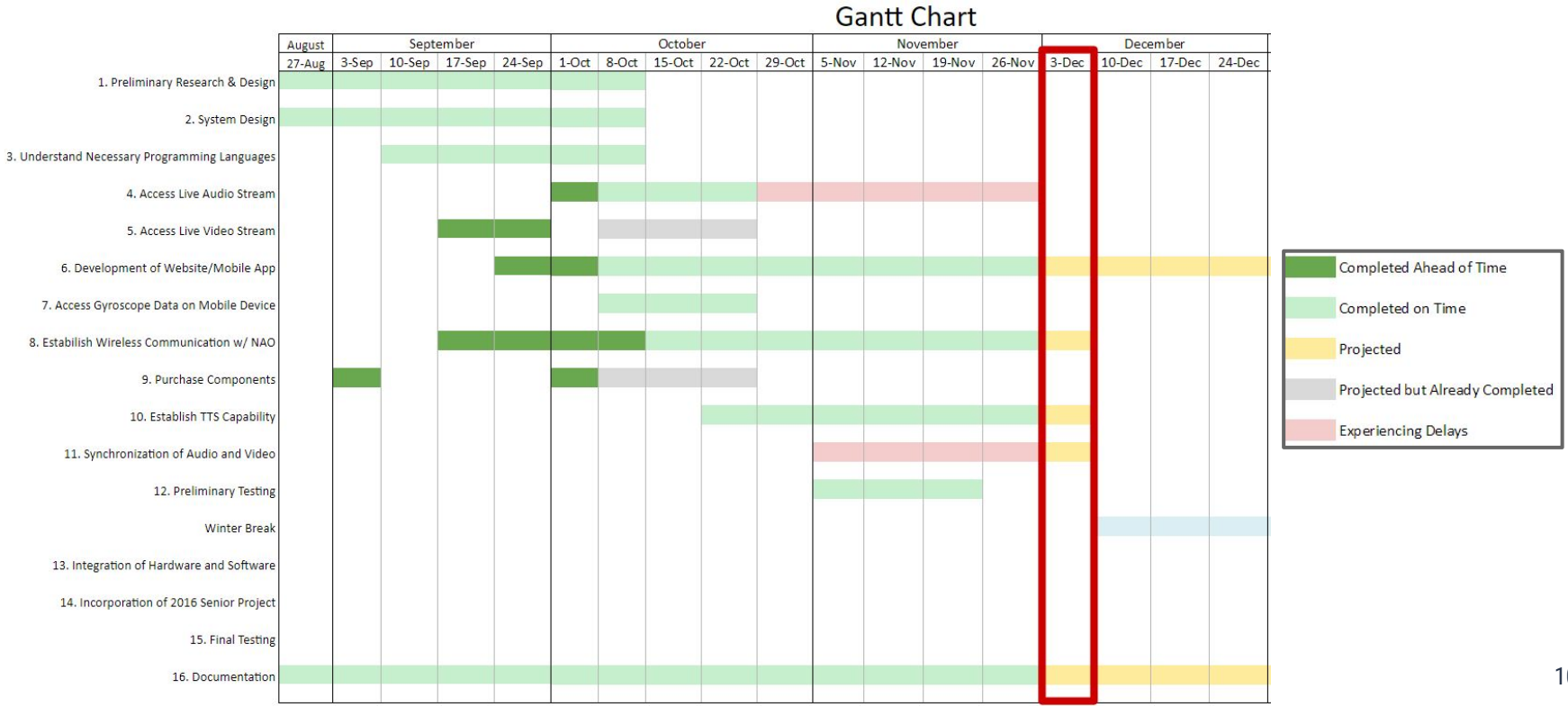
Hardwire Connection →

Quantitative Specifications

Field of Vision	60° horizontally by 50° vertically
Weight	Headset < 2.5 lbs Arm Controller < 1 lb
Battery Life/Power Consumption (robot system and user system)	1-2 hours
Video Resolution	320×240 pixels
Framerate	15fps

Tolerated Latency	<1 second
Movement sensitivity	TBD
Degrees of Freedom in Teleoperated Robot	6
Wireless Range	TBD
Wireless Transmission Reliability	TBD

Schedule


Gantt Chart
August
September
October
November
December
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
1-Oct
8-Oct
15-Oct
22-Oct
29-Oct
5-Nov
12-Nov
19-Nov
26-Nov
3-Dec
10-Dec
17-Dec
24-Dec
1. Preliminary Research & Design
2. System Design
3. Understand Necessary Programming Languages
4. Access Live Audio Stream
5. Access Live Video Stream
6. Development of Website/Mobile App
7. Access Gyroscope Data on Mobile Device
8. Estabilish Wireless Communication w/ NAO
9. Purchase Components
10. Establish TTS Capability
11. Synchronization of Audio and Video
12. Preliminary Testing
Winter Break
13. Integration of Hardware and Software
14. Incorporation of 2016 Senior Project
15. Final Testing
16. Documentation
Completed Ahead of Time
Completed on Time
Projected
Projected but Already Completed
Experiencing Delays

Task 1: Preliminary Research and Design

August 27th - October 14th

- Research similar projects
- Determine a feasible preliminary design
  - Decide the mobile platform and research app development
  - Determine appropriate hardware and software

Task 2: System Design

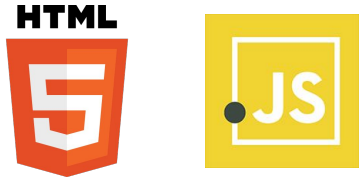
August 27th - October 14th

- Create block diagram of the system
- Outline system specifications
  - Qualitative and quantitative goal specifications for the project

Task 3: Understand Necessary Programming Languages

September 10th - October 14th

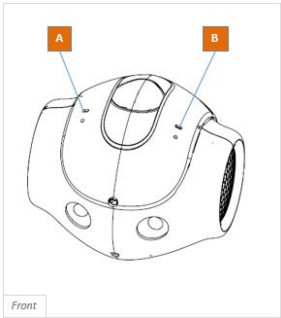
- Learn how to work with various programming languages needed for the project:
  - Python
    - NAOqi SDK
    - Flask (web framework module)
  - Front-End Languages
    - HTML/CSS
    - Javascript



Task 4: Access Live Audio Stream

~~*October 8th - October 28th*~~ → *October 1st - November 25th*

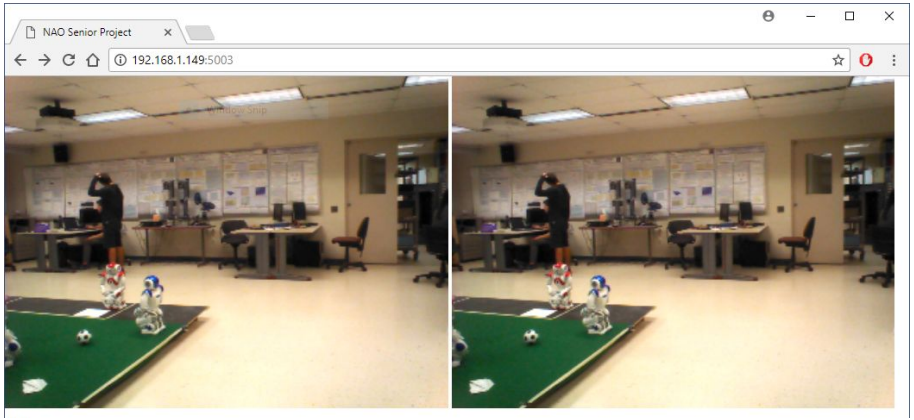
- Access NAO audio buffers from NAO's microphones
- Using NAOqi ALAudioDevice API
  - Subscribe to the buffer containing microphone channels
  - Pass these buffers to the web application using Flask



Task 5: Access Live Video Stream

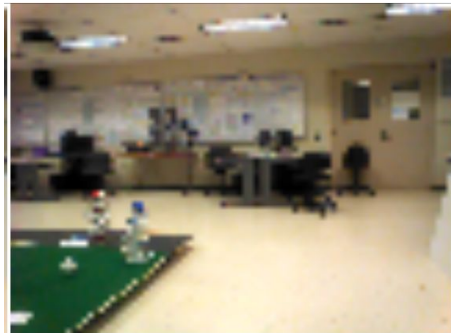
~~*October 8th - October 28th*~~ → *September 17th - September 30th*

- Access the video stream through the web
- Using NAOqi ALVideoDevice
  - getImageRemote function to return a video feed



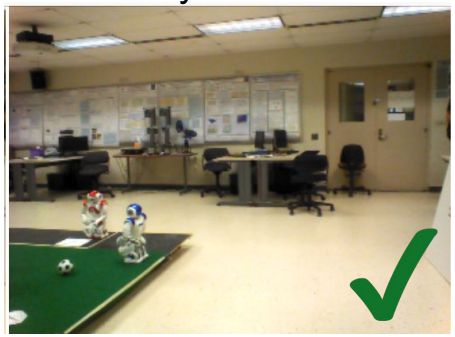
Resolution Examples

Resolution: 40x30
Latency: 0 seconds

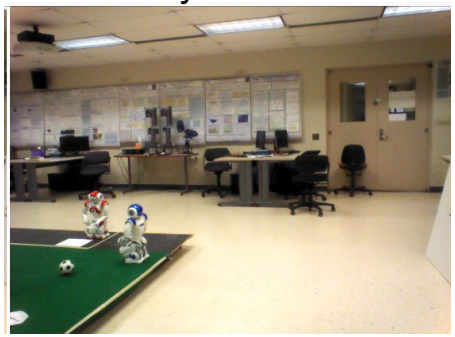


Resolution: 80x60
Latency: 0 seconds

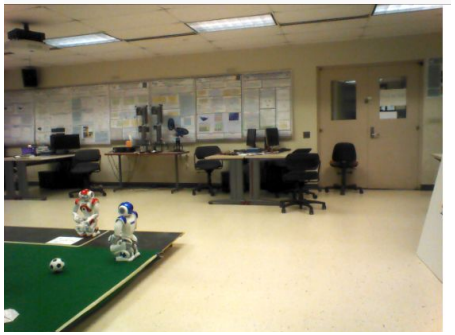
Resolution: 160x120
Latency: 0 seconds



Resolution: 320x240
Latency: ~0.6 seconds



Resolution: 640x480
Latency: ~3 seconds



Resolution: 1280x960
Latency: ~10 seconds

Task 6: Development of Website/Mobile App

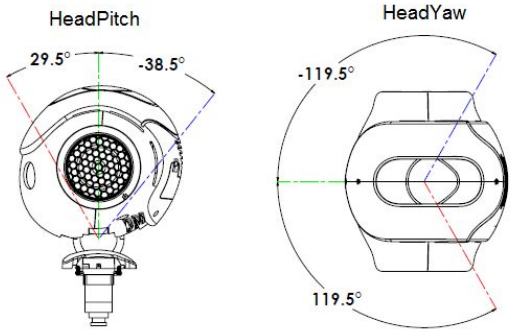
~~*October 8th - March 10th*~~ → *September 24th - March 10th*

- Create a website (which can be accessed using a phone)
- Develop alternative system implementation in a mobile application (iPhone and Android devices)
- Design a user interface navigable through the headset controller

Task 7: Access Gyroscope Data on Mobile Device

October 8th - October 28th

- Use HTML5/Javascript to access gyroscope data through the phone



Task 8: Establish Wireless Communication with NAO

~~*October 15th - December 9th*~~ → *September 17th - December 9th*

- Establish connection over Wi-Fi to the NAO
- Simultaneously send and receive data with NAO

Task 9: Purchase Components

October 8th -

- Purchase a headset with a high fidelity microphone
- Purchase two Google Cardboard VR headsets
  - Purchase materials to incorporate VR head strap

Task 10: Establish Text-to-Speech (TTS) capability

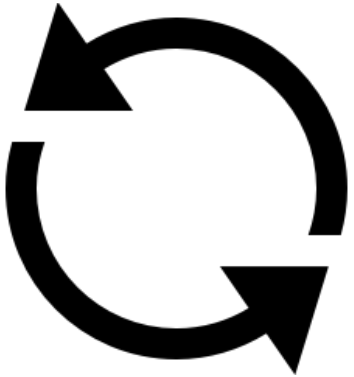
October 22nd - December 9th

- Use a Python script to take user speech, convert it to a string, and send the string to the robot to recite
  - Utilize speech_recognition and pyaudio packages
    - speech_recognition package uses Google Speech Recognition API
  - Use NAOqi ALTextToSpeech API to allow the robot to say the input string

Task 11: Synchronization of Audio and Video

~~*November 5th - December 9th*~~ *Pushed to next semester*

- Develop multiplexer for proper live audio and video mixing
- Adjust latencies and/or framerate when out of sync
- Investigate GStreamer, FFmpeg, and other video processing support libraries

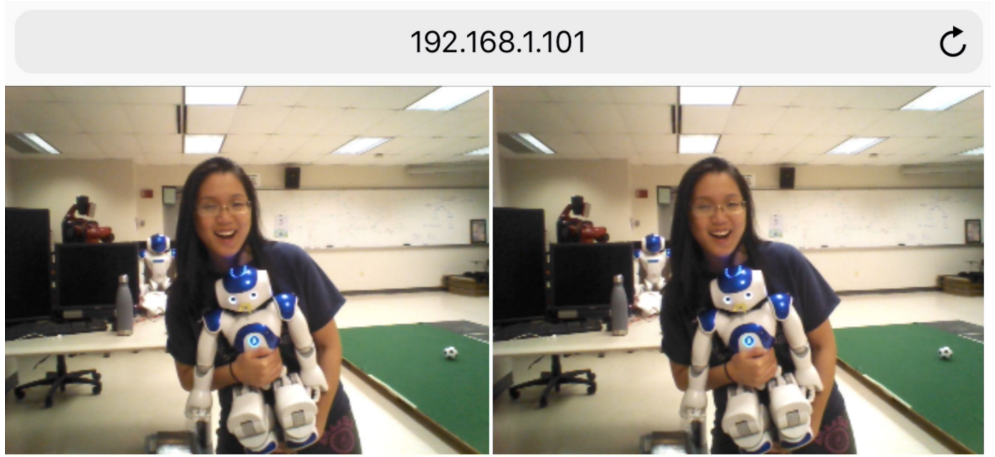


Task 12: Preliminary Testing

November 5th - November 25th

- Test components individually for unit functionality
  - Tested live video, audio, head control using gyroscopic data, text-to-speech

```
y: 16
z: 36
init y: 1
init z: 360
```



Task 13: Integration of Hardware and Software

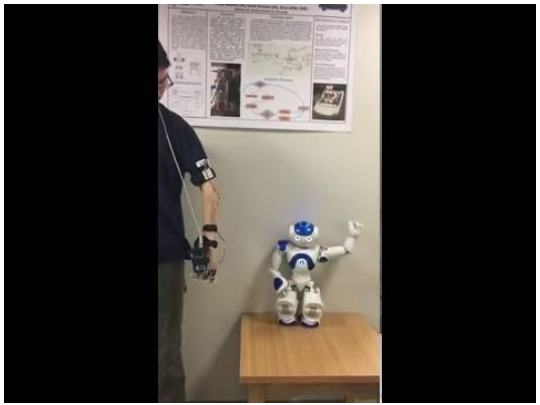
January 21st - March 3rd

- Integrate all software modules interfacing with hardware
- Ensure ability to wear all user interfacing devices (VR headset and Gaming headset) with web application running

Task 14: Incorporation of 2016 Senior Project

January 21st - March 3rd

- Provide support for both:
  - Leg control (discrete), using a gesture sensor
  - Arm control (differential), using accelerometer, magnetometer, and gyroscope
- Resolve previous years problems communicating to the Arduino in COM



Task 15: Final Testing

March 4th - April 21st

- Test system against our quantitative specifications
- Test system in different environments and scenarios
  - Areas with low Wi-Fi connectivity, high levels of noise, different human operators, etc.
- Debugging
- Fine-tune components to create the most comfortable and intuitive experience

Task 16: Documentation

Ongoing throughout whole project

Budget

Total Budget: $300

Item	Quantity	Cost per Quantity ($)	Total Cost ($)
Gaming Headset	1	$ 128.46	$ 128.46
Google Cardboard	2	$ 19.99	$ 39.98
NAO Robot	1	$9,500.00	N/A
Miscellaneous (extra parts, shipping, etc.)	N/A	$8.63	$8.63
Total Cost			$177.07

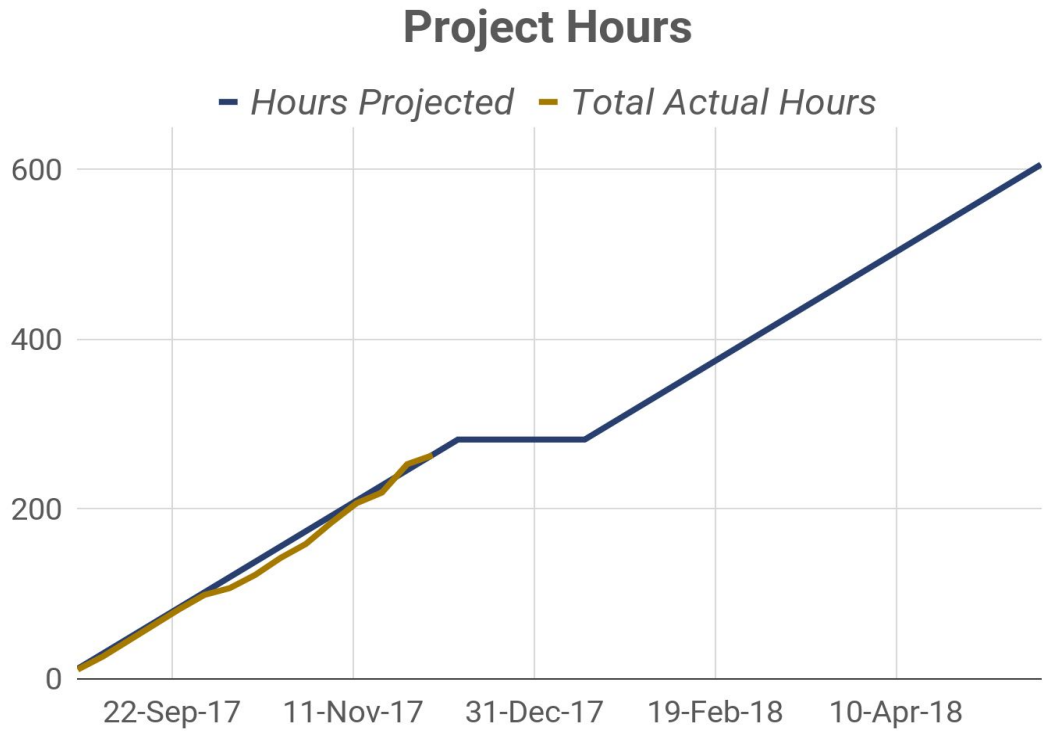
Trade-Off Analyses

Headset	DSCVR: Link 	Alternative Google Cardboard: Link 	*Samsung Gear VR Virtual Reality Headset: Link* 	*Oculus VR Oculus Rift - Virtual Reality Headset: Link* 	*Homido V2 Virtual Reality Headset: Link* 
Platforms	Android/iPhone	Android/iPhone	Samsung Galaxy smartphones (S7, S6, Note, etc.)	Linux, Mac OS, and Windows (not for mobile device)	Android/iPhone
Price	$19.99	$29.99	$42.74	$359.62	$79.99
Pros	-Inexpensive -Compatible with Android or iOS -Support exists for developing on Cardboard	-Inexpensive -Compatible with Android or iOS -Better enclosure for cellphone	- Includes head strap - Relatively inexpensive	-A full headset with headphones -Dedicated Dev community	-Great enclosure for phone with easy access to buttons -Head strap is included -Fits many size mobile devices -Allows for easy focusing onto the phone screen -Allow for adjustment of inter-pupil distance
Cons	-No headstrap	-No headstrap	- Not compatible with iOS	-Way beyond our budget -Not for mobile devices	-Sort of expensive -Could not plug audio headset into headphone jacks (could use bluetooth?) -Hinge on the phone drawer falls open

Trade-Off Analyses

Headset	*Logitech - G633 Artemis Spectrum Gaming Headset:* 	*Turtle Beach XO Three Gaming Headset: Link* 	*Turtle Beach - Stealth 350VR Amplified Virtual Reality Gaming Headset: Link* 	*Sennheiser PC 360 Special Edition Gaming Headset: Link* 
Price	$99.99	$75.98	$62.36	$128.46
Pros	-7.1 surround sound -Noise-canceling microphone -USB and 3.5mm analog inputs -0.83 pounds	-"Crystal Clear Chat" -High sensitivity mic -Good sound for its price -Removable mic	-Intended for use with VR headsets -Provides clearance for VR headbands and cables!! -Active noise-cancelling microphone -Detachable cables -Mounted audio controls on headset -Lightweight design (1.1 lbs) -Ergonomic design	-Professional quality sound -Noise-cancelling microphone -Most likely more clarity than other lower end microphones -Compatible audio adaptors with 3.5 mm jack -10 ft long cable (replaceable) -Lightweight and flexible -On-ear volume control
Cons	-Buttons difficult to reach -Micro USB-C connector results in poor sound quality -Cable is easily tangled	-No replaceable cord -Cord is not reinforced so it is prone to damage -Mediocre reviews online	-Minimal isolation provided by foam cups	-Headset might be tight

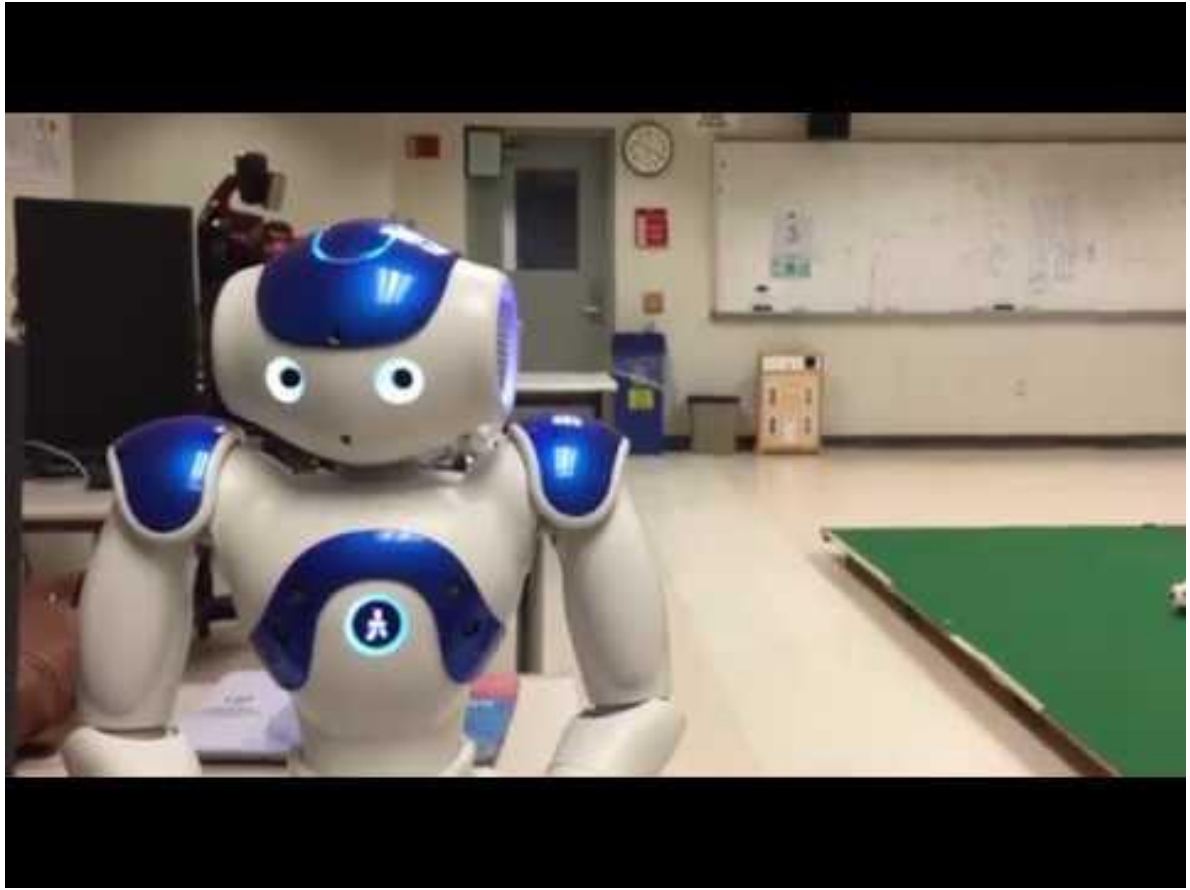
Projected Hours



Conclusion

- Completed items
  - Access raw microphone buffers from NAO on webpage
  - Displayed live video on webpage
  - Established wireless link to send video and audio from NAO to webpage
  - Accessed gyroscope data from mobile device
  - Sent gyroscope data to control NAO head movement
  - Created script that can send user speech to NAO

Our Progress



View the video on our website here

Senior Project II Plans

- Audio processing
- Synchronization of video and audio
- Integration of functioning components
- Integration of 2016 motion controller project
- Continued development of website application
- Final system testing

Questions?