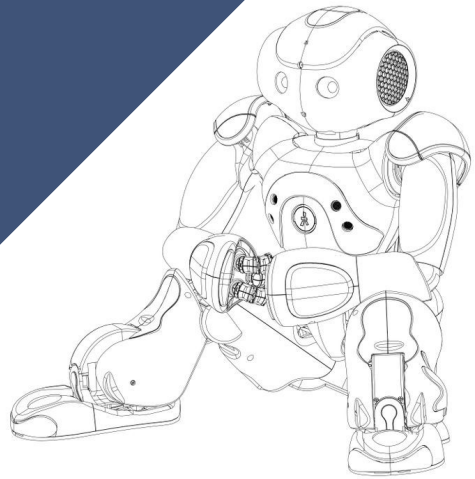
Visual and Aural Telepresence via NAO Robot



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Advisor: Dr. Seung-yun Kim

October 25, 2017

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Overview

- Project Goals
- Project Status
- Schedule
- Task Breakdown, including:
  - Trade-off Analyses
  - System Block Diagram
  - Quantitative Specifications
  - Budget
- Projected Hours
- Summary
- Open Actions Items

Project Goals

- To aurally engage the user and audience using the NAO robot
- To develop wireless communication between the NAO and a user wearable headset, connecting movement between the two using a gyro sensor
- To develop a web/mobile application which receives a live video stream from NAO
- To incorporate some or all arduino modules from the previous year's senior project using NAO (*Motion-Based Humanoid Robot Controller* by Olivia Shanley and Yilin Yang)

Project Status

Design changes

- Preliminary development of a web application compatible with mobile devices

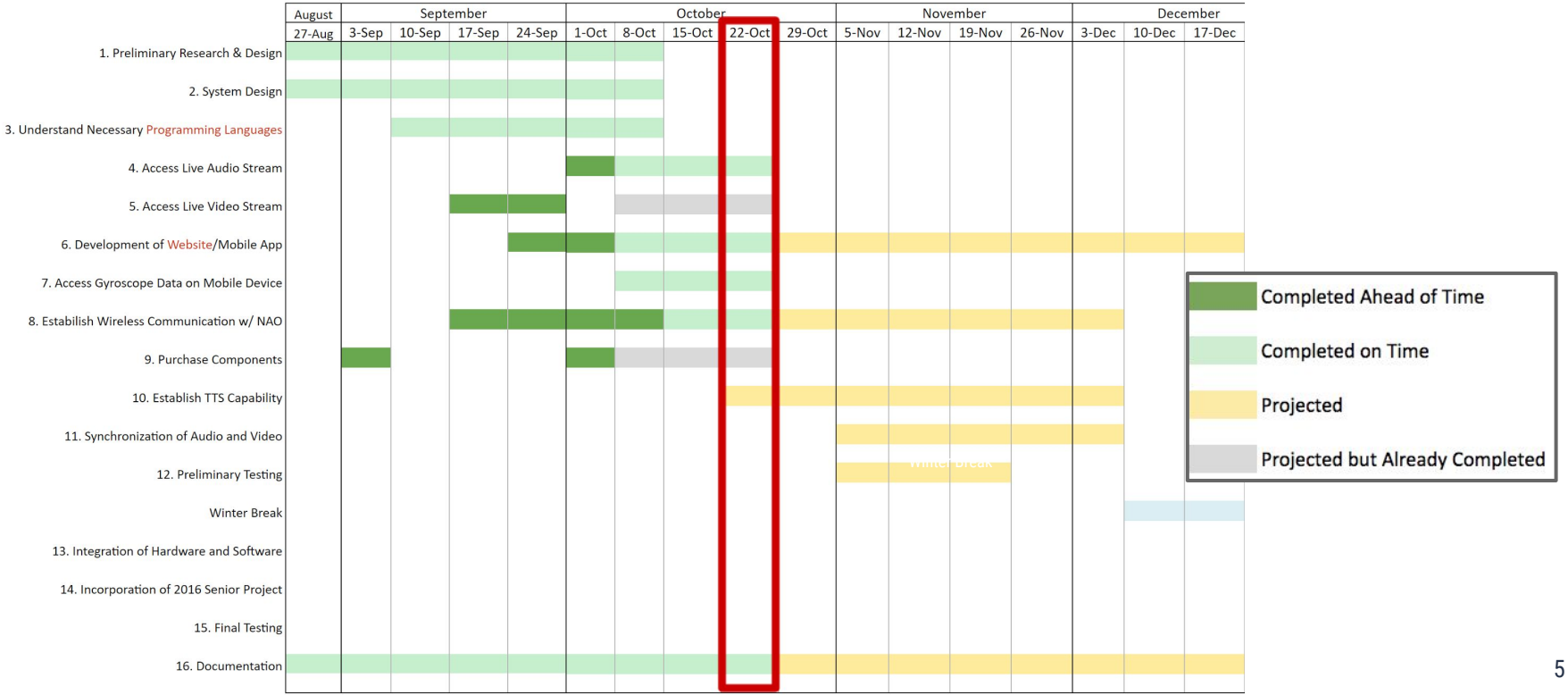
Functioning components

- Video stream from NAO with varying resolutions
  - Projected stereoscopic image
- Access to real-time gyroscope data through web application

Project Documentation

- Defined quantitative specifications
- Trade-off analyses on VR headsets and gaming headsets
- Created block diagram and new Gantt chart

Schedule


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
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

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

Trade-Off Analyses: VR Headsets

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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	$39.98	$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: Gaming Headsets

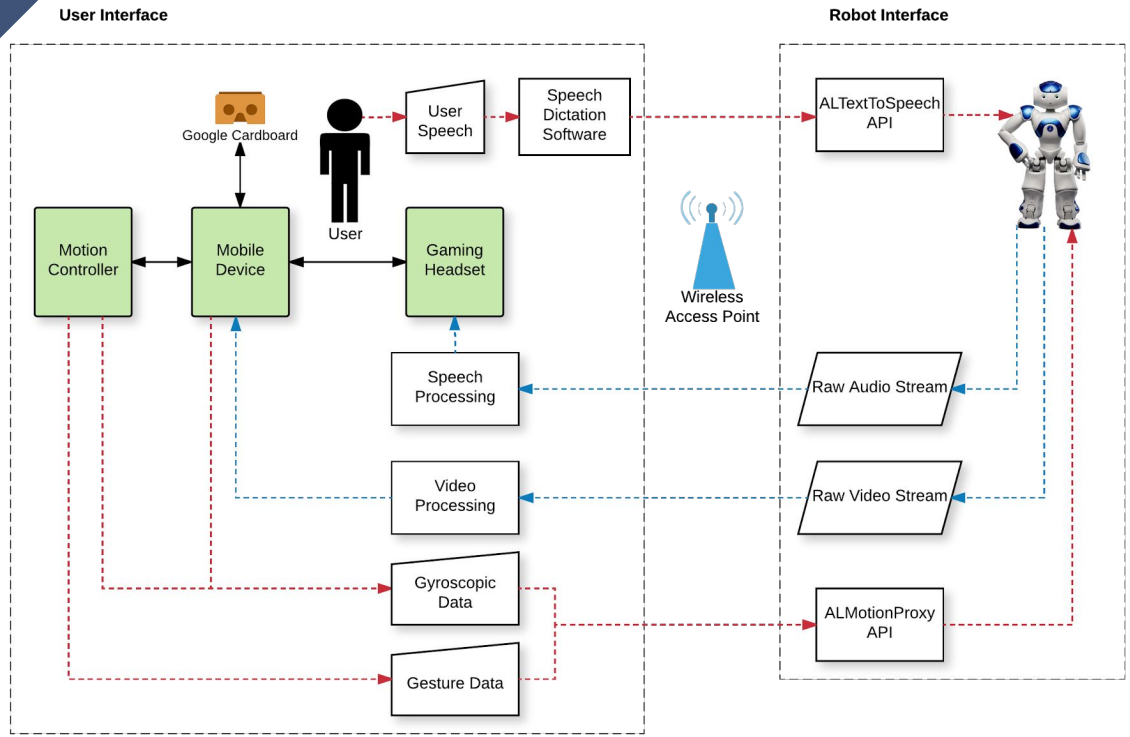
Headset	*Logitech - G633 Artemis Spectrum Gaming Headset:* 	*Turtle Beach XO Three Gaming Headset: Link* 	*Turtle Beach - Stealth 350VR Amplified Virtual Reality Gaming Headset: Link* 	*Sennheiser PC 360 Special Edition Gaming Headset: Link* 
Price	$99.99	$75.98	$62.36	$128.46
Pros	-7.1 surround sound -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 were 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 sort of tight

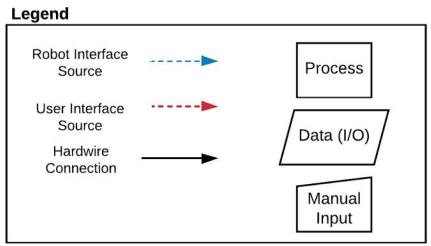
Task 2: System Design

August 27th - October 14th

- Created block diagram of the system
- Outlined system specifications
  - Qualitative and quantitative goal specifications for the project

Detailed Specifications





Quantitative Specs

Field of Vision	Approximately 60 degrees horizontally by 50 degrees vertically
Battery Life/Power Consumption (robot system and user system)	1-2 hours for a conference or a lecture
Weight	Gaming headset is 1.36 lbs. VR Headset is 0.58 lbs. Phones range between 0.24 - 0.33 lbs. Total Weight: 2.18 - 2.27 lbs.
Resolution	320*240
Movement sensitivity	TBD
Framerate (fps)	15
Degrees of Freedom in Teleoperated Robot	TBD

Supported Mobile Operating Systems	Android 4.0.3 or higher iOS 8 or higher
Tolerated Latency	<1 second
Wireless Range	TBD
Wireless Transmission Reliability	TBD
NAO Robot Requirements	NAO v5 NAOqi > 2.1.4

Task 3: Understand Necessary Programming Languages

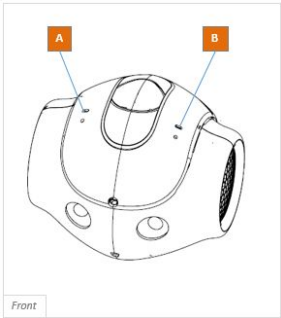
September 10th - October 14th

- Learn how to work with various programming languages needed for the project:
  - Python ⟶ NAO SDK
  - HTML/CSS + other possible front-end languages
  - Flask (web framework)

Task 4: Access Live Audio Stream

October 8th - October 28th

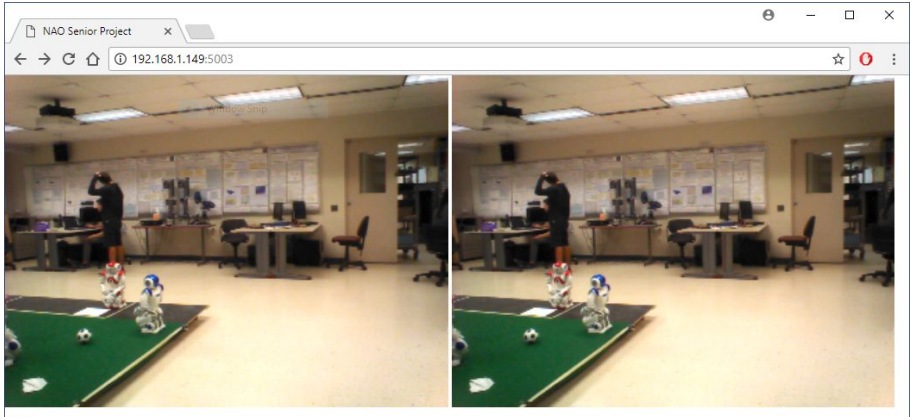
- Access NAO audio buffers from NAO's microphones
- Using NAOqi ALAudioDevice API
  - Subscribe to the buffer containing microphone channels
  - Pass these buffers to the web application using Flask



Task 5: Access Live Video Stream

October 8th - October 28th

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

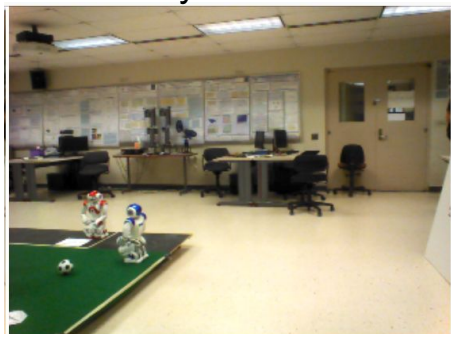


Resolution Examples

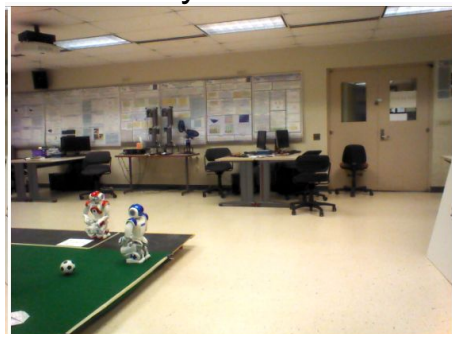
Resolution: 40x30
Latency: 0 seconds

Resolution: 80x60
Latency: 0 seconds

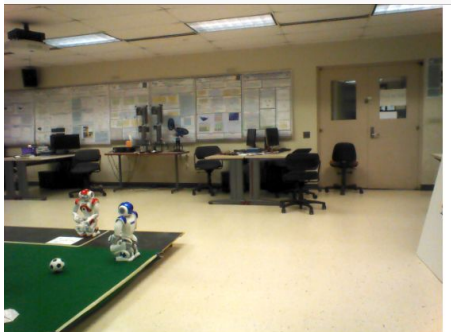
Resolution: 160x120
Latency: 0 seconds



Resolution: 320x240
Latency: ~0.6 seconds



Resolution: 640x480
Latency: ~3 seconds



Resolution: 1280x960
Latency: ~10 seconds

Task 6: Development of Website/Mobile App

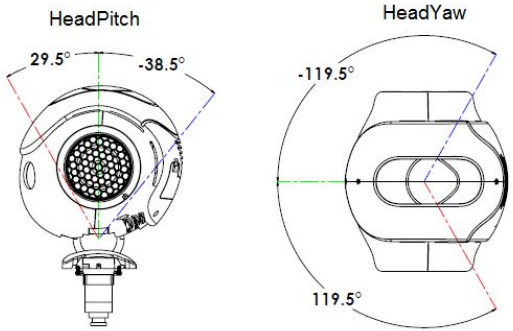
October 8th - March 10th

- Found existing code that helped get video streaming from the NAO
  - Will focus on creating a website first (which can still be accessed using a phone)
  - Work on the mobile app later in the project

Task 7: Access Gyroscope Data on Mobile Device

October 8th - October 28th

- Have successfully used HTML5/Javascript to access gyroscope data through the phone



Task 8: Establish Wireless Communication with NAO

October 15th - December 9th

- Establish connection over Wi-Fi to the NAO
- Simultaneously send and receive data with NAO
  - Currently able to access data, but need to establish connection the other way (TTS, ALMotion to control NAO head joint)
- Develop a way to connect to the robot when it is not on the local network

Task 9: Purchase Components

October 8th - October 28th

- Purchase Sennheiser headset with a good mic
- Purchase two Google Cardboard VR headsets
  - Purchase materials to incorporate VR head strap

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

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

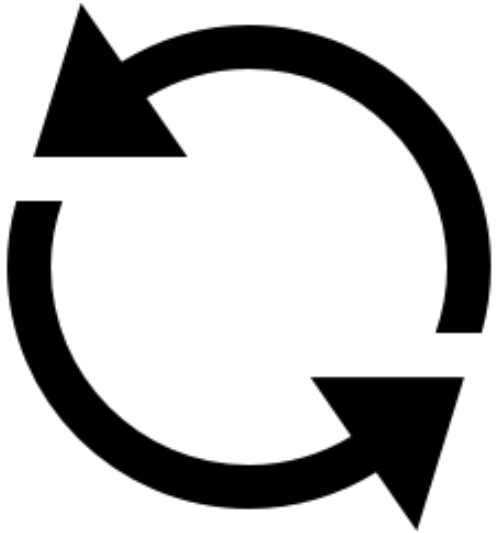
October 22nd - December 9th

- Perform speech recognition to convert speech to text
  - Research possible APIs
    - Google Speech Recognition Engine with Python
- Use NAOqi ALTextToSpeech API to allow the robot to speak

Task 11: Synchronization of Audio and Video

November 5th - December 9th

- Prevent audio and video from going out of sync
- Adjust latencies and/or framerate when necessary



Task 12: Preliminary Testing

November 5th - November 25th

- As the project progresses, components will be tested individually for unit functionality
- Preliminary testing will involve integrating existing components that students have working closer to the end of the semester to create a prototype
- Will have a prototype to present at the end of the semester

Task 13: Integration of Hardware and Software

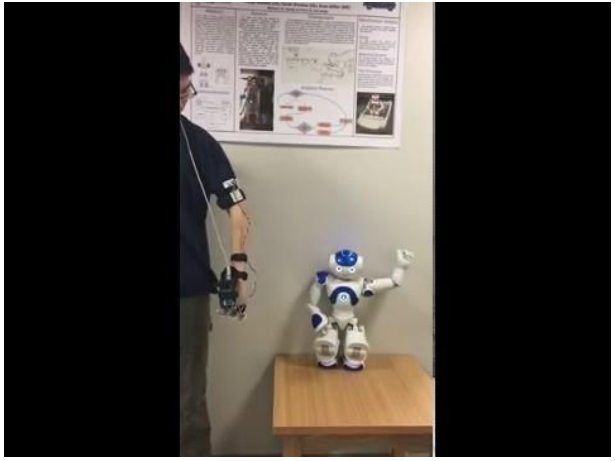
January 21st - March 3rd

- Integration of all software modules interfacing with hardware
- Able to wear all user interfacing devices (VR headset and Gaming headset) with web application running
- Debugging of integrated system

Task 14: Incorporation of 2016 Senior Project

January 21st - March 3rd

- Refactor 2016 Senior Project to work with our system
- 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

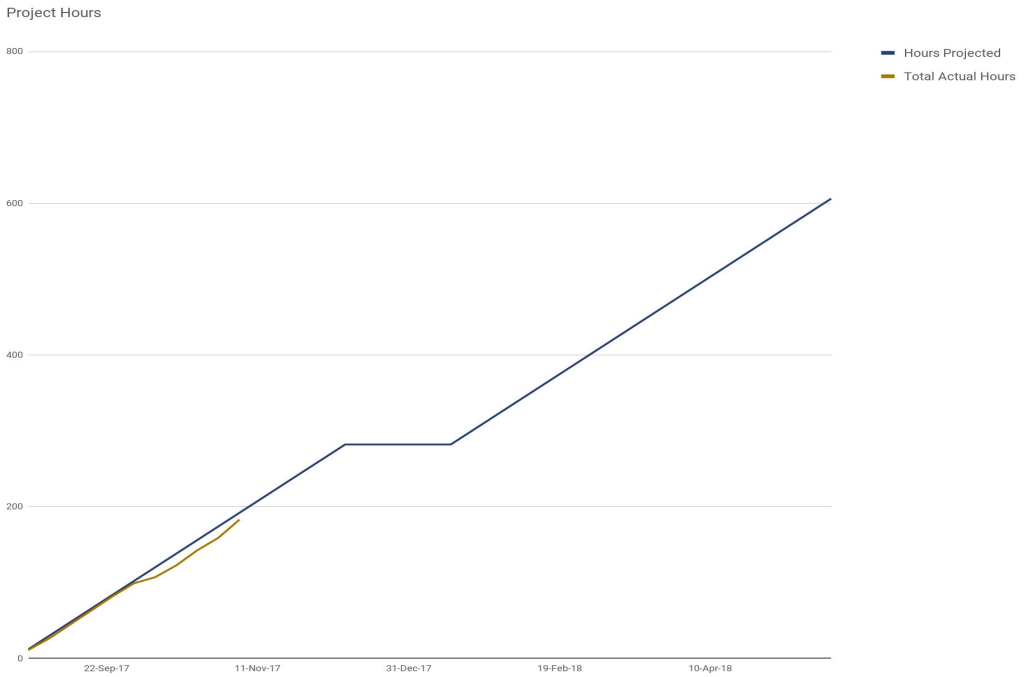
March 4th - April 21st

- Testing system against our quantitative specifications
- Robust testing in different environments and scenarios
  - (Areas with low Wi-Fi connectivity, high levels of noise, different human operators, etc.)
- Fine-tuning components to create the most comfortable and intuitive experience

Task 16: Documentation

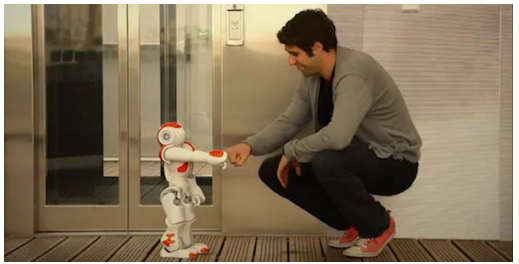
Ongoing throughout whole project

Projected Hours



Summary

- Completed items
  - Established wireless link to send video and audio from NAO to mobile device
  - Displayed live video on webpage
  - Accessed gyroscope data from mobile device
- Current progress
  - Stream audio to the webpage
  - Using microphone on headset to send strings to NAO
  - Using gyroscope data to control NAO



Open AIs

Action Item	Assigned To	Due Date
Calculate max fps for each resolution	Dan	November 5, 2017
Investigate CPU replacement	Theresa	November 1, 2017
Purchase head strap	Chelsea	November 1, 2017
Try to perform audio buffer access using code similar to camera module	Chelsea	November 3, 2017

Questions?