ABLE Alley - Capstone Report

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Overview

Pulse Lab: The Able Project

Pulse Lab is McMaster's dedicated space for projects leveraging biometric technologies and tools. ABLE refers to Pulse Lab's Art Based therapies for encouraging Longevity in the Elderly. Using wearable sensors in footwear, the current platform lets users complete physiotherapist-prescribed exercises with visual (art-based) prompts and feedback. The project is within its first iteration and currently runs with a tablet computer.

ABLE Alley

In an attempt to compliment the ABLE Project, ABLE Alley aims to target isolation in order to encourage longevity in the Elderly population. ABLE Alley utilizes concepts of gamification in order to provide an experience that will decrease isolation.

Abstract

The ABLE Alley project will be an interactive turn-based bowling game that is suitable for AMICA-type arrangements (elderly residences). This environment was chosen based on the ABLE Project's existing arrangements with the company. The game was to be built to run on a Google Chromecast. This is chosen because it would minimize the efforts of setup (for the staff)

Research

Elderly Population and Health Risks

Loss of mobility (ending in falling/slipping) is so frequently occurring that in just one year, 1 in 3 Canadian seniors above the age of 65 will likely fall at least once [5]. This is a very extreme statistic. There is research that also reinforces the ideas that the elderly need to view mobility as critically important. It relates that once the elderly have experienced a fall/slip, they are even less mobile for the fear of falling and slipping can be so extreme. Introducing some healthy activities to promote mobility can have a profound effect on sustaining mobility for a longer time.

Social Isolation in Seniors

A senior's social connection is essential to their mental and physical well being because close social connections reduced mental health issues such as depression as well as allow seniors to be in a better physical shape [13]. On the hand, social isolation can lead to risks of physical injury if seniors are often alone [13]. One in three Canadians over the age of 65 are

at risk of social isolation, one in five canadians are socially isolated and hope to have the chance to participate in more social activities [13].

Healthcare and Cost

The number of senior falls and risk of falls in Canada is much higher than one would think. In fact, 85 percent of injury related senior hospitalization are due to a fall and a fall leads to 95 percent of all hip fractures leading two billion in direct health care cost per year[4].

Fear of falling in seniors leads to higher chances of falling. Falling in turn leads to fear of falling and more falls[5]. One motivation of our project is develop a game to motivate seniors to exercise more in order to reduce the chances of falling which in turn reduces health care costs. However, exercise itself can lead to risk of falling which means the amount and extensiveness of the exercises should also be taken into account.

Elderly and Gamification

We were not able to find many games built using Chromecast available on the market let alone Chromecast game designed for seniors. In order to researching about the connection between elderly and gamification we looked into studies using a similar product, the Wii. Chromecast projects the game onto the monitor while the smartphone is used to host the game and act as the controller.

A study in Singapore shows that the Wii can be used as a tool to improve seniors' social interactions, as well as their physical and mental health and the acceptance level of Wii among seniors are high as long as they perceive Wii as easy to use. A way to improve elderly's' perception of Wii as easy to use is to make the activity resemble real life activities as much as possible [1]. This is one of the reasons we choose bowling as the game to develop because bowling is a common physical activity well known to most seniors.

We also looked into a comparison between regular physical activities vs activities through the Wii. Seniors find Wii to be more motivating compared to physical activities as they were able to compare their results with each other among different games[2]. This further shows Wii exercise allows seniors to interact more with each other. Another study of physical and psychological effects of Wii gaming among older women revealed senior themselves to bring up social benefits the most [3]. A lot of senior women bonded with each other during the exercise and learning more about technology makes them feel closer to their grandchildren and the modern world which they previously felt alienated from[3].
With the support from our research, we have chosen bowling because of three major reasons:

1. It is familiar to seniors which reduces their skepticism of new technology
2. There is a lot of walking involved back and forth however at the same time the activities are not overly vigorous for seniors who with physical limitations
3. Bowling does not require too much attention other than the player's turn. A lot of interactions are involved between the turns where seniors can socialize.

Gamification Concepts

Environment

The elderly population is not native to technology and least of all sensory experiences and games. Likely they have experienced arcades at an adult age but nothing to the degree of simulation that can be provided today. The environment that the game takes place in needs to have an amount of realism for them to relate to, and most importantly, remember. In order to target a demographic with such a vast range of sensory and physical disabilities (hearing aids, glasses, walkers, etc) it is important to make the most affordances in order to account for as many as possible. For that reason, ABLE Alley wants to choose something familiar to most of the players, something common enough to precede most memory loss.

Story

Previous user studies conducted with ABLE project concluded that the experience needs to have a fitting purpose, story or reason behind the actions. The elderly participants did not like actions that produce a random outcome, rather than working towards a goal or intention.

Implementation

Technologies

Socket.io

The socket library is used to open Web Sockets for bidirectional communication between the controller and the model and the model and the view. Using sockets was a more recent development as it would be able to render graphics well depending on the end system running the view. It allows us to have the same user interaction as with the original Chromecast implementation (using a phone as a controller and having a different view to interact with).

Read more here: https://socket.io

Bulma

Styles for the controller were built on top of Bulma. Bulma was chosen for many reasons, some of which are customization, performance and full coverage documentation. We are using Bulma with Sass (using node-sass to compile into css and minify) in order to be able to inject our styles into their predefined sets. Building with Bulma offers better performance since we can import only the node modules that are needed for the components we need. This keeps our codebase smaller (since it is only added when compiling to css), faster to load and easier to read (scss syntax is much better). Bulma also has lots of documentation

for customizing their styles and adding your own as well as using Bulma with other package managers.

Read more here: https://bulma.io

Node.js Node Package Manager

We use node and npm to install and control our dependencies and development dependencies. Node.js is also used by Express (below).

Read more here: https://www.npmjs.com/
Read more here: https://nodejs.org/en/

Express

Express is a node.js application framework that offers an extensive amount of customizable middlewares for building web applications. Express is used in order to run a server to connect to the sockets for the view and controller. It in run from index.js in the home directory and is also responsible for serving static files needed (from /public).

Read more here: https://expressjs.com/

Three.js

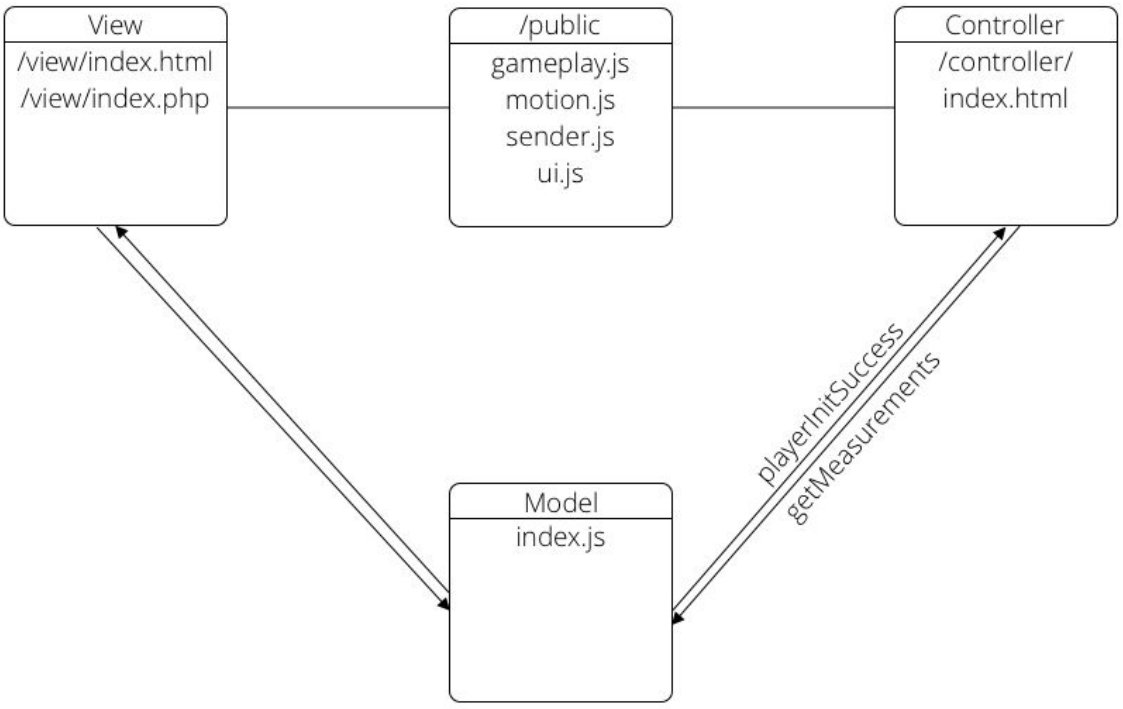
Three.js is a WebGL wrapper that makes working with web graphics quick and easy. It is lightweight and uses JavaScript to create and display animated 3 Dimensional graphics on web.

We chose Three.js because it allows us to build 3D animations without using plugins. Developing the game in the browser also ensures portability as anyone with a smartphone will be able to play the game regardless of the mobile operating system they have. Additionally, this library is widely used with a lot of documentation and featuring project to help us during the development process.

Three.js is used to make our game UI on the view. A plugin called physi.js is used to handle the physics simulation of the bowling ball rolling and hitting the pins in order to calculate the score. DDSLoader.js loads the textures for the bowling pins. MTLLoader.js and OBJLoader.js are used to load the model for the pin.

Read more here: https://threejs.org/

Model/View/Controller Framework



Model

The model maintains the participant information and game state data. The server adds bidirectional support between view and ctrl.

View

The view contains the animations and collision detection and also provide feedback to the users. The view is currently displayed on the computer but a bigger screen is recommended for better user experience.

Controller

The controller is the phone which collects input and motion data. The UI is also used to displays information to the user about game state such as starting the game, the player's turn, and the player's name.

Analysis

Difficulties

Technology

Chromecast has minimal interest from the community (in regards to development with games). Throughout the development process, ABLE Alley created three implementations of the prototype. There was one on Chromecast using Three.js, another one on Chromecast using the canvas API solely and the final prototype is socket based with Three.js.

There were a few reasons for iterating through the technologies and frameworks. Firstly, the project was focused on providing an easy to implement, easy to use and more importantly - *an out of the box ready product*. Going with the Chromecast meant moving through development without any thought of hardware dependability. However, it was seen through the first and second iteration that the processing power of the Chromecast is limited. Running Three.js (which is a WebGL wrapper) was not fluid and there were problems with loading models with textures, etc. Requiring better processing on the view (to run frames per second as needed) is why we moved to a socket implementation. Since the view is just another served html page on any end system, it was possible to revert back to using Three.js which was ideal since the graphics are more polished.

Movement Sensing

ABLE Alley uses sensors on mobile devices to measure and calculate the speed along the x-axis and the acceleration rate on the y-axis. More specifically, it utilizes the accelerometer sensor and the gyroscope sensor.

Speed Calculation

Upon successfully creating a new game session, namely when the user clicks the "Play" button on the mobile device and “playerInitSuccess” returns success on the backend, both accelerometer and gyroscope sensors are being initialized with a frequency of 60Hz and all the data collected within the 2 seconds after the sensor initializations are used to calculate the speed.

Accelerometer sensor is used to collect data for the acceleration rate on the x-axis. Variable t is used to keep track of the time, while ax and vx are used to store the acceleration rate and speed along x-axis respectively. The speed is then calculated using the following steps:

1) *t, ax,* and *vx* are all set to 0 when the sensor is initialized.
2) when a shake is detected: speed is calculated using the below formula: *vx + dt * (ax + acl.x)/2)* where *vx* is the speed from the last calculation, *dt* is the time spanned since the last calculation and *ax* is the last acceleration rate while acl.x is the acceleration rate of this particular moment.

3) If the player does not shake the phone hard enough, *t, ax,* and *vx* are all set to zero;
4) Repeat step 2 and 3 till the timeout (2 seconds)

Shake Detection

The movement along all three axes are quantified using Math.hypot() which returns the square root of the sum of squares of the acceleration rates along the 3 axes, i.e., var magnitude = Math.hypot(acl.x, acl.y, acl.z). When the value of magnitude is greater than 11, we consider it as a shake. The reason why we chose 11 as the “shakeThreashold” is because through the experiments, 11 works the best, meaning it is small enough to detect most of the shakes.

Insights

Through the course of our implementation for the project, we realized Chromecast lacked the processing power which makes it unsuitable for game development. Rather, Chromecast is mostly used for streaming audio-visual contents. For portability and easy set-up, a single-board computer such as Raspberry Pi is a better replacement.

In order to make the game perceived by seniors as easy to play, we implemented the game with several considerations in mind. The design of the game has a vintage style and a space theme, which adds familiarity to seniors from their era. The motion required to roll the bowling ball is simply a flick of the phone after clicking on the play button. This way, motion will only be recorded after the button is clicked to prevent erroneous input when the senior is not ready. When the speed and angle is received from the phone, the numbers are adjusted by a factor which prevents a high precision required in the motion of throwing the ball in order to hit the pins in the valley and a high real speed needed considering seniors with limited mobility. Finally, the design of the bowling lane is also simplistic resembling an actual bowling valley to reduce the amount of confusion from other graphics in the game as seniors are not as technology adept as the younger generation.

Future Applications

In the future, we hope to make this game available for anyone to play. This game is designed with the senior home environment in mind where seniors can easily get together for a fun session of light physical activity with the bowling game and also have the chance to be able to socialize with each other.

Currently, the implementation of the game is socket based with Three.js which requires a computer to host the server. However, we are expecting either Chromecast will advance in processing power or we can find another replacement for Chromecast to be able to support the game in order to make the game more portable. We are hoping this game will not be restricted to a pre-setup environment which can allow seniors to play bowling with their family and friends in any environment as long as a smartphone and projecting device with some processing power is available, thereby maximizing the social and physical benefits received by seniors.

ABLE Alley designed this game in partnership with the Pulse Lab to explore options to reduce isolation and increase longevity in seniors. Future work might involve user studies in senior homes and more work on how to collect data from these sessions. Based on the feedback and data collected, new requirements can be added to the current bowling game and more games of this form can be possibly developed.

Onboarding

For “Non - Disclosure Agreement”, “Anti - Harassment” and “Conduct Guidelines” documentation, please see the github repository.

Job Advertisement

Do you thrive in cutting-edge technical environments? Are you eager to have a career where you are encouraged to meet your potential and have the opportunity to help the elderly population by decreasing isolation?

AbleAlley is currently seeking a number of ambitious and driven candidates with the aptitude for working in a fast paced technological environment.

AbleAlley is focused on creating social experiences suitable for seniors. We are currently developing a wearable sensor based audio visual interactive experience that corresponds to users’ movements. AbleAlleys seeks to assist older adults, as they age, to stay mobile, active, and engaged with the community and the people they love.

We are currently seeking candidates interested in building a career in Mobile and Web Development.

Software Developers at AbleAlley will work with a range of responsibilities, including: writing, developing, testing, and reviewing code in JavaScript; working with the Google Cast SDK; liaising with end users through user studies to fix defects, find solutions, and test them; adding functionality to applications by designing and implementing solutions; and more.

You’ll gain experiences with the latest technologies in Web Development. As part of a small, experienced and dynamic team you will enjoy a creative, challenging and collaborative environment.

Essential Criteria:

- 4 year degree (preferably in Computer Science, IT, Engineering, Mathematics, or similar)
- A strong aptitude in IT and the interest and drive to expand your IT skill set
- A problem solver with a keen eye for detail
- Able to engage yourself in a project and enjoy the challenges and processes involved

- Flexible, eager, ambitious, and adaptable to change
- Eligible to work in Canada (citizen/permanent resident/work permit with sufficient length of validity)

Technical Skills:

- Strong Knowledge and experience with JavaScript (HTML5) preferred
- Agile methodologies: Scrum, Test Driven Development, Waterfall
- Strong knowledge of software development life cycle
- Passion for technology

Desirable Criteria:

- Exposure to JavaScript, SQL, HTML/CSS, Node.js
- Exposure to Google Cast Technologies
- Experiences with three.js is a plus
- Exposure to development frameworks such as Angular
- Experience with mobile development (Android) is beneficial
- Has studied or completed Information Technology or related courses in post-secondary education

AbleAlley is an Equal Opportunity Employer. All qualified applicants will receive consideration for employment without regard to race, colour, religion, sex, sexual orientation, national origin, age, disability, veteran status or any other status protected by federal, provincial, or local laws.

Job Offer

January 31, 2019

Yasamin Sartipi
1280 Main St West Hamilton, ON L8S 4L8

Personal and Confidential

Dear Yasamin:
ABLEAlley is excited to bring you on board as a Software Developer!

We're just a few formalities away from getting down to work. Please take the time to review our offer. It includes important details about your compensation, benefits and the terms and conditions of your anticipated employment with ABLEAlley.

The Position

ABLEAlley is offering a full-time position for you as Software Developer, reporting to the development team starting on March 1st at McMaster University.

The working hours shall be in accordance with the standard working hours applicable to your department or section. You also agree that ABLEAlley may transfer your work place and work assignment, as necessary for the business needs.

Effective Date

Your employment will commence on March 15t h 2019, or at another mutually acceptable date.

Compensation

You will be paid an annualized salary of $60,000.00, in biweekly payments.All payments are subject to deductions and withholdings required by law.

ABLEAlley pays on a bi-weekly basis on Friday and has 26 pay periods per year.

As part of your compensation, we're also offering bonus and stock options.

Vacation

Vacation pay will be equal to 4% of earnings. Vacation pay will be paid in a lump sum at the earlier of the contract end date or the end of the vacation year in which the vacation pay was earned.

Benefits

As an employee of ABLEAlley you will be eligible for Manulife health insurance.

Privacy Consent

By accepting this offer you agree that ABLEAlley, or related parties such as its affiliates or service provides, may collect, use, transfer, stor, access or disclose your personal information for the purpose of hiring and managing the employment relationship in accordance with applicable law and privacy policies in place, and as amended, from time to time.

Termination of Employment

You may terminate your employment upon two week’s notice.

Agreement and Acknowledgements

Please indicate your agreement with these terms and accept this offer by signing and dating this agreement on or before [offer expiration date].

Sincerely, ABLEAlley

I accept ABLEAlley's offer of employment as outlined above and in the enclosed attachment(s):

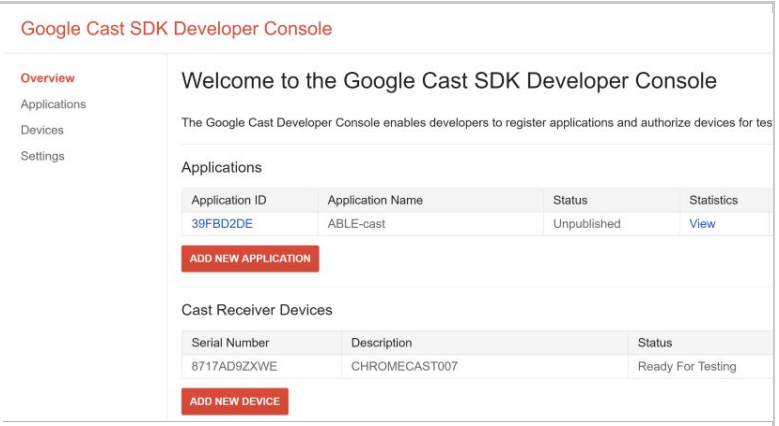
Signature _____
Date _____

Project Management

Meeting Notes

Date	Description	Additional Information
Monday, Sept 10, 2018	Meeting Dr.Zheng (Rong) to Discuss the ABLE Project	Discussion of the groups prior experience with mobile development and game design experience Learning more about the ABLE project
Monday, Oct 1, 2018	Meeting with Stephen Sterling. Overview of ABLE Project, current games and team. Discussions about psychology of gamification, habit formation, and elderly physiotherapy.	Lit review for next meeting (topics such as gamification and the elderly).

Monday, Oct 15, 2018	Meeting with Stephen Sterling. Discussing Chromecast as an option to get handheld movements for inputs. Wii as an option or webcam based computer vision integration.	How to deal with a generation that is not used to "soft controls"? Exploring and researching possibly technology for the project: Wii, Chromecast, Myo bands, VR/AR
Wednesday, Oct 17, 2018	Core team meeting. Adopting project management tool (Trello) Research organization (OneNote + Slack integration, Trello + Slack integration).	Need to rapidly determine *IF* we can do what we need to do with Chromecast. Google GameManager API has been deprecated and we need to use it's replacement or define custom functionality ourselves. We need to critically analyze how the front end (receiver) will work before we commit to a technology. Narrowing down to Chromecast + Web app (to reach Android and iPhone users).
Monday, Oct 22, 2018	Meeting with Stephen. Second literature review. Discussing ideas surrounding mentality of the elder generation, their control, dexterity and motivations when creating experiences. Discussions on Aveda type situations of "shared" living for elderly.	Is there a way that we can create a game that can be single player or multiplayer? (Of course there is, but how do we go about that in a *Chromecast application*) If there is a multiplayer game, does it need profiles? Profiles allow applications to target habits of the users and create routines (which would be an ideal outcome for physiotherapy games) that keep them coming back. It is harder to provide that same experience without knowing the user. Other thank profile based - look into turn based games. Real life example: bowling (only one person is taking their turn at the same time) Tech example: hearts (on old windows operating systems, mario party) *Mario party is interesting because each player has their own turn but also participate on other players' turns.*

Wednesday, Oct 24, 2018	Registration with Google Developer Console (5$ USD registration fee, 40$ CAD Chromecast)	
Thursday, Oct 25, 2018	Create working session between chrome sender and chrome receiver application.	Sender.html - chrome sender application just initializes and creates a session Receiver.html - chrome receiver application just displays a blue screen and the text "working" Registered as a Custom Receiver (building a remote receiver, meaning that the display does not mirror the display on the phone screen, it rather displays the output to the received input).
Wednesday Oct 31, 2018	Development Plan and Next Steps	Work on sending and receiving signals Work on sensing the movements from the phone to display it on the screen

Monday Nov 5, 2018	Meeting with Stephen	Sessions within floors - on the same wifi? (socket.io, websocket) OR just a floor leaderboard? Play as a team or against each other Discussing: Commitments + Stretch Goals Commitments: ● Chromecast sender (with gesture recognition) + receiver application ● Turn based game style (1 game, affords 1-5 players - POC) Stretch Goals: ● Leaderboards ● Team style or Melee ● Custom grip to help dexterity Making meeting with profs: What we need: ● Research Overview ● Technologies (overview + demo) ● Commitments and Stretch Goals ● Rubrics from the prof
Monday, October 1st 3-4pm	Meeting with Rong Zheng, Stephen	Getting Capstone approval for development Presented all research, objectives and plans for the project to receive critique, direction and approval.
Monday November 19, 2018	Non-Formal Meeting with Stephen	Poster discussion regarding styles, sources, layout and resources.
Thursday Dec 21, 2018	Meeting with Dr.Anand	Discussion regarding project management techniques Decision to upload all research and documents to GitHub
Monday Jan 14, 2019	Informal meeting with Stephen	Briefing on onboarding documents and requirements.

Wednesday Jan 16, 2019	Meeting with Rong, Stephen	Discussion of next steps (development progress, management progress etc). Requirements for the first prototype by end of January: ● Bowling valley ● Triggering bowling ball Inquired about user study design
Monday, Feb 4, 2019	Meeting with Stephen	Tutorial on how to create 3D model using Blender
Wednesday, Feb 12, 2019	Meeting with TA(Yasamin) for onboarding	
Thursday Feb 28, 2019	Group meeting to combine front and back end	The group has separately worked on the animation for the bowling, the 3D background, the motion detection on the phone, and the controller UI on the phone. This meeting was to combine the individual parts together
Friday Mar 1, 2019	Continuation of the previous day	Got the bowling ball combined with the background Able to trigger bowling ball from phone click
Monday, March 11, 2019	Meeting with Stephen	Discussed details on animation style for seniors
Monday, March 18, 2019	Group meeting to test bowling game	Discussed lagging caused by limited processing power on Chromecast to support OpenGL With 3D background and model, the game works properly on the computer but stops displayer after being casted to the screen using Chromecast
Wednesday, March 20, 2019	Group meeting to simplify bowling game	Tried removing animation and 3D texture to reduce the load on the process, lagging issue persists, only the bowling ball shows on screen
Monday, March 25, 2019	Trying to integrate speed and angle collected from phone into simplified bowling game	Animation of the bowling ball rolling lags too much, sometimes mouse clicks are unresponsive Decision made to try recreating the game using HTML canvas
Wednesday, March 27, 1029	Short meeting to discuss HTML canvas design and decisions	
Monday, April 1, 2019	Group meeting to work on HTML Canvas game	Tried integrating speed and angle into the canvas game The animation in the background still causes lags When the animated background is removed, the ball rolls but is still lagging in the beginning of the animation

Monday, April 8, 2019	Meeting with Dr.Anand	Discussed limitations of Chromecast for animation processing Decision made to use socket server for relaying message between game view and phone UI
Wednesday April 17, 2019	Develop model/view/controller framework Worked on Report and slides	Developed server to relay message from controller and update the view
Thursday April 18, 2019	Integrating Game with model/view/controller framework	Added game UI to run as view and phone UI to run as controller Changed game background and colours to space theme
Tuesday April 23, 2019	Relaying messages between model/view/controller framework	Using socket.io to relay message from controller on phone to model in order to update the animation on view based on the speed and angle Animation on view determines score based on collision detection and sends back score for model to calculate total score
Wednesday April 24, 2019	Wrap up meeting to finish development, slides and report	

GitHub

ABLEalley

This repository includes the game UI made using Three.js, Onboarding documents, research notes in OneNote, and Poster. This is the main repository which we use for project management and the first part of the development.

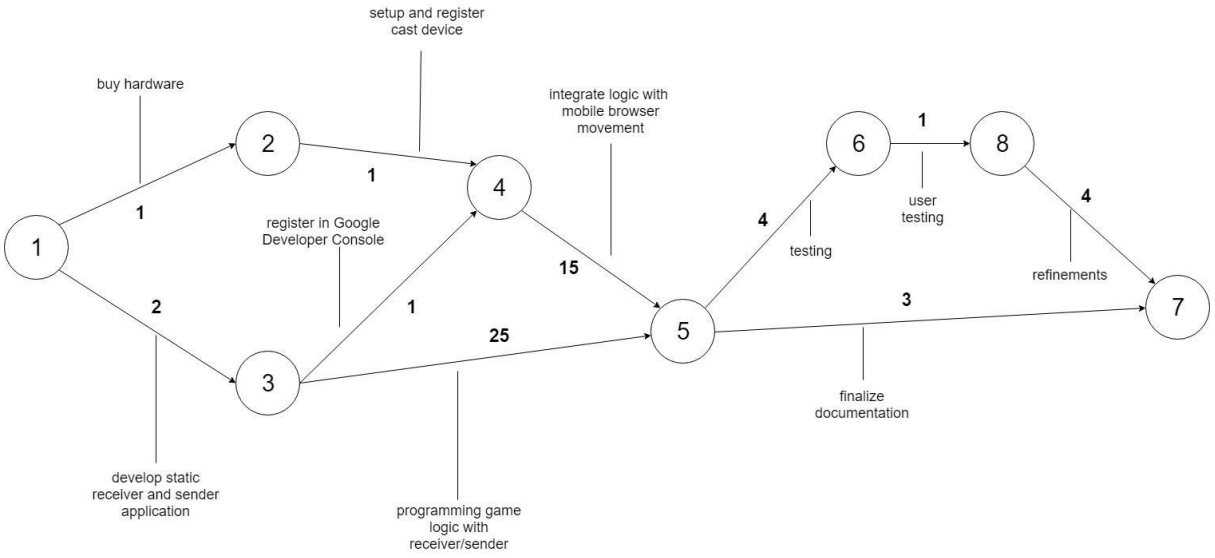
Read more here: https://github.com/ShiyuL/ABLEalley/

able

This repository is used to combine the front end and the back end of the project. In the first iteration of the project, we hosted the sender and viewer application on a server in order to register the Chromecast device as the debug device. In the second iteration of the project, we replaced the Three.js game UI with HTML canvas. In the third iteration of the project, we are using this repository for the view/model/controller framework and we are using socket.io to relay information from the front to the back end and the other way around.

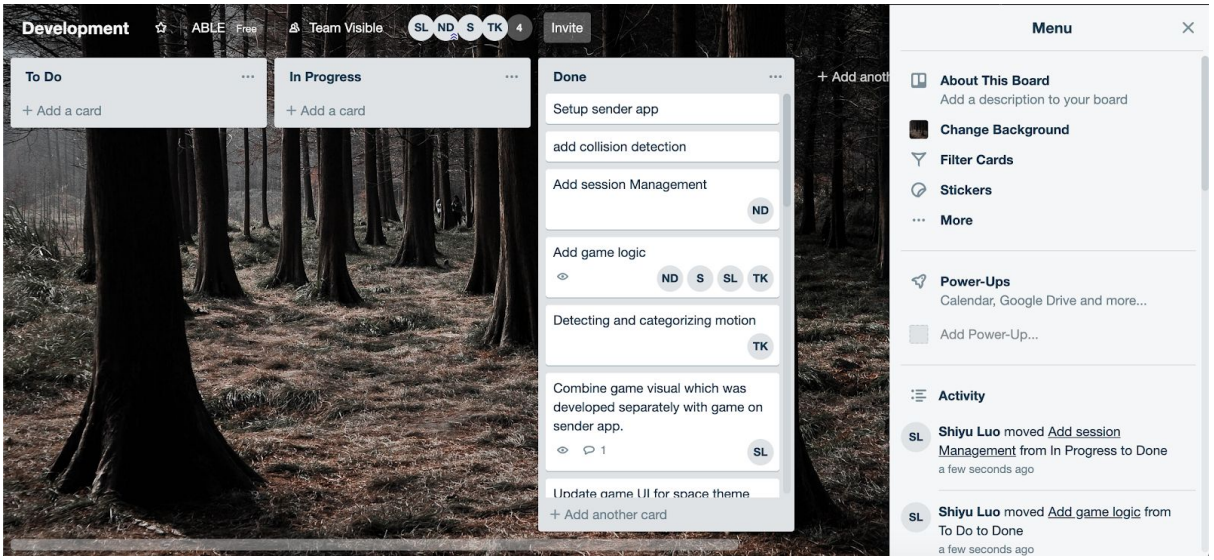
Read more here: https://github.com/natashadecoste/able

PERT Chart



Trello

Development Board



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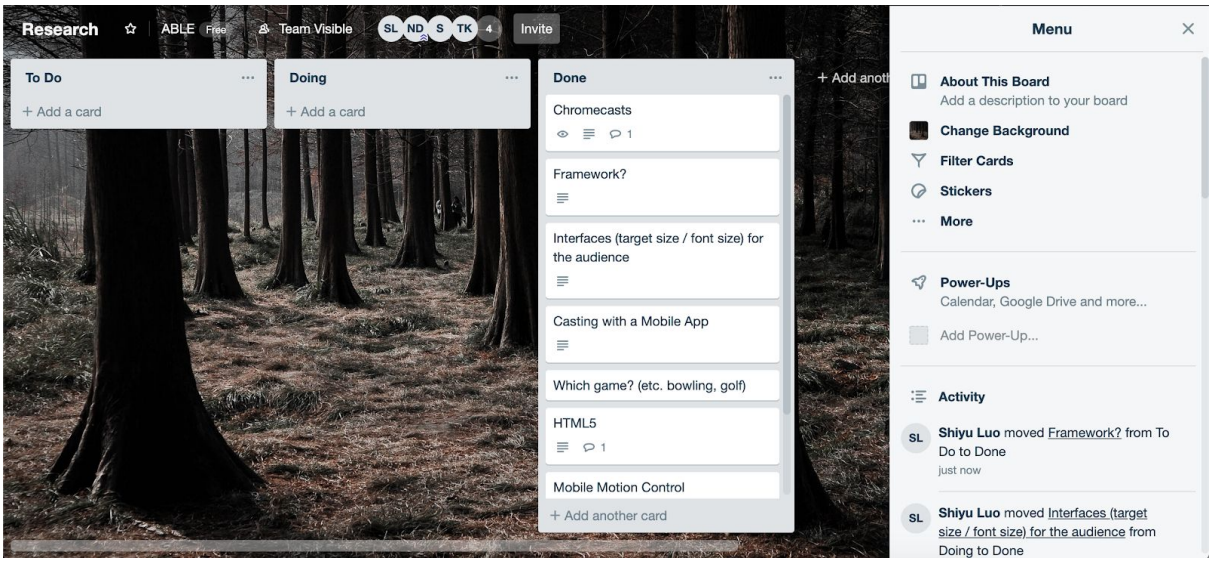
Research Board



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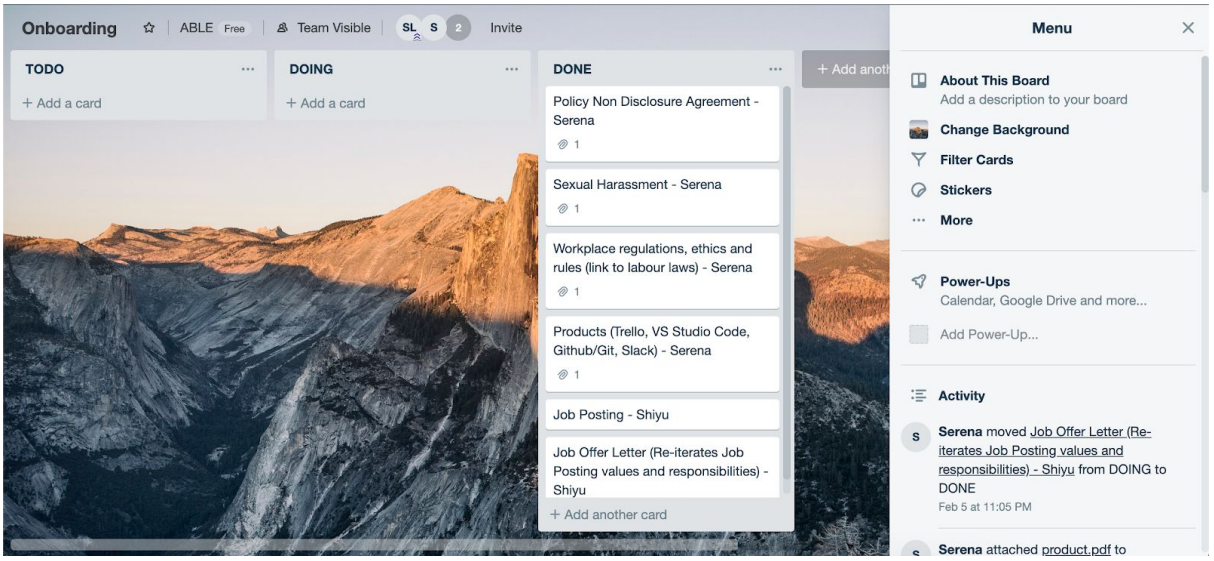
Onboarding Board



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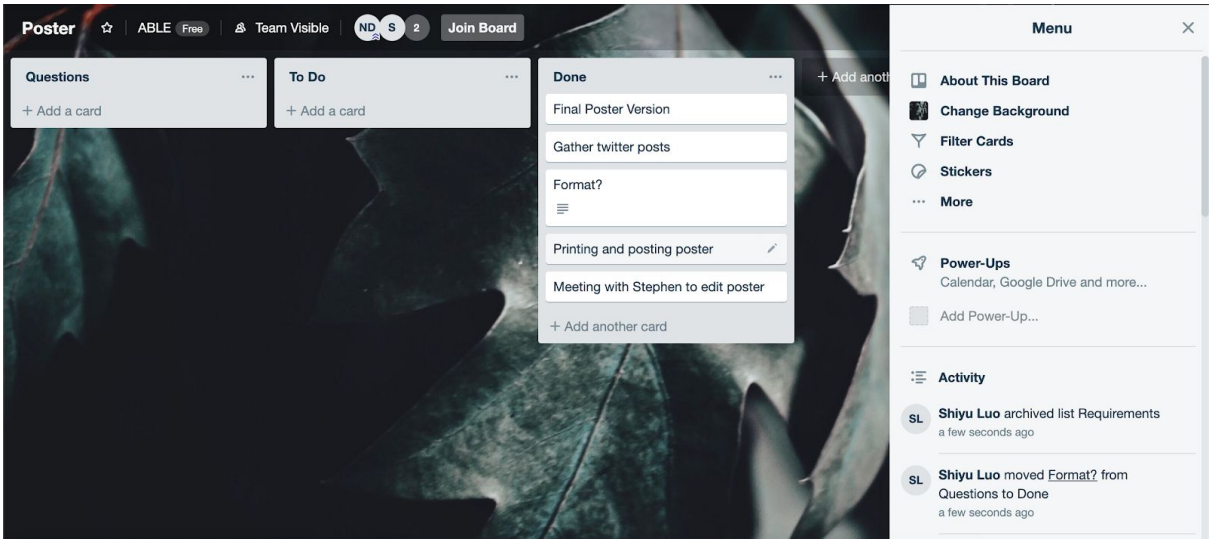
Poster Board



Read more here: https://trello.com/b/NNAbWI2u

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