Requirements Specification

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biomotum

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Introduction

Walking may seem like a mundane task for most. We do it everyday without much thought to get from bed to breakfast, home to work, and everywhere in between. Unfortunately what seems so easy for many of us, there are many who cannot move as easily. According to the CDC, 1 in 4 individuals have a disability in the United States and of those individuals, 12.1% have mobility issues[1]. For example, Cerebral Palsy is a disease that affects the development of the brain and impares reflexes and movement. These symptoms appear in early childhood and make physical development much harder for these children. Due to the lack of mobility, those with Cerebral Palsy have harder times engaging in everyday activities and exercise and these difficulties compound over time causing future health problems.

Biomotum was founded in 2019 and has been developing solutions to make it easier to walk and aim to solve this problem. As a company, Biomotum exists in the medical device industry and are developing robotic exoskeletons that can assist movement or provide resistance to train an individual to engage the muscles that unimpaired individuals use without much thought. One of the challenges they have found is performing training sessions with children and keeping them engaged throughout lengthy walking sessions. This is where our solution comes in.

Dr. Zachary Lerner, Biomotum's Co-founder and current CSO, runs a lab at Northern Arizona University called Biomechatronics Lab where development of the exoskeletons take place and research is performed to prove viability of the devices and make improvements based on findings. As the director of this lab, he has tasked us with creating a game that can be controlled as a user walks in the exoskeleton, using the device as a controller. The purpose of this game will be to run a trial to collect data and help the user with training while providing a fun and engaging activity for children to interact with and rewards them when they engage the proper muscles required for correct movement. In this document we will discuss the requirements of this project and detail our plans for making this project successful. We must understand what the problem our client is trying to solve and what solution we have decided to pursue. Then we can explore all of the requirements of the project and the potential risks as well as the plan for development we will follow.

Problem Statement

Before we can discuss the problem our team is solving, you must understand why this solution is necessary in the first place. Currently, when Biomotum runs a trial with a participant they come into a lab for a controlled study, get fitted for an exoskeleton, and walk on a treadmill while the iOS app records data and applies a torque to assist or resist the user as they walk. The goal of this process is to understand an individual's gait pattern, the cycle of the legs as they perform locomotion, and correct any improper movements to be closer to more efficient means of moving. A concrete example of this is an individual with Cerebral Palsy. A common symptom of Cerebral Palsy is the brain failing to signal the calf muscles in the leg to stretch and contract the way an unimpaired individual would. This causes those with the disease to walk without much ankle flexion and as a result, rely on the hip and knees more.

While these trials are very effective and have proven to aid individuals with walking impairments, the trials can be lengthy. A lengthy experiment may not be an issue for an adult who may or may not have had to deal with long and somewhat boring situations before, but it can be a big problem when trying to perform a study with children who might have a shorter attention span. This is the main problem Biomotum is facing with their process and have partnered with us in order to find a solution. Currently, when a trial is performed, there's a way of viewing biofeedback[1], the product of force applied through the foot and the speed at which the ankle is flexed. In this biofeedback page, a researcher can set a threshold to overcome and when that happens, a sound is played and confetti is shown on the screen as a reward indicating the user is performing well. This system is not enough for a child or participant with ADHD who has a harder time concentrating on one task for extended periods of time. Biomotum needs a new solution to make training more appealing and effective for all types of people.

Solution Vision

Motus Methods' proposed solution to the lack of engaging trials is to build a game that can be played as a type of training. This will provide a user with more entertaining feedback and

[1] See Biofeedback in Glossary

a better understanding of how they should engage their calf muscles in order to succeed with walking in the exoskeleton. Along with the game to be played, Our client Dr. Lerner has requested that we include customizable avatars to reflect the user who is playing the game. We will also compile the training data and store it in a user profile that can be viewed at a later time. A stretch goal is to incorporate ChatGPT or another large language model that can provide feedback on the data from trials as well as encourage a child with issues such as insecurities over disabilities. Let's discuss some of the details of the solution to get a better understanding of this project and its scope; starting with how the game will integrate with the existing application that Biomotum has and uses.

Our game will be an extension of the Biomotum app. This means that when a user is getting ready to do a trial or training session, they can choose to play our game instead of initiating a normal trial. This branching point will help us achieve the following:

- A page with an avatar representing the user and customization options
- Game start button
- A game loop using Flame to load in assets such as
    - Sprites[2]
    - Music
    - Audio cues and effects
    - Environment
- A review page to see progress, highscores, and previous results from gameplay
- Our stretch goal of an AI chat bot

The main data in this game is all coming from Biomotum's exoskeletons that will be acting as inputs form the user, a left and right leg. This data is a combination of the exoskeleton's FSR[3] and the speed at which a user rotates their ankle. This product provides a single number that is normalized to determine whether or not the user is achieving the appropriate force. Other types of data that our project will use is the user profiles system that currently exists in the app. This data will show name, weight, optional diagnosis, link the user to previous sessions. What we are adding to this is the avatar on the user profile which will be the character running/walking in the game.

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[2] See Sprite in Glossary

[3] See FSR in Glossary

Part of our solution will require some computational cost and data manipulation. This means we had to consider what game engines could be implemented on modern smartphones and tablets such as iPads. This is why we chose Flame as our game engine as it integrates with Flutter which is ideal for mobile developments. The main chunk of computation has already been implemented by Biomotum, including normalizing the input data and uploading trial/gameplay data to AWS[4] for remote reviewing of training information.

This solution is very straightforward yet has many small requirements that need to be addressed in order to get the game running. Although the core of the project is simple, it will be a major upgrade for Biomotum's workflow when collecting data with children or those who require more engagement when doing a more repetitive or mundane task. Our aim is to create a game that is addictive enough that those who play will want to keep playing over time and simultaneously get better at walking due to the increasing challenges with each level.

Project Requirements

Broad Overview: Create an iOS application that provides a game that the user can play while wearing an exoskeleton that is engaging and aids in the physical therapy process. It will also provide profile information that will help the experience become more personal per user. Statistical information should be accessible in order for trainers/PT[5] leaders to see and use to help improve the user's training.

Functional Requirements

1. Game - A level-based "runner/walker" that will move with the user as they walk to control the game. Scores will be provided, and in-game currency will be gained based off of the user's performance in the level.
    a. Create levels
        i. # of levels
        ii. 5-10 minutes (typical physical therapy session length)

[4] See AWS in Glossary

[5] See PT in Glossary

iii. Special sections - areas during the level that ask for reduced/increased effort in part of the user walking

b. Track user performance
    i. Read input from exoskeleton (mostly done already through existing application) as “performance”
    ii. Set threshold amount to cross for good performance, below for underperforming
c. Provide rewards based on performance
    i. In Game Currency

2. Personal tracking/data management - The app should allow for a user to create their own “profile” that separates them from other users. This profile will also contain various data (some modifiable by the user) to be used as part of training.
    a. Data Management
        i. AWS server that can be used/refer towards managing profile creation
        ii. Username/ID that can be used to retrieve profiles when needed
    b. Non-Editable Data for profile
        i. Exoskeleton Data - Data provided by the exoskeleton towards the user’s performance while using it.
        ii. Session Data - Data that helps track session details about the user concerning the game
            1. Date the session took place
            2. Duration of the session
        iii. Data needs to be Viewable - Let doctors (and potentially others) helping with the user’s treatments view data to best service the user’s physical therapy
    c. Editable Data for profile
        i. Avatar Creation - A virtual model for the user that is customizable and is the main conduit of representing the user in the game
            1. Diverse customization - must offer choices that promote diversity to allow ANYONE to be best represented in-game
                a. Body

        i. Race
        ii. Gender
        iii. Clothes (not too expansive, just to help provide personalities the users can relate too)
    b. Face
        i. Eyes
        ii. Mouth
        iii. Hair
    c. Name
3. UI[6]/Menu Elements
    a. Main Menu - Navigate through all functions in the application
        i. Transitions into Profile, Connection, Options
        ii. Logout - lets the user log out so the next user can login and use the application based on their own profile
    b. Profile Menu (Ties in with 2) - Displays and holds operations for user to interact with their profile data.
    c. Connection Screen/Indicator - Screen that will help indicate connection status/initialization to the exoskeleton for the application
        i. Transitions into main game
    d. Results Screen - Screen at the end of the main game that will show an overall display of user performance in the game as well as other statistics if needed
        i. Potential stats - Time played, distance walked,
        ii. Transitions into main menu
    e. Options Menu - Allows user to customize various aspects of the application to best tailor the experience to them
        i. Transitions back to main menu
        ii. (Options) Potential admin access/functions
    f. Login Screen - Opening screen of the application that asks the user for their profile to best prepare/open the game for that user.

[6] See UI in Glossary

g. (Stretch Goal) AI-Chat Log/Messaging - A screen that records the history of conversations with the AI chatbot as well as provides messaging systems to continue talking
    i. Potential expansion - Communicate with other irl (BIG STRETCH)

Performance Requirements

1. Gameplay UX[7]: Factors that, while not necessarily affect gameplay itself/game mechanics, greatly affect the user's experience playing the game
    a. Engagement - Details that focus on keeping the player engaged with the game and wanting to come back/keep playing. (Think things that Casinos use, like flashy lights, addictive sounds and general positive reinforcement, to keep people in the casino)
        i. Sound Effects
        ii. Music
        iii. Graphic Style
        iv. Positive reinforcement
            1. In-game currency
            2. Score
    b. "Real-Time" Feedback - In order to best help the student with physical therapy, we need to read exoskeleton data as close to real time as possible to best motivate the student if underperforming or reward the student (see engagement) for good performance.
    c. (Optional Stretch) Adaptive challenge - Takes in and utilizes settings that are specific to the user's situation/data in their profile to best provide personalized training regimen via the game application
2. Application UX: Factors outside of the gameplay that help the user enjoy their time with the application and still make it enjoyable

[7] See UX in Glossary

a. Ease-of-Use - since the application is mostly going to be used via children, the application should be aimed to be easy to use and navigate to keep engagement high and avoid possible frustrations.
b. (Optional Stretch) AI chat integration – In order to best accommodate the user and their personal struggles, having someone to talk to about these issues and help provide motivation/encouragement for their daily life is highly desirable.

Environmental Requirements

1. iOS - Since this is the typical format that is used for devices in the Biomotum lab, the application must be able to run on this specific operating system.
    a. Game Environment - Flame
        i. 2-D application
        ii. Graphics/Animations - Due to the tools available, and the skills of the team, we need to make sure that, while the game still looks good (basic requirement for any game), the graphics aren't too intensive and animations are mostly simple to keep focus on the gameplay, where the team shines brightest.
2. Existing application - Since an application already exists that simply accepts data from the exoskeleton, we need to find a way to integrate it into our game to best utilize resources/time
    a. Flutter - In order to merge the application into ours, we need to utilize the same framework in order to keep the transition-process as streamlined as possible
        i. Version control
        ii. Communication between app and exoskeleton
    b. We must bring the current application to an updated version of Flutter so that we can utilize Flame's more advanced features to make a polished product. This requires changing some of the libraries Biomotum uses on the app as they are no longer maintained

Potential Risks

Introduction

The risks in our project are based on standard risks within the gaming industry while also having risks that pertain with the system of the exoskeleton.The ability to discern and figure out what the game has to be and the certain challenges that come with it is vital for our success in this project. So understanding the potential risks for the interactions between the game, the user and the exoskeleton needs to be clearly defined. If the majority of these problems are fixed before we head into production and development, the path for success is easily obtainable.

Risk One: Unable to migrate the flutter app into the newest version

If the app does not migrate with the flame game, then the application has to be separate from the game. There must be a transfer of data from the game to the application through various channels. This may affect gameplay and performance based on what method we implement.

Risk Two: Data is not sent properly to the client and the inputs are messed up.

Since data transfer may not be reliable, and the exoskeleton being the only movement, there needs to be a check for if the data is being received in a certain amount of time and if not then the game ends. If the data transfer is not available then the game does not work and if the game does not work then we fail the project.

Risk Three: The game is not to the client's liking.

Rework the game until it becomes to the client’s liking by showing him and potential patients prototypes of the game and then adding all of the features that we need.

Risk Four : Certain gameplay features are not possible with the engine that we use.

We lower the scope of the project until we meet those requirements and make the game simpler and simpler until we react to the game minimum.

Risk Five: The game is unable to calculate the player input in real time.

We create a timer system that tracks the data from the exoskeleton and makes sure to get the data during that time, when the data changes make the character react after the timer.

Risk Six: The threshold/limit is messed up and messes up the exoskeleton.

Not a real risk since the threshold is defined by the exoskeleton before the game starts, and will have no way to change it during gameplay. But we have to make sure that the difficulty of the game is proportional to the threshold so that the patient does not wear themselves out.

Risk Seven: The data for the play session is not sent correctly.

This is a small issue since the exoskeleton app already carries the data so if the data does not match the app data, then it will not render and just use the app data.

Risk Eight: Children do not like the product and prefer something else

Then we have failed, but had created the project, so not a huge risk since the player base may be subjective.

Risk Nine: The threshold affects both legs instead of one.

Having an automatic stop button to make sure that the game is calibrated correctly, but since it does not affect the exoskeleton, then it should not be a big risk.

Risk Ten: The game not being able to render on the desired device.

We have to work on macs and apple products as well as do ample testing in order to make sure that we have the app being shown on the iphone and ipad correctly.

Conclusion

These risks are certain aspects of the video game that we have to check with the current system that we have. However these risks are simple due to the fact that the project is simpler than anticipated. There was the original risk of the exoskeleton being affected by the video game but the way that the trail is set up, the threshold/ limit that the user has to pass is arbitrarily value and a value that does not affect the exoskeleton at all. So the current risks reflect the risks that we have with the exoskeleton as well as general risks that we face with the video game.

Project Plan

All projects need a thought out plan and proper management to execute that plan. As of right now, Motus Methods' project is separated into two semesters as decided by the Capstone

Experience class. Simply put, the first semester is the conjuring of the plan and the second is putting that plan into fruition. To be more specific, each month is strategically organized to have milestones for the sake of the team, mentor, and client.

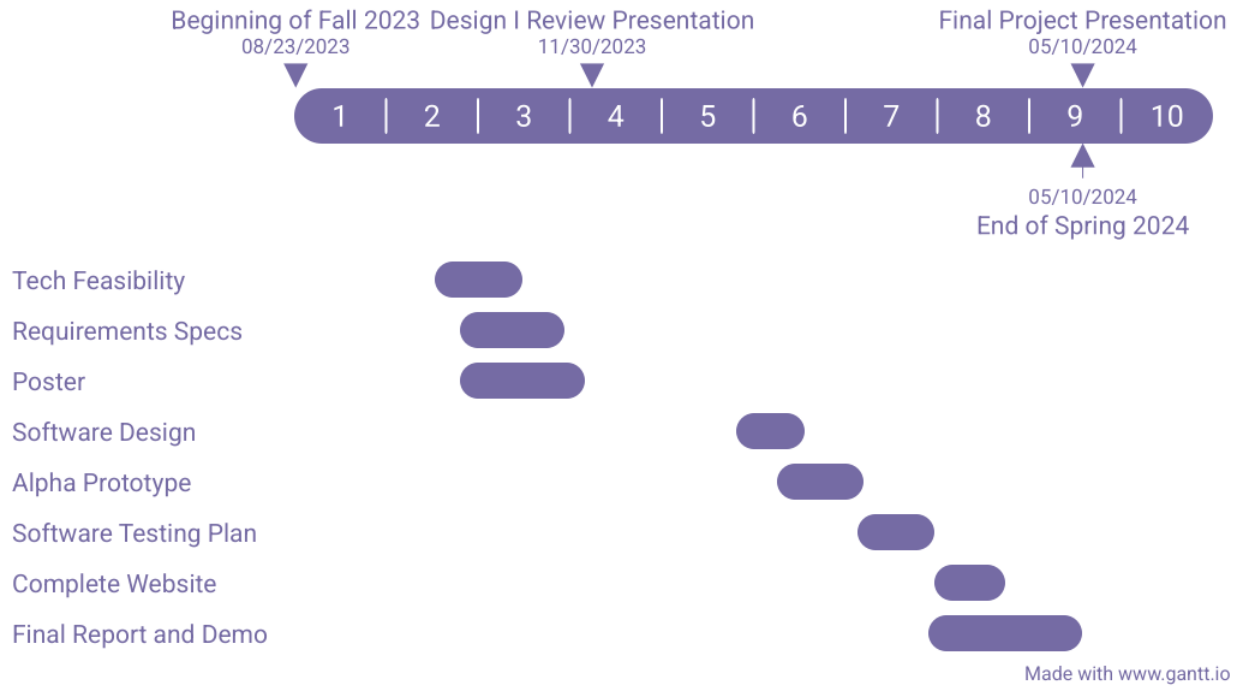
The first large milestone of November is having a fleshed out technology and requirements specification to present to the client and other organizations. Biomotum already has an amazing app that connects to their ankle exoskeletons. This app uses the framework called Flutter, which is great for creating iOS apps and has a smooth bluetooth connection system. This is a first look at how Motus Methods will be using Flutter and its game engine, Flame, to create our vision. As well as deciding what this vision, mainly the game, will be. We then present these organized ideas as a poster in a live conference at the end of the month.

In December we will have a tech demo milestone that will show off the technology: Flutter and Flame, with the classic pong game. We will use the exoskeleton data that it retrieves with the movement of the user to move the two blocking walls on each side of the screen that will hit the pong ball. Demonstrating the capabilities of 2D game development and the conjunction of the exoskeleton. Following December is January, the semester where the project starts to ramp up.

In January the next milestone is the Software Design document. This will actually be the start to design the architecture of the project. It is not building and implementing anything but so that we could easily look at the document and be able to start that next phase. Following this is February where we will build a fully functional alpha prototype based on the design document. This will have all core elements and modules of the project to demonstrate what the final product may look like.

March then has a couple of milestones, notably the second poster presentation and the software testing plan. For the software testing plan we will outline the unit and integration testing. This is an important part of the process to ensure the app will work as intended without glitches and bugs. Following March is April and May which are the most robust milestones to reach in the process. We will have a final presentation of our product, a fully finished website, a final report, and final project delivery.

While these milestones are spread out through to the end of spring 2024, they will come quickly, which is why a plan is needed. Below is a Gantt chart that has the major capstone milestones which are the two presentations. It also includes the smaller milestones required to get to those milestones. This is a great way of mapping out the tasks to see what is coming up. With this organized plan, our project will move steadily and make great progress as we continue.



Conclusion

Mobility disabilities are difficult yet common impairment for many. It can be extremely strenuous for those afflicted to have the energy and motivation to go through therapy and stick with it. Motus Methods is pairing up with Biomotum to develop a gamified walking app to help children with motor disabilities help improve their mobility. However, every ambitious project needs an ambitious outline of the necessary requirements. Requirements that describe a vision, as well as the risks and plan that will decide the outcome of the project. Risks and challenges need to be known and have a plan to overcome them. Milestones and their dates are also important to specify to have smooth transitions through the timeline of the project. Requirements are the backbone of a project with outlines that will determine how well the implementation will be.

Appendix

[1] CDC - Disability Impacts All of Us Infographic, https://www.cdc.gov/ncbddd/disabilityandhealth/infographic-disability-impacts-all.html

Glossary

AWS - Amazon Web Services; a portfolio of services offered by Amazon for cloud computing, our project will be using the AWS's database service for uploading, storing, and viewing trial data.

Biofeedback - a visual representation of what a user's leg is doing while they walk. Specifically the force they apply in their step combined with the speed at which the ankle is flexed.

FSR - Foot Sensor Reading; a sensor on each exoskeleton footplate that measures the amount of Newtons in each step.

PT - Physical Therapy.

Sprite - a term used in video game development used to describe 2D characters and objects. Typically a series of images or a bitmap in order to animate.

UI - User Interface.

UX - User Experience.