



Software Design Document

Version 2

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Rehab Remote

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Introduction

In the United States, 1 in 345 children has cerebral palsy, a set of neuromuscular disorders effective around birth. Cerebral palsy can reduce the mobility of those that have it. Around 58.9% of children with cerebral palsy can walk independently, 7.8% walk with assistance, and 33.3% have limited or no walking ability [1].

The current treatments for cerebral palsy consist of medication, therapy, and surgery. Biomotum stands within the therapy category by developing a battery-powered ankle exoskeleton that increases walking speed by 32%, stride length by 21%, and improves efficiency by 29% [2]. The business currently works with children with cerebral palsy. However, they wish to expand to people with other conditions that reduce their mobility, such as strokes, surgeries, broken bones, and more.

Biomotum's current workflow starts with the use of the ankle exoskeleton. First, they place a child on a treadmill with the exoskeleton and other physical assistance. Next, the researchers measure how much energy the child uses during testing and track the child's movements. The test is then repeated with different forms of physical assistance while collecting data. After a session of the exoskeleton's use, the patient will access their data through the Biomotum phone application. The patient can visualize their steps, tork, duration of use, and more within the application.

The issue within the business workflow is a lack of desktop visualization. Biomotum currently extracts the raw data by unhashing the file and running the data through code on MATLAB. By the end, the researchers visualize the data through MATLAB, a series of steps that the average patient could have difficulty understanding.

To create a solution for Biomotum's problem, Team Rehab Remote plans on making a web-based portal that visualizes the data collected from the ankle exoskeleton. Requirements can be listed as:

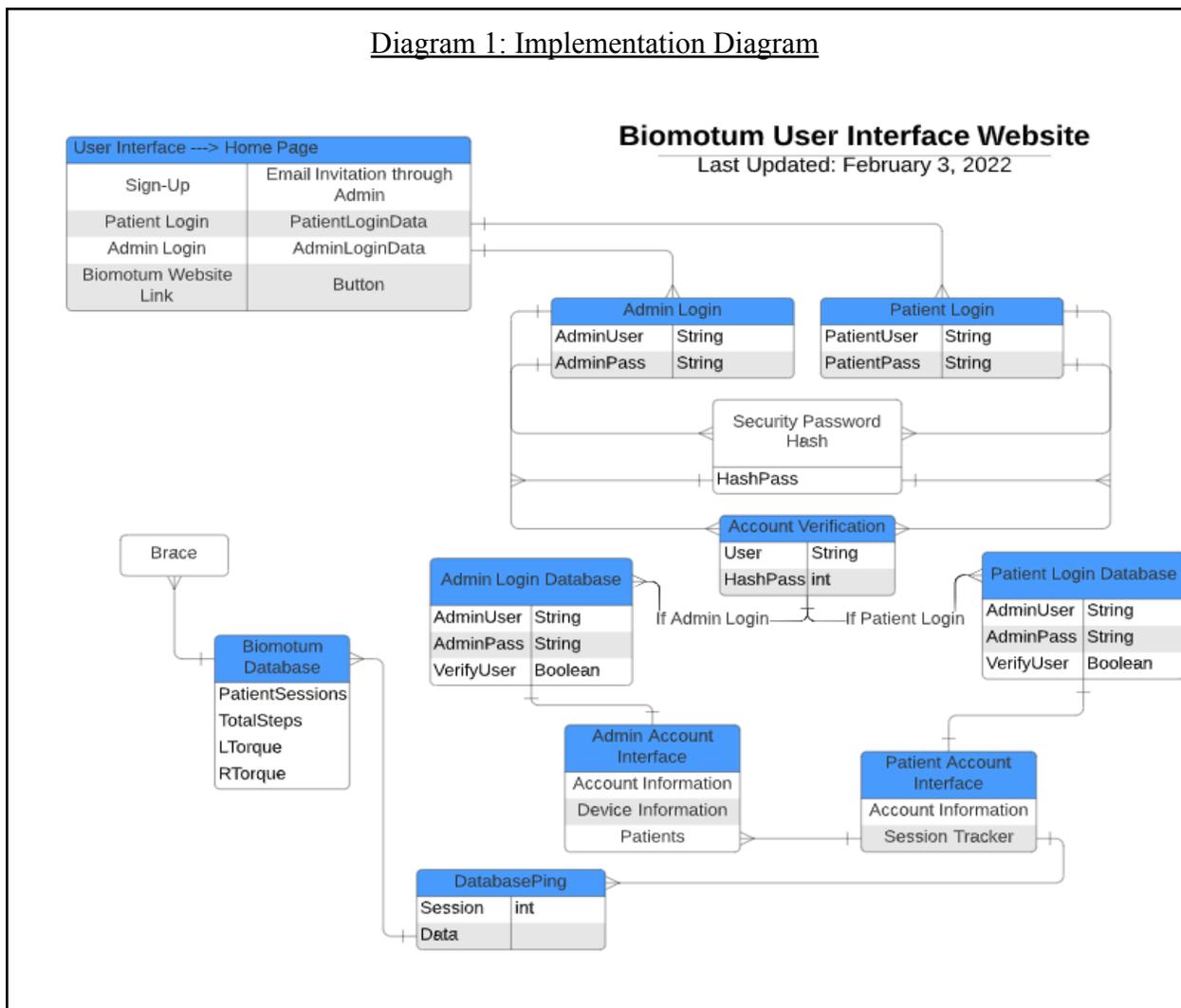
- User-Level Requirements:
 - Users can see their data, and admins can see global data
 - The data is formatted in graphs
 - Admins can access the global data in by different groups/filters
 - The user can collect the graphical and raw data for offline use
 - The user interface is simple and easy to understand

- Functional/Performance Requirements:
 - A user account system will be included with a username and password database, and a connection to the users data
 - These accounts must be secure and only accessible by the users
 - All data must be visualized
 - All data must be in a hierarchical form
 - All data must be downloadable in raw and graphical format
 - The user interface must be easy to use
 - Data pinging must be quick
 - Data load time must be fast

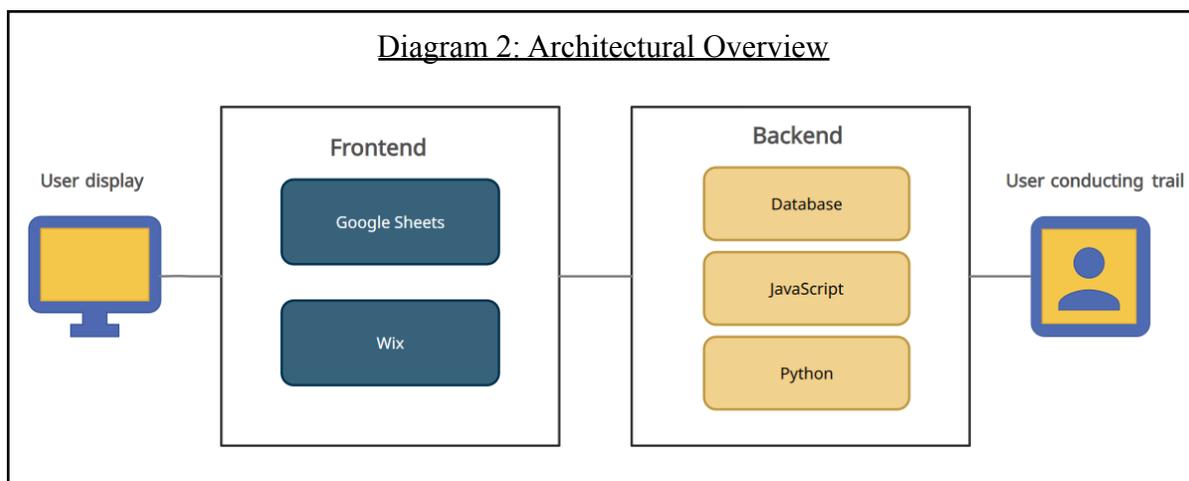
- Environmental Requirements:
 - The dataset, which is not managed by Rehab Remote, but managed by Biomotum
 - The web hosting technology (Wix)

Implementation Overview

The implementation of this web-based user portal begins with user account access and creation for patients and doctors to view session data. This is achieved by setting up an email-based invite system such that administrators could create their account using the email that sent the invitation and create a secure password. Secondly, the user account interface will include account details and session logs for patients with the addition of a patient list for administrators. In addition, we will refine the database ping system to accommodate for load time and swift recovery of data for the patient. Lastly, we will finalize the graphical views of collected datasets to include data filters so specific information for a patient's session may be represented for the user. The UML diagram below shows how the web application will be connected.



Architectural Overview



The final web application that Team Rehab Remote will build is going to use Wix, Python, JavaScript and Google Sheets. The combination of these resources will enable the device to send data to a database which Wix and Google sheets will then interact with to create a visually appealing, inexpensive, interactive web interface for the user.

The database is the foundation of our project. Each time a user with a device conducts a trial(being any recorded occurrence of the device in use) the data is tracked and logged. Once this trail is over the data is then sent to the database in the form of raw data, this data is mostly unintelligible to those who do not have prior knowledge on what the data means.

This is where Python comes in, the current code implemented is there to understand and interpret the data. Python can turn what was intelligible code into a somewhat readable CSV (Comma Separated Value) file. This CSV is now in a more understandable format. Unfortunately while the new form of the CSV is now readable, it is still not easily understandable by the user. Google sheets is now the next step in making this data presentable to the user.

Google sheets is a very powerful tool that is a free, web-based spreadsheet application that is provided by Google within the Google Drive service. Google sheets allows users to edit, organize and most importantly analyze different types of information. It does this by enabling the user to take raw data and turn it into easily understandable charts and graphs. This is extremely useful as it is a fantastic tool and ticks all the boxes in what we are looking for. These graphs will then be displayed on our site that will be hosted and created through Wix.

Wix will be the primary frontend tool we will be using. Wix is an easy to use website building tool that allows you to use pre created website templates and functions to drag and drop in your site. Wix also allows developers to have all control over how the site looks and functions, this is done with JavaScript and will be the primary language that we use to get interactive with our site. A primary bonus is that Wix allows connections with other api's such as Google Sheets.

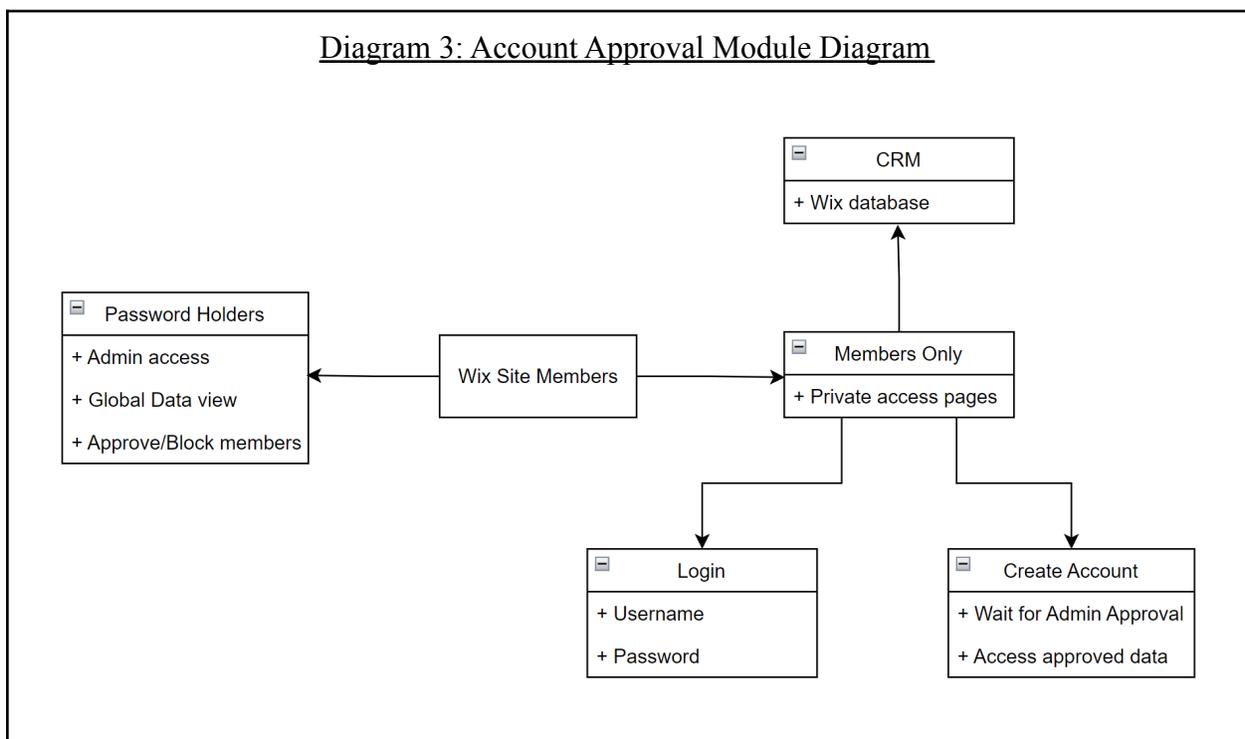
As shown in Diagram 2, we will be using a combination of the DataBase, Python, JavaScript, Google Sheets and Wix. With our careful and planned out structure we will be creating an interactive and visually appealing website for the user.

Module and Interface Descriptions

This section will outline in detail the project designs that involve responsibilities within each component, a UML (Unified Modeling Language) class diagram of the classes involved in the component, and descriptions of the public interface of the component.

Account Approval Module

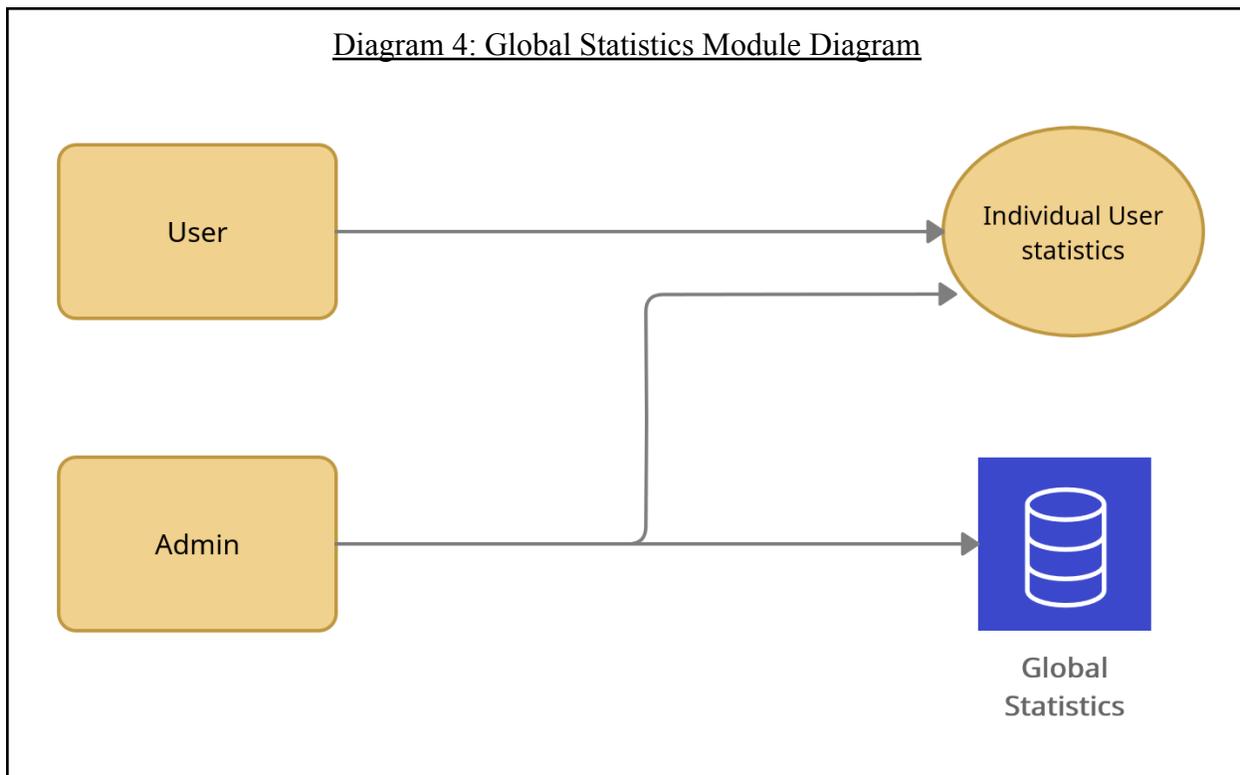
The Account Approval Module will be used in order to give users access to the biomotum exoskeleton data. Biomotum Administrators will be able to log in to the web portal to view global statistics as well as approve new accounts requesting access to the data. Admins should be able to allow users to view only specific exoskeletons in which they are working with. When a new user wants access to his or her data, they will have to register for an account and wait for the Biomotum admin to approve their request. Once approved, the user will receive an email notification that they have been approved and can continue to sign into the web portal.



As shown in Diagram 3, the account approval module will be implemented through the Wix site members feature. First off, there will be a page locked by a password which will be the Admin page. Biomotum admin will have a password they can use to login and access global data as well as approve or block new and existing site members. New users will have to register for a new account which sends a request email notification to the Biomotum admin and shows up in the admin dashboard. Once the account request is approved, the user can use the registered email

and password to login and view the data which they are approved to access. All member data will be stored in Wix's CRM (Customer Relationship Management) database for easy collecting, storing, and analyzing customer information.

Global Statistics Overview Module



The Global Statistics module will be the overhead logic and method for displaying the Global Statistics for the Admin account and only the Admin account. The global Statistics module will be in charge of collecting all individual data, ignoring the user that it is taking the data from. It will then use that data to create a large pool of data that can be used and interpreted as we or the Admin logged in wants to see.

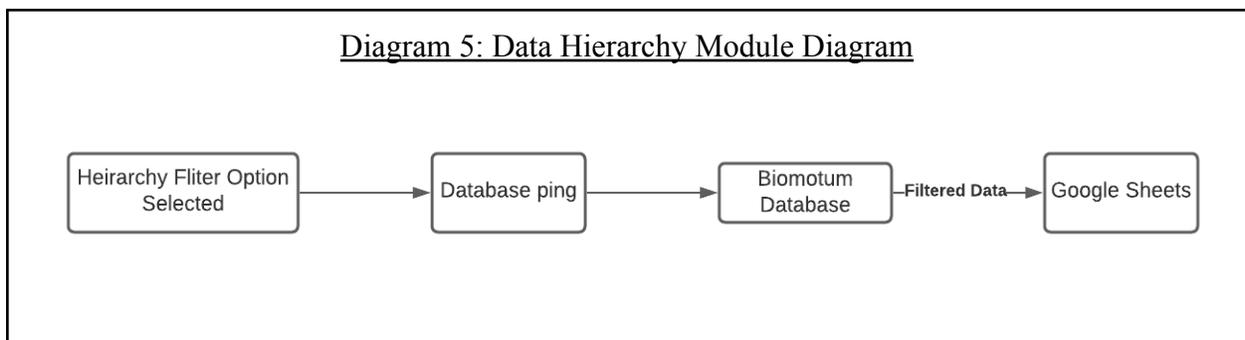
Before anything else we must first consider the restrictions in place to ensure the confidentiality of the individual users and their personal protected information. This is a major consideration that we have accounted for. This roadblock is accounted for by ensuring that only the care provider (in this case that is the administrator) can view the global statistics. This ensures that no other user will be able to access the data that is personal and confidential to another individual user. Yet another consideration that we will implement for good measure is that the global statistics are only interpretable as global data, not individual in any way. When the user sees the global data page displayed, it will not be possible to see what part of the particular

data is linked to the particular person. This ensures that even in the case a user find a workaround to view the Global Statistics that they will still not be able to understand another individual users specific data

By request of our client Dr. Zachary Lerner, we will have Global Statistics be front and center for the current Administrator signing in. A roadblock for this could be the loading time presented by collecting a very large amount of data and then going about calculating the data and inputting it into Google Sheets for presentation. This process could take minutes, the admin does not have minutes to wait for their website to load. This roadblock will be overcome by taking care of the calculations before the administrator even signs in. Every few hours (time variable can be adjusted), the website will recalculate the global statistics. With the precompiled statistics, it will be simple to grab the pre calculated data and then simply display it to the user, this process will be quick and seamless. A stretch goal is that the administrator can force a recalculation if there is something they need to do, of course understanding the potential slowdown.

Data Hierarchy Module

The Data Hierarchy Module will be responsible for detecting data filters being applied to the graphs on the user interface. The filters will be connected to the Google Sheets graph such that upon selecting an option, the data will be displayed for the user to view. The process is represented in Diagram 5. The options will appear as a non-exclusive checklist beside the graph. Upon selecting the desired data to be viewed, the website will ping for that specific data. Once the data is received, the graph will be updated to display the data selected.

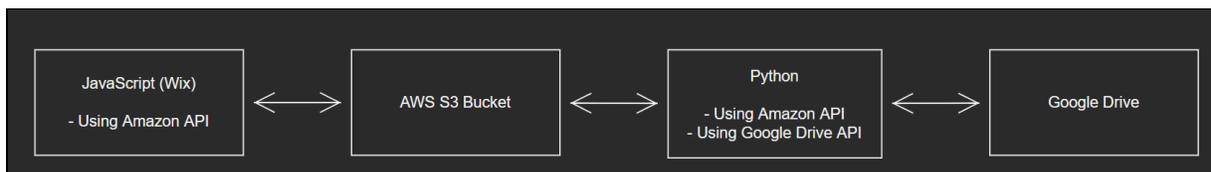


AWS (Amazon Web Services) Pinging Module

The AWS Pinging Module will be responsible for connecting to Biomotum's file manager bucket, reading the information within the bucket, and pulling the information into the website. To connect to the file manager bucket, the JavaScript Amazon API (Application Programming Interface) will be used within Wix's JavaScript. To read the information within the bucket, the Biomotum bucket secret ID and key will be used to enter the bucket with permission and use the API functions to read the data. Then, to pull the information into the website, the API function to read the data will be used to copy the data and store it within the Wix website. Meanwhile, there is a separate AWS Pinging Module that sends the data to Biomotum's Google Drive using Python and the Python Amazon API, as well as a Python Google Drive API.

The AWS Pinging Module fits within the architecture as the backend section, being the database, JavaScript, and Python. The database correlates to the AWS file manager bucket, the JavaScript referring to Wix's developer section that works around JavaScript, and the Python referring to the Python program sitting in an AWS server for Biomotum.

Diagram 6: AWS Pinging Module Diagram



Description:

The diagram shows the relationship between Wix's JavaScript, the AWS S3 bucket, Python, and Google Drive. JavaScript reaches out to the AWS bucket to read the data within, then the information from the bucket is brought back to Wix. Python reaches out to the bucket to do the same as JavaScript, then brings back the information once again. Python also reaches out to Google Drive and reads all of the folders and files created, then writes its own files to Google Drive that are missing compared to the AWS bucket.

As for methods that will be used to proceed with this module, we will have to combine a Google Drive API with Wix's JavaScript for the ability to drag in organized data to the website. The Python and Google Drive connections have already been implemented, using an AWS API within Python code, as well as a Google Drive API, to take data from AWS, organize the data, and place it into specific folders within Biomotum's Google Drive.

Downloadable Raw Data Module

This module is responsible for updating the downloadable data buttons according to the data being displayed in the charts. For example, if a user is viewing a chart with data from all trials of one exoskeleton, they can download that specific data in a raw form as a CSV file. The user should also be able to download the chart visuals themselves as a PDF (Portable Document Format) file. This allows for future researchers to easily work with the data and manipulate it for other purposes.

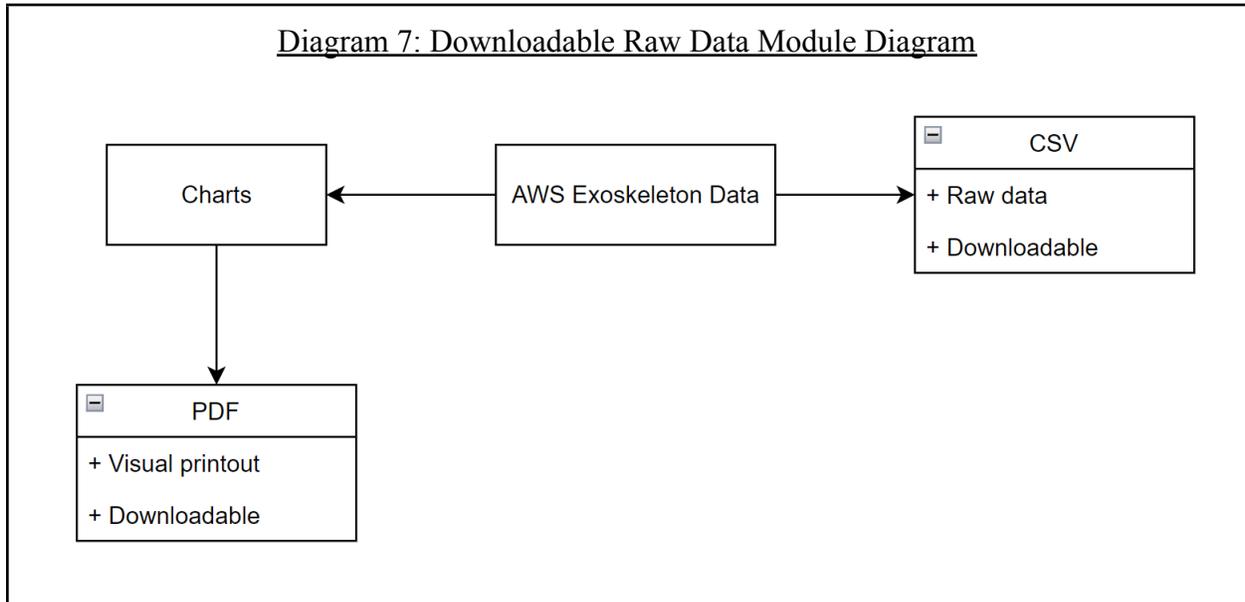


Diagram 7 shows the basic structure of how the data will have the ability to be downloaded in a raw form. After data is pulled into the web portal from AWS, it can be immediately downloaded as a CSV file. This data will be used to plot various charts to visualize the data. These charts will also be downloadable as a visual printout and to save for future reference. When a user filters through the data hierarchy filter, specific data is pulled in from AWS which is made available for download and this raw data will always match the output of the graphs since they are both being updated systematically.

Implementation Plan

The plan to implement all of these modules is by having each team member focus on a specific module. This will greatly support parallelism and allow us to get the individual main modules of the overall project done quickly. This will give us more time to integrate all of the modules, test the system and verify it with our client.

Diagram 8: Implementation Plan Gantt Chart

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Admin Data Visualization	█	█	█	█												
User Account Authentication		█	█	█	█											
Hierarchy Data Filter			█	█	█	█	█									
AWS ping				█	█	█	█									
Downloadable Raw Data						█	█	█	█							
Module Integration								█	█	█	█					
Bug Fixes		█	█	█	█	█	█	█	█	█	█	█	█			
Testing												█	█	█	█	

Diagram 7 shows the most up to date plan for implementing the main modules of this project in a gantt chart. Many of the modules will be worked on at the same time since they will be split up for each team member to focus on one module. Everyone will still have some input and contribute to each module but having each team member assigned to a module allows us to get the project done quicker and more efficiently. This allows for everybody to have something to work on all the time and if somebody gets done early, they can always help with another module. As shown in Diagram 7, we are aiming to get the main functionalities completed by week 10 which is Spring Break. This will allow us to be ready for the Alpha demo before we take our Spring Break. After that, we will continue fully integrating the modules as well as fixing any bugs throughout. Lastly we have four weeks set aside for testing the project and verifying the UI with our client to make sure he is happy with the software before it is delivered.

Conclusion

While there are different options for cerebral palsy rehabilitation, Biomotum has created an incredible high-tech system that will track the progress of a patient and eventually assist others in need of rehabilitation. Our project will assist patients and researchers involved with Biomotum by helping to understand the data that the ankle-exoskeleton collects.

By researching the user requirements provided within the introduction, we managed to flesh out our architectural overview, modules and interfaces, as well as our plan for implementation. The architectural overview consists of the front end (Google Sheets and Wix), and backend (Database, Python, and JavaScript). The modules include an account approval module that allows for the admin to approve users to the website, a global statistics overview module that will be the main method in displaying the global statistics of the Biomotum data to the Admin account, a data hierarchy module that will be the main method in displaying the subsections of the Biomotum data statistics to the Admin account, the AWS pinging module that updates the data in Wix with information provided in AWS, and the downloadable raw data module that will be the method of keeping the website's data downloading buttons updated with the correct information according to the user.

After taking time to research technical options, find out the project requirements, and plan these architectural designs as well as modules, we are confident to proceed with our decisions and implement these modules within our project. We will be able to provide examples of these working modules within our demo, where we hope to start making an impact within Biomotum.

References

- [1] Centers for Disease Control and Prevention. (2020, December 31). Data and statistics for Cerebral Palsy. Centers for Disease Control and Prevention. Retrieved November 5, 2021, from <https://www.cdc.gov/ncbddd/cp/data.html>.
- [2] Science & Outcomes. Biomotum. (n.d.). Retrieved November 5, 2021, from <https://www.biomotum.com/science>.