



Requirements Specification Document

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Rehab Remote

Project Sponsor

Dr. Zachary F. Lerner

BiOMOTUM, Inc.

Faculty Mentor

Felicity H. Escarzaga

Team Members

Kylie Cook

Brandon Roberts

Robert Bednarek

Katarina Marsteller

Accepted as baseline requirements for the project:

Client: _____
Signature Date

Team Lead: _____
Signature Date

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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% [3]. The business currently works with children with cerebral palsy. However, they wish to expand to people with other conditions that reduce mobility, such as strokes, surgeries, broken bones, and more.

Biomotum is currently in its investment phase, meaning that the company gains its money from startup accelerators, angel investors, and grants. The business has four devices deployed for use, and no current patients, only testers.

The primary business workflow of Biomotum 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 they continue to collect 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.

Problem Statement

Biomotum has no means of displaying the data being collected by the exoskeleton via personal computer. The data collected is in a raw heap of numbers which is unreadable to those untrained in MATLAB or Python. In order for the data to be placed into a more understandable format, it must be transferred to a Comma Separated Values file (CSV). Even then, not many common place visualization tools accept CSV files as inputs. Ultimately, the data being collected from the exoskeletons must have the following qualities in order to be properly usable.

- Easily understandable to the average user without requiring any prior knowledge,
- Viewable in an appealing format that is clear for all users,
- Allow the users to access and analyze the data collected in a convenient environment.

With the above qualities, the exoskeleton data becomes a dynamic tool in aiding individuals with mobility issues. Patients will be able to comprehend their progress and be encouraged to continue making said progress. Administrators will be able to properly calibrate the exoskeletons toward the patient's needs in addition to receiving live feedback about the patient's usage of the exoskeleton.

Solution Vision

Biomotum's vision is to create an easily accessible web interface separate from the phone app. It allows users to view and interact with their selected data in an easily accessible way that is also pleasing to the eyes. The raw data will be passed to the web application through the use of python and javascript, allowing researchers and users to access the graphs and charts and draw conclusions seamlessly. The need for the raw data to be fed through MATLAB for each user will be eliminated through the ease of use through the clients website.

The current plan in place is to continuously work with our client over the next year to further define the requirements as the application continues to develop. The major key components of our web application are as follows:

- A reactive front end web application displaying interpreted datasets in visually understandable ways
- A responsive back end api in charge of continuously updating the front end by serving fetch requests to the data set
- The ability to interact and work with large data quantities without loss of functionality or a dramatic slow down in speed

While the phone application is a portable means of viewing the data collected, the web application has a secure login system, up to date graphs and charts, and hierarchy system of data. This is the project in a broad and abstract sense. In the following sections of the provided document each process is covered in much more detail.

Requirements

The project must have multiple requirements implemented to cover the previously explained solutions to Biomotum's problem. In the following sections, the topics of functional requirements (functions to the application), performance requirements (how the functions will perform), and environmental requirements (constraints to the project) are covered. The web application must cover a secure way for Biomotum researchers to access all of the data collected by the deployed ankle exoskeletons and for the users only to have the ability to access their data. It also needs to have the ability to display the data in ways that the average user can understand.

Functional Requirements

The functional requirements are the required functionalities that need to be present in the Biomotum web application:

- **User Account System**

To display specific exoskeleton data to distinct users, the web application will need to have a user account system. The system will connect a specific user to the data they are authorized to see. It will also allow for an administrator user to log into the web portal and see the global data of all patients that are a part of the Biomotum program.

- **Username and Password Database**

A database will need to be used to store the usernames and passwords for all web portal users. That way, when users log in, the database will be searched through to find their saved information and send them to the page with their specific exoskeleton data.

- **Connection to the User's Data**

When a user or administrator logs into their account, either the user's personal or administrator's collective information needs to be displayed on the screen. This calls for the data to be connected to a specific Python script that calls for the user's CSV files or all CSV files if the user is an administrator.

- **Data Pinging**

In order to keep accurate data on the web portal at all times, the Biomotum AWS (Amazon Web Services) Database needs to be pinged every couple of seconds. This way, every CSV file can be implemented into the web portal and the visualizations can always be up to date.

- **Secure Accounts**

Since this data will consist of personal user progress of the ankle-exoskeleton, which may be considered medical records, the accounts will need to be secure under HIPAA (Health Insurance Portability and Accountability Act) Privacy Rules.

Therefore, the accounts need to have some security to ensure the safety of the web portal's information.

- **Password Hashing**

A specific way that the web portal can maintain security is by password hashing. Hashing is a one-way transformation that turns a password into a String and cannot turn back into the original password [4]. When a user logs in, their password becomes hashed. It gets compared with the original hashed password that the user used to create their account. This way, if anyone attempts to get information from the database, they will only have the hashed versions of passwords, which would not work when attempting to log in due to the system trying to hash the hashed password.

- **Data Visualization**

One of the main requirements from Biomotum is to visualize the data that they collect from their ankle-exoskeletons so that users can understand how to track their progress. The data is currently in large CSV files that can be difficult to understand by the average person. By taking the data and turning it into color-coded graphs, the patients can better understand the information.

- **Connection to Google Charts**

The web portal will have embedded sections of Google Charts that will map out the data given from the CSV files. Google Charts has the ability to create easily understandable graphs from such files, and will be used for the data visualization.

- **Hierarchy of Data**

A specific request from the client is to include a hierarchy of data that the admins will have access to. The data will be visualized into graphs, as previously explained. The administrator will log into the administrator account and immediately see the top of the hierarchy data visualization, which is global data, then hospital/physical therapy data, then patient data.

- **Global Data**

The global data will consist of one graph of visualized data for the collection of hospitals/physical therapy units that use the ankle-exoskeleton. Then, in the global data section, there will be an ability to view the next section in the hierarchy, which is the individual hospital/physical therapy units.

- **Hospital/Physical Therapy Data**

The hospital/physical therapy data will consist of multiple graphs that visualize the data for each area that uses the ankle-exoskeleton. Each graph will contain the data for the specified hospital/physical therapy unit that it maps to. Within each hospital/physical therapy section, there will be an ability to view the next section, which is the patient data.

- **Patient Data**

The patient data will consist of graphs that visualize the data collected from the patient's ankle-exoskeleton.

- **Downloadable Data**

The web portal will include a download ability that allows for the users to download either the graphs (visualized data) displayed on the screen or the raw data in CSV form.

- **Hierarchy Downloadable Data**

For the administrator, each hierarchy section will have its own button to download the collection of graphs. The global data section will download the visualized data of the global information, the hospital/physical therapy section will download the visualized data for the hospital chosen, and the patient data section will download the visualized data for the patient chosen.

- **Patient Downloadable Data**

Similar to the patient section of the hierarchy downloadable data, the patient user will be able to download their personal visualized data in PDF form or the raw data in CSV form.

- **Data Pinging**

In order to keep accurate data on the web portal at all times, the Biomotum AWS (Amazon Web Services) Database needs to be pinged every couple of seconds. This way, every CSV file can be implemented into the web portal and the visualizations can always be correct.

Performance Requirements

The performance requirements describe how the functional requirements are expected to perform:

- **Database Pinging**

The exoskeleton stores its data in an AWS database. This database will be accessed with consistency to ensure the user's data is up to date. The data, if needed, will be updated on the web portal and visualizations.

The pinging system will be tested on speed and accuracy. The speed should fall between 50 ms and 100 ms to be considered [5]. The accuracy of the pings should return values that are within 0.001 of the value stored in the database.

- **Data Load Time**

The data will be expected to load within a reasonably short period of time for both patient data and administration. The graphs and charts will be loaded at an equally fast time frame to ensure the visualization is given to the user.

Similarly to the pinging system, the speed and accuracy of the data being displayed will be testing metrics. The speed of the graphs' load time should be no more than 10.3 seconds as research shows this to be the average load time for a web page for a desktop [6].

- **Easy to Use Interface**

Both administrators and patients expect a clean environment for viewing their data collected from the exoskeleton. Therefore, ensuring that the interface is user friendly with cleanly dictated tabs in a taskbar will avoid navigation issues and confusion on the location of certain features, creating a quick navigational environment.

Ease of use will be measured based on surveys taken by testers and will be recruited once development allows. The survey questions will range from spacing of the page to the color scheme of the page and graphs.

Environmental Requirements

The following section will cover environmental requirements. The Environmental Requirements will cover the features and requirements that must be worked around or with. There are not very many environmental requirements. These requirements will include external features that the team must conform to, such examples may include the client's current technologies.

- **The Dataset**

The dataset is a major restriction on the type of information that can be displayed. The data set is limited to the information provided by the device in use, should there be any other data information, it will be limited to the abilities of the device.

- **Web Hosting Technology**

The web hosting technology that is used (Wix) will be a major environmental challenge/requirement. The rules and restrictions from Wix will be a major determining factor when developing the web portal. Such restrictions could be listed as programming languages that are compatible with Wix (ex. Javascript) which is the only language compatible with the modules that Wix provides.

Potential Risks

There are many potential risks associated with this project. The biggest risk has to do with the security of patient data. Other risks are less significant but still have the potential for negative consequences like a mistake in the display of exoskeleton data. For all risks associated with the project, there are various levels of severity within each potential risk depending on the extent of the situation. This section will go into detail describing some of the biggest possible risks from the software being developed. Each risk will have a severity level and likelihood on a scale of 1 - 5 with 1 being the lowest and 5 being the highest severity/likelihood. A plan for mitigation will also be included with each risk.

Patient Data Breach

Severity Level: 3

Likelihood: 2

The biggest potential risk with software that is dealing with patient data is the possibility of an unauthorized user gaining access to patient data. As mentioned in “secure accounts” of the Functional Requirements section above, the HIPAA legally enforces all relevant patient data to be secured in some way. There are multiple rules that HIPAA enforces to make sure that companies managing any sort of patient data are following and staying up to date with. One of these rules is the “Breach Notification Rule which requires organizations that experience a PHI (Protected Health Information) breach to report the incident, depending on how many patients are affected by the breach” [2]. This is a safety measure in case a breach does occur, especially now with more and more hackers going after things like patient information, this is a very possible risk. The damages resulting from a data breach would typically be moderately severe and would only slightly affect patients as they would be recommended to change their password. In the most severe case, a hacker with access to personal information could use that to potentially gain access to bank account and credit card information on other sites leading to identity theft. Some of the impacts of identity theft include financial loss, credit score damages, damage to reputation, and stress. Patients should not have to worry about identity theft and should be able to trust the security of Biomotum’s web portal.

Mitigation

The current plan to mitigate a patient data breach is through the use of password hashing. Many people tend to reuse the same password on many different sites so if a

hacker obtains a user's password, they will attempt to steal information on other sites as well. Password hashing makes it extremely difficult for hackers to breach so that will be our main defense system with this risk.

Unauthorized Portal Access

Severity Level: 4

Likelihood: 2

Someone who does not have authorization to access the Biomotum web portal but still manages to obtain access and has malicious intent is considered a hacker. On the company side, Biomotum could face potential fines and lose a lot of money if a hacker were to gain access to the exoskeleton data and change things in the code. Even something simple like messing with the code base could cost thousands of dollars in finding the issues and resolving them. Another possibility is a hacker could release some sort of malware into the Biomotum system and this could wreak havoc on the entire system depending on the type of malware and how extensively it spreads. A malware attack has the potential of costing companies millions of dollars in restoring their systems but since Biomotum is a small start up company, it would be easier to restore the working software. However, this would still be a large set back and expensive inconvenience. This is a very severe risk due to the high potential consequences that Biomotum could face. However, the likelihood of unauthorized portal access is low because there will be proper security measures in place to mitigate the risk.

Mitigation

Unauthorized portal access will be mitigated by sending a link to specific people that should have access to the portal. The link will allow the specified user to create an account on the portal so they have access to the data in which they are authorized to view anytime they log in. Sending out links to users allows Biomotum to pick and choose exactly who can have access to the site. The potential issue with this is sending a signup link to the wrong person. This can be further mitigated by revoking access for the incorrect email and sending out a new link to the correct address.

Inaccurate Display of Data

Severity Level: 1

Likelihood: 3

A mistake that causes inaccurate display of the exoskeleton data has a very low level of severity. A minor mistake is moderately likely and would create the least severe consequences or might not even cause any noticeable impact at all depending on what the mistake is. For example if there is a minor rounding error, this probably will not cause any damages, although it should still be avoided. The problem with this kind of mistake is that if it is small enough, it will be hard to detect. The potential consequences for the data being inaccurate would be patients not getting the most effective treatment possible from the ankle exoskeleton. Although patients would likely not notice this, it is not ideal for patients to not receive the full benefits of the technology. As the worst case scenario regarding a mistake with the display of exoskeleton data would result in potential physical harm to patients. For example, a doctor might not notice an error, consequently thinking that more torque is needed in a patient's ankle exoskeleton. This could possibly result in a patient over-extending their leg, or stepping wrong and hurting themselves. This would increase the severity level to 2 but the likelihood would decrease to a 1 as it would most likely be caught early on.

Mitigation

An inaccurate display of data will be mitigated through the use of easy to read charts. This will allow errors in the data display to be easily detected. Another mitigation will be the use of a recurring AWS data ping to ensure the data is constantly being updated into the web portal which will in turn update the data displays. Lastly, there will be multiple people looking at the data charts from Biomotum admin to doctors themselves, which will greatly reduce the risk of a data error slipping through.

Project Plan

The project execution plan covers multiple milestones in terms of functional requirements for the system. As the project stands currently, we are working on refining exactly what the specific functionalities will be in the final product of the web portal but we have a good general foundation of what needs to be accomplished to meet the client's goals. As shown below in Table 1, some future milestones for the project include admin data visualization, user account authentication, hierarchy data filter, AWS pinging, and downloadable raw data. Table 1 displays a gantt chart of these milestones that will be accomplished in the Spring semester starting from week 1 through week 16. We will start out with creating an overall admin view of all exoskeleton data. Concurrently, a user account authentication system that includes some kind of admin login will be implemented. After the admin view is completed, we can work on implementing the hierarchy data filter where doctors are able to view their patients data and the exoskeleton trials. A recurring AWS ping will be implemented as well to keep the data visualizations updated at all times. Lastly, as one of our stretch goals we can include a link to download the raw data in the web portal as well as a link to download the charts and graphs from the data visuals. Bug fixes will be worked on continuously throughout the semester as they come up. Weeks 14 through 16 will be dedicated to verifying and testing the software thoroughly before delivering it to the client.

Table 1: Milestone 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 pinging							█	█	█	█						
Downloadable Raw Data										█	█	█	█			
Bug Fixes		█	█	█	█	█	█	█	█	█	█	█	█	█	█	
Testing														█	█	█

Conclusion

Biomotum has developed an ankle-exoskeleton that will track the progress of patients with cerebral palsy and eventually assist others in need of rehabilitation. Our project will assist doctors and researchers involved with Biomotum by helping to understand the data that the ankle-exoskeleton collects. We will accomplish this by creating a web portal that continuously pings an AWS server which contains all of the ankle-exoskeleton data. The data will be sent and updated in the web portal where it is organized into various hierarchies including global data, clinic data, doctors' patient data, and trials. From there the web portal will display various charts that are easy to understand pertaining to the exoskeleton data as well as a button to download and save the raw data or charts.

There are many requirements in this project that must be met to ensure success of the project as well as client needs. Some functional requirements include a user authentication system that's secure with password hashing, data visualization in the web portal, a data hierarchy that can be filtered to find specific sets of data, recurring AWS pinging, and the ability to download the raw data. All of these functional requirements have their own unique performance requirements that allow for the web portal to run smoothly and efficiently. There are also environmental requirements in the project that are outside of the development teams control like the dataset itself, and the web hosting platform. Furthermore, this project contains multiple potential risks that have varying severity levels including a patient data breach, unauthorized data access, and inaccurately displaying the data. The current team has made a lot of progress in terms of understanding the requirements and technologies that will be used to satisfy those requirements but there is still a long way to go. The team plans to start development at the end of this semester which will carry over into the Spring where the major milestones will be met.

References

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