MAX: Maximizing Aerobic Exercise

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1 App Goal

Every year, over 60,000 individuals in Canada are diagnosed with a stroke [1]. The majority of these individuals will go on to develop poor cardiovascular fitness that can result in further health complications [2]. Thankfully, aerobic exercise has been proven to be a safe and effective way to improve cardiovascular fitness post-stroke [3] [4]. Unfortunately, however, most stroke survivors have difficulty engaging in enough aerobic exercise to improve their cardiovascular fitness.

The aim of the MAX app is to help individuals who have had a stroke to engage in regular and effective aerobic exercise. Specifically, the MAX app will help stroke survivors meet the aerobic exercise recommendations set for them by their physiotherapists. There are a variety of factors that may prevent an individual from engaging in aerobic exercise. In particular, the MAX app hopes to address issues around lack of motivation, lack of guidance and lack of performance feedback that may limit a stroke survivor's ability to exercise effectively.

2 App Design

The following figures demonstrate the core features of the MAX app and what users will see.

The log in page is the first point of interface for the user of the MAX app, from there they can create a personalized account that will store their information and exercise progress on an online database. Using the log in page, a user who already has an a account can log in and access their personalized account. Once a user logs in, the MAX app will direct them to the Dashboard page. The Dashboard page will provide an overview of a user's weekly exercise performance. It will provide current, minimum and maximum heart rate recordings for the week as well as the total number of exercise minutes, the total time spent in their target heart rate zone and lastly the number of days they exercised for the week.

From the Dashboard page, a user can then access all the key features of the MAX app.

Figure 1: Login and Dashboard Page

The Settings page allows users to enter their age, sex, and the maximum heart rate and minimum heart rate set for them by their physiotherapist. These settings will be vital for the MAX app to provide personalized feedback for users during their exercise.

The Exercise Session Start page can also be easily accessed from the Dashboard. Prior to starting an exercise session, a user can enter the type of aerobic exercise they are performing, how long they want to exercise for and how tired they are feeling prior to exercising. This additional information will be saved and allow for users to have a more complete understanding of their exercise progress.

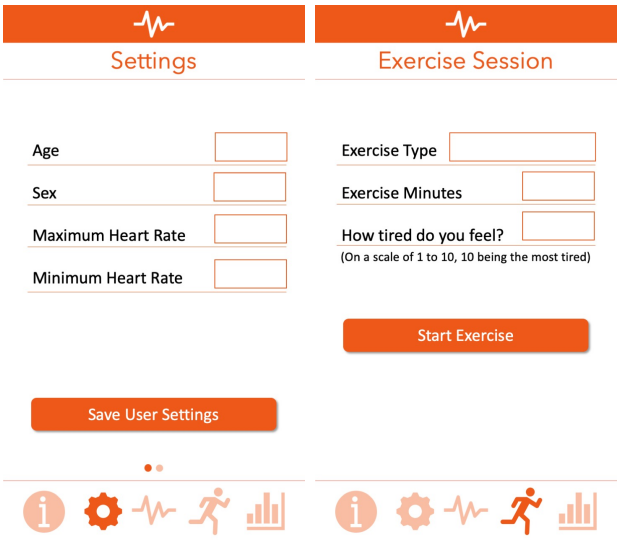

Figure 2: User input and Exercise launcher

While the user is exercising, the MAX app will provide continuous feedback regarding their exercise performance. Information regarding exercise session duration and the user's current heart rate will be displayed. To enhance the user's ability to maximize the time spent in their target heart rate zone they can see if they are at, below or above their target heart rate zone. When a user is in their target heart rate zone the colour of the heart rate tracker will be green, if they are below their target heart rate zone, it will be yellow, and lastly if they are above their target heart rate zone, it will be red. At any point in the exercise, the user can pause or end the exercise session.

Figure 3: Heart Rate Tracker and Alert System

Once the exercise session is ended, the user is directed to an Exercise Summary page that provides a summary of their total exercise time, the total time spent in the target heart rate zone, and their maximum and minimum HR during the exercise. Additionally, they are able to input how tired they are feeling post exercise.

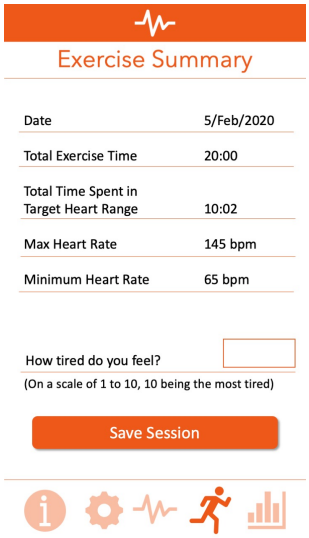

Figure 4: Exercise Summary Page

Once the exercise session is saved, the user will be directed to the Exercise Log page that will allow them to view their exercise history. The Exercise Log page, will provide high level summaries of their weekly exercise history.

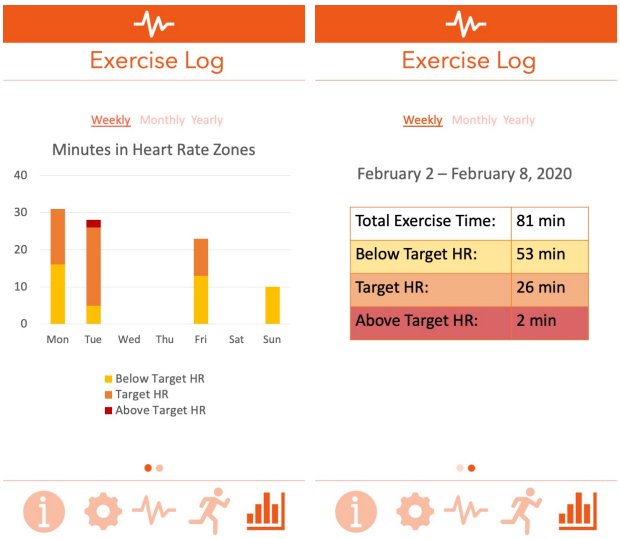

Figure 5: Exercise Log

3 Block Diagram

The block diagram in Fig. 6 depicts MAX's software structure, highlighting the main participants and the data exchange between them.

3.1 Heart Rate Data Poller

The top block, labeled "heart rate data poller" is the most important block in this structure, and the one on which most of the others depend on. It is, therefore, a critical block for the app's success.

It represents a process that will be periodically running, querying the heart rate monitor sensor, and getting this data into a format that is useful for the rest of the application.

3.2 User Input

As the name suggest, this block is responsible for collecting all the required information from the user, which will include personal identification data, required exercise duration and most importantly the minimum and maximum heart rates prescribed by their physiotherapists.

3.3 Heart Rate Monitor and Alert

This block is a high level representation of the main view that users will have of the app, where their current heart rate and the defined minimum and maximum are constantly

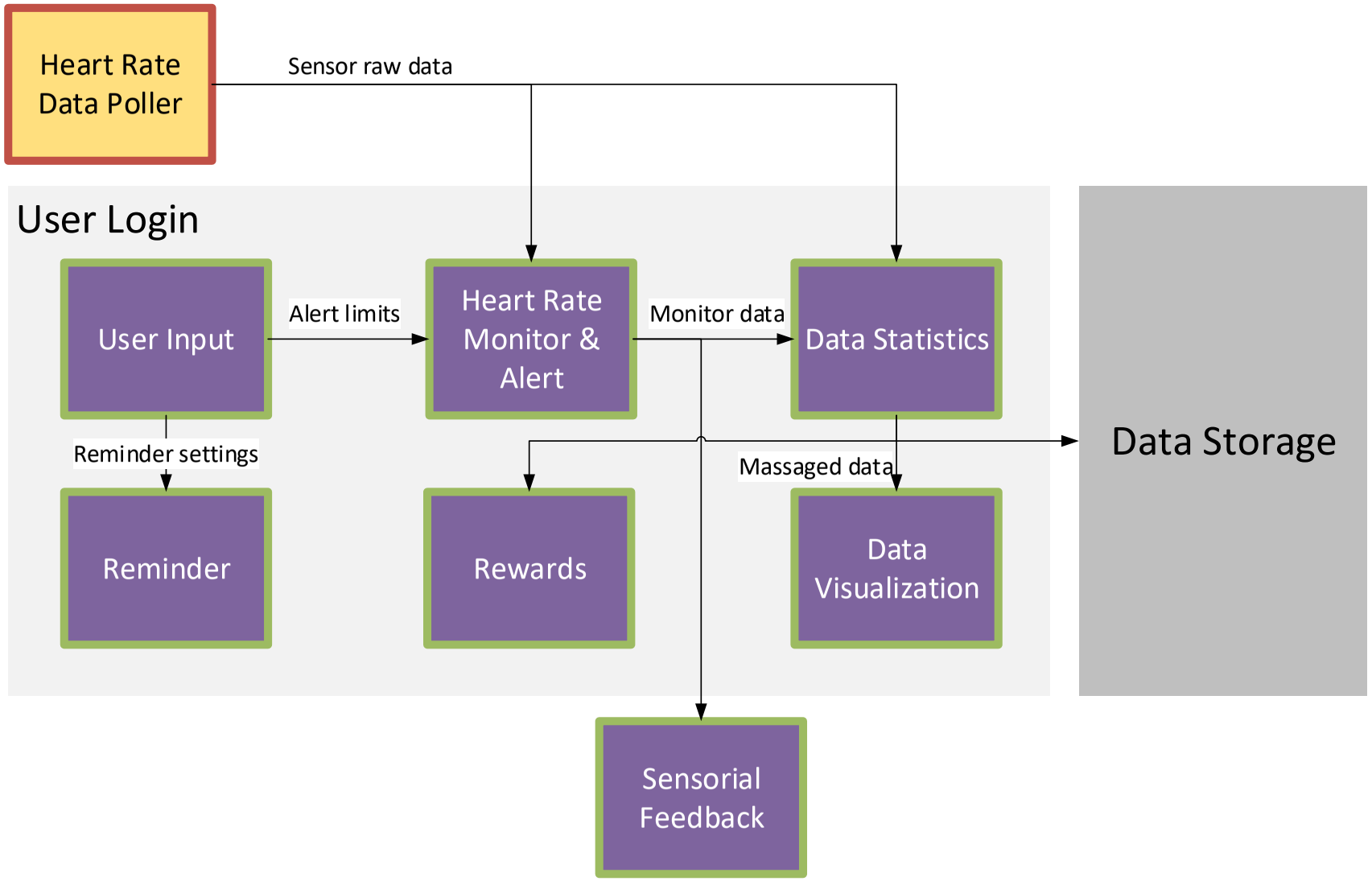

Figure 6: MAX's Software Block Diagram.

monitored and alerts are issued when these limits are reached. This is the core functionality provided by MAX, and in terms of user visibility, this is the block that will be the most exposed.

3.4 Data Statistics

This is a general data massaging block that formats data before dispatching it to other pieces of the software. For example, it would make little sense to store all the heart rate samples in storage, but aggregations like minimum, maximum and average for every exercise session would be valuable. In summary, this block takes care of diverse data transformations between producers and consumers, like the aforementioned one.

3.5 Reminder

This will be an add-on feature which could be enabled or disabled at user will. If enabled, this block will get the required exercise duration from the User Input block and will keep track of the amount of exercise done throughout the day. If the user misses an exercise session, this feature will remind them to exercise through a notification.

3.6 Rewards

This feature is targeted at increasing the users motivation towards exercise by rewarding them when they achieve certain goals given to them. This is an attempt to gamify aerobic exercise and get patients more engaged in their own recovery.

3.7 Data Visualization

An umbrella under which all sorts of data dependent visualizations are represented. Examples include, but are not restricted to: exercise performance charts, exercise progression, dashboard etc.

3.8 Data Storage

Represents the mechanism that will be used to store user data. In this block diagram the arrows only point in the direction of data storage, but essentially every block may also get data back from the storage. This reverse path is not shown explicitly through the arrows to avoid cluttering the design.

3.9 Sensorial Feedback

This block deals with various sensorial feedback (in our case, sound and vibration) used to alert the users when they exceed or fall below the previously set minimum and maximum heart rates while exercising.

4 Risks/Issues

The critical element for MAX's success is the heart rate data poller. This is the center piece of the application and the one that must work for the proposed software to be

meaningful.

For this reason, derisking this module is of the utmost importance and shall be done since the earliest iteration of the project. As further elaborated in Section **??**, Spiral 1 will be centered around the heart rate monitor and functionality that directly depends on it.

Additionally, based on the programmer's experience with the course assignments, there are potential issues with conflicting information in online sources regarding the correct usage of certain APIs and resources. Therefore, to mitigate this issue, at least for the groundwork of each feature, the programmers will work together to speedup the search of a solution that works.

5 What We Need To Learn

5.1 Specialist's Learning

The specialist will need to learn more about several areas to help with the development of the app. First, they need to become more familiar with the overall app development process and determine where they can specifically contribute. Next, they need to learn to navigate around GitHub to assist with testing and issue tracking. With regards to testing itself, the specialist will need to become familiar with the testing procedures (on android studio/on the android phone) as the app develops.

5.2 Programmer's Learning

The programmers will have to learn how to get the raw heart rate data from the app. The sensor we have for this project is a Wahoo TICKR Monitor, which allegedly works both with Wahoo's proprietary API and the Google Fit API. While it is good to have options, committing to one or the other might be a challenge.

Another point to consider is that the process polling data from the sensor and the app UI should run asynchronously, which is an aspect of mobile app development that the programmers have not experienced yet. This constitutes another learning opportunity for the team and a risk in the project.

They will be also dealing with some advanced UI features and APIs to draw charts in the app for graphical data visualizations. One other feature which might be challenging is, running the app process in the background to set up reminder notifications for the user. These three aspects will have to be learnt by the developers.

6 Specialist Statement

My PhD research looks specifically at how to improve aerobic exercise training practices in in-patient stroke rehabilitation. With so much focus on mobility, function and independence within in-patient stroke rehabilitation, it can be challenging for physiotherapists to ensure that their stroke patients are engaging in aerobic exercise safely and effectively. Typically, when a stroke patient is on an aerobic exercise machine, a physiotherapist will verbally check-in with patients to ensure that the resistance level and the speed their patients are exercising at is appropriate for them. In such busy settings, physiotherapists do not normally have the time constantly check on their patients' heart rate or fatigue

level. Therefore, providing patients a way to monitor their own aerobic exercise performance, after the initial guidance from a physiotherapist, will be greatly beneficial for the physiotherapists and the patients themselves, to maximize their aerobic exercise and thus the benefits on their cardiovascular fitness.

The MAX app will provide real-time feedback for individuals who are exercising regarding whether they below, above or at their target exercise intensity. Stroke survivors are recommended to exercise for a minimum of 20 minutes (exclusive of warm up or cool down), three times a week at a light intensity (less than 40-45 percent of Heart Rate Reserve), for 8 weeks to gain cardiovascular benefits. This recommendation is quite conservative as compared to the aerobic exercise recommendations for a healthy population. This highlights the importance of heart rate-based feedback regarding exercise intensity to ensure that stroke survivors are exercising at the correct heart rate zone without overexerting themselves. The MAX app will address this need and provide a more accurate way for stroke survivors to maximize their aerobic exercise and their cardiovascular fitness. Overall, the MAX app has great potential to advance aerobic exercise training practices in stroke rehabilitation.

As the specialist, I aim to be an active participant throughout the development of the MAX app. My key role would be to guide the overall design of the MAX app and maximize its value by providing key information from my area of expertise and by providing constructive feedback as we develop the app. Specifically, I would be involved with testing the various iterations of the MAX app, ensuring that it meets the needs of our intended users. I would also be actively tracking issues on GitHub to flag any issues I find on testing, address any issues that I can resolve and follow up with other tasks as needed. Lastly, I will continue to help with designing the user interface, including learning to code and assisting on Android Studio as able, and helping make key decisions regarding what features to include or to omit if necessary.

References

[1] Heart and Stroke Foundation. 2018 stroke report.

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[3] H.M. Boss, S.M. Van Schaik, I.A. Deijle, B.T.J. van de Berg, E.J.A. Scherder, W.M.J. Bosboom, H.C. Weinstein, and R.M. Van den Berg-Vos. Safety and feasibility of post-stroke care and exercise after minor ischemic stroke or transient ischemic attack: Motives and moveit. *NeuroRehabilitation*, pages 34: 401–407.

[4] M.Y. Pang, J.J. Eng, A.S. Dawson, and S. Gylfadóttir. The use of aerobic exercise training in improving aerobic capacity in individuals with stroke: a meta-analysis. *Clin Rehabil*, pages 20(2): 97–101.