Lab 1 – SuperU

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CS 410

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1. Introduction

Reaching weightlifting goals can be challenging for an individual when training without supervision. This is important because receiving proper guidance will allow an individual to get results faster and more effectively. A study was done with 20 men weightlifters separated into a supervised group and an unsupervised group, and the results showed that (Mazzetti, S, et al., 2000). Receiving guidance is important because many critical factors may be overlooked by a person who lacks enough experience. These factors include the intensity (RPE) of a set, volume (reps and sets) of a lift, body fat ratio of the lifter, body weight of the lifter, and quality sleep of the lifter.

Overtraining and undertraining can lead to plateaus in a person’s lifting progression. Overtraining leads to not allowing the body enough time to rest so that the individual can lift again and undertraining leads to a person not receiving the proper stimulus to gain strength and muscle (Cronkleton, E, 2020). Therefore, it is important to for a weightlifter to execute their exercise sets at a proper target intensity. The RPE scale can be used to battle this problem. A study was shown that lifters who use RPE for their sets increased the weight on their lifts more than those who use pure 1 rep max percentages (Helms, ER et al., 2018).

RPE measures the intensity of a lift on a scale from 1-10, 1 being the least intense and 10 being the most intense. This means that if a user is told to perform a lift at RPE 7, they would be lifting a mildly heavy weight, and the set should move slightly slower than RPE 6 but faster than an RPE 8.

<table>
<thead>
<tr>
<th>RPE</th>
<th>Potential Reps Left</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>Maximal exertion. Weight moves extremely slow.</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Really heavy, weight moves very slow.</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>Weight is heavy. Mild slowdown in 5085.</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>Weight is mildly heavy, slightly slower.</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>Slightly harder, but still relatively easy and fast.</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Easy. Weight used for warming up and moves fast.</td>
</tr>
</tbody>
</table>

Figure 1. RPE Scale

Lack of sleep is another factor that can hinder a person’s performance with lifting weights. The CDC found that 1 in 3 people do not get enough sleep on a day-to-day basis (“1 in 3 Adults Don’t Get Enough Sleep”, 2016). A study that was conducted with a collection of student athletes showed that those who had on average, less than 8 hours of sleep on average, were 1.7 times more likely to injure themselves during training than athletes who slept for more than or equal to 8 hours on average (Milewski, M, et al., 2014). This study shows that the more sleep a person gets, the less prone they are to injuring themselves during strength training. The
more rest a person gets, the more energy they must do physical activities as well as more energy to properly set up for exercises.

![Figure 2. Sleep Research](image)

To become stronger on a certain lift, weightlifters must properly track their data and make optimal choices that will improve their one rep max. Their workout plan will also need to be adjusted whenever their progression reaches a plateau. To solve these issues, SuperU, a smartphone application that utilizes a weightlifter’s data and workout history along with AI algorithms to generate optimized workout plans will be created.

![Figure 3. Current Solution Process Flow](image)
2. **SuperU Product Description**

SuperU will use AI algorithms to generate a workout plans for the weightlifters based on their performance as well as allow weightlifters track their progress using visuals.

When opening the app up for the first time, the weightlifter will be prompted to answer questions in a questionnaire for the lifts that they would like to increase. For the initial plan, the weightlifter will be baselined for the first week. The components that will be baselined are the weightlifter’s heart rate, body fat ratio, body weight, sleep, and speed of lifts at a specified RPE to baseline the weightlifter’s RPE.

The smartwatch will be used to collect critical data for the workout plan generation: sleep, heart rate, RPE, and bodyfat. The RPE is taken by using the accelerometer during the lift to estimate the intensity of the lift. FitBit API tracks the quality of sleep patterns as a sleep score and the duration of sleep.

SuperU’s main goal is to increase a person’s desired lift by using a workout plan generator. The data collected by the smartwatch as well as the progress of the weightlifter will be used in conjunction with the algorithm to generate a workout plan. This workout plan can be adjusted by a personal trainer if enabled by the weightlifter and sent back to the weightlifter.

### 2.1 Key Product Features and Capabilities

One of SuperU’s key features is to visualize the user’s progress as well as data collected by the smartwatch sensors. The progress of a weightlifter’s lift will be displayed as charts showing where the one rep max is heading to. The charts featured will be line graphs and bar graphs. Sleep score and time will also be viewable by the weightlifter.

SuperU will allow a weightlifter to receive scheduled optimized workout plans tailored to them. The plans will tell the user what RPE their sets should be, the number of reps and sets, and the duration of the rest intervals they should take in between their sets. These workout plans will be generated by an algorithm using artificial intelligence concepts such as decision making, decision weights, and neural networks.
A personal trainer or strength coach, if enabled, will be able to view a visualization of the weightlifter’s progress as well as the data collected from them via smartwatch. The personal trainer can adjust the workout plan if needed.

2.2 Major Components (Hardware/Software)

The hardware used for SuperU will be the smartphone to host the client side of the application and the smartwatch to collect the sensor data.

The software that will be used will be Android Studio (Java) for Androids and Swift for iOS. Fitbit API will be used for collecting the sensor data on the smartwatch. Fitbit API will record heart rate, accelerometer, sleep, and body fat data.

SuperU will use Firebase Firestore as a cloud database. It will store user information as well as the critical information for the workout plan generator. Firestore’s architecture consists of collections, documents, and subcollections. The collections will be users, trainers, active days, active weeks, exercise sets, and recommended exercise sets.
Within the users collection will contain user documents that have the display name, user ID, profile picture URL that points to picture in Firestore storage, age, and their trainer’s ID. The subcollections in users will be weeks and active days. The weeks collection consists of documents with the date range, average sleep score, average body weight, and average body fat ratio. These averages are generated from the data inside of the active days documents inside of the active days collection. The active days collection consists of the daily sleep score, daily body weight, daily body fat ratio, and date. The active days have the subcollections of exercise sets and recommended exercise set. Inside of the exercise sets collection are documents that contain exercise name, weight lifted, reps, RPE, set number, and the estimated one rep max. The recommended exercise sets collection is generated from the workout plan algorithm and contains the exercise name, reps, RPE, and set number.

Inside of the trainer collection is the trainer’s user ID, and a subcollection of clients. This collection possesses documents that have a user’s ID. These ID’s are for the user’s that the trainer will observe and help.

![Database Schema](image)

*Figure 6. Firestore Cloud Database*

Firebase Functions will be used to do scheduled database backups and free up data. Firebase Functions will also be used to directly store data from FitBit API to the Firebase Firestore. Firebase In-App Messaging will be used to deliver important notifications to the user. Firebase Authentication will be used for user registration.

For unit testing, Junit will be used for Android development, and XCTest for iOS development.

3. **Identification of Case Study**

The product will be used for weightlifters, powerlifters, bodybuilders, people who want to get stronger, and personal trainers. The application will be used so that these individuals...
can increase their one rep max. Other people who might benefit from it are people who need to meet strength requirements for their occupation, athletes, and businesses in the fitness industry to analyze the data for decisions.

4. **SuperU Product Prototype Description**

The SuperU prototype will still display most of the key features in full functionality. Features that will be completely functional in the prototype include trainer’s ability to view and adjust workout plans, workout plans being generated by algorithm, client’s data being collected for workout plan (current day), tracking sleep, cloud storage, user account registration, questionnaires, and accelerometer counting reps and estimating RPE. Due to time constraints, the prototype will have simulated data for the previous weeks of the month to help generate the workout plans.

The prototype will allow admins to update and modify the Firestore database manually. The FitBit watch will be used as the smartwatch.

### Real World Product vs Prototype

<table>
<thead>
<tr>
<th>Functional Elements</th>
<th>Real World Product</th>
<th>Prototype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trainer can adjust workout plans</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Workout plan generated by algorithm</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Clients’ data is collected for workout plan</td>
<td>Fully Functional</td>
<td>Simulated data for previous weeks, normal functionality for current day</td>
</tr>
<tr>
<td>Tracks sleep via heart rate (BPM)</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Tracks heart rate (reading and typing)</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Cloud Storage</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Create new user account</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Questionnaire for collecting data</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Accelerometer counts reps and estimates (RPE)</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Data for Plan and Progress</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
<tr>
<td>Trainer can view client’s data</td>
<td>Fully Functional</td>
<td>Fully Functional</td>
</tr>
</tbody>
</table>

*Figure 7. Real World Product vs Prototype*

4.1 **Risk Mitigation**

It is possible that the smartwatch can malfunction. To mitigate this risk, data can be manually input by the user if necessary. For example, if the FitBit’s accelerometer is halted by some error or malfunction, the user can input the reps and RPE themselves.

For whatever reasons, a database can end up being corrupted. To mitigate this risk, data will be backed up by exporting it into a Google Cloud Storage bucket periodically. The exported data in the bucket will then be imported if there is a corruption. If the Firebase server is down while your data is being collected, your data will be saved in a local SQLite file until the connection is remade.
To avoid injuries from incorrect form, SuperU will provide visuals and detailed information on how to properly perform lifts. If a user is also feeling any sort of pain during the workout, they have the option to pause the workout and unpause it when ready.

If a customer loses their phone, they will have the option to reset their password with another device by using Firebase Authentication's built-in reset password via email feature. To avoid potential data breaches, Firebase automatically encrypts all data present in the database.

![Figure 8. Risk Mitigations](image)

4.2 Prototype Architecture (Hardware/Software)

The hardware used for the prototype will be the smartphone and the FitBit. The software utilized will be the Firebase Firestore for the database and Firebase Cloud Functions and In-App Messaging for the server. The development tools for the prototype will be Android Studio and JavaScript for the Firebase Functions.

5. Glossary

**Rating of Perceived Exertion (RPE)** – A numeric estimate of the intensity of an exercise set on a scale from 1 to 10, 1 being the least intense and 10 being the most intense (Rated Perceived Exertion Scale).

**One-Rep Max (1RM)** – The maximum amount of weight a person can lift for a single repetition of a lift (Rogers, 2019).

**Weightlifter** – One who lifts weights for exercise, muscle strengthening, and/or athletic competition.

**Plateau** – The state where a weightlifter fails to improve their 1RM for a long period of time.
6. References


RPE Course Content. (2019, June 13). Retrieved September 30, 2020, from https://muscleandstrengthpyramids.com/rpe-course-content/#:~:text=The Borg rating of perceived,that are taken to failure


