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Computer Audio

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Simulator Design Document – Weightlifting Assistance

The primary overview of this project is to assist beginner weightlifters by identifying proper form and muscle activation in which uses sonification to notify the user. This project will notify the user on their set count, repetition count, proper start form, and optimal range of motion for the four primary lifts: overhead press, bench press, squat, and deadlift. The main outcome of this project is to give new lifters confidence in motion while optimizing their workout alongside minimizing the risk of injury from these compound movements.

User Personas and Scenarios

My project is aimed at new able-bodied weightlifters looking to learn form for compound lifts such as bench press, overhead press, deadlift, and squat. The project will be able to identify when proper range of motion is achieved indicating that muscle groups are properly activated. With the help of the project compound lifts can be simplified, optimized, and safer for the beginner weightlifter.

![A person wearing a red shirt

Description automatically generated with medium confidence]()

Name: Pranav

Background: Has never weightlifted before, has a rather sedentary lifestyle such as an office job. The primary goal Pranav wants is to get a more aesthetic body using compound lifts as he heard this trains many muscles rather than isolating. He does not want to spend a lot of time at the gym and does not have the resources to get a coach. He has no previous knowledge of form nor the experience however he has seen how the compound lifts are performed through YouTube.

Problems: Since he has no experience, he has no idea how to properly get in form for any compound lift mentioned before. He may not realize when the motion for any of these lifts are fully completed and when he is fully activating his muscles. He may not know if he is properly incorporating voluntary muscle movement for all the muscles he wants worked. Furthermore, he may not remember how many repetitions he has left in his set, and how long he should be taking a break for. Pranav is also scared of injuring himself as his friend has had injuries from not breathing during motion resulting in him passing out with heavy weight on him.

User Scenarios

* Get in proper start form for the compound lift
  + The user has the device on that reads body position and movement
  + The user designates how many repetitions and sets they are going to perform and which exercise at which weights (in further development it can preselect what weights would be best for you based on what you want to train for)
  + The user gets in form and then if they are in proper starting form the user will hear a checkpoint sound indicating they are properly starting the compound lift, otherwise they will hear a buzzer that indicated they are not in proper starting form and are at risk of injury or suboptimal training
* Get full range of motion, breathing properly during set, and count repetitions for that set
  + Assuming the user has proper start form, they will now go into motion and have previously calibrated their full range of motion with low weights
  + When the user reaches their full range of motion a number is repeated to them indicating which repetition they are on within the set, if full range of motion is not reached the user will not hear the number
  + Additionally, the interface can be set up to have a breath in noise when they are supposed to breath in during the movement and a breath out noise for when they are supposed to breath out ensuring users breath properly during motion
  + When the user finishes the last rep, the project tells them that the set is complete and to rest
* Getting proper rest between sets
  + Once the first set is complete a timer will run on the interface that is set by the user, or can adaptively track optimal rest time calibrated for each user (hard to implement)
  + The interface can tell the user what time it is at specific intervals i.e., every 10 seconds, or can be silent and only make noise when time is fully over

Throughout all these user scenarios the application interface is the primary source of control of how the data is used, whereas all of the data collection from the user is from the physical device that reads the body’s status. The primary focus of the sonification process is to ensure that the start position before motion is proper, then making sure the movement is optimal according to that person’s calibration, making sure the user knows how many repetitions are left, ensuring proper breathing, and finally allowing for a proper break. All of this data should be collected and then used through the interface live and give feedback live.

Event Description

Events:

* getGripPosition
* getBodyPosition
* getRangeofMotion
* Muscle
* ChooseExercise

Event Parameters:

* Set (Integer)
* Repetition (Integer)
* X position (-1 to 1, 0 is neutral)
* Y position (-1 to 1, 0 is neutral)
* Range of Motion (Good, Bad, Dangerous, Rest)
* Rest Time (Seconds)
* Exercise (Class)
* Activation (0 – 1 scale for contraction or extension)
* Muscle Type (Class derived from exercise)
* Muscle Priority (1 to 3, 1 is the most important)

Event Examples:

* ChooseExercise
  + Exercise: Deadlift (specifies which lift is being chose)
  + Set: 3 (three sets are going to be done)
  + Repetitions: 5 (five reps will be done within each set)
  + Rest Time: 120 (120 seconds will be rested between each set)
* getGripPosition
  + Exercise: Overhead Press (specifies which lift is being chose)
  + X position: .2 (specifies a wider grip rather than narrow being negative)
  + Y position: 0 (specifies the lift is in the starting position)
* Muscle
  + Exercise: Bench Press
  + Muscle Type: Chest
  + Activation: 0 (specifies the muscle has not been exerted at all so in rest position)
  + Range of Motion: Rest
  + Priority: 1 (chest is the most focused muscle in bench press)

The UI elements consist of a basic screen that allows the user to select their exercise, specify the number of sets and reps the activity will go on for and then the application will start logging the body information specific to that exercise and the user is ready to start the exercise. The sonification aspect of the UI is that to get in proper position, there will be a starting tone and the user must move their body so that the tone is not muffled indicating that it is within a proper range; this can be done in a way that tracks body movement for calibrated start position from the grip and correlates with higher muffled sounds if the user is under adjusting and if the user is over adjusting. Once the tone is clear then the starting grip is proper, the rep can commence. During the exercise motion, a tone will increase in frequency to the checkpoint sound effect, the lower the tone the shorter the range of movement. Once the body activity has recognized that the full range of motion has been achieved, a checkpoint sound effect will play, and text-to-speech rep number will play. After the reps are finished, a different checkpoint sound effect will play, and the text-to-speech will say set number over and proceed to rest. After rest is finished it will say rest finished and loop back to the initial form check to make sure the user is in proper form for the next set. As far as visual elements, the primary visual element on the app will show the set and rep count during the active set, furthermore it will show the time left within the rest.

Software Diagram

Diagram

Description automatically generated

The hardest portion of this project would be to find a way to simulate receiving body position information and making the sonification work properly to that body position. The UI can be much simpler than described so that will take off some extra unnecessary effort as this project primarily focuses on sonification. A realistic timeline would be to set up the events properly for when a rep is completed then create real-time sonification to represent each of those event triggers and sonify the relevant information to each of those events and the finally adding the extra components such as filters and effects once the main objective is finished. These should be accomplished within the due date of PD 4.