BarPro

ECE 445 Design Document Check

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1 Introduction

1.1 Objective

A weightlifting device called BarPro will be built for people who do barbell exercises such as bench press and deadlift. Many weightlifters, especially beginners, have a problem with keeping the barbell level while doing their repetitions which can lead to serious injuries. Many weightlifters also do not do full movements of their repetitions, especially at the end of their sets when muscle fatigue is forming. The BarPro solves these problems by checking if the barbell is level and notifying the lifter if it is not. It also allows the lifter to calibrate the minimum and maximum heights of their lifts and notifies them if they are not doing their full repetition. Finally, the device also keeps track of repetitions and sets so the lifter can focus more on their workout.

1.2 Background

Uneven barbell positioning could result in serious injuries, especially when lifting heavy weights. This uneven positioning causes uneven weight distribution on muscles and joints such as shoulders [1] during the bench press exercise. In order to reduce the risk of these injuries, a weightlifter has to make sure they are keeping their barbell level at all times. Although a weightlifter can sometimes notice an uneven barbell themselves, oftentimes people go through an entire motion with an uneven barbell unnoticed. A spotter or partner can definitely notice an uneven barbell, but a lot of gym-goers work out alone, especially now during the COVID-19 pandemic where social distancing measures are enforced. The BarPro device will have the ability to be that spotter or partner and notify the weightlifter when the barbell is uneven. It will perform even better than a human being by using an accelerometer to know exactly when a barbell is not positioned evenly.

Exercises such as the bench press and squat require full motion to activate the desired muscle groups. When full motion is not completed by the weightlifter, maximum efficiency is not reached from the workout and some muscles may undergo minimum usage. To eliminate the possibility of doing exercises with incomplete motion, weightlifters should practice proper form

with little weights to create the muscle memory needed for a proper lift. The BarPro device can aid in this process by allowing the user to calibrate their full range of motion for their workout and notifying the user if they are not completing a full repetition of motion by using an ultrasonic height sensor.

Finally, keeping track of repetitions and sets is an important factor of every weightlifting session. Different repetitions and sets are executed by the weightlifter depending on what their goal in working out is. Some people want to build muscle strength and size so they stay in the lower range of repetitions, while others want to build muscle endurance and train with higher repetitions. It is actually recommended to train with less weight and more repetitions if reducing the risk of injuries is desired [2]. Although mentally keeping track of repetitions and sets may be a fairly easy process, lifting heavy weights for a long duration of time does lead to fatigue that may cause a weightlifter to forget what set they are on or how many reps they have completed. BarPro will have the ability to keep track of these repetitions and sets so the user can focus on weightlifting and not worry about doing too little or too many repetitions and sets.

2 High-level Requirements

- Accurately count repetitions of motion during a workout (+/- 1 rep).

- Accurately read the user's barbell tilt angle (~30°) to be set during initial testing.

- Measure the height of motion (bench press: +/- 2cm, deadlifts: +/- 5cm) during a workout.

- Intuitive user interface with buttons and LEDs displays reps and level of bar. Buttons will be used to calibrate the sensors to fulfill requirements 1-3 above and correctly clear the screen from displaying reps. The two LEDs will display which side is unlevel and a buzzer will buzz with a frequency corresponding to the level of the bar at 5° increments.

3 Block Diagram

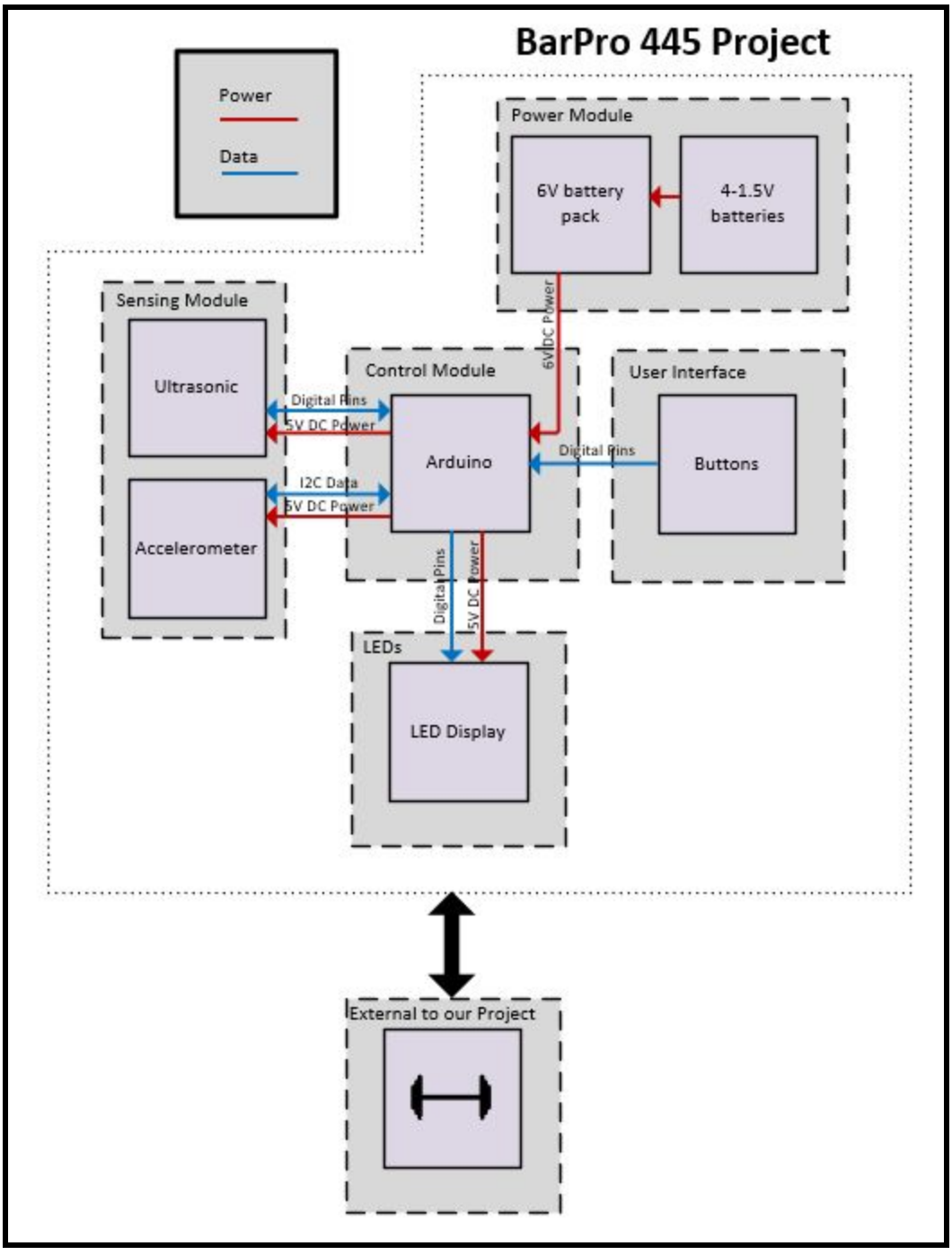

Figure 1: Block Diagram

4 Physical Design

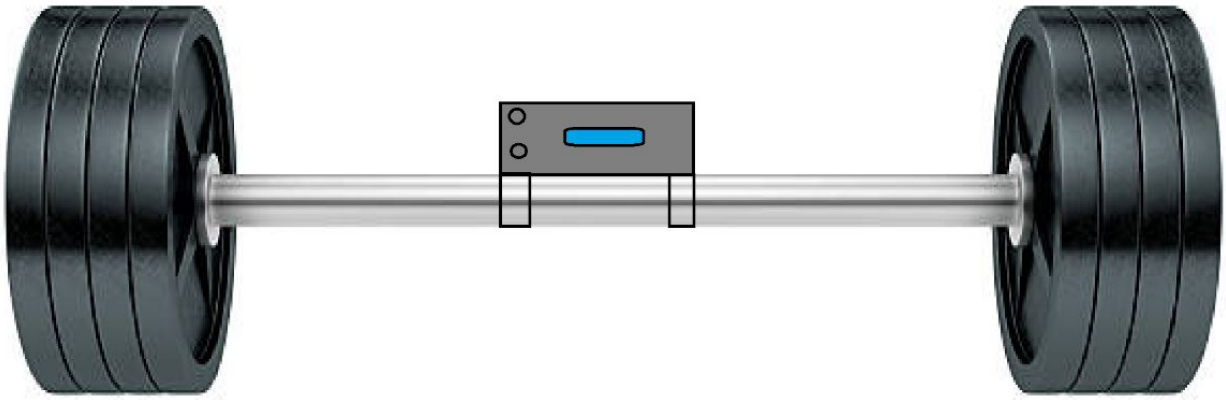

Figure 2: Physical Design (barbell not to scale)

5 Requirements and Verification Tables

Requirements	Verification
1) Accurately count repetitions of motion during a workout (+/- 1 rep). 2) Accurately read the user's barbell tilt angle to a limit to be set during initial testing. 3) Accurately measure the height of motion during a workout. 4) Intuitive user interface with buttons and LEDs.	1) Strap the device to a barbell and have an experienced user do full repetitions of motion during various workouts and compare our observations to the data collected. 2) An experienced user will complete full range repetitions of motion and the data collected will be compared with a physical level. 3) An experienced user will do a full range motion exercise and the physical height read with a tape measure will be compared with the data collected. 4a) Bring the BarPro device to new users (following COVID-19 guidelines including social distancing)

	4b) Provide a small set of instructions on how to use the device and wait for the user feedback on intuitiveness and effectiveness of our user interface elements.

Table 1: RV Table

6 Plots

Our plots would be related to our tolerance analysis, measuring percent error of our calculated accelerometer level vs. actual level. Graphs can be collected for both left and right unlevel scenarios and can be interpreted for optimizing and debugging our code. Collecting data at different points in time will allow us to compare our results and aid in programming.

7 Circuit Schematics

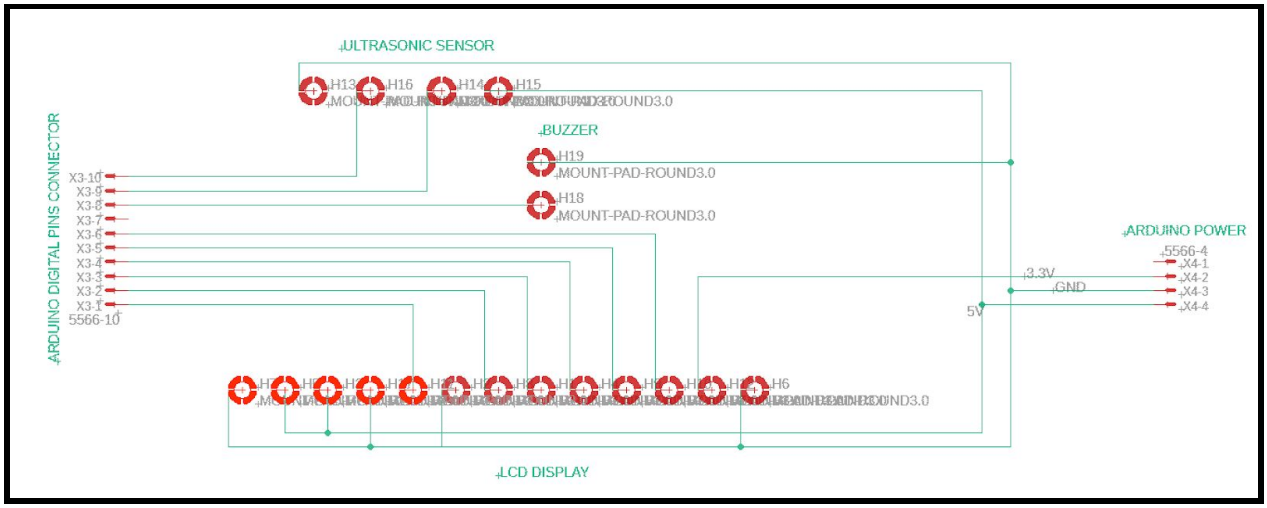

Figure 3: BarPro Schematic

8 Tolerance Analysis

Quantitative analysis will need to be performed on the tolerance of the accelerometer. The accelerometer will read acceleration values corresponding the level of tilt of the barbell. These acceleration values will need to be converted into degrees of tilt using calculations, and a maximum tilt angle/acceleration value will be determined. A tradeoff may need to be made

between desired maximum tilt angle and acceleration values depending on how closely a relationship can be calculated between degree of tilt and N*m of acceleration.

9 Safety and Ethics

The product that emerges from completing this project has the possibility of being a fantastic aid to the general public that enhances workouts and body fitness goals. This also comes at the cost of possible misuse causing issues with safety. We do not recognize any ethical issues with the BarPro product. It is simply a device to aid beginners on their workout journey by stopping bad habits with form. It does not store any personal data that could be misused such as user profile information. To avoid safety issues regarding the BarPro product, only very light weight will be used for testing purposes. Using light weights will minimize the possibility of injury during testing. When the BarPro is used at the gym, individuals need to make smart decisions about the weight they workout with. The BarPro is only present to ensure proper motion and data tracking, it will not stop a careless individual from pushing their limits too far. This product will have warnings regarding the use of heavy weights which will hopefully steer individuals in the right direction and promote safety measures. These precautions are in line with rule #9 in the IEEE Code of Ethics regarding the requirement to never injure individuals [3]. Our product will use AA batteries from a reputable manufacturer such as Energizer so they will meet US Consumer Product Safety Commission regulations, but as with any battery, there is always a possibility for an explosion or fire. The batteries used will be alkaline instead of lithium to decrease this possibility, and alkaline batteries will also be easier to dispose of by the user.

10 Citations

[1] Issaonline.com. 2020. *Shoulder Injuries | ISSA*. [online] Available at: <https://www.issaonline.com/blog/index.cfm/2011/2/11/shoulder-injuries> [Accessed 18 September 2020].

[2] ScienceDaily. 2020. *Military Surgeons Report 'Alarming Frequency' Of Bench Press Injuries*. [online] Available at: <https://www.sciencedaily.com/releases/2018/03/180322124948.htm> [Accessed 18 September 2020].

[3] Ieee.org. 2020. *IEEE Code Of Ethics*. [online] Available at: <https://www.ieee.org/about/corporate/governance/p7-8.html> [Accessed 18 September 2020].