Design of a Barbell Training Sensor

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Introduction

The Coach Barbell Training Sensor is a device that attaches to the end of a barbell and provides the user with acceleration and vertical path alignment data for any recorded lift. Our team's goal is to create a weightlifting sensor that is durable enough to withstand a seven-foot drop, has the ability to attach to all sizes of barbells, is inexpensive, and accurately displays data on a user interface. There are currently several weightlifting sensors available on the market, however, none of these sensors have the ability to track and display the vertical position of the barbell at any given instance. For weightlifters practicing lifts such as the Clean and Jerk or the Snatch, *The Coach* is a perfect device to provide the athlete with accurate and effective results for every lift.

Design Process

- Define the product parameters
- Create a House of Quality, outlining the Customer Requirements (CR's) with the Engineering Characteristics (EC's)
- Create a GANTT Chart to create deadlines over the next two semesters
- Research and critique similar products
- Research and test different sensors and data analyzation methods
- Create a Bill of Materials (BOM)
- Design and build a prototype of the housing, circuit, and application
- Create and perform Engineering Tests
- Redesign using Failure Mode and Effect Analysis (FMEA), Design for Manufacturing (DFM), and Design for Assembly (DFA) techniques
- Test, optimize, and create the final prototype

Figure 1. Section Cut of The Coach

Figure 2. Top View of The Coach

Figure 3. Bottom View of The Coach

External Components

- Two components connected using a cantilever snap
- The housing was designed to enclose the printed circuit board (PCB) and the battery to power the device.
- Includes four 12 lbf magnets embedded in the bottom housing (Figure 1). This magnetic mount design allows The Coach to attach to the sleeve at the end of a the barbell without the need of a clamp or strap.
- Features an extrusion that wraps around the end of the sleeve to prevent the housing from sliding off of the barbell
- Designed entirely in SOLIDWORKS 2018[1]
- 3D printed using PLA material

Internal Components

Prototyping circuitry was done using the HC-05 bluetooth module and the Sparkfun Razor that includes an accelerometer, gyroscope, and magnetometer. While not yet implemented, the final design circuit board is based off of the Razor, but removes unnecessary components and adds onboard bluetooth functionality. the circuit runs off of a single cell LiPo battery and has an onboard charger.

Figure 4. Exploded View of The Coach with the Top Housing (A), Bottom Housing (B), Razor (C), and Battery (D)

Software

The software was created using Java in the Processing[2] IDE and consists of two programs. The first program, "Capture", will record a video using either a camera built into a laptop or an external camera. The acceleration data will be recorded from the accelerometer and stored within the second application, "Trace." This program will playback the first video or prompt the user to select a new video and uses computer vision to track and trace a user-selected color while displaying the recorded acceleration data(Figure 5). Scan the QR code to view a demonstration of all of the features in the application.

Figure 5. The Coach - Trace Application

Watch video

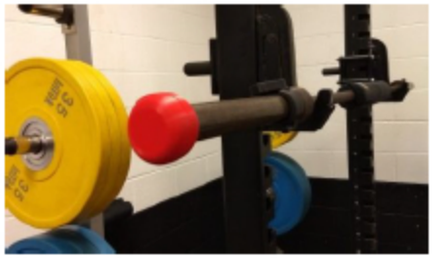
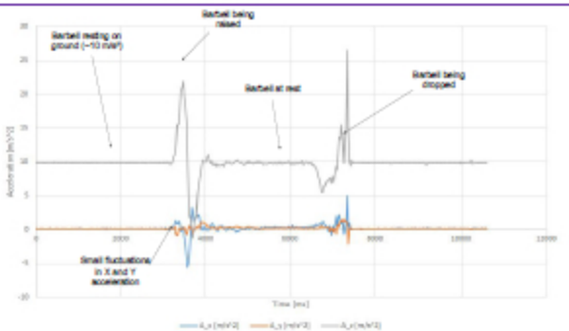


Figure 6. prototype of The Coach attached to a barbell

Results

At first, the vertical tracking software performed poorly because it required too much CPU power to display the data in real time. The solution to this was to split up the application into two separate programs which allowed for a higher frame rate of 30 FPS. The best colors to use on the housing were red, green, and purple. However, because the tracking is based on color, wearing a color that is very close to the tracked color could cause errors. The Coach's plastic housing went through several engineering tests, however, it was not able to stay attached to the barbell when thrown down with significant force (simulating a professional weightlifter throwing down a barbell). While the final circuit board has been fully designed, limitations with available equipment have kept the team from advancing with testing. Therefore, only the prototype board was ready for use.



Graph 1. Acceleration versus Time for a simple deadlift

Future Reccomendatoins

Although The Coach has been through nearly 8 months of development, there are still several things that our team believes could make the user experience and the overall product even better. For example, the user interface could be written using C++ or C# to better optimize the software for compatibility with different Operating Systems and better memory management. the tracking software could be made more robust by further filtering out unwanted objects based on other features like shape. Also, instead of using PLA, the use of Nylon material could increase the resistance to impact for the housing.

References

1. "SOLIDWORKS 2018," Solidworks.com, 2018. [Online]. Available: https://www.solidworks.com/. [Accessed: 30- Apr- 2018]
2. "Processing", Processing.org, 2018. [Online]. Available: https://processing.org/. [Accessed: 30- Apr- 2018]