Dead-Lift Assistant

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Introduction

Objective:

Every year, nearly 500,000 people get injured in the gym while performing exercises due to poor technique and form [1]. The deadlift exercise, in particular, is one of the most dangerous in the weight room due to the large amounts of weight and the sensitive muscles that are involved in the motion. One of the most common deadlift technique mistakes is arching your back. This simple mistake can lead to severe injuries that can cost thousands of dollars in medical services to repair an injured back. A cheap and reliable technique-feedback system would save thousands of people from injury and medical costs.

Our solution to this problem is a computer-vision technique analysis system. Our system records video of a user performing a workout and provides feedback on their technique via green and red LEDs that indicate good and bad form respectively based on the angles detected between the user's joints during the lift. Our system uses a camera, accelerometer, proximity sensor, and computer vision algorithms to provide accurate feedback. This product is intended to be installed in gym equipment so that anyone can integrate it seamlessly into their workout without having to put on any physical sensors.

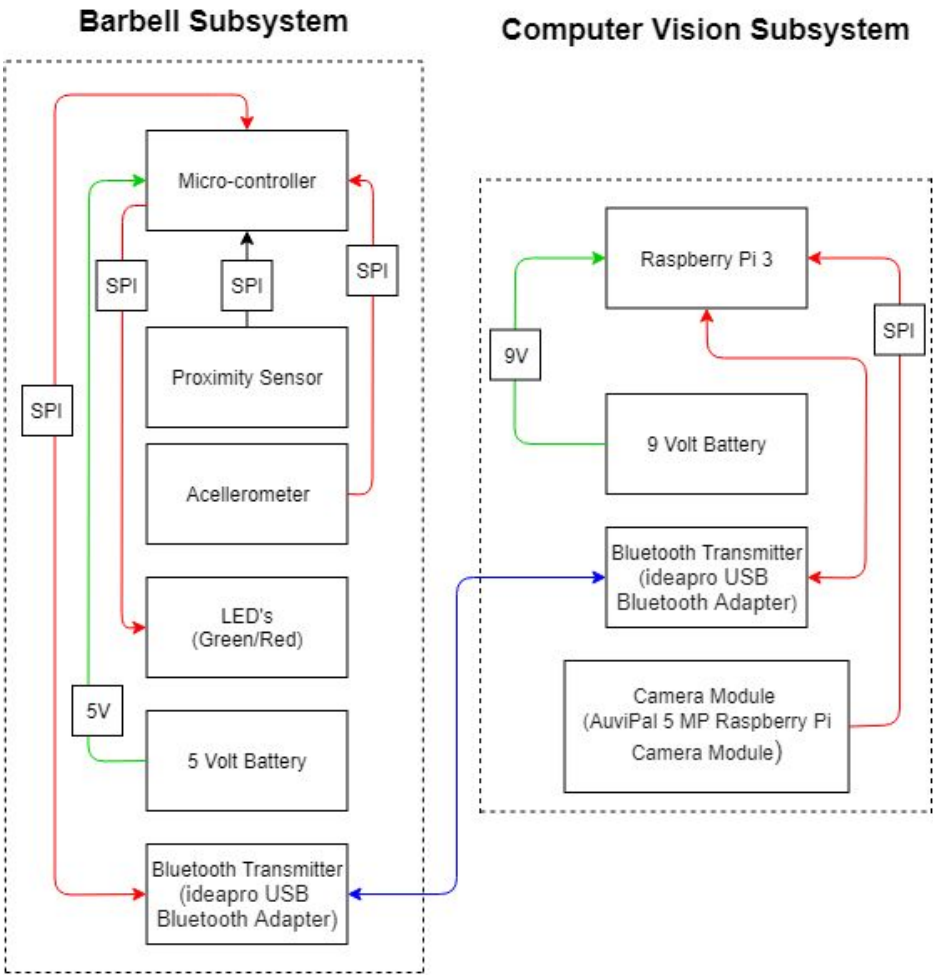
Background:

Back pain is one of the main reasons preventing many people from engaging in daily activities [4]. Half of all working Americans admit to having back pain symptoms each year. It accounts for more than 264 million lost workdays within a year. It may seem counterintuitive

that exercise, something that is supposed to keep people healthy, can often be the cause of this pain. Poor mechanics while lifting weights cause injuries due to the abnormal amounts of stress put on the body incorrectly during a flawed workout. One of the most dangerous workouts is the deadlift. This exercise requires lifting large amounts of weight with your leg and back muscles. While it is one of the most effective workouts for staying in shape, it is also extremely dangerous when performed incorrectly. Poor form in this exercise typically entails the rounding off one's back which forces the lower back muscles to over-exert themselves throughout the deadlift motion. These are the same muscles that so many Americans admit to having debilitating pain with. While physical trainers are one option to correct poor form, the majority of people who go to the gym decide not to hire a trainer because they either don't want to spend extra money or they do not even know that their exercise technique needs correcting in the first place.

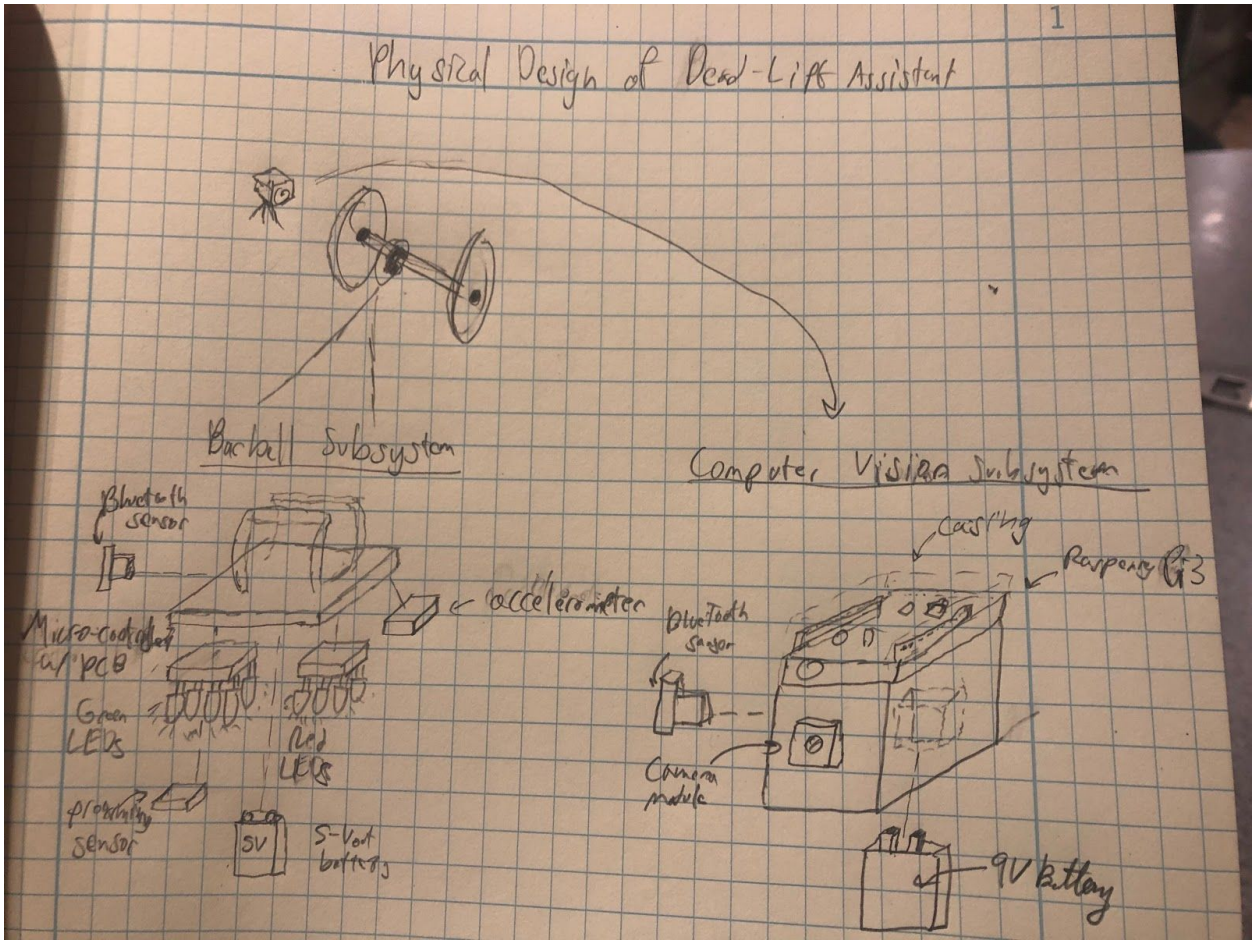
Design

Block Diagram:



Our product is composed of two subsystems. The Barbell Subsystem is a device attached to the barbell itself. Its purpose is to poll information from the barbell's movement and indicate to the Computer Vision (CV) Subsystem which part of the exercise the user is currently on. The CV Subsystem then critiques the user's joints' angles depending on if the current motion of the exercise is raising and lowering the bar. Depending on how good the user's form is, the CV Subsystem will relay information back to the Barbell Subsystem to trigger the appropriate LEDs.

Physical Design:



Functional Overview:

1.0 Micro-Controller

This subsystem will be controlled by a microcontroller. This will process the data from the sensors and relay them appropriately to the computer vision subsystem via Bluetooth transmission.

1.1 Proximity Sensor

This will indicate when the bar has started to move up as well as when the bar has reached its final position on the ground. This tells the computer vision subsystem when to start and stop polling camera data so it knows when the routine has ended.

1.2 Accelerometer

This sensor tracks the motion of the barbell as it goes up and down to signify to the computer vision subsystem what kind of spinal motion to look for. The angle and motion of the spine and back form when lifting up the barbell is different from setting it down, so these movements need to be distinguished.

1.3 LED's (Green/Red)

There will be LED feedback (red/green) indicating whether or not the user performed the deadlift with good form after their routine. This will be determined by feedback from the computer vision subsystem.

1.4 5-Volt Battery

This system will be powered by a 5-volt battery. This battery must keep this subsystem running for the duration of the movement and computer vision processing.

1.5 Bluetooth Transmitter

The Bluetooth transmitter is used to relay the accelerometer and proximity sensor's data to the CV Subsystem as well as receive feedback from the technique-analysis algorithm.

2.0 Raspberry Pi 3

A microcontroller will run a computer vision algorithm to detect bad form and provide feedback to the barbell subsystem on whether or not. To implement the algorithm, we will be using OpenCV body tracking [2] to track the angles of every major joint used in the deadlift exercise. We will write the logic behind our algorithm to determine if the user of our product is performing the exercise correctly. When the microcontroller is done processing whether the user's form is good or not, it will relay signals back to the Barbell Subsystem so the proper LEDs light up.

2.1 9-Volt Battery

This system will be powered by a 9-volt battery. This battery must keep this subsystem running for the duration of the movement and computer vision processing.

2.2 Bluetooth Transmitter

The BlueTooth transmitter is used to receive the accelerometer and proximity sensor's data from the Barbell Subsystem as well as to send feedback from the technique-analysis algorithm.

2.3 Camera Module

We are also attaching a camera module to the microprocessor to record the deadlift movement and compare the user's form to the proper form. This will be placed at the side of the user to get a view of their bodies, specifically their backs, movement.

Risk Analysis:

Detecting the user's skeletal joints is the cornerstone of our project. For our project to be successful, we need to prioritize the accuracy of the angle measurements between joints, specifically those in the back. If we fail to do so, our product may lead to even higher rates of injury due to false feedback on lifting technique. In order to prevent such a situation, it is vital for us to put our highest emphasis on accurately using OpenCV Pose Tracking.

Ethics and Safety

Because our project is intended to be commercialized within the fitness community, we will make sure to disclose all information about the project. According to the IEEE Code of Ethics #1, we will make sure to fix issues and inform the public of any dangers that can come with the use of our equipment [3]. Because our product does not require any peripherals to be placed on the user, the use of it will not increase the dangers of weight lifting any more than weight lifting's intrinsic danger.

We will do our best to present our product in an unbiased way according to Articles 2, 4 of the IEEE Code of Ethics. We will be honest in stating estimations when making our product marketable according to Article 3 from the IEEE Code of Ethics.

We are making a promise to support our colleagues and co-workers in their professional development and also support them in respect of the code of ethics. We will "treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression" as stipulated by Article 8 of the IEEE Code of Ethics.

References

[1]
https://www.cpsc.gov/s3fs-public/2018%20Neiss%20data%20highlights.pdf?NGBgKPVglSz.ShB_W6Y0ENRjhr6qAtWr

[2]
https://github.com/CMU-Perceptual-Computing-Lab/openpose/blob/master/python/openpose/openpose_python.cpp

[3]
"IEEE IEEE Code of Ethics." IEEE - IEEE Code of Ethics, https://www.ieee.org/about/corporate/governance/p7-8.html Accessed 19 Sept. 2019.

[4]
"Back Pain Facts and Statistics." Accessed 19 Sept. 2019
https://www.acatoday.org/Patients/Health-Wellness-Information/Back-Pain-Facts-and-statistics