SMART GYM EQUIPMENTS

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Introduction

Nowadays smart fitness equipment is boosting up our workout. Many Apps are available in the market to track the performance index. These apps are incredible for keeping people motivated to be active and helping them track their fitness levels and weight. But there is a paucity of cheap commercially available devices to meet the increasing demands of budding athletes or health conscious people. Also, there is a lack of devices that specialize the performance of muscle activity. Hence, we are trying to integrate small commercially available equipment with different sensors and controllers so that the users can track their performance of their work out details.

Projects leading up to the final project**:**

Project 1: The Smart Gym equipment: Hand gripper
Project 2: The Smart Gym equipment: Hand stretcher

Project 1: The Smart Gym equipment: Hand gripper

The primary usage of grippers is for testing and increasing the strength of the hands. The common features of standard grippers are that they use a torsion spring fitted with two handles. The exact dimensions of these elements vary, as well as the materials used to make them. A compact and portable lever-type device is squeezed in order to strengthen wrists and forearm muscles. Athletes practicing hockey, cricket, tennis etc. often use this device to improve their striking power. Many of these sports depend on high lower arm strength, and working out with hand grippers helps in its development. The main benefits of using the hand grippers are

1. It improves the forearm muscularity.
2. I increase muscle endurance.
3. It increases the hand’s grip.
4. It helps to improve the hand dexterity.

Components of the project:

1. Hand gripper
2. Hall effect sensor
3. Arduino Uno
4. Smartphone App

The sensor used for this project is a linear Hall Effect sensor. It varies the output voltage based on the magnetic field. It uses encompass proximity switching, positioning, speed detection and current sensing applications. The sensor used for our application is Allegro Microsystem A 1302 Hall Effect sensor. It is optimized to accurately provide a voltage output that is proportional to an applied magnetic field. These devices have a quiescent output voltage that is 50% of the supply voltage.

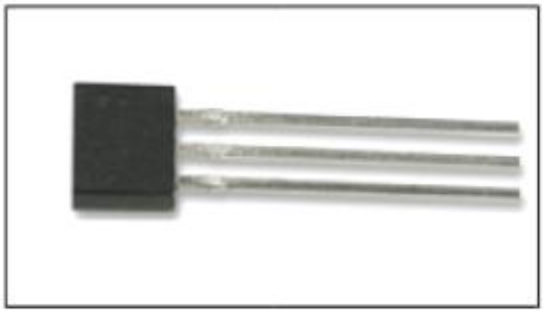

Figure 1. Hall effect sensor.

Working principle of Project 1:

The hall effect sensor is attached to one hand of the gripper and a small magnet is attached to the other hand. When we pressed the gripper the hall effect sensor will detect the magnet and produce a voltage corresponding to the magnetic field.

Figure 2. Hand gripper with sensor

A double threshold method is applied to make the device more robust. In double threshold method, the sensor has to detect two threshold values and hence increase the count by one.

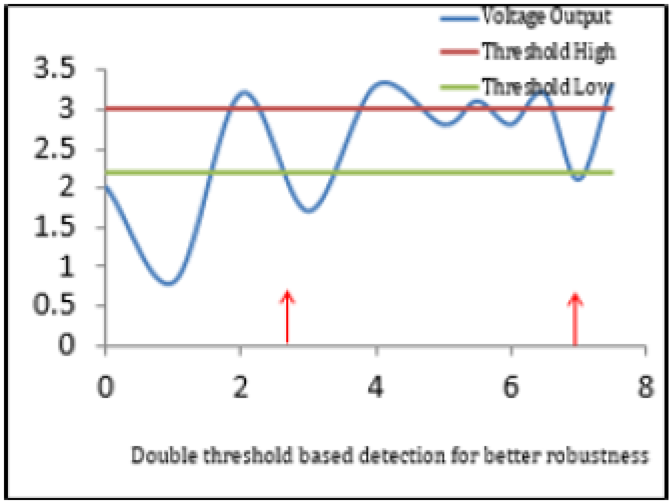

Figure 3. Double threshold method.

The count of the gripping action is given to the App. App connects the Arduino via Bluetooth. Arduino sends the variable like count, count rate and the total time the gripper is pressed during a trial. Based on this value the performance index can be calculated using the equation

PI= log10[10*(T_pressed * n + 1)] *(r +1) where n is the total number of count and r is the count rate.

Figure 4. App showing performance index

The performance index indicates how well the exercise can perform. The performance index varies from person to person

Project 2: The Smart Gym equipment: Hand stretcher

The second mini-project focuses on another exercise equipment, the smart chest expander. For this project, we used a stretch sensor, propeller microcontroller, and a smartphone application. Similar to the first mini-project, we focus here on measuring the overall performance index over one workout session. The counts along with the performance index measure provide the user additional capability to track and record the history of their workout session.

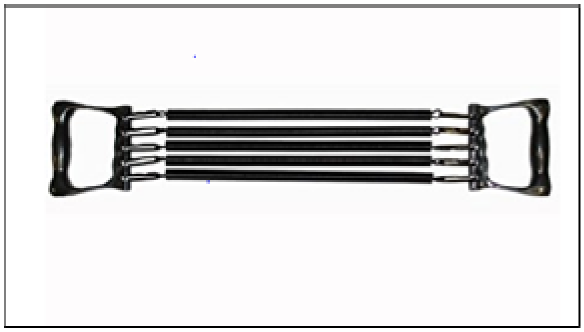

Figure 5.Hand stretcher

Hand stretcher is a simple affordable exercise equipment that helps to build the upper body strength in chest, arms, back and shoulders.

We integrated the hand stretcher with the stretch sensor. Stretch sensor varies the resistance when stretched. When relaxed the sensor material has a nominal resistance of 1000 ohms per linear inch.

Components of the project:

1. Hand Stretcher
2. Stretch sensor
3. Parallax Propeller
4. Smart phone App

Working principle of Project 2:

The stretch sensor is attached to the hand stretcher. When the hand stretcher is stretched,the resistance of the stretch senor will change. Voltage fluctuations due to the change in resistance will transferred to the parallax propeller. The data be transferred to the smartphone App via blue tooth. The application shows the rate of the count and the performance index.

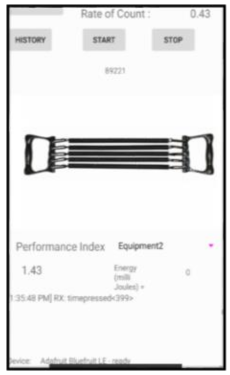

Figure 6. App showing performance index

Final Project: The Smart Gym equipment: Dumbbell

The third and the final project is a culmination of all our efforts on previous two projects.

By designing a system, which does not require sensors attached to the device, we do not have to modify the original exercise equipment. Utilizing a camera and a raspberry pi, we can use image processing with OpenCV libraries to detect the movement and track counts/repetitions of a dumbbell, the exercise equipment, using a tracker with a bright color (green) and setting a triple -threshold on the pixel movement at the centroid of the tracker.

The dumbbell is inexpensive, versatile, and easy-to-use equipment that is used in a variety of workouts to improve muscle strength. Athletes practicing weightlift, gymnastics, volleyball etc. often use this to expand and strengthen their muscles in the chest, arms, back, and shoulder. Great for home-trainees who have limited space and equipment.

Figure 7. Smart dumbbell

1. Dumbbell
2. Myoware Muscle sensor
3. Arduino Uno
4. Raspberry Pi
5. PiCam
6. Smartphone App

The sensor used for our project is Myoware muscle sensor.

•The Muscle sensor is a unique sensor, which measures muscle activity by monitoring the electric potential generated by the muscle cell (EMG).

•The electrodes should be placed in the middle of the muscle body and aligned with the orientation of the muscle fibers

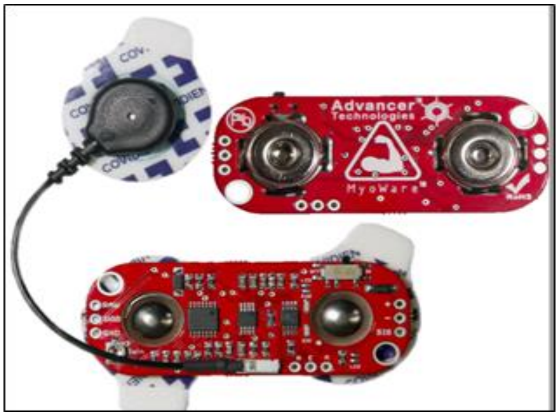

Figure 7. Muscle sensor

Muscle sensor is attached to the biceps of the person doing the dumbbell exercise.

Working principle of the final project:

The working principle of the project consists of two parts.

1. Image processing for finding the number of repetitions of the dumbbell activity
2. EMG data processing to find the average muscle activity

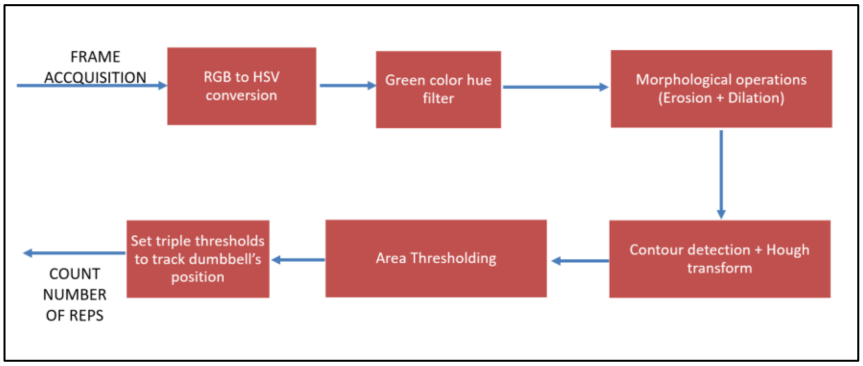

Figure 8. Block diagram to find the number of repetitions of dumbbell

Figure 8 shows the block diagram of the image processing used to get the count of several repetitions of the dumbbell. Color can be processed using RGB color space or HSV color space. RGB color space describes the colors in terms of red, green, and blue and HSV color space describes colors in terms of hue, saturation, and value. HSV color model is often preferred over RGB color model since HSV color model describes the color similarly how human eyes tends to perceive the color. HSV is the cylindrical coordinate representation of RGB color model. Hue represents the color type. It is the dominant color as perceived by an observer. Saturation represents vibrancy of the color, which means the amount of white light mixed with a hue. The value represents the brightness of the color or it is the chromatic notion of intensity. The Pi camera uses RGB model and needs to convert it to HSV model. Then it constructs a mask for green color and a series of morphological operations like erosion and dilation are used to remove any small blobs in the mask. Then it finds the contour and initializes the (x, y) center of the mask. Then it finds the largest contour in the mask and finds the minimum enclosing circle and centroid. Hough transform is used for this purpose. After that drawing, the circle and centroid on the frame and update list of tracking points. Then set the threshold level to track the dumbbell's position. If the dumbbell crosses all these three threshold lines, two times the count increased to one.

Muscle sensor is attached to the biceps of the human hand doing the dumbbell exercise. The signal voltage is directly proportional to the muscle activity.

For the muscle sensor, the readings are calculated using dynamic mapping as:

$$Avg.\,Muscle\ Activity\ (\%) = \frac{(Sum(Window\ Average) - N \times [Min(Window\ Average)])}{N \times [Max(Window\ Average) - Min(Window\ Average)]} \times 100$$

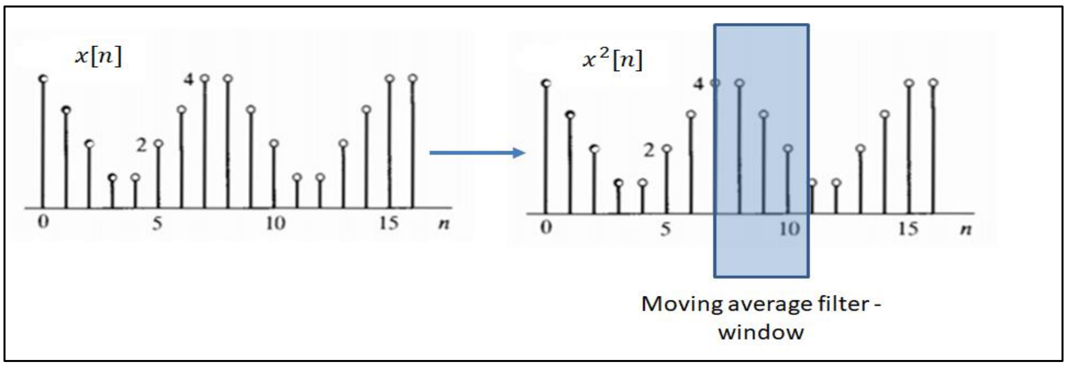

Figure 9. EMG data processing using moving average filter window.

The number of repetitions of the dumbbell and the average muscle activity is transferred to the App through Bluetooth and the App shows the average muscle activity in percentage.

Average muscle activity reflects the relative muscle stress during one workout session of the localized observed muscle area.

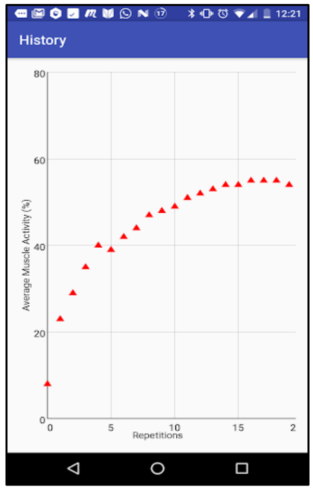

Figure 10. App showing the average muscle activity

Discussion & Conclusion:

Smart gym equipment can provide an inexpensive workout tracking system for beginners who wish to track their performance and progress on a monthly/weekly basis. The idea discussed here can be not only extrapolated to new equipment, but also to different styles of using the same devices. For example, dumbbells cannot be used only for training biceps, but also to train shoulders and chest. These categories can further be segregated to the duration of specific muscle training, rather than illustrating device used.

Electromyogram (EMG) signal, as shown in the final project provides an interesting method of calculating the efficiency of the workout session. The beginners usually ignore this analysis during exercise. The methodology and technique used for inferring Average Muscle Activity combined with the repetitions history thus seem a vital measure to be shared not only by the user but also to a coach offline. Augmented Reality can be used to teach the users correct exercise techniques to the users.

Some key ideas worth iterating in this subject deal with the efficacy of the performance index criteria and Average Muscle activity. This is the area where extensive research might be required to develop these novel ideas into a fine product, which can be used directly by the consumers.