Interactive Training Bag

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***ABSTRACT* — INTERACTIVE TRAINING DEVICES ARE IN THE INCREASE DUE TO THE DESIRE TO EXERCISE AT HOME. THE OBJECTIVE FOR THIS PROJECT WAS TRYING TO CREATE AN INTERACTIVE YET ECONOMIC WAY TO OBTAIN AN INTERACTIVE TRAINING BAG. THE MAIN COMPONENTS FOR THIS PROJECT WERE HANDMADE PRESSURE SENSORS AS A MECHANISM TO RECORD THE INTERACTIONS BETWEEN THE USER AND THE DEVICE, AND AN XBEE ANTENNA AS A COMMUNICATION BETWEEN A REMOTE AND THE BAG. THERE ARE FOUR ACTIVE INTERACTIVE MODES FOR THIS DEVICE, AND AN IDLE MODE TO MAKE THE DEVICE VISUALLY PLEASING AS A LIVING ROOM DECORATION.**

***INDEX TERMS* — PRESSURE SENSORS, XBEE, AC POWER SUPPLY, AC-DC CONVERTERS, TRAINING BAG, EXERCISE**

I. INTRODUCTION

For our Senior Design project, we are creating an interactive boxing/martial arts stand up workout bag, where the athlete can choose different types of workout patterns and receive results to view progress. A regular standup punching bag alone does not have the capability to improve a user's performance, since it does not provide feedback or results without a boxing/martial arts trainer. With an interactive design, the user would be able to improve performance in cardiovascular strength, accuracy, reaction time and speed. This design should be easy to use for first time athletes as well as experienced athletes because the user is able to select different mode levels that are most suitable for them, and increment their levels as needed to continue to receive better training.

This report describes how the interactive martial arts bag will be designed, built, and tested. In the beginning, the first sections will define our goals and objectives our project must meet to be successful. The research and design considerations follow, giving details on the technical investigations done to meet our goals and objectives, as well as compare different design approaches. The hardware and software design will then be overviewed, including the design of each subsystem and each component's role in the complete system. Next, our test plan is reviewed, detailing how each subsystem will be tested, as well as the system as a whole.

II. GOALS AND OBJECTIVES

This device should be able to implement downtime modes:

- Idle Mode
- Display Mode
- Off Mode

This device should also be able to implement the following exercise modes :

- Combination Modes (Side A)
- Cardio Mode (Side B)
- Reaction Mode (Side B)
- Accuracy Mode (Side B)

III. MARKETING REQUIREMENTS

Marketing requirements detail the characteristics that our team would like the device to embody, which can be used to appeal to the audience of users and possible users of this device. These requirements include behavior, interaction, and output of the equipment. The plus sign(+) means that if this trait goes up, it will be beneficial for this project. The negative sign(-) means that if this trait goes down, it will be beneficial for this project to have.

• Durability: Device will be able to withstand impact from regular use. (+)

• Cost: Device must be cost efficient for a typical consumer; priced reasonably compared to other multimode home-gym fitness devices. (-)

• Portability: Device must be able to be moved if necessary, without large risk of damage, and must be able to be used in a variety of different environments. (+)

• Intuitive: The user interface will be easy to understand for and welcoming to experts and enthusiasts alike. (+)

• Versatile: The device will have multiple modes of operation utilizing both sides and orientation of sensors for a well-rounded user experience. (+)

• Device life: The device should last as long as possible; at least 5 years for the user. (+)

IV. TECHNICAL REQUIREMENTS

Technical requirements are characteristics that we, as engineers of this device, are aiming for each component to have. These requirements will be met through our choices of components and our integration of the individual components within the device as a whole. As with the marketing requirements, the plus sign(+) means that if this trait goes up, it will be beneficial for this project. The negative sign(-) means that if this trait goes down, it will be beneficial for this project to have.

• Durability: Components will be able to stand up to impact at a rate of over 120 hits/minute. (+)
• Power: Components will be power efficient; no more than 1.1kW. (-)
• Compatibility: Components will integrate well with other components used in the device. (+)
• Component Costs: Total cost of type of components of good quality will be within our budget, but as low as possible. (-)
• Implementation Time: The time taken for the design and implementation of modes using the sensors should not be excessive. Our goal is 12 weeks or less to build and develop. (-)
• Longevity: Components shall provide approximately 5 years of use. (+)

V. STANDARDS

These following are the standards for this project: Power Supply (IEC 60906-2:2011), Regulation Workout Bag(ASTM F2276-10(2015)), PCB Standards(IPC-221B), and Communication Protocol Standards (IEEE standard 802.15.4).

VI. BASE SYSTEM HARDWARE DESIGN

The base system will be on the standing bag, fitted with indicators and sensors that will gather data on the user's performance.

A. Processor Design

The processor chosen for this project is the ATmega2560. The ATmega2560 was chosen because the chip supports avr architecture, which is required for many of the libraries used for the serial communications for the XBee chips and the LCD display. In addition, the ATmega2560 provides 256KB of flash and 8KB of ram.

B. Body and Design Plan

The body of this device will be a used Wavemaster branded bag by Century Martial Arts. On this bag, there will be LED indicators designating the zones to hit as well as physical markings to guide the user. Side A's sensors will be laid out to simulate hitting the areas on a physical opponent. Side B has a target showing the center that the user will be aiming for when using modes on this side. For each of these zones, it is required of the markers used to endure large amounts of physical contact without much deterioration of the design. These markings can be seen on the bag designs below.

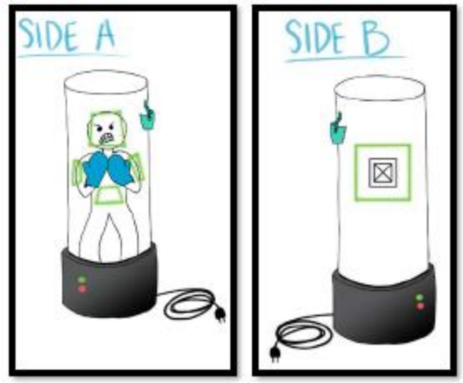

Fig1. (Left) "Side A" of the device . (Right) "Side B" of the device

C. Sensor Design : Side A and Side B

The sensors for this project will be handmade pressure sensors from Adafruit using stainless steel conductive thread, Velostat, Conductive fabric and shapeable foam from any craft store. The materials and the shape of each sensor will be shaped depending on both sides. On Side A, the shape of these sensors will be based on the target zones on that side. On Side B, the sensor will be designed with four rings, where the center ring is the desired target zone, and the furthest ring is the least desired zone.

D. Indicator Design

The indicator that was decided upon after technical research is the addressable Pixel LED strip with the WS2811 LED drivers. The LED strip is cuttable by sections of 3 LEDs, which allows us to outline each target zone with a specific number of indicators. Each LED requires 60mA at 12V to be used at full power. Therefore, to use 50 LEDs, we would require a power supply that provides a minimum of 3 amps.

E. Power Supply

The power supply will originate from the AC outlet and will be converted to a 12V DC signal with an AC/DC converter. This 12V DC signal will be used to power the LEDs directly. This is necessary as the LEDs require a 12V signal to power on. The sensors will be powered using the 5 V output power pin from the MCU. This will allow us to both power and read from the sensors using the same device. This will simplify the power design and allow us to use less connectors. The MCU will be powered using both the AC/DC converter and the DC/DC converter. First the AC/DC converter is used to convert to a 12VDC input, then the DC/DC converter is used to convert the 12VDC signal to a 3.3VD and a 5VDC signal suitable for the MCU.

VII. USER INTERFACE HARDWARE DESIGN

A. Overall Design

The user interface system that will be used to control the punching bag will be controlled by a handheld, wireless remote. Since the UI component of this overall device is its own individual device with independent hardware requirements from the base, the details of its hardware design will be discussed in this section. A sketch of the first draft of the UI Remote can be seen below.

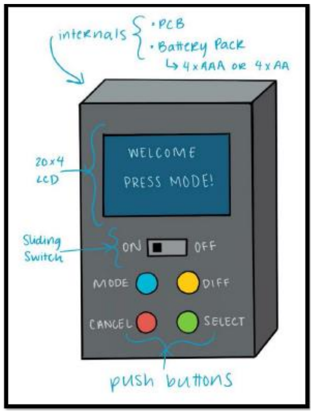

Fig 2. Draft sketch of the UI system for the device

B. Processor

The processor is to receive data from the user, display user selections, and communicate with the base system. The processor needs standard GPIO pins to connect external devices to the MCU. The processor should also be capable of I2C and UART communication. The I2C communication is required to send data to the LCD display on the remote, and UART is used to communicate with the XBee chip antenna. With these specifications a processor can be chosen to put in the remote. Due to the low expense and the meeting of the technical specifications, the same processor (ATmega2560) can be used for the base and the wireless remote.

C. Display

The LCD display is a 20 column by 4 row screen. The MCU communicates with the display controller, the PCF8574T, to configure the LCD as well as send data to the display. The LCD driver uses I2C and requires two GPIO ports, as well as 5VDC for its power supply

D. Buttons and Switches

Push buttons will be used to control different functions for the remote. The push buttons require GPIO pins to connect to the MCU that are able to trigger external interrupts. One pin is needed for each push button, for a total of four GPIO pins necessary for the four buttons. To read a high value from the push buttons, the push buttons should be pushed in. To set this up in the correct way, the resistors for these configurations should be set to pull down mode.

Another input method needed for the remote is a rocker switch. This switch selected is a single pole single throw switch to control the power supply to the remote.

E. Power Supply

The processor requires an input power from 5VDC. The LCD display requires 5V for full functionality and the XBee chip requires 3.3VDC. This means that a 5V DC signal is the lowest possible voltage required to power on all of the electronics inside the remote. To generate this amount of voltage using wireless methods four AA batteries will be included in the remote. The four batteries together will supply 6V, which will be enough voltage to power all the essential electronics inside of the remote. The four AA batteries will also provide more amp hours than four AAA batteries, although the AA batteries are larger.

F. Protective Case

The housing of the remote is required to hold all of the components inside the remote. The only components that will be accessible from the outside are the switch, buttons, and the battery pack on the back of the housing. To design and manufacture a shell that will fit these requirements a 3D printer. Instead, for our design we will be using sections of plexiglass to create a more durable case for the internal components.

VIII. UI AND BASE SOFTWARE DESIGN

The software for the interactive workout bag is implemented using agile software development. This method emphasizes the use of adaptive design methodologies where our team will plan, design, develop, test and deploy. The technologies integrated in our designs thus far are not set in stone, per say. During development, the technologies, and design choices may change, due to our team taking advantage of adapting our designs as new information is uncovered while the product is being built and tested.

With this method of design, it allows us to implement specific components, test their performance, and make adjustments to each component along the way, it also allows our design to be flexible, and to take other design restrictions into account.

A. Design Environment/Tools

The software design environment depends greatly on the processor that is used. Because our design implements the use of Atmel microcontrollers, the Arduino IDE will be used as the IDE to write, push, and debug the program onto the microcontrollers. This choice is beneficial for the team because everyone has experience with programming microcontrollers to perform various tasks, which include the low power modes, interruptions, display drivers, and more. Arduino IDE uses embedded C as the program language, which all of our team members have experience in as well. Arduino IDE also already comes with the header files and interrupt vectors for the Atmel chips, and multiple useful libraries used for complex math and communications, which makes it easier to implement into our designs.

B. General Overview

The software for the workout bag will be split into two different areas: UI system and Base system. The UI system is a separate device from the base and handles the interface between the user and the system. The base system is the electronic components tasked with reading sensors, providing light sequence patterns, and communicating with the UI system (also called the remote).

In general, the user turns on the device with the UI system. In the UI system, the user selects the mode and difficulty on the remote. The UI system then transmits the users' selections to the base. Once the base receives the mode and difficulty, the workout bag's targets blink to indicate to the user that they can get in front of the correct side. The base system then executes the desired mode and difficulty by enabling various timers, sensors and target area LEDs. The base system will then complete the sequence, and compute the results related to the mode, and send them back to the UI system for the user to see. The UI system then returns to the beginning, allowing the user to select another mode and difficulty or to shut down.

C.UI System

The first action to happen, is when the user turns on the system by using the on/off switch. The system then turns on the screen, and displays its welcome message, and prompts the user for their selection. There are two branches based on the user selection, system off or mode. If the OFF button is pushed, the system shuts down. If the Mode button is pushed, the user is able to select a mode. The user can press the Mode button to cycle through the modes and uses the Select button to choose a mode. Once the Select button is pressed, the user then can choose a difficulty setting, based on the mode. Similar to the mode selection, the user can use the difficulty button to cycle through the difficulty options. The user then presses select a second time. The mode type and difficulty type are sent to the base system MCU and the UI system enters a low power mode, while the rest of the sequence happens at the base. The buttons used for the user inputs are susceptible to the bouncing effect, where the user may press the button only once, but the MCU receives several phantom pushes. To correct this, a de-bouncing method is used, that incorporates a small delay that disables the button to avoid the processor receiving multiple button pushes.

D.LCD Display

The LCD display will have several different types of messages printed to the screen. The first screen displayed is the Welcome Screen. Centered on the first row, the display shows "WELCOME!". On the third row, the display shows "Press Mode". Because the buttons do not have individual LEDs, the display will show the mode and difficulty selection on the screen, as the user presses the buttons to cycle through the options. Once the user has selected a mode, the LCD prints the difficulty options on the second line. Lastly, once the user has selected a difficulty, the LCD will print "Get Ready!" on the fourth line. At the end of the session, the LCD will display the results for each mode.

E. Communications with Base

The base and the UI system will need to communicate in order to send the user inputs to the base and send the results back to the user. To do this, the MCU in the base and the UI system will require a transceiver. The transceiver is connected to the MCU with four wires, for power, ground, serial data and serial clock. The transceivers used are the XBee chips which use the IEEE standard 802.15.4 for creating the wireless personal area network (WPAN). The XBee transceiver chips are used to support the frame handling, buffering, and transmission. The chip contains the zstack software called Zigbee to configure/maintain the communications between the two devices on the WPAN.

F. Base System

When the base system receives power, the MCU initializes its devices (communication, LEDs and Sensors) and then enters low power mode. Once the base system receives the user's mode selection and difficulty selection from the UI system, the base system will enable its LEDs to cycle through a color sequence. This is to indicate to the user that the base system is about to start the mode. The base MCU will then load the premade sequences based on the mode selected. The base system cannot enter low power modes here, as the processor is actively turning on/off target indicators and capturing sensor data from the target areas that are light up. Once the main sequence timer ends, the processor can begin to compile the data into the results which are provided to the user, and then sends the results to the UI system and returns to low power mode.

IX. FUNCTIONAL MODES

A. CARDIO MODE (SIDE B)

This mode would have the user punch the target as quickly as they can aiming to increase their heart rate. By changing the difficulty, it increases the duration of the mode.

TABLE I
DIFFICULTY VALUES OF CARDIO MODE

Difficulty	Duration
Easy	30 seconds
Medium	45 seconds
Hard	60 seconds

B. Reaction Mode (Side B)

Reaction mode would have the user hit the target as soon as possible after they see the LED signal on. By changing the difficulty, it changes the interval of the random time between the target is chosen from.

TABLE II
DIFFICULTY VALUES OF REACTION MODE

Difficulty	Interval (Random time between…)
Easy	2-3 seconds
Medium	1-3 seconds
Hard	0.5 – 3 seconds

C. Accuracy Mode (Side B)

The purpose of this mode will have the user to hit the target close to the center. By changing the difficulty, the accurate radius decreases.

TABLE III
DIFFICULTY VALUES OF ACCURACY MODE

Difficulty	Accurate Distance
Easy	Within 3 inches
Medium	Within 2 inches
Hard	Within 1 inch

D. Combination Mode (Side A)

The combination mode indicates one of the four targets at random and allows the user a certain amount of time to react to hit the correct zone. By changing the difficulty, it changes the interval of the time that the user has to hit the correct target.

TABLE IV
DIFFICULTY VALUES OF COMBINATION MODE

Difficulty	Interval
Easy	7 seconds
Medium	5 seconds
Hard	3 second

E. Ambient Mode (All Sides)

The option to add a display mode is also open, and would add a fun, homely touch to this device intended for home workouts. This option is not necessary, but it may help the marketability of the product to consumers who may be on the fence regarding whether such an item belongs in their place of living.

X. TESTING BASE SYSTEM

A. Sensors

The sensors were tested individually to see how much current would go through the electrical circuit. A 220 Ω resistor was placed after the sensor to protect the PCB from having too much current. Then, a threshold, using a 5 V input, was chosen to be at 3 V to have anything above it as a hit and anything below is not considered a hit.

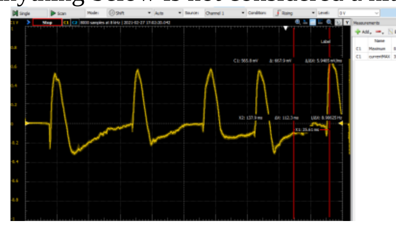

Fig 3. The sensor's behavior after five quick hits

B. Indicators

Indicators were tested by turning them on, and the best voltage level for proper function of the indicators was 12 V since it is enough power to display all colors accurately, with high output intensity. The intensity is adjustable within the software if the lights are too bright once connected to the full 12 V input.

XI. TESTING UI SYSTEM

The UI system will be tested by executing each mode and each difficulty setting, verifying each message is displayed correctly. In addition to testing its functions, the UI system will also be tested to make sure the user is unable to "break" the code, which could result in unreliable behavior.

XII. FUNCTION ANALYSIS AND DEVELOPMENT

The software in the UI and base systems will depend on the creation and implementation of several functions and interrupt service routines that interact with each other. From a high-level viewpoint, the program will remain in a loop, waiting for instructions. The instructions are provided from the user input, which can either be a push of a button or when a sensor detects a user's hit. Within the functions that respond to the user input, several other functions will be called indirectly, depending on specific status registers which indicate which state/mode the program is in. For example, within the button interrupt service routines, multiple functions need to be indirectly called to display information on the display, and to communicate with the base. In addition, several more functions are required to initialize both the base and UI system before receiving any user inputs, displaying any information or any communication, as well as functions to handle moving the system into a low power mode which also depends on the state of the program. The next several sections review the information related to the design and development of the needed functions.

A. LCD Configuration

The type of LCD used will be the HD44780 that has 4 display rows. The LCD is able to be configured using the register select pin (Rs). When Rs is low (logic 0), the LCD chip interprets the data lines (D0 - D7) as control commands, whereas when Rs is high (logic 1), the LCD chip interprets the data lines as display data.

B. XBEE Configuration

The base system and UI system communicate using the IEEE 802.15.4 protocol. Both MCUs (in the base and the UI system) will be connected to a XBee device. The two XBee chips communicate over a wireless personal area network (WPAN). The WPAN must be configured in each XBee before they can be used in the system. Unlike the LCD, the XBee chips are configured with another software program called XCTU, which allows WPAN ID's to be set up.

C. MCU and XBEE Communication

Because the MCU and the XBee use UART to communicate, the MCU will need to divert two pins that support the eUSCI communication. Therefore, a function for diverting those pins and configuring the two-word control registers will need to be called before any communication can happen between the XBee and the MCU. In addition, the receive and transmit interrupt vectors will also need to be configured, which allows the MCU to transmit/receive the data stored in the transmit/receive buffers.

D. Buttons Configuration

The buttons on the UI device and at the bottom of the base are used as the user inputs. When each button is pressed, an ISR is called to handle the specific action that must be completed. The button ISRs are using the majority of the created functions to perform the necessary actions, such as updating a specific register, writing data to the LCD, or initiating serial communication to XBee. Depending on which pins are used as button inputs, the corresponding port vector will be used to handle the ISR. Several pins shar a port vector, therefore each time the ISR is called, the program must check which pin had raised an interrupt flag.

E. Timer Configuration And ISR

The UI and base system implement timers. In the UI system, a failsafe timer is used and in the base system a failsafe timer and various mode function timers are used. Because our design is dependent on receiving inputs from the user to proceed in the next step in the program, failsafe timers can be implemented to either move on to the next sequence (in the base system) or turn the system off (in the UI system).

F. General Mode Functions 0-4

When the base has waited enough time to start the mode sequence, the mode function (dependent on the mode select register) is called. The mode functions each begin by starting the first timer, which controls the total length of the session. Depending on the mode, the first timer can be fixed, or variable (dependent on the difficulty select register). Next, the sensor and LED configuration functions are called. the second timer is configured and started. The rest of the mode function is controlled by interacting the timer ISR's and sensor readings to move through the session. The session ends when the first timer's ISR is called, which turns the LEDs and sensors off and continues to the results sections.

G. LED Use in Modes

The LEDs used to outline the target areas are controlled by the WS2811 driver. The driver is connected to the MCU over SPI to control the LED group, the LED brightness and the LED color. The color is controlled by sending 24 bits of BRG values (255,255,255). The brightness is controlled with 8 bits (255) and the LEDs are grouped into 3 (3 LEDs per group). During the mode function, these are the values that will be controlled to either turn on a target area or turn off a target area.

H. Sensor Use in Modes

The sensors are connected to the analog ports of the MCU to read the voltage across the sensor. As a user hits a target zone, the voltage across the sensor increases as contact between the two pads increases. As the voltage rises above a set threshold, a series of loops are used to determine when the voltage returns back to its original state. This is also used to eliminate false "hits" as the analog pins can return errors, such as returning a value of zero or very low voltage for a brief moment.

XIII. RESULTS CALCULATION FUNCTION

A. Combination Generator Results

The combination generator mode has three results, which are the number of hits, the number of targets, and the hit ratio. The number of hits is found incrementing a hit register after the sensor voltage is detected to increase and then decrease, while the number of targets is increased each time a new target is displayed. Lastly, the hit ratio is found by dividing the hits by the targets.

B. Reaction Time Results

The reaction time mode has four results, which are the number of total hits, the average time per hit, the shortest hit time and the longest hit time. The number of hits is found the same way as in the combination generator mode. As the user hits the sensor, the time it takes from the user seeing the indicator to when the user hits the sensor is recorded in an array. The smallest value in this array is the shortest time, where the largest value is the longest time. The average time is found by summing each value in the array and dividing it by the number of hits (size of array).

C. Cardio Mode Results

In the cardio mode, the three results are the number of hits, total time, average time per hit and hits per second. The number of hits the same way as the last two modes. The time is found by displaying the length of the session, which is a hard coded value. Next, the average time per hit is found by dividing the total time by the number of hits, and the hits per second is found by taking the inverse of the average time per hit (hits divided by total time).

D. Accuracy Mode Results

In the accuracy mode, the four results are the number of accurate hits, the number of targets displayed, the accuracy rate and average time per hit. Depending on the difficulty level, the accurate hit is counted if the hit occurs inside defined zones. The number of targets is found by incrementing a register each time a new target is displayed. The accuracy rate is found by dividing the number of accurate hits by the number of total targets. Lastly, each time the user hits a target, the time it takes for the user to hit since the indicator was enabled is stored in an array. The average of this array is the average time per hit result.

XIV. PRINTED CIRCUIT BOARDS

Since there are two main components of this device that each require their own printed circuit boards (PCB). These PCBs will each hold one microcontroller, as well as sufficient connection pins for all power, sensor, and indicator inputs and outputs. The PCBs will also incorporate DC/DC converter circuits and an oscillator. The base system will house one of the PCBs on top of the bag, as this is the location on the bag least likely to get damaged by a hit. The UI system handheld component will house the second PCB.

A. *Base System Design*

A summary of the connections in the base system device are seen below. They will be detailed throughout this section. There are 13 points of interests between sides A and B: (1-4) Individual Pressure Sensor 1-4, (5) Zigbee Module, (6) Power Supply and Conversion, (7) MCU, (8-11) LED strips, (12) Pressure Sensor grid, and (13) LED strip circle.

B. UI Handheld System Design

There are several points of interest and function on the remote used to power on and control the device. There are a total of 9 points of interest labeled on the diagram. They include: (1) MCU, (2) Zigbee Module, (3-6) Buttons 1-4, (7) LCD Module, (8) ON/OFF switch, and (9) Power Supply

C. Prototype and Preliminary Testing

Before any PCBs are assembled, it is extremely important to make sure all of the circuits work properly in the prototyping phase. Prototyping circuits involves using a breadboard to ensure that both the ICs and the passive circuit components are arranged in a way that ensures smooth functioning. Prototyping should begin by testing the ICs to make sure that each chip works properly. This is essential to learn which chips are DOA, so they can be discarded. After the chips are verified, the next step is to verify that the circuits in the schematic perform the proper functions when tested on the breadboard. Final design for the PCB will be outlined during this prototyping phase as there is a large chance some circuits will have to be altered from the schematics.

Power components should be tested to ensure the specified power is being delivered. Specifically, the battery pack and converters should be checked for proper conversion and generation. This can be done just by measuring the output voltage of the converters on the breadboard using a multimeter. This same method should be used to measure the output voltage from the battery pack. The output voltage should be 6V. The converters should only be mounted once successful conversion is recorded in testing.

XV. PROTOTYPE

The prototype was settled after the testing of all the components and modes of the device was done. It was also covered with a red fake leather to match the previous color. The sensors were attached in the bag using pins and all the cables were rerouted to have all the cables organized in certain areas of the bag only. This device shows that it motivates other people to improve their scores in each mode that they tried , and it also increases their heart rate.

XVI. CITING PREVIOUS WORK

The idea of a dynamic interactive punching bag has existed for a while. The first time it was patented, a device like the one we are designing was back in 2010 [1] in which a patent was submitted for a martial arts bag with one or more sensors for measuring a workout performance.

We also found two research articles from the Czech Republic in which they used [2]and [3] In which, both measure a direct punch applied to a martial arts bag using strain gauges inside of the martial arts bag. In regard to the type of strain gauge used, both [2] and [3] use a strain gauge type SRK-3/V , and in [3] also uses a strain gauge L6E-C3-300Kg in their measurements. It was found interesting since in [3] came to the conclusion that L6E-C3-300Kg strain gauge has a better precision, speed, and simpler to use than the strain gauge type SRK-3/V, but in [3] that was made with the same people used the latter instead to further intensify the research about measurement direct punch force.

PADIPATA™ created an interactive punching bag, with all its sensors in the middle of the punching bag and it only leaves the user to use punching instead of using the user's legs as well. This device comes in 3 sizes but is only available in the form of a hanging bag as opposed to a self-standing bag with a base on the ground, the design which our group has chosen. It also has surround sound with an interactive screen inside of the band. This product was created in Changsha City, People's Republic of China and retails for a price of $25,000 (USD); our intent is to create a device that is much lower in cost than that, so that it is accessible to a wider audience than the PADIPATA™ bag.

XVII. CONCLUSION

The biggest goal and hope that we were set to achieve is that getting into fitness should not be expensive and to expand the limited variety in the current market. Fitness equipment should allow the user to be more interactive with the product and should make their interaction with the equipment worthwhile, especially now that everyone is in their homes and unable to go to gyms due to COVID-19. Everyone should be able to have fun while working out in the commodity of their homes at a reasonable price.

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