Interactive Self-Standing Training Bag

University of Central Florida

Department of Engineering and Computer Science

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EEL4914: Senior Design I

Initial Project and Group Identification Document

(Divide and Conquer 1.0)

Group 22

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Introduction: Project Statement/Narrative

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. Our motivation behind this project stems from the idea of creating an easy yet engaging way for a trainee of any level, to exercise, train, and track their progress in various perspectives of fight training without the need for a training partner. The Coronavirus pandemic has made this even more relevant since most training locations closed for an extended time, leaving many people without a method or physical partner to train at home with.

Another aspect of our project is that our design will be at a lower cost to those on the market, which can do some, but not all, of the actions as our interactive design. Currently on the market, interactive standup punching bags usually sell for about $25,000. Because our design can provide feedback/results after a session as well as provide interesting/fun workout patterns, the user can practice their skills in an engaging manner without paying the $40 to $70 average hourly cost of a personal trainer. Additionally, our design can be used at home which saves the user the monthly cost of a gym membership necessary for the correct equipment: a cost that ranges from $10 to $100 per month.

In order to capture as many different aspects of training as possible, the bag will have a dual-sided design that accommodates various modes that the user can train with. “Side A” will have various zones with binary touch sensors that will detect whether a certain area was hit. These zones will be loosely based on different practical locations that a fighter would be making contact with in a boxing, kickboxing, or martial arts environment against a real opponent, so that the user can have the most immersive and accurate training possible. On “Side A”, the device should be able to generate random sequences of techniques landing in various areas; this can be extended to using multi-color indicators to signal which side or technique type should be used to attack the opponent. “Side B” will contain a target zone with a sensor/cluster of multiple sensors arranged within this target so that more focused training can also take place and create a complete, rounded training session. These sensors will gather data on the training session and report it back to the user so that the user can quantify their performance in different types of workouts and track their progress. Some modes that can be implemented by “Side B” include a cardio mode where users try to make as many hits as possible within a time limit, a reaction mode where users aim to land their hits based on a stimulus by the indicator, and an accuracy mode where the user practices hitting a specific area as precisely as possible.

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 precision, 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.

Technical Requirements

General – All

This device should be able to:

- Implement downtime modes
  - Idle Mode
  - Display Mode
  - Off Mode
- Implement exercise modes
  - Combination Generator (Side A)
    - Uses set zones on opponent
    - Binary sensors count correct hits and save data for user
    - Practice training against an "opponent" to improve the user's skill
  - Cardio Mode (Side B)
    - Uses sensor target to count hits
    - User goal: make as many hits as possible in a certain time period
    - more hits = higher score
  - Reaction Mode (Side B)
    - Uses sensor to detect time for user to hit target after illuminating indicator
    - User goal: hit target as soon as possible after it lights up
  - Accuracy Mode (Side B)
    - Uses sensor to detect how close to center mark target is hit
    - User goal: hit center as accurately as possible to increase score

Sensors (Nicole)

Sensors used in this device should:

- Be durable enough to withstand the force of a punch/kick.
- Be able to detect distinct, rapid, successive hits in the same location (Side B), or in different locations (Side A).
- Be able to detect the location of a hit relative to a target point (Side B).
- Consume a low amount of power.
- Cover a zone with no more than four individual sensor units.

Indicators (Natesha)

The indicators used on this device should:

- Produce light with high enough intensity to be visible behind a translucent cover.
- Require no more than 12V to be powered.
- Be compatible with the processor or microcontroller.
- Be durable enough to withstand repeated hits.
- Not emit excessive heat.

Processor & Memory (Joseph)

The processor used by the device should:

- Have sufficient input lines for all sensors and communication necessary.
- Have sufficient output lines for all indicators and communication necessary.
- Communicate with the UI system to provide raw data.
- Require internal ROM and RAM.
- Work with a volatile memory large enough to store data from multiple sensors.

UI System (Hannah)

The device's user interface should:

- Provide completed results to the user including number of total targets, number of total successful hits, total time per mode run, and average time per hit.
- Receive user inputs such as turn on/off, select mode, and select level of difficulty.
- Be capable of communication between itself and the base.

Programming (Hannah)

The programming implemented by this device should:

- Work with both the base system and the UI system.
- Incorporate receiving user inputs, communications, and computational mathematics.
- Include low power modes while the system waits for input.
- Utilize multiple timers to control the indicators and the sequence.
- Detect when a sensor registers a hit and continue the sequence.

Power Supply (Joseph)

The device's power supply should:

- Connect to a standard US AC 110-120V input.
- Use an AC-DC voltage converter (such as a 20V 60Hz AC to 12V DC converter) to provide power to the system's DC components.
- Provide AC voltage of the expected magnitude to any components that require an AC input.

Project Diagrams

Mode Software Flowchart

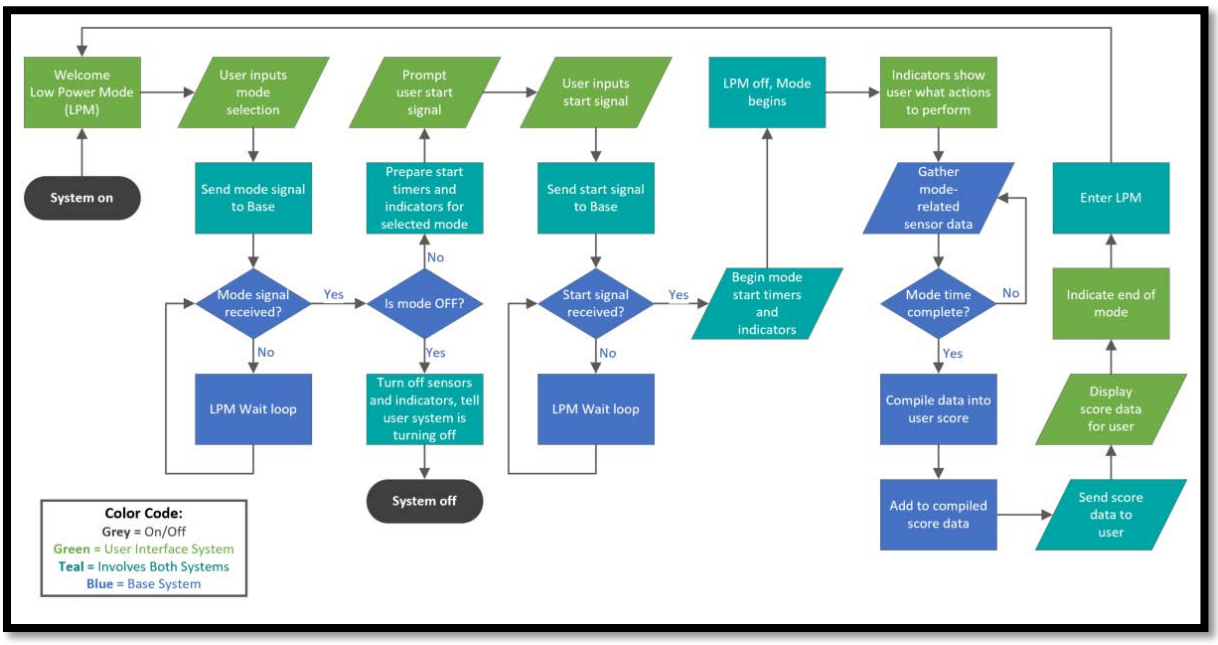

Image 1: Potential Software Flow Diagram

Hardware Block Diagram

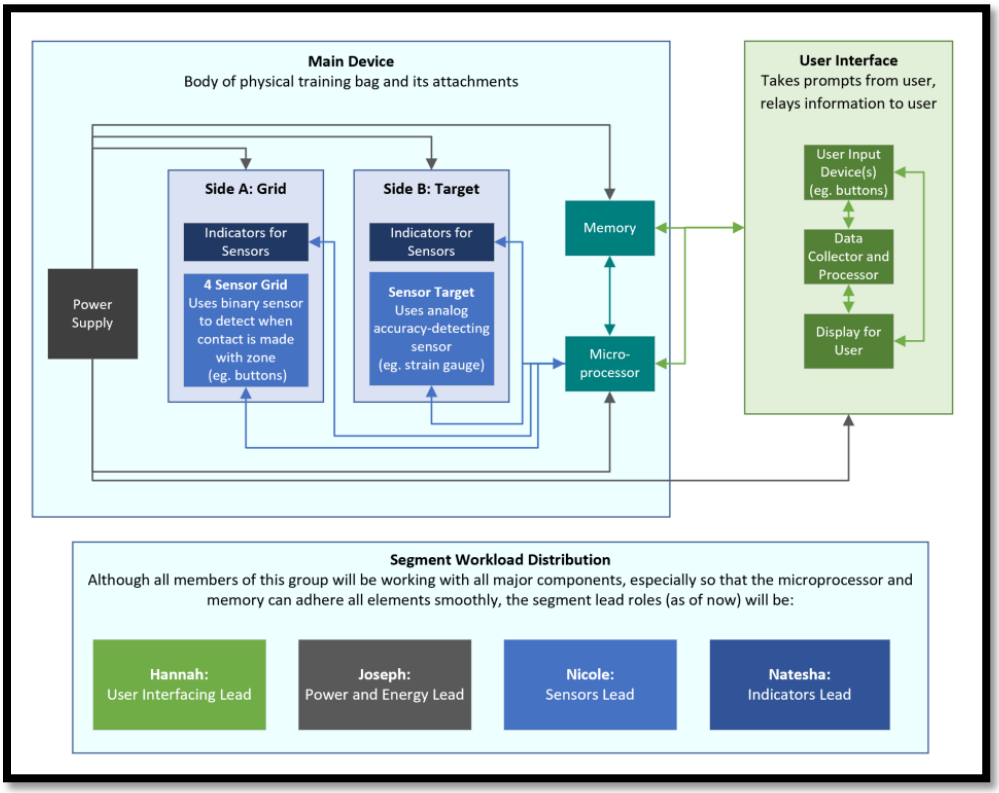

Image 2: Hardware connection block diagram; description of current distribution of group roles

Prototype Concept Illustrations

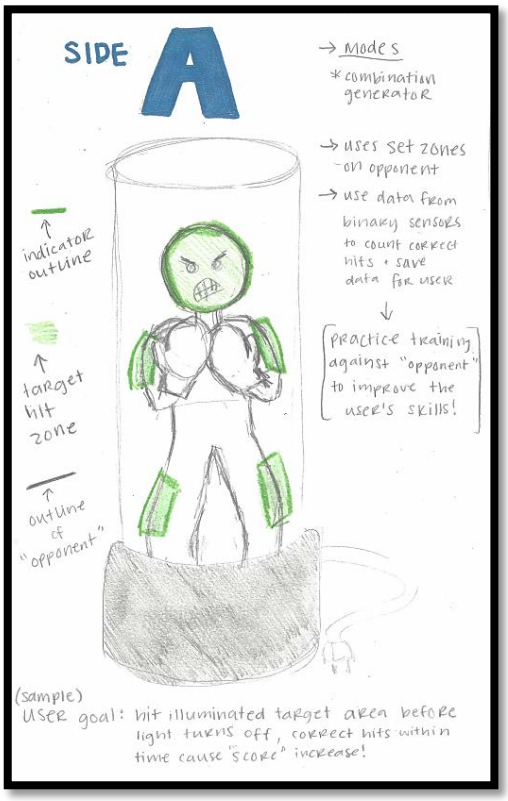

Image 3 (Left): "Side A" of the device

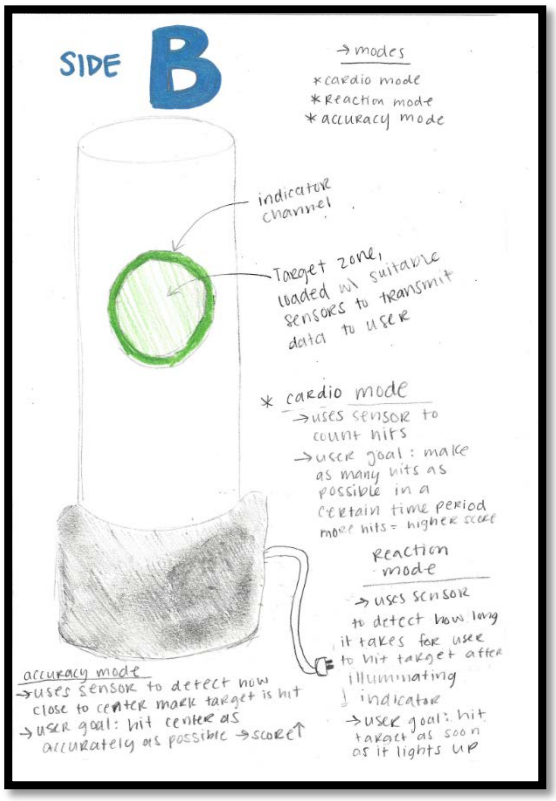

Image 4 (Right): "Side B" of the device

Note: the descriptions of modes in these diagrams are available to be read in the General Specifications section on page 2.

Design Considerations and Decisions

Initial Milestones and Timing for Senior Design 1 and 2

Components: Decide Processor, Sensors, Indicators, UI System

The prototype should be done by the end of December, and the prototype UI System should be finished by the end of January, to give us enough time to debug the project, and move our components over to the final design. Temperature sensors are optional to the very end to measure the temperature of the sensor grid and to make sure it is not overheating.

Construction: Complete Sensor Grid (Side A) and Target (Side B)

This project will need multiple areas with sensors, so these will need to be completed as soon as possible to be able to incorporate the electrical components, indicators, and the software which depend on the sensors. The deadline for the first sensor grid prototype is beginning of January, and the other three are no later than the end of January.

Final Touches: PCB and Interface Completion

The PCB components should be completed no later than the beginning of March. This will give us time to finalize the project and be sure that all modes that are included are functioning as intended. Once this has been verified, we would like to begin working on additions that will make this device something that will be worth the cost for a customer. One possibility of this is making an extra display on the body of the bag to interface with the user and add another element of interactivity. This will be challenging due to the frequent impacts the bag will face that could damage the screen, but it would allow more elements to be added to diversify the training possibilities from this device alone.

Group Member Familiarity With The Project Elements

- Hannah is familiar with software since she works in a company with software engineers. She also likes writing code and programming in her free time.
- Joseph is familiar with processors and microcontrollers. He has knowledge of the process of ensuring a system is powered sufficiently.
- Nicole took an in-depth sensors class, so she is familiar with various types of sensors that we could use for this project.
- In addition to knowledge of typical electrical engineering curriculum, Natesha has many years of experience with and regularly uses a self-standing kicking bag since she is a fourth-degree black belt in karate and works as a sensei in her dojo.

With the group's combination of knowledge of electrical engineering principles and real-world experience with all aspects of this project, we should be able to successfully create and develop this device.

Project Challenges

Most challenges that our group will be facing are a result of the CoVID-19 pandemic that we are currently living through. Due to social distancing, we will need to work on our sections separately; as of now we will not be able to get together unless it is to test the device. As of now we are doing most of our meetings and communication via Discord, but once sensor/indicator testing begins, we will likely face difficulty in being sure everyone has what they need to individually test components.

In general, being able to optimize the parts used to cater to all specifications as well as being low cost, accessible, and realistic for the scope of this design prototype will be a challenge. The pandemic has also slowed electrical component production around the world, meaning that we will have to be sure about our designs before ordering many items and begin attaining and assembling components as soon as possible in attempts to avoid roadblocks.

One non-pandemic related obstacle is the size and scale of this project. A self-standing training bag is a large and heavy piece of boxing equipment, so this component should be in a location accessible to all members with sufficient space to work on device assembly and construction.

Budget and Financing

Our group will self-fund this project. We are budgeting to contribute a maximum of $500 USD, divided equally among our teammates. As of now, no equipment aside from standard circuit components (eg. wires, resistors) has been acquired. All parts of this project must be attained at some later point. Table 1 below depicts estimated costs of each component.

The individual component that would cost the most money is a self-standing kicking bag since it is a big and technical instrument aimed at people who are experienced in this area. However, finding a used bag will lower the cost of this item, and will not make a difference in the quality of the bag as it will need to be changed to incorporate our components regardless of its condition.

Although sensors are generally inexpensive, we would need enough components to detect contact in the large target area so that the device can test accuracy in addition multiple sensors to detect contact in a binary “hit or no hit” manner in all areas of the sensor grid.

Component	Price (USD)	Quantity	Total (USD)
Sensors	$0.4 to $5.00	20	$6.40 to $100.00
Processor	$10.00 to $15.00	2	$20.00 to $30.00
RAM	$50.00	2	$100.00
Miscellaneous Buttons	$1.00 to $5.00	4	$4.00 to $20.00
Standup Punching Bag	$130.00	1	$130.00
Indicators	$10.00 to $30.00	1	$10.00 to $30.00
AC to DC converter	$2.36 to $20.00	1	$2.36 to $20.00
Miscellaneous Hardware	$20.00 to $30.00	n/a	$20.00 to $30.00
Total			$292.76 to $430.00

Table 1: Expected costs for this project