ECE 445
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Project Proposal

Pacer Runner

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1. Introduction

1.1 Problem

Beginner runners know how difficult it is to keep a constant pace during a long run. Using a smartwatch or a smartphone, they can measure their pace and heart rate. However, an issue associated with these devices is that the runner doesn't receive any feedback until their training has ended, resulting in the runner not having any convenient way to maintain their pace throughout the run. Thus, they need a solution which can provide them with feedback instantly.

1.2 Solution

The solution involves a laser device that will be worn by the runner on their chest which would be capable of tracking their pace and giving real-time feedback on their performance. To do this, we seek to design a line laser device that changes the projection angle depending on whether the runner's pace is too fast, too slow or ideal. Thus, the pointer will move further if the runner decreases their pace and closer when they increase it.

1.3 Visual Aid

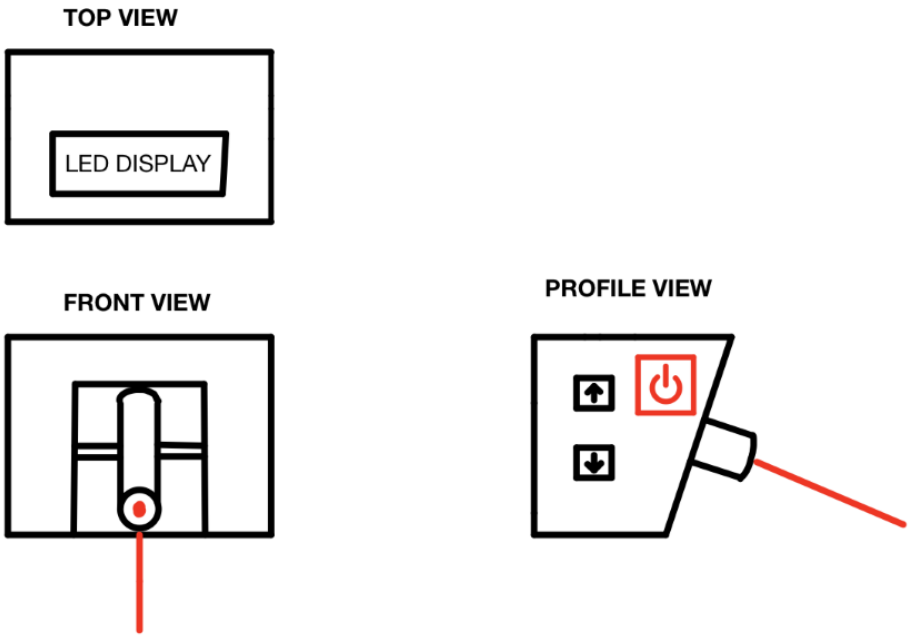

Figure 1: Orthographic Projection

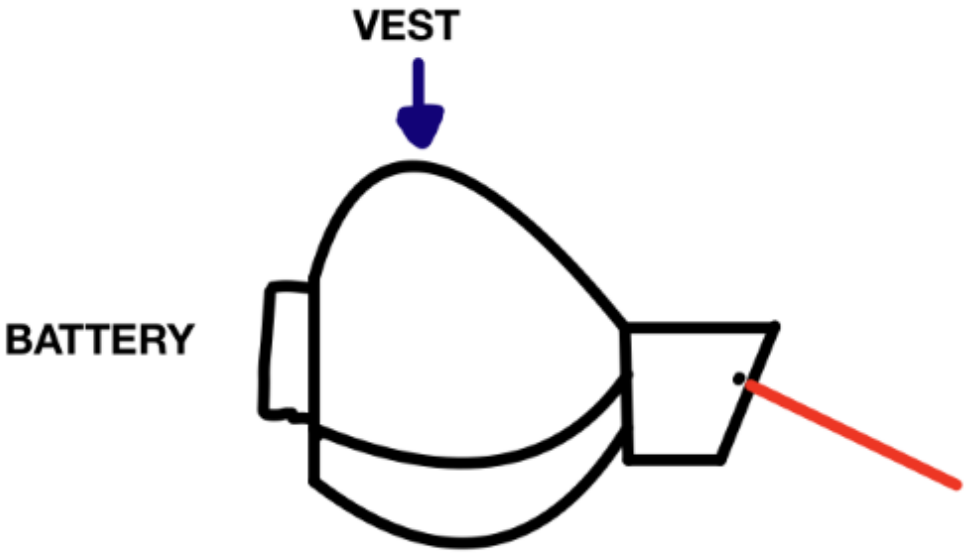

Figure 2: Vest Design

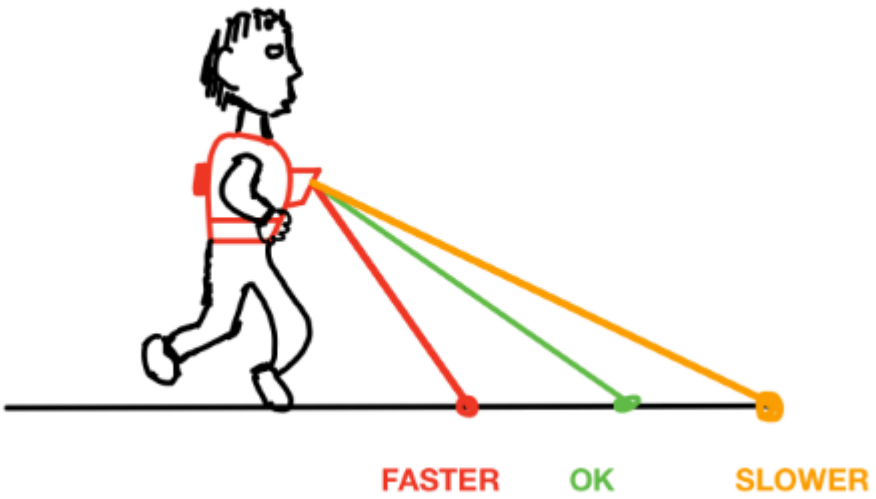

Figure 3: Working Illustration

1.4 High Level Requirements

- The servo-motor changes the angle of the laser in response to the runner's change in pace. There will be three possible positions: slower than target pace, at target pace, faster than target pace.

- The GPS module will calculate the runner's pace up to a 70% accuracy. (*See 2.3 Tolerance Analysis*)
- The physical input buttons change the target pace, and the LED display output will reflect these changes.

2. Design

2.1 Block Diagram

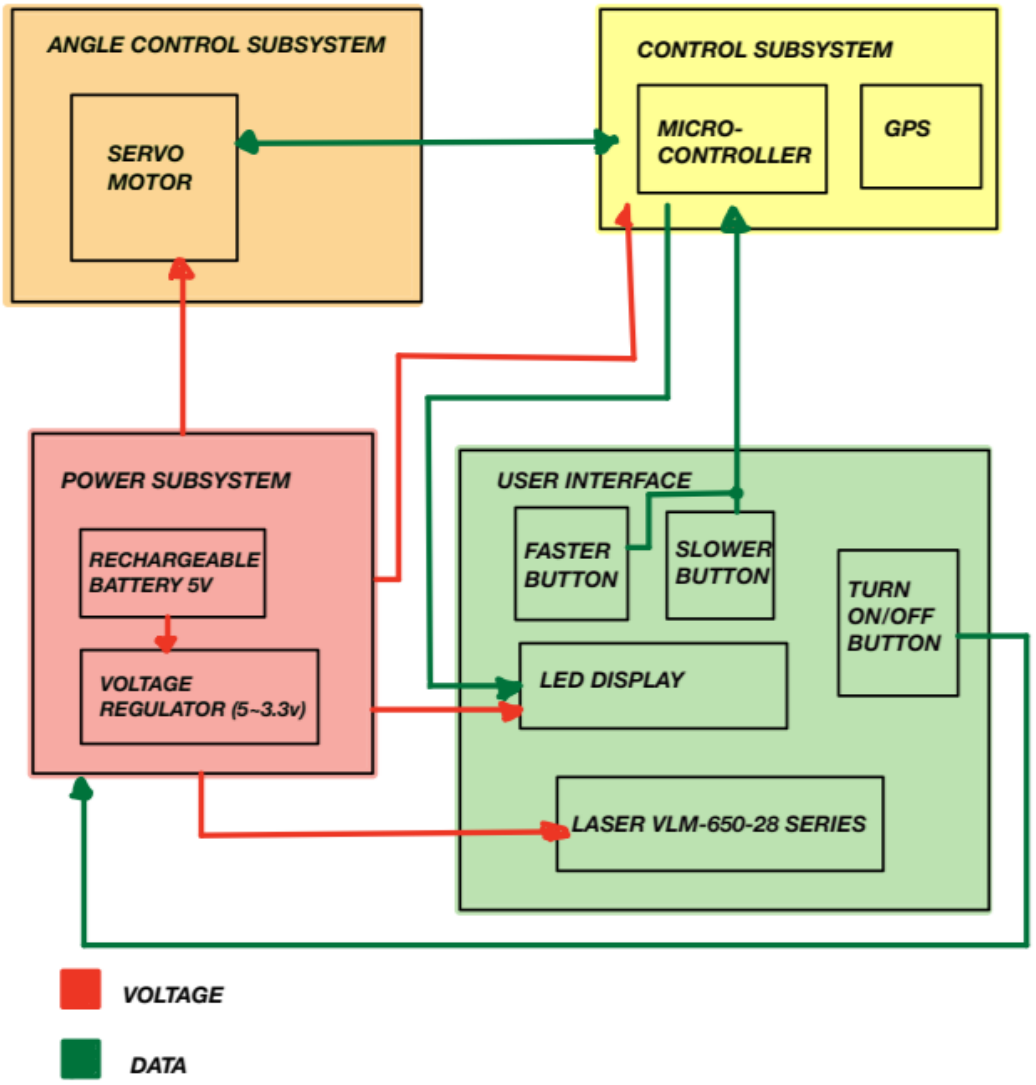

Figure 4: Block Diagram

2.2 Subsystem Overview

2.2.1 Power

Overview:
We require a rechargeable battery (5 V) which can power the laser, motor, microcontroller, and LED display. We also may require a voltage regulator which can

step down this battery's voltage to whatever voltage is required for certain components (e.g. 3.3 V).

- It is rechargeable and can power all components for at least one hour (e.g. > 100 mAh).
- Since our device needs to be worn by the runner, the subsystem is relatively light (< 150 g).
- This subsystem does not overheat to the point it is uncomfortable to wear.

Requirements:

- Finally, the voltage regulator can successfully step down the voltage to 3.3 V.

2.2.2 Angle Control

Overview:
This subsystem includes a servo-motor which will adjust the angle at which the line laser is projected onto the ground. Our initial estimate of this component is HS-311 Standard.

Requirements:

- We can mount and easily rotate our line laser onto this motor.
- It can rotate at least 60 degrees.
- The motor rotates based on a data input from the microcontroller.

2.2.3 Control

Overview:
This subsystem includes a microcontroller, along with a GPS module. This is the main brain of the project.

Requirements:

- The microcontroller that we use is compatible with all our other components such as the LED display, the buttons, the motor.
- The GPS module can track the user with a high success rate of 90%, and with this data, the calculation of the runner's pace must be accurate up to 70%.
- We can calculate the user's pace on the microcontroller through code.

2.2.4 User Interface:

Overview:
This subsystem includes all the user facing components such as:

- The LED two digit display which displays the current target pace
- Three buttons: Increase Pace, Decrease Pace, Turn On/Off
- The line laser which is used to project in front of the user (VLM-650-28)

Requirements:

- The LED display correctly display the current target pace

- The pace increase/decrease buttons modify the target pace
- The turn on/off button works perfectly
- The line laser is visible in ideal laboratory conditions

2.3 Tolerance Analysis

For this project, the component which poses the highest risk of failure is the GPS system. This project requires that the GPS module can be used to successfully compute the runner's pace at any given moment. However knowing the current limitations of a GPS module (i.e. **within 4.9 m**)[1], we will only be able to calculate the runner's location every ~5 m.

Now let us make some assumptions to calculate how to navigate this limitation.

$$\text{Average speed of runner} \geq 2 \text{ m/s}$$
$$\text{GPS location updates every } 5 \text{ m}$$
$$\text{Time between GPS updates} \leq 5/2 = 2.5 \text{ s}$$
$$\text{So we need to update our laser's position every } 3 \text{ s}$$

By moving to this non-instantaneous approach, we can navigate this issue in a practical manner. It is also more reasonable for the project overall, since we need not concern ourselves about overloading the motor in constant changes.

Another consideration regarding the GPS is how long it takes the module to ping off a satellite and be available to use. Based on this GPS module datasheet, the hot/cold starts can take anywhere from *1s - 32s*, which means our project will require at least **45s** after turning on before it can be used.[2] This is something we need to consider, but a 45s start time is **not impractical**.

3. Ethics and Safety

3.1 Ethics

One specific ethical issue to consider is the collection of the runner's GPS data. We need to make sure that this data is not distributed, nor used in any manner outside of the runner's knowledge.

More generally, we need to make sure we follow the ACM and IEEE code of ethics to the best of our ability. [3][4]

Because our project involves working with teammates in the ECEB senior design lab, we need to make sure we follow all the lab's safety guidelines. Additionally, we must properly use and maintain all the lab equipment.

Since this project will include software components, care is needed to properly credit all the resources we utilize.

3.2 Safety

Our project utilizes a laser which is potentially dangerous to the human eye, thus we must make sure that we do not use a laser which is unsafe outside laboratory conditions. Additionally, we must add some safety constraints to properly shut down the component in case of any harmful situations.

This project will also require us to design our own PCB, along with soldering, thus we must carefully follow all laboratory safety guidelines for our protection as well as that of others in the space.

4. References

[1] GPS Accuracy. "How accurate is GPS." GPS.gov. [Online]. https://www.gps.gov/systems/gps/performance/accuracy

[2] GPS Receiver Module. "Datasheet" linxtechnologies.com. [Online] https://linxtechnologies.com/wp/wp-content/uploads/rxm-gps-rm.pdf

[3] "ACM Code of Ethics and Professional Conduct." ACM.org. [Online]. Available: https://www.acm.org/code-of-ethics.

[4] IEEE Board of Directors. "IEEE Code of Ethics." IEEE Code of Policies, Section 7 - Professional Activities (Part A - IEEE Policies). [Online]. June 2020. https://www.ieee.org/about/corporate/governance/p7-8.html.