ECE 445
Spring 2022
Pacer Racer
(Previously Pace Maker for Running)

Project Proposal

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1. Introduction

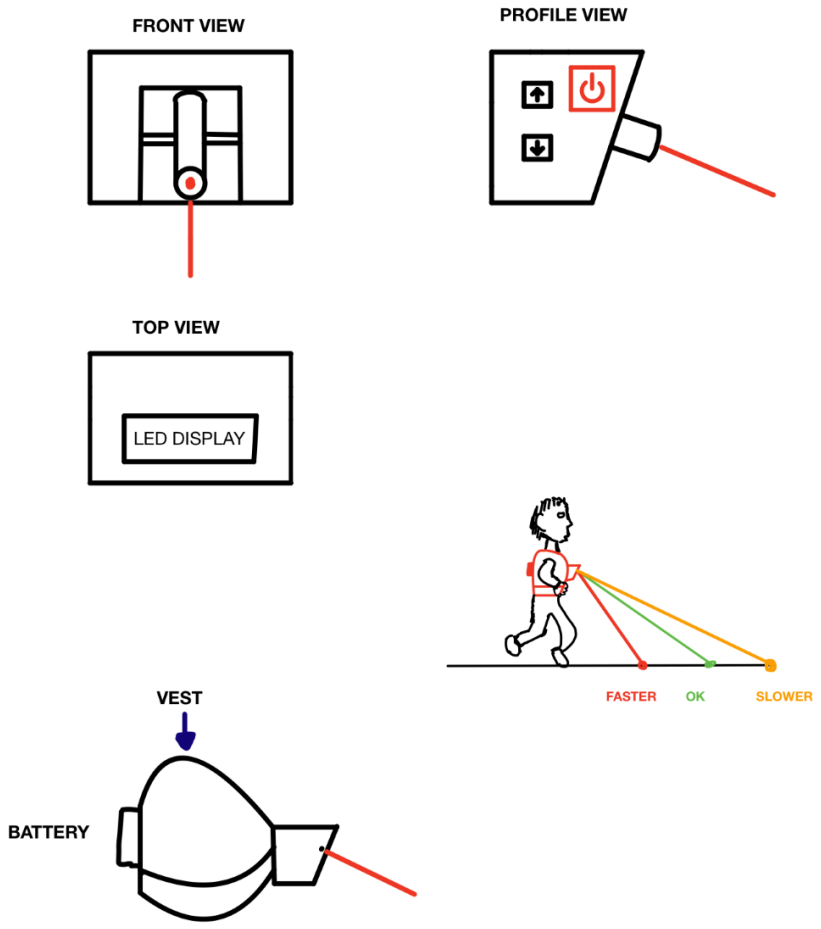
1.1 Problem

If you are a beginner runner you will know how difficult it is to keep a constant pace during a long run. You have some ways to measure your pace like an AppleWatch or a smartphone, they give you information about your pace and your heart rate. The only problem with this is that you don't have any feedback until your training has ended, resulting in no real way to maintain your pace throughout the run. You need instant feedback on your pace to achieve your goals.

1.2 Solution

The solution is designing and building a laser device that you will wear on your chest, capable of tracking your pace and giving you real-time feedback on your performance. To do this, we should design a laser device that changes colour depending on if your pace is too fast, too slow or you are keeping the ideal pace. Furthermore, the pointer will move further if you decrease your pace or closer if you increase it.

1.3 Visual Aid

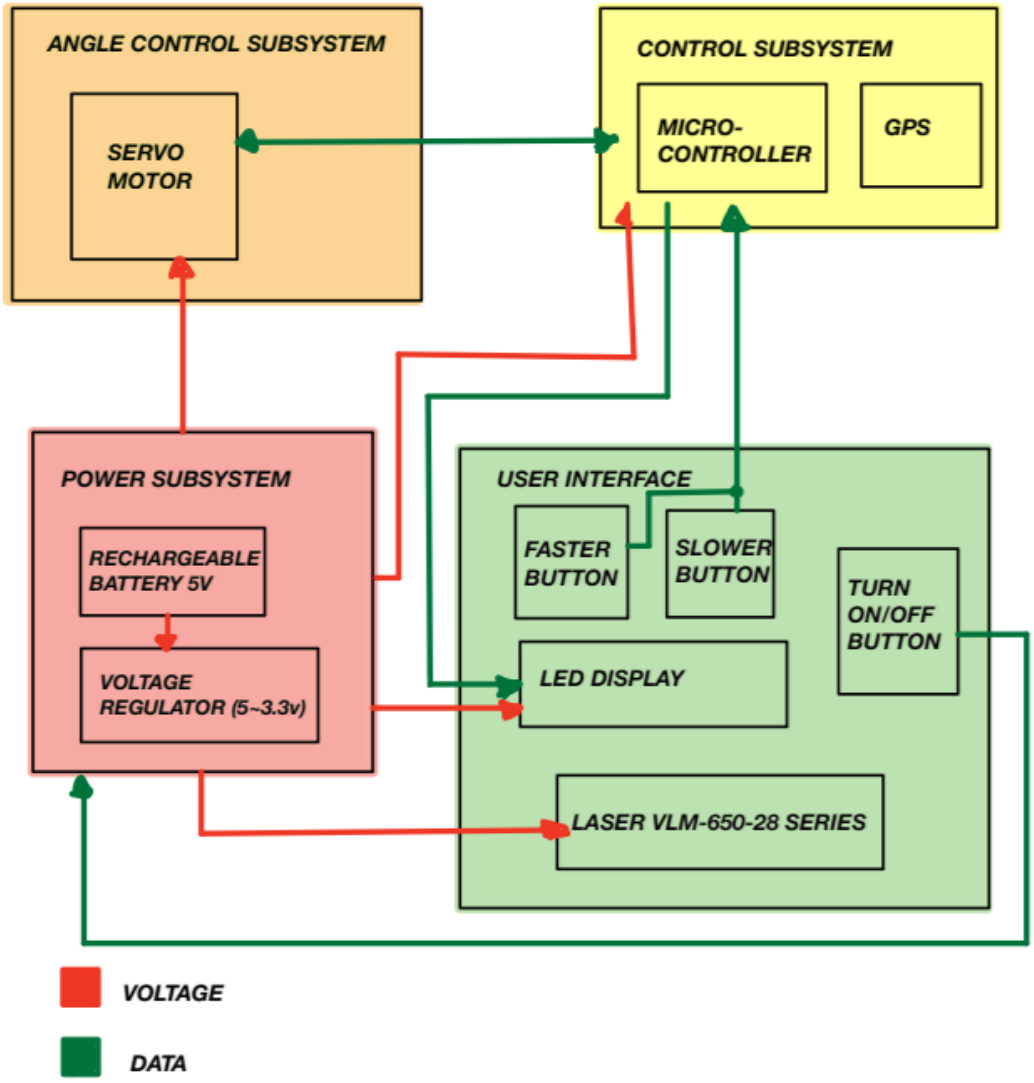


1.4 High Level Requirements

- The servo-motor changes the angle of the laser in response to the runner's change in pace. There will be 3 possible positions: slower than target pace, at target pace, faster than target pace.
- The GPS module is able to calculate the runner's pace up to a 70% accuracy. (*See 2.3 Tolerance Analysis*)
- The physical input buttons should change the target pace, and the LED display output should reflect these changes.

2. Design

2.1 Block Diagram



2.2 Subsystem Overview

Power:

Overview:

We require a rechargeable battery (5V) 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. 3.3V)

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

Requirements:

- Finally, the voltage regulator should be able to successfully step down the voltage to 3.3V

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 should be able to mount and easily rotate our line laser onto this motor
- It can rotate at least 60 degrees
- We should be able to rotate this motor based on a data input from the microcontroller

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 must be compatible with all our other components such as the LED display, the buttons, the motor
- The GPS module should be able to 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 should be able to write code to calculate the user's pace on the microcontroller

User Interface:

Overview:

This subsystem includes all the user facing components such as:

- The LED 2 digit display which displays the current target pace
- 3 buttons: Increase Pace, Decrease Pace, Turn On/Off
- The line laser which will be used to project in front of the user (VLM-650-28)

Requirements:

- The LED display should correctly display the current target pace
- The pace increase/decrease buttons must modify the target pace
- The turn on/off button must work perfectly
- The line laser should at least be 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 ~5m.

Now let us make some assumptions to calculate what must be done to navigate this limitation.

$$\text{Average Speed of Runner} \geq 2m/s$$
$$\text{GPS Location Updates every } 5m$$
$$\text{Time Between GPS updates} \leq 5/2 = 2.5s$$
$$\text{So we need to update our laser's position every 3s}$$

By moving to this non-instantaneous approach, we can navigate this issue in a practical manner. It's also more reasonable for the project overall, since we need not worry 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 ready for use. Based on this GPS module datasheet[2], 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. This is something we need to consider, but a 45s start time is **not impractical**.

1 https://www.gps.gov/systems/gps/performance/accuracy/#:~:text=within%20a%204.9%C2%A0m%20(16%C2%A0ft.)

2 Figure 4: https://linxtechnologies.com/wp/wp-content/uploads/rxm-gps-rm.pdf

3. Ethics and Safety

3.1 Ethics

One specific ethical issue we need to be mindful of 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 IEEE code of ethics to the best of our ability.

As we will be working with our 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, we must be careful to properly credit all the resources we utilise.

3.2 Safety

Our project utilises a laser which can be 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 fail safes 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 be careful to follow all laboratory safety guidelines for our protection as well as others in the space.