Initial Project and Group Identification Document Divide and Conquer

Portable Finish Line Data Capture System for Sprinters

Senior Design I

Group 30

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Potential Customer/Sponsor

At this particular time in our planning phase of our project, we have not had the opportunity to acquire any sponsors or significant contributors. As of right now we will fund this project ourselves unless a sponsor or other funding can be obtained at a later date.

Possible clients can be anyone who wants to monitor running times to show improvements in their speed. Not only is this just for individuals, but this device can be used in many sports during practice such as track, football, soccer, baseball, rugby and any other sport that requires speed.

The Problem

This device will be designed and created for track runners and anyone who wishes to improve their running speed by recording and collecting data in a short distant race. This gives the person the ability to see their improvements overtime and see what may or may not be working in their training sessions. The main problem is that when you want to see how fast you can possibly run, it can be very difficult to time yourself from start to finish and get an accurate time. You can ask a second person to time you but if you want to train at frequent intervals, that second person may not be available. There are already some automatic timers that use mats, rfid chips, photocell, and cameras but the main problem is that it's not aimed for the individual consumer, its aimed more for the professional teams and runners and because of this it can get very costly, ranging from a couple 100 dollars for a full system to a couple thousand dollars. Thus I propose to construct a device for individual consumers that is cheap, small, light and portable enough to take with you anywhere and setup takes only moments. According to SGMA, the U.S. sporting goods industry is $68.4 billion business (at wholesale), which is why I think developing this product as a consumer ready product will be a great investment in both time and money.

Device Description/Operation

The device will be equipped with some type of wireless communication that will be connected to an electronic portable device such as a phone that majority of the population already own. The portable finish line device will be placed at the desired finish line and the user will return to the start line where he/she will connect to the device via Wireless communication through the provided app that has been developed for this specific device. Once the runner/user is in position and ready to race they will place the phone on the floor next to them and press the start button on the phone. The device will wait for a random amount of time and emit a visual light as well as an audible tone letting the runner know to start running. Once the runner passes the device at the finish line the timer would stop and a visual and audible sound would engage letting the runner know the race has finished and the time has been recorded. The time of the runner would be sent from the portable finish line device to the app so that the runner can see their personal time and their improvements over the course of time.

Goals

The main goal is to provide the everyday consumer with a light weight, affordable, and portable product that can be taken anywhere. The device is aimed at single races for now. The device should be easy to set up and able to be used without the need of a second person to keep track of their own time.

Requirement Specifications: Electronics and Hardware

1. Sound and Speaker System: A speaker would be needed to alert the runner when to start running. In accordance to the NCAA, it will require at least 112 dB at 15 feet for audible tones. Given that college athletes would be a subgroup of customers; it would be best to meet this standard as it would also benefit with adapting the ear to that level of dB. The speaker size will have to be appropriate/ proportional to the size of the device and also meet the dB range noted above. The loudness/ quality of the sound will have to be analyzed with how much power (watts) it will take from the system. Simply stating, an increase in dB is an increase in watts, therefore the system will have to meet this need. In terms of battery power, a reasonable higher limit to dB would have to be at about 80-90 dB measured at 1 meter since as a portable device the voltage and thus the wattage would be limited.
2. Lights: Using an LED is the most feasible and durable lighting source for a visual start trigger. It should be bright enough to be visible even on an extremely sunny day. The most common LED lights used to signal the start of a race are red and green. Red is used to indicate to the runner that he races has not begun yet, while green indicates that the runner may leave the starting block (if using one) and that the race has started. The LED would have to be synched with the speaker so that as the LED turns green, there is a simultaneous starting noise.
3. The sensor would need to perform such that the microcontroller receives the message and also such that no outside interference results in miscalculations.
4. The device size does not really matter except for the need to be able to fit on a tripod. In this way, the height can be adjusted to work well with athletes of different sizes. It would also need to be somewhat durable enough to not overheat in hot external temperatures. The device must not overheat at a minimum of 100 degrees Celsius, in order for the device to function in varying climates.
5. The device should be able to connect to the app quickly and be ready to use on the spot with some user input on the app side. That being said, it would take less than 5-10 minutes to be ready to start the race.
6. The device should be no bigger than 1’2” * 1’2” * 1’2” for portability.
7. In terms of battery life, it would be useful to have the battery last for up to 3 hours. The battery life would be determined by overall power use. Using college athletes as a benchmark, track runners practice on average 2.5 hours a day. This doesn’t mean that the device would necessarily be on all the time.
8. The total weight of the controller and towers will weigh less than a total of 10 pounds.

Software Requirements

Microcontroller Requirements (Microcontroller programming, Fig. 1)

1. The microcontroller must communicate via Bluetooth/Wi-Fi at a frequency of 2.4 GHz with a mobile smartphone with Bluetooth/Wi-Fi capability running an Android Operating System.
2. The microcontroller must be able to receive interrupts and have Interrupt Service Routines written.
3. The microcontroller must be able to accurately count a real time seconds timer with the minimum precision of 0.1 of a second. (This is to meet "Timing Accuracy" in House of Quality (Table 1))
4. The microcontroller must have enough registers to handle computations for a velocity calculation. All calculations for timing will be computed on the microcontroller and sent to the application upon completion, this is to optimize timing accuracy (see House of Quality (Table 1))
5. The microcontroller must transmit calculated time and speed via Bluetooth/Wireless communication to the user's smartphone. The smartphone app should receive the sprint data within 5 seconds of sprint completion.
6. Upon the sensor being tripped by the runner, the microcontroller must be able to receive an interrupt from the sensor input within 0.001 seconds to record the time of the sprint. (This is to meet "Timing Accuracy" in House of Quality (Table))
7. The microcontroller must be able to stop, transmit, and reset its second's timer.
8. The microcontroller must receive an interrupt via Wireless communication to reset its state to time another sprint within 5 seconds of the request being sent by the smartphone app.
9. The microcontroller must play a sound through a speaker within 0.001 seconds of the clock starting to time the sprint.
10. The microcontroller must toggle an LED from red to green to signal to the user to start within 0.1 seconds of the speaker signaling to start.
11. Upon the user requesting to begin a sprint, the microcontroller must be ready to begin a sprint and begin its countdown in at most 10 seconds.
12. The microcontroller should be able to identify at least 2 (optimally 5 or more) separate wireless devices connected to it and be able to receive interrupts and transmit sprint data to all devices connected.

Smartphone App Requirements (Application GUI Interface, Fig. 1)

1. The app must be able to communicate with the microcontroller, sending interrupts and receiving data from the microcontroller via Bluetooth/Wi-Fi at a 2.4 GHz frequency.
2. The app must have an interactive GUI for the user to time a sprint, view past sprints, and save a sprint.
3. The app must be able to store a list of times on the smartphones non-volatile storage (at least 10 most recent sprints).
4. The app must take input from the user to start a sprint.
5. Upon taking input to start a sprint, the app must inform the user to prepare for their sprint and pass control to the microcontroller (within 5 seconds of a user requesting a sprint to start).
6. The app must send an interrupt to the microcontroller to begin a sprint (all sprint setup and calculation will be done vi the microcontroller, to minimize latency).
7. Upon completion of a sprint, the app must receive the time and calculated average speed from the microcontroller, and display the data to the user within 5 seconds of sprint completion. (This collection of data will be referred to as a sprint). This is a goal of connection speed (Table 1)

1. The user must be able to save a sprint permanently on the phones local storage.
2. The app must store a set number of recent sprints on the phones local storage (at minimum 10).
3. The app must allow the user to provide the user to input the distance of their sprint, and using wireless communication with the microcontroller, estimate distance from the smartphone to the microcontroller within an accuracy of 10 cm, to show the user an approximation of their sprint distance.

Commented [LW1]: Please summarize key specification here with numbers,

Market Requirements

Commented [LW2]: Also summarize market requirement used in HOQ table.

1. Product must be lightweight and portable for ease of transport and setup by the target audience (sprinters)
2. Product will be compatible with a packaged app that can be run on the customers' Wireless communication compatible mobile phones if running the android operating system.
3. Hardware will use a relatively low cost processing unit to perform simple calculations to fulfil its tasks.
4. Product will have a high precision timer, emphasizing on fractions of seconds to market towards sprinters looking for a tool to measure their improvement.
5. The mobile app will be very easy to use and have a simple user interface layout for easy operation by the user.
6. The product will be very easy to setup, simply power on the devices, line up the sensors on the track where desired, and connect to the device via the android mobile app using Wireless communication.

7. The product will be relatively low cost. While it requires wireless communication to be implemented, a very fast processor isn't needed, and a cheap speaker and low cost LEDs can be used in the construction of the hardware.
8. The mobile app will store the data for a user's sprint on their phone, allowing the user to use the app as a tracker of progress.
9. A relatively cheap speaker can be used. The speaker simply must emit one tone, but must emit the tone at a relatively loud volume so the user can hear it in a track environment. (The sound will also be used in the mobile app in case the user is out of range of hearing the microcontroller).

House of Quality

			Engineering Requirements							
			Sound Quality	Weight	Connection Speed	Battery Life	Connection Range	Timing Accuracy	Cost	
			+	-	+	+	+	+	-	
Marketing Requirements	Size	-		↑		↑				Each 'pylon' will be 1' x 2"
	Timing precision	+	↑				↑	↑	↑	Each time trial will consistantly
	Set up time	-		↑	↑				↓	Quick set up time 5 - 10 minutes
	Smartphone Connectivity	+			↑		↑		↑	Will easily connect to a smartphone
	Cost	-	↑		↑	↑	↑	↑		The goal is to keep it low cost for users
			112dB min	< 10lbs	5 sec	≥ 3 hours	100m max	Within 0.1 sec	< $500	

Table 1

Block Diagram

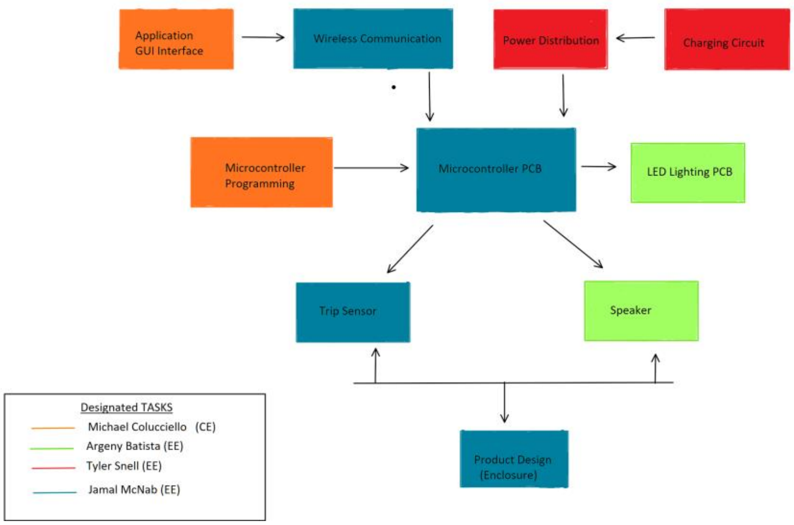

Fig. 1

Current Status of Blocks

- ☐ To be acquired- meaning the block will be purchased or donated
- ☐ Acquired- block has been donated or purchased
- ☑ Research- block design approach is being investigated
- ☑ Design- block is currently being designed
- ☐ Prototype- block is currently being prototyped
- ☐ Complete – block design is finished prototype

COST AND BUDGET

Parts	Quantity	Estimated price
Microcontroller	1	$30
PCB LED	1	$50-$100
Wireless communication	1	$15
Enclosure prototype	1	$26
PCB Main	1	$50-100
Trip Sensor Transmitter	1	$30
Trip Sensor Receiver	1	$5
Charging PCB	1	$50-100
Miscellaneous parts	1	$30
TOTAL		$286-436

Table 2

As stated before we currently have no sponsors at this particular time, so this project will be funded solely by team members. The chart above represents a rough estimate of prices to build product based on current research that we have collected. The above chart represents a cost for one product however during construction we will purchase in multiples to account for mistakes or damages that may occur during the build process. These prices and parts are subject to change due to further research and construction of the product.

Project Milestone

Week	Description
1	Define Project Idea
2	Initial project documentation and requirement specs/ group meeting on roles and tasks
3 to 7	Decide basic hardware for microcontroller and other main components
8 to 9	Work on PCB layout
9 to 10	Start ordering parts
10 to 13	Designs for hardware systems and layouts for software
10 to 16 (end of Fall semester)	Write and Finalize the Document.
	Component check.
	Work on prototyping with breadboards
(Start of Spring Semester) 16 to 18	Order any changing parts and PCB
17 to 19	Power system designed
18 to 21	IR beam and wireless communications design & microcontroller set up
19 to 22	Project hardware finished
22 to 24	Software interface finished
26 to 30	Fine tuning

Table 3