Project SafeTee

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1. Introduction

1.1 Objective

Currently, cyclists and those who use alternative transportation face many difficulties while on the road. One of the main difficulties is the lack of vision and ability to communicate intentions such as turning and stopping using hand signals, especially when it is dark. Our goal is to avoid these unnecessary fatalities by producing a standard for all of those who wish to travel the roads in a medium other than a motorized vehicle.

We will achieve this goal by building and developing a universal jacket that can be used for both adults and children. Usage of the jacket will not only be available for cyclists but also be available for those who look to use scooters, skateboards, and other types of alternative transportation. The jacket will provide users with an intuitive gesturing system, that allows others on the road to see a clear indicator of their intended movements. Further, the jacket's smart motion sensors will provide a separate braking signal that will be displayed when the user is slowing down. Each of these indicators and sensors will be represented by LEDs that are not only bright but also intuitive for others to understand, allowing for clearer communication for all on the road.

1.2 Background

In this day and age, approximately 100 million Americans ride their bikes each year, with over 14 million Americans riding two or more times per week [1]. However, those who go for leisurely rides or commute via cycling ride under the threat of an inherent safety risk while sharing the road with cars and other larger vehicles. Although bike lanes have begun to pop up from time to time, cyclist fatalities have risen over 10% in 2018, with the current estimation by the NHTSA is 857 fatalities in 2018 [2] [3].

Current structures and solutions that exist have helped but have not done enough to mitigate the damage. One of such is the universal hand gestures that are taught in traffic school, with the left hand out meaning a left turn, left hand out and up meaning a right turn, and left hand out and down meaning a brake. However, these gestures have become less and less well known, and even using these become less effective in the dark. While other solutions look to combat the same problem, such as a company called *Blinkers*, they prove not effective enough and can fail out of business [4]. Further, none of these solutions have the added capability of controlling the functionality based upon the actions of the user, while our product looks to incorporate a brake light based upon the speed of the user. Our product will do this as well as combine the simplicity of gesturing with the added visibility of the Blinker product. These efforts will be towards reducing the number of fatalities to zero.

1.3 High Level Requirements

When the user raises either arm past a 70 degree angle starting from the body, perpendicular to the frame of the bike, the LEDs on that arm should light up. The control unit should react to this gesture and send the appropriate signal to the LED's within a second after the user holds this gesture for 2 seconds.

The brake indicator LED should light up when the user decelerates sharply, indicating to others that the user is braking. This should happen when the user slows down more than 50% of their average speed in the last 5 seconds.

The LEDs should be visible within 100 feet during ideal nighttime conditions, and 50 feet in ideal daytime conditions.

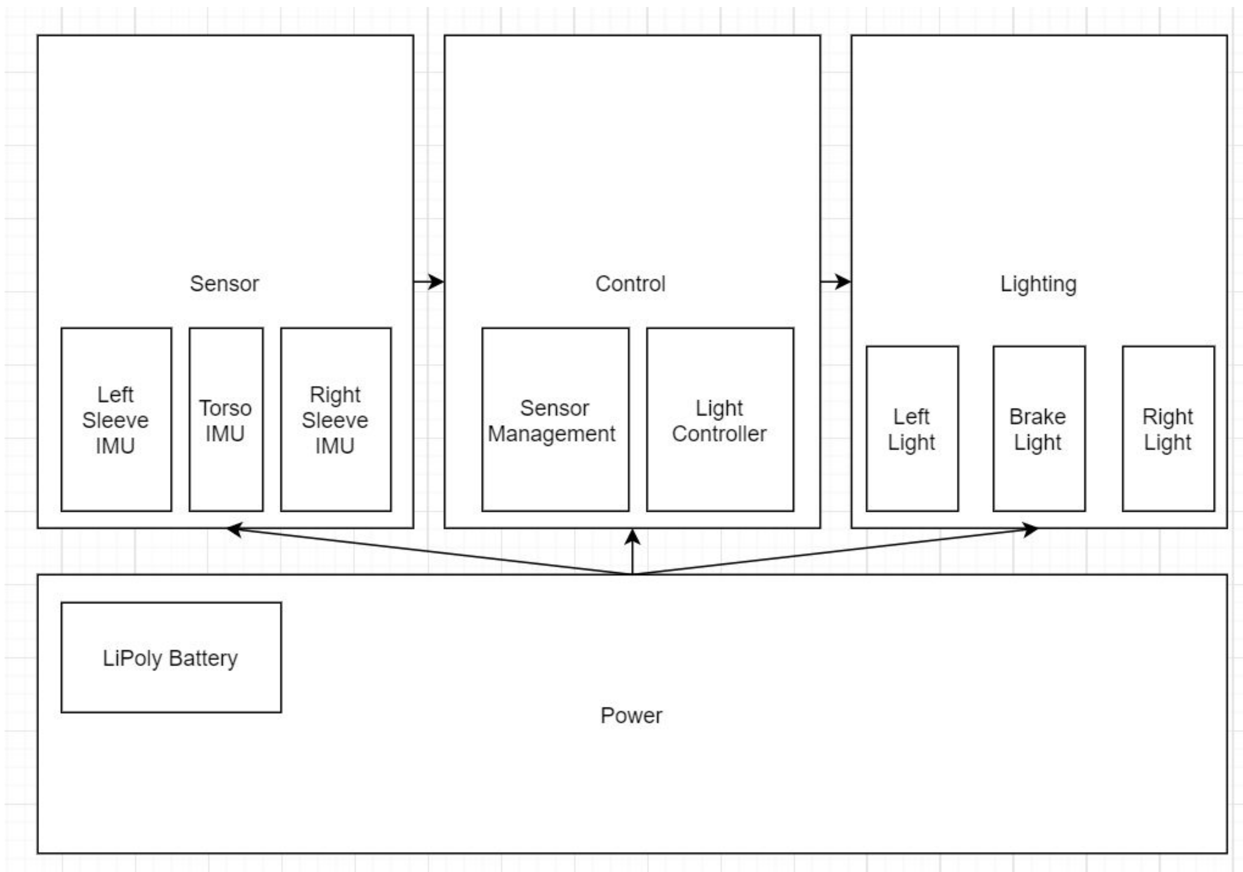
2. Design

Our safety jacket will employ a series of modular components to be able to operate successfully, specifically lighting and sensor arrays, a control unit, and a power subsystem. In order to achieve our high level objectives as stated above, each module has a specific function that it must perform.

The power subsystem will be used to store energy used to power the other modules, and as such it must be able to provide a steady 3.3V output and be rechargeable so as to allow consistent use and reuse of our device. The sensor array, consisting of three IMUs will need to provide the control unit with orientation and acceleration data for both of the user's arms and their torso at a refresh rate greater than 2Hz. Then the control unit will be used to translate the data provided by the sensor array into gestures made by either hand as well as deceleration events, which it can then use to generate output signals for the indicators. The LED array will then show turns signals and a brake light indicator based on the outputs provided by the control unit that are visible to others on the road up to 100 feet away.

Using these modules, we will be able to embed the ability to sense user gestures and communicate effectively with other drivers into our jacket and provide a seamless experience for our users.

2.0 Block Diagram



2.0.1 Physical Diagram

2.1 Power Supply

An independent power supply is necessary to provide power to the electrical components on board our jacket. This includes the LED's, IMU's, and Microcontrollers. We decided to use a LiPoly battery as the primary power supply, since they are compact and light, and have a high capacity. They are also rechargeable, which will reduce the cost for the user to keep the jacket in operation and improve the longevity of the product. The power supply will be located on the back of the jacket near the torso, which will be easily accessible to recharge.

Requirements: We anticipate needing at least 3 watts of power, but this may be adjusted after we have assessed the system draw in practice.

2.2 IMU

We plan to use a 9-DOF Inertial Measurement Unit that combines an accelerometer, gyroscope, and compass into one package that we will be able to use to determine a user's movements in 3D space and send that data to the control unit over a protocol such as I2C. Three of these sensors will be placed strategically on the jacket such that we can isolate hand and arm movements from the motion of the person as they are travelling down the road.

Requirement: The IMUs used should be able to report 9-DOF data on their position and orientation at a rate of at least 2Hz to ensure accurate and low-latency gesture identification.

2.3 Microcontrollers

We plan to use microcontrollers to handle communication with the IMUs and the LED array that will provide the necessary logical support for translating orientation data into gestures and producing lighting cues that can then be displayed on the jacket. While we have not finalized the microcontrollers that we plan to use, we intend to pull from the Atmel family of chips because of their small form-factor, manageable power requirements, and ease of usability in mobile projects similar to this one. The processing of sensor data and the translation of gestures into light cues will be performed on separate microcontrollers which will communicate over I2C.

Requirement: The microcontrollers must be able to communicate with both the IMUs and the LED array and update the outputs at a rate of at least 2Hz for the outputs to be considered low-latency.

2.4 LEDs

In order to maximize visibility, we decided to use a multitude of LED strips to indicate the directional intent of the user. More specifically, our design calls for three independent LED strips fashioned as rings around the biceps of each arm. This way, when the user raises their arms to indicate that they want to turn in a certain direction, others are able to see the LEDs in all directions. In addition to the three LED strips on each arm, our design also has a LED strip fastened around the torso, which will be used to indicate braking.

Requirement: Must provide light brighter than 100 lumens to ensure visibility in unobscured conditions.

2.5 Risk Analysis

The ability for the IMU's to successfully interpret the users gestures poses the biggest risk to the success of our project. The challenge of minimizing noise and signal interference, coupled with user error (a poor understanding of how to operate the jacket) could potentially cause the LEDs to fail to trigger at critical times. In order to minimize the chance of false positives and false negatives, we plan to implement a filter in software that isolates the signals and noise components that are necessary to successfully operate the jacket. Which signals we need to isolate will be determined during testing. We also plan to include a pamphlet that comes with the jacket, that accurately describes to the user how to operate the jacket to avoid any confusion.

3. Safety and Ethics

In the effort to create a product that is meant to save lives, it is important to consider the safety and ethical components of not only the creation of this project, but also the usage of it by the populus. While building the project, as we are working with electrical components, we run the risk of harm to ourselves and those around us. Our utmost concern will be laboratory training and safety with regards to the Division of Research Safety training [5].

Furthermore, when considering the production of our product, we must adhere strictly to Rule 3 of the IEEE Code of Ethics, which states that we must be “honest and realistic” with our claims with respect to available data [6]. Our plan of development includes extensive experimentation that allows for the easiest and most intuitive usage of Project Safe-Tee. The jacket must always light up when the user brings up his arm, as there is an even greater risk when the user thinks that others on the road can see his turning indicator when in fact they do not. Our project further must follow Rule 9 of the code of ethics, to ensure that our product will neither indirectly cause harm due to missing indicators nor directly cause harm due to malfunctions [6].

We are cognizant that there are multiple concerns that stem from the creation of the project that may directly cause harm to a user. One of the most obvious is short-circuits, as our device is an electrical one that is meant to be used outdoors. As a result, we will ensure that the internal components of our project will be dry while submerged up to 1 meter of water, adherent to the IP67 guidelines [7]. Finally, the LiPo battery is well known for its inherent safety risks, as it is not difficult to start a fire or even an explosion under certain circumstances. To combat this, we will ensure that the charger prevents overcharging outside of the 4.2V range, and we will tell the users basic safety tips, such as to wait for it to cool before charging it after usage, as well as to never leave the battery unattended while charging [8].

4. References

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[7] Palmer, Mark; “IP67 vs IP68: Waterproof IP ratings explained”, Trusted Reviews, Feb 11 2019 [Online] https://www.trustedreviews.com/opinion/what-is-ip68-ip-ratings-explained-2947135

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