SignalMe – A Safety Vest for Micromobility

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The Problem

Transportation, especially on college campuses, is becoming increasingly multi-modal. New developments in micro-mobility from ride-share startups to the emergence of electric personal transportation in the form of e-bikes and "boosted boards" are allowing for clean and efficient forms of short distance travel to become more popular and common.

With this, however, comes problems of safety, particularly where these new "modals" intersect with the traditional traffic of motor vehicles and pedestrians. While the problem can be addressed with policy, statute, and infrastructure, it can also be tackled through technological advancements of the transportation itself to allow riders to be safe and seen.

Proposed Solution

We proposed a motion informed vest with embedded lighting to keep riders visible in all light conditions. With a user input fob, a rider can initiate turn signals at the push of a button and the signal will automatically turn off after the turn is made. Similarly, a brake light turns on at times of rapid de-acceleration. Taken together, signaling is more intuitive for those used to motor vehicle lights, both for riders and other on the road. Additionally, we provide other common road signal features including headlights, hazards, and a special automatic high visibility crash mode.

High Level Requirements:

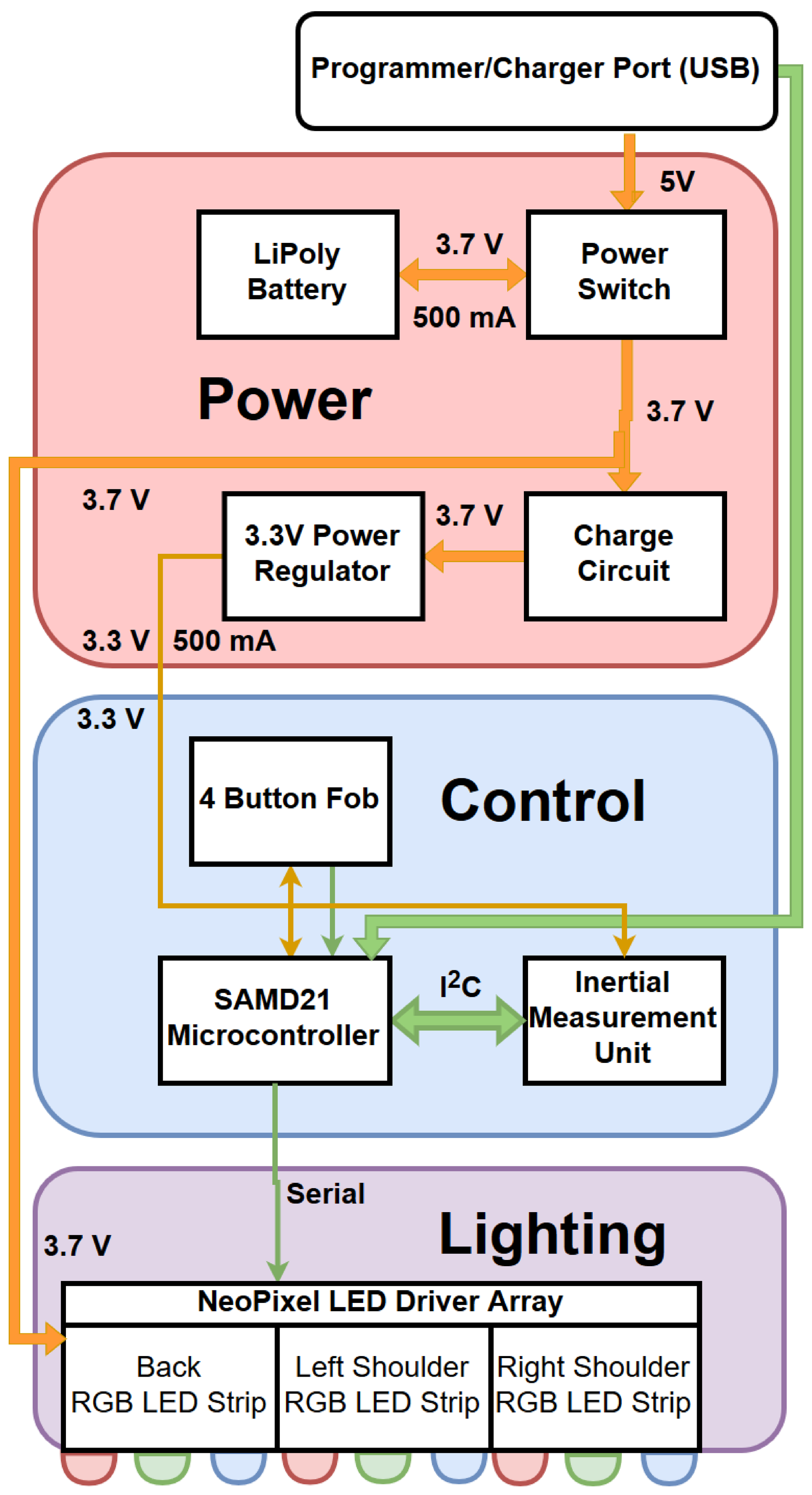
1) Automate the turning off of a user initiated turn signal and brake signal, akin to a motor vehicle.

2) Produce lighting to be street legal at night.

3) Hold battery life for 2 hours of operation.

Hardware Design

Block Diagram



Micro-controller

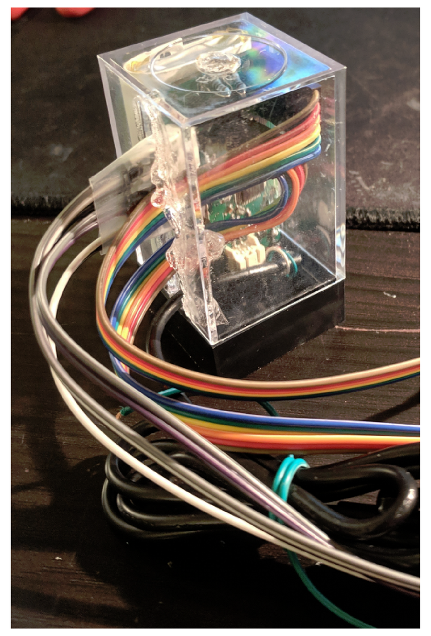
The controlling element is a 32-bit arm based micro-controller with Arduino compatibility to give us access to a large set of support libraries for both the IMU and the Lighting.

Inertial Measurement Unit

The IMU is a 9 Degree of Freedom MEMS based sensor. Magnetic, angular and linear acceleration data are processed into key motion events.

Lighting

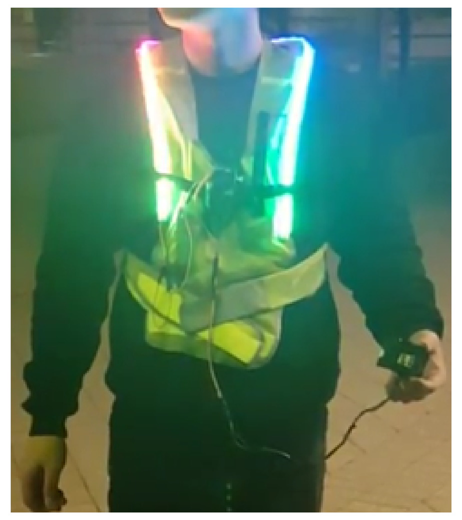
For lighting we use "NeoPixel" lighting strips. These RGB LED strips have individually addressed LEDs. Combined with the provided code libraries, this allows us to control entire strips with one data line at a speed that lets us do live animations at various brightnesses.



Control Box

Vest and Lighting

Vest at Night



Headlight Feature

Software Design

Turn Detection

To make the turn lights more intuitive, we needed to determine when the turn had finished so that the lights could be turned off automatically. We achieved this by using the acceleration in the y-axis (lateral displacement for the user) and the yaw (angle around the vertical axis of the rider). We saw that these two values changed significantly during a turn, but have an almost constant behavior during a straight path. A turn can be detected when each of these values have gone over a specified threshold (meaning the turn is being executed), and after that have had values below another predetermined threshold (the straight path is retaken).

Brake Detection

For this specific detection we used a derivative control, in order to make the acceleration in the x-axis (front direction of the rider) to be more precise and useful. By detecting the deceleration of the rider we can turn the brake lights on when necessary.

Crash Detection

In order to detect when the rider has fallen off their desired method of transportation, we measure the acceleration in the z-axis (vertical axis), which has little variance during the ride, but changes suddenly during a fall. As in other detections, the crash is detected when this variable has gone over a threshold.

Results and Data

By the end of the project we could clearly meet all 3 stated high level requirements:

1) Automate the turning off of a user initiated turn signal and brake signal, akin to a motor vehicle.

We were able to, and have documented with video that all detection algorithms work under live field test conditions on bicycles.

2) Produce lighting to be street legal at night.

Shown in the photos on the left, the lighting is visible from over 100 feet at night.

3) Hold battery life for 2 hours of operation.

We have performed calculation along the four main modes of power operation and found on a 1 Ah battery, we can get just under 2 hours of operation with half of that in headlight mode.

Conclusions

This project has shown that movement on personal transportation can be tracked with love cost consumer level hardware. In the future, features could be expanded into more elaborate and efficient detection algorithms, other form factors may be tried, and connectivity to devices and apps such as on smartphones can be possible.

Acknowledgement

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