Traffic Control Smart System

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1. Introduction

1.1 Objective

Modern day traffic control is conducted using large traffic wands that quickly fatigue traffic officers. They also tend to only have one light setting and on top of this drivers are often not properly educated on traffic control gestures so communication between officer and driver is very vague and can cause confusion.

Our solution alleviates the fatigue associated with traffic control by replacing the heavy wands with lightweight gloves and flexible LED panels that can be attached to the front and back of the officer's vest. They are all lined with LEDs whose colors can be varied and controlled with simple and easily accessible buttons on the gloves and chest. The LED panel will have toggleable settings between displaying "STOP" and "GO" which will make communication clear and easy for the officer, removing any possible confusion at the intersection. Our system is also modular so gloves and body panels are completely separate but can still communicate with each other through wireless transceivers. We also hope to keep everything relatively cheap compared to what current traffic wands cost so that our product is affordable for the police department. Lastly, everything is powered separately with lightweight rechargeable batteries.

1.2 Background

Currently, officers on traffic control duty for busy intersections use large wands that are essentially lit up traffic cones with a handle. These traffic wands are very cumbersome and quickly cause a lot of fatigue for the officers as they wave them around directing traffic for elongated timespan. The job of Traffic control usually takes 15-20min but can sometimes last long for 2-3 hours. In addition to this, communication between officers and drivers are conducted through arm gestures that are ambiguous and hard to understand for many. This poses as a large issue to both the officer and drivers in the intersection. Officers get fatigued and lose focus as the shift goes on and on the off chance a careless driver comes to the intersection and does not heed the officer's orders, lives are in danger.

We have partnered with Jake Fava and Ava Bilimoria from the Siebel Center for Design and Sgt. James Carter from the University Police to solve this issue, and have also gone in person to see how a traffic control shift is performed. After interviewing a few police officers on their opinions on these shifts, they all have the same view as us on the problems with how traffic control is currently done and have experiences that support our ideas. One officer has even told us about how a driver almost hit him once because the driver did not understand his gestures.

1.3 High Level Requirement List

- Our entire system must be lightweight so that police officers can freely wear the gloves and panels without feeling much more weight than usual. Their uniforms and vests are already extremely heavy and adding a substantial amount of weight will only do more harm than good. On top of this they need to be flexible enough so that officers can easily reach for and operate any tools they need to at will, for example a pistol from their belt. An additional requirement we should meet is that the gloves and panels are completely separate.
- The LEDs need to be bright enough to be seen from at most ten meters away and additionally the words spelled out on the panel need to be legible from the same distance. The LEDs also need to be able to exhibit at the very least red, green, white, and black colors (although they should be programmable to any color). The color and status of the LEDs must also be able to be controlled wirelessly from buttons on the gloves.
- The system must be entirely powered by lightweight, rechargeable batteries that can sustain power for elongated duration (at least two hours).

2. Design

2.1 Block Diagram and Physical Design

- The Power module will used as safe to use, regulated power supply for sensor module, Control System and the LED module for elongated duration.
- Sensor module will used as a trigger for the microcontroller to change animation on the LED module.
- Control System will be listening to trigger generated by Sensor module and will change animation on LED module accordingly. It will transmit the trigger signal to other microcontrollers via the wireless controller.
- LED module will respond to the control signals by the Control system.

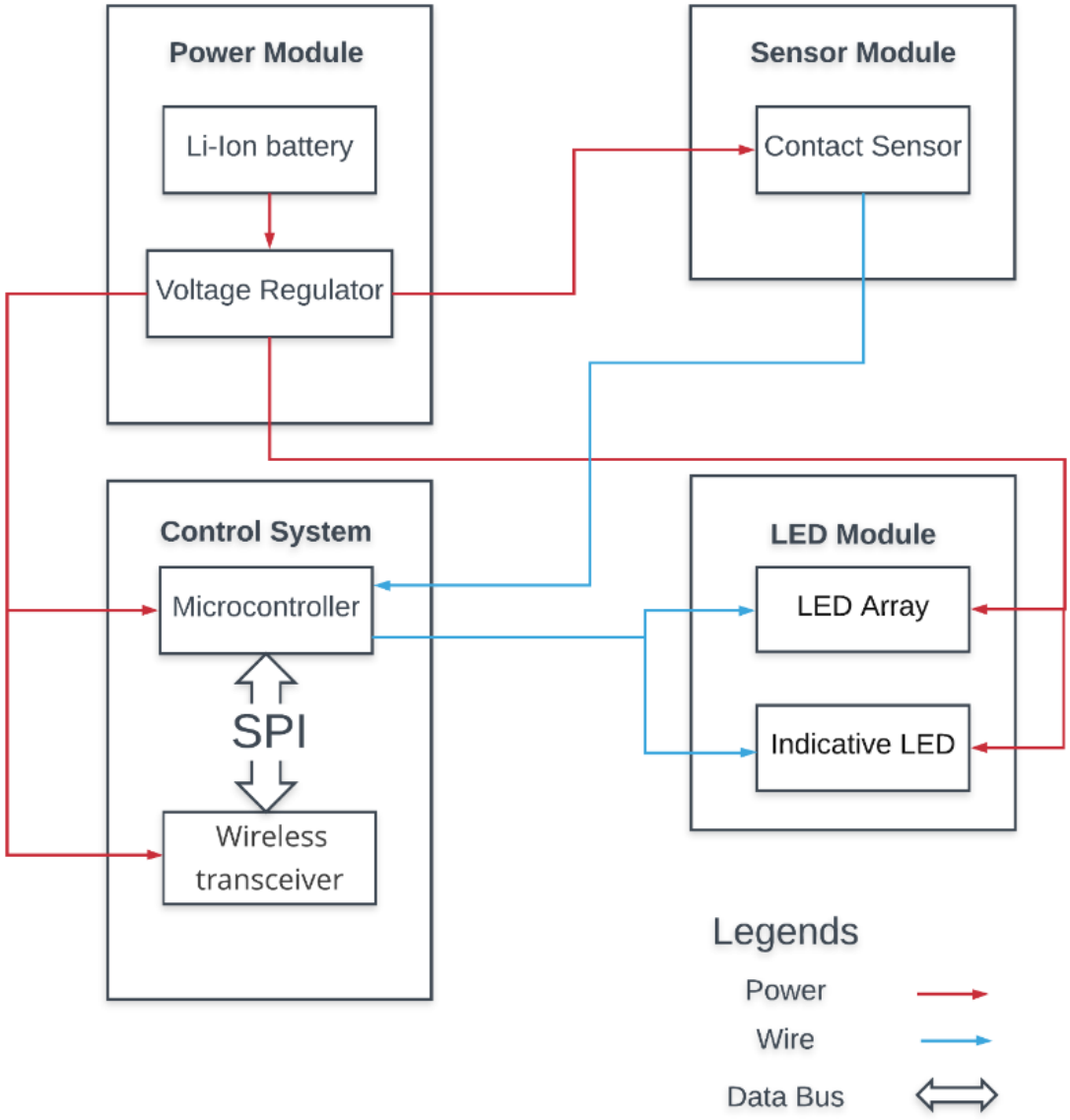

Figure 1. Block Diagram

- For the vest we plan to have a microcontroller with a wireless module which will be essentially communicating with the glove (mainly waiting for the trigger signal from the glove) and controlling the front and the back panel accordingly. The front and the back led panel will be a 14-segment display with 4 characters power by 3 li-ion cells.
- For the gloves we plan to have microcontroller with a wireless module which will be essentially communicating with the vest (mainly sending trigger signal from contact sensor) and controlling the LEDs on the glove based on trigger signal from contact sensor.

Figure 2. Front and Back View Conception of Vest

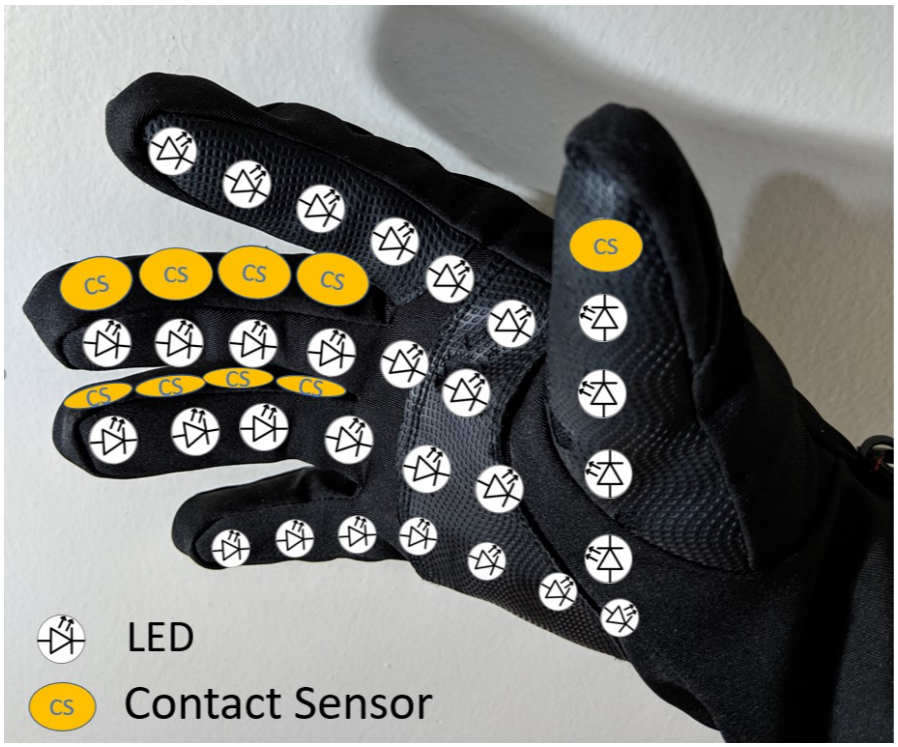

Figure 3. Glove design conception

2.2 Block Description

2.2.1 Li-ion battery

For our project, we have three major power requirements. Microcontroller consuming 50 mAh at 5v, LEDs consuming 50 mAh at 5v per LED and Wireless Trans-receiver consuming 15 mAh at 3V. Our plan is to use Li-ion batteries due to their high energy density, as they typically have approximately upto 3400 mAh of charge. Due to high sensitivity and dangerous hazards associated with Li-ion batteries, we also plan to implement a protection circuit for safety purposes. We estimate to have at least 25 LEDs per glove and 80 LEDs for the vest, and therefore we plan to use 2 cells per glove and 3 cells for the vest which can power the gloves for 4-5 hours and vest for 2-2.5 hours. At last, the Li-ion battery will be used an input supply to voltage regulator though a protected circuit.

Req1: Should be able to power at least the vest for minimum of 2 hours.

Req2: Li-ion batteries should be able to operate safely at all times.

2.2.2 Voltage regulator

The microcontroller and the LEDs require a 5v supply and the Wireless Trans-receiver requires a 3v supply. Therefore, we plan to use two li-ion cells in series, and then use a DC-DC converter which can step down 7.2v to appropriate levels for each device. This module should be able to convert the DC supply to appropriate regulated levels with minimum ripple.

Req1: Should be able to output 5v and 3 v by stepping down source input with minimal voltage ripple (±10%).

2.2.3 Microcontroller

For our design we plan to incorporate total of three microcontrollers (two for each glove and one for vest). As the brains of our project, microcontroller should be able to communicate with other microcontrollers, take input from the contact sensors and accordingly be able to controls the LEDs simultaneously. The microcontroller should be able to distinguish between multiple contact sensors for which it must have about 8 inputs pins (since eight contact sensors per glove) free after the IO pins for trans-receiver and the LEDs have been utilized. It should be able to send the control signal for LEDs and as also should be able to follow SIP protocol. It should also be able to store the state of the LEDs and be able to establish wireless connection automatically when powered on.

Req1: should be able to communicate with other microcontrollers modules over SPI and simultaneously send control signal for controlling led strips.

Req2: Should be able to establish wireless connection automatically when power on.

2.2.4 Wireless Trans-receiver

Since we want the gloves to be wireless and hassle-free, we need three wireless modules connected to each microcontroller which would allow the gloves to communicate with the vest. The wireless trans-receiver should be able to establish a network of at least three nodes and allow them to have a seamless bi-directional communication. The module should be able to send data captured from the contact sensors on each glove should be able to transmit the data to all other modules concurrently. Since the gloves and the vest are in close vicinity, range should not be an issue for out project.

Req1: Should be able to establish a network of at least three nodes.

2.2.5 Contact sensor

For smooth control of incoming traffic, we need to be able to change LED colors and animations instantaneously. Thus, we need a set of buttons that can trigger the microcontroller to change animations appropriately with each button triggering a different animation. Since multiple hard-buttons can become cumbersome while active usage, we plan to use some kind of touch sensor which can detect a contact between two surfaces There will be multiple instances of contact sensor which will act a trigger for a different animation.

Req1: should be able to differentiate between open circuit and close circuit.

2.3.6 LED array

To fulfill the main objective for our project, LEDs will be used to display a vibrant color scheme and establish a precise/unambiguous communication between motorists and police officers. They will be arranged in a serial connection and will be controlled via microcontroller. Due to the hasty nature of use-case of this product, we require the LEDS to respond quickly based on the control signal by the microcontroller.

Req1: Should be individually addressable with brightness and color control.

2.3.7 Indicative LED

As discussed before, we plan to have a LED panel on back side of the vest as well. Since it is hard to see, the current animation on back panel, we want an indicative light on the glove which indicates the current animation being displayed. So, this particular LED should be able to respond synchronously with the back panel. The LED will be controlled by the microcontroller and will be present on only one of the gloves.

Req1: should be able respond in synchrony with the back panel.

2.3 Risk Analysis

The power supply could be a significant risk to successful completion of the project. Due to lack of prior experience of building power circuits, there is high possibility that we might fail in overcoming the engineering challenges associated with protection circuit and the voltage regulator. Also, in case if it becomes infeasible to build a protection circuit, we would purchase 'protected li-ion cells' with are Li-ion cells available with built-in protection circuit.

Although we have an approx. estimation of the power consumption, we might be missing some factors that may not give us long hours of usage of the product or may not even light LEDS with significant brightness. If that happens, the objective of our project that is to improve the communication in busy intersections, even at night, won´t fulfill effectively. By adding more batteries this problem could be solved but it would be in conflict with the purpose of the product being light-weight. So, in case we don't have enough power, we plan to add batteries and compromise on the light-weightedness of our product.

As due to lack of prior experience with the microcontroller and wireless transreceivers, there might be a possibility of not being to successfully establish a three-node network. In case, the wireless module fails to get implemented, we will use direct wire connections as a remedy and would compromise on the hassle-free feature of our product.

3. Ethics and Safety

Since our main objective is to protect police officers while directing the traffic and also avoid accidents by improving communication between them and drivers, our decisions when developing the project must follow the IEEE Code Ethics, #1: "To accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public" [1].

We must ensure that the color of the gloves and the words written in the panel are the ones chosen by the user since an error in either of these would probably cause a car accident. So, based on the ACM Code Ethics Section 2.9 [2], in order to ensure that the system works as intended, we will make it intuitive for everybody to use it.

As for the design, both batteries and wire connections for the LEDs might be an issue since the user will wear the gloves and the panels for a long time while being exposed to any weather condition. So, all components will be isolated and properly hidden to prevent accidents.

4. References

[1] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html [Accessed: 5- Feb- 2019].

[2] “The Code affirms an obligation of computing professionals to use their skills for the benefit of society.,” Association for Computing Machinery. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 06-Feb-2019].