Modular Light Array
Noah Feinberg - nbf2, Ashwin Mukund - amukund2
TA:Megan Roller
Spring 2020

Introduction

Objective

The holiday decoration industry is an incredibly lucrative field. At the end of 2018, the national retail federation reported that the average consumer spent about 1000$ on Christmas decorations, with retail sales of around $720 billion (Greene, “Spending on Christmas decorations remains the same in 2018”). Among outside decorations, lights are the most common example, with some types including mini string lights, animated/color changing lights, LED rope lights, and LED projection spotlights. While these options provide a high degree of customization for home owners to optimally decorate their houses during the holiday season, these decorations are static, in that they are usually set in a permanent pattern, unable to be changed or modified once set up. This problem of the inability to modify and come up with patterns on the fly for home light decoration displays is one that has very few if not any existing solutions.

Our proposed solution involves the creation of a modular 2D LED array, which would be able to replicate drawn designs from a separate application. This application would let you draw a gray-scale design and translate that design onto the 2D LED array, sending this data through a bluetooth module. This translation would relay the necessary brightness for each LED within the 2D array by transforming the gray scale design from the application. The 2D panel LED light display, which would be hooked up in parallel, connected to a raspberry pi which would interpret the gray scale image translation and update the lights to match the drawn image. Such a system would allow for easy updating of light based simple images.

Context

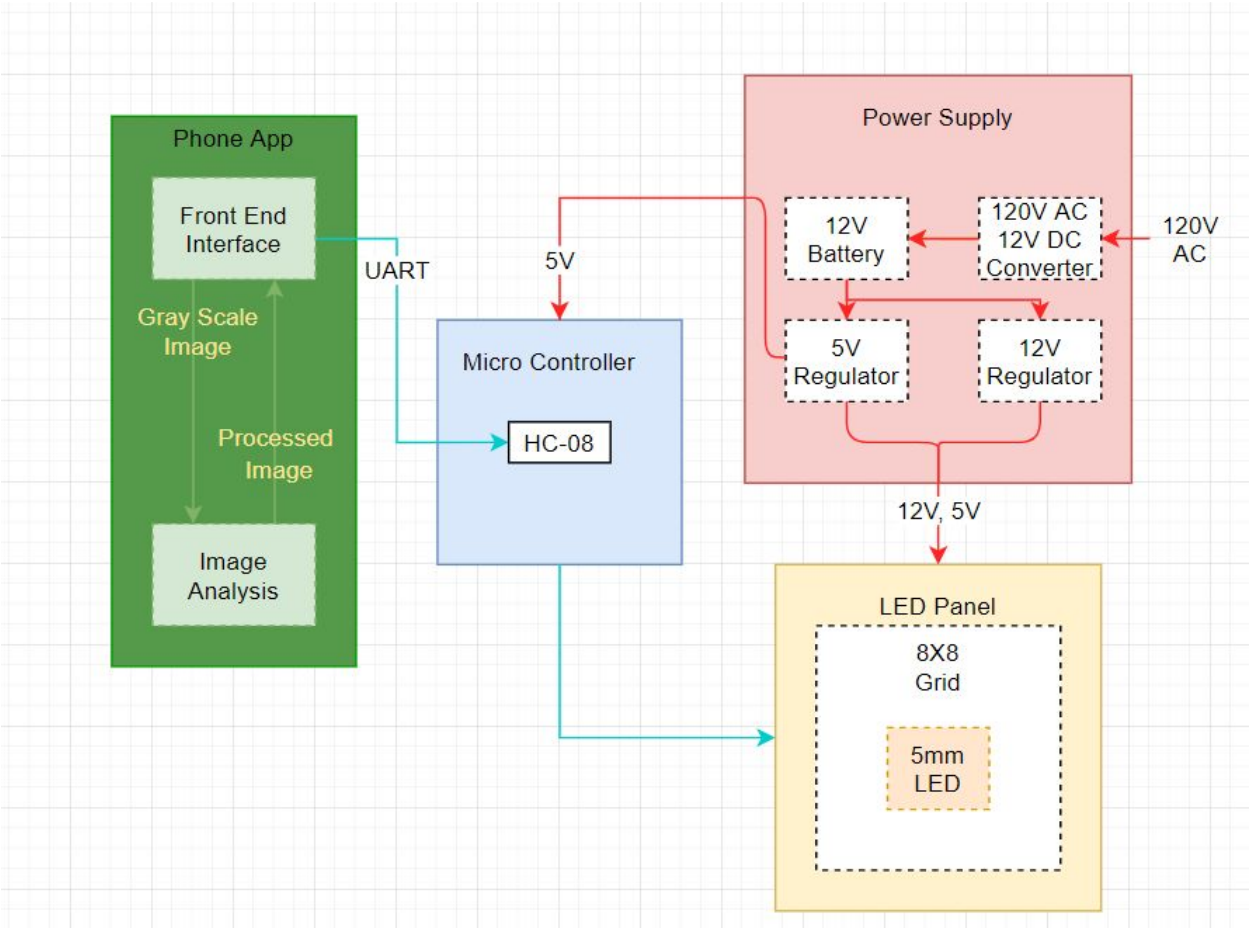
An important facet of our design is the ability to update the LED display easily by simply redrawing a design within the phone application. Currently, similar products require reprogramming the display if you wish to change what is displayed. The modular design would also raise another benefit, namely the ability to quickly and efficiently update LED display panels with ease from the phone app assuming there were multiple. Another important distinction within our design is the use of differing levels of brightness to indicate grayscale values from the phone app.

High Level Requirements

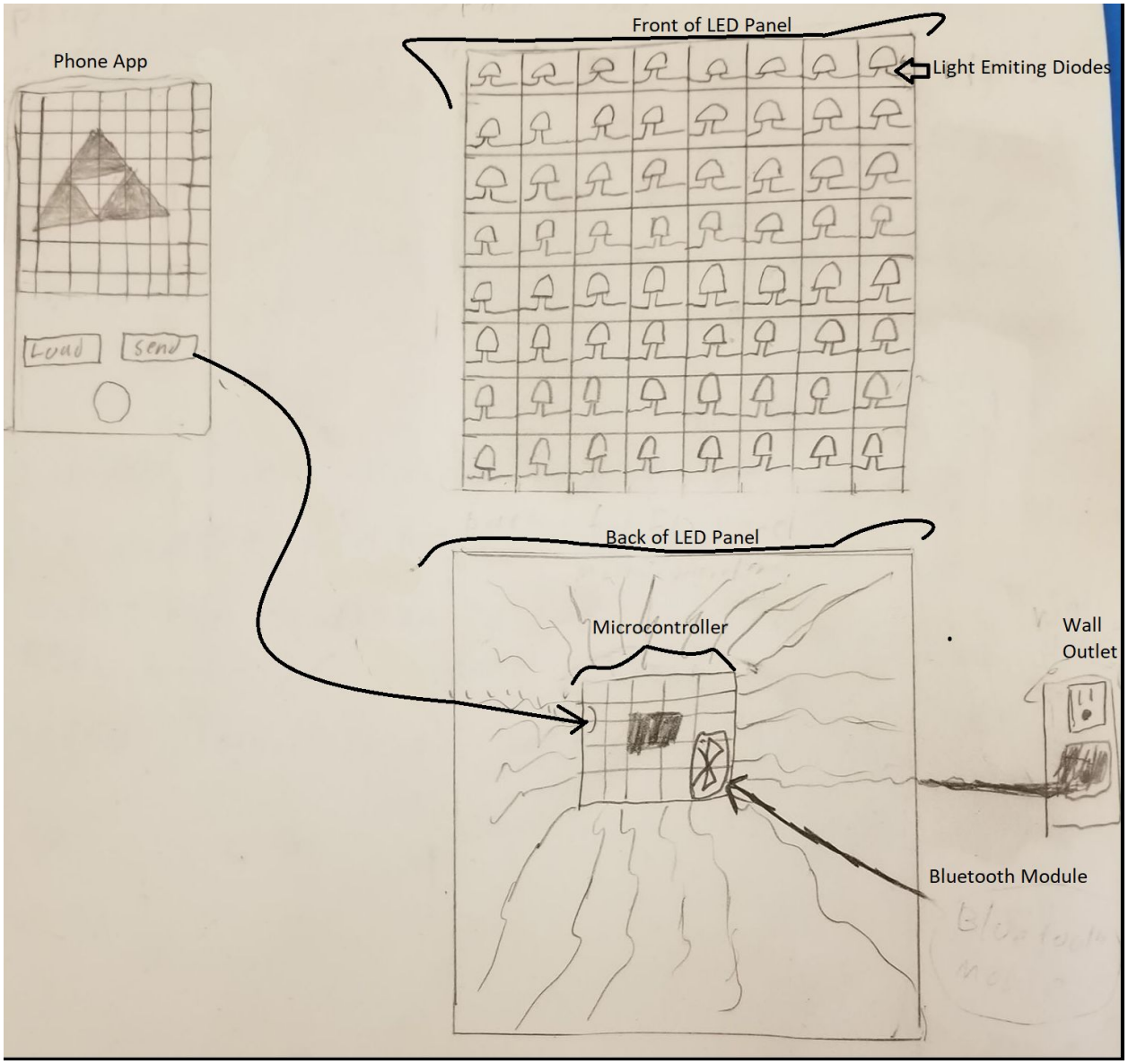
1. Being able to accurately send image grayscale values from the phone application to the microcontroller, through the bluetooth module.
2. The microcontroller can successfully interpret incoming data and send out appropriate signals to the LED panel to display the grayscale image.
3. The image on the LED panel can be easily and quickly updated by changes from the phone application.
4. The image on the LED panel is identifiable filling in at least 60% of the original image when overlayed

Design

Block DIagram



Physical Design



Function Overview

There are four major components to this project that interact with each other to make it work. To start off with, we have the phone application. This is the component that the user interacts with to make their design and choose to send it to the LED panel. After the user chooses to send their design to the panel, it'll be translated into a grayscale image, and sent over UART to the bluetooth module connected to the microcontroller. The microcontroller is the second component of this project, receiving signals from the phone app through bluetooth, and interpreting those signals to be sent to the LED drivers on the LED panel. The LED panel is responsible for displaying the image in grayscale that the user sent from the phone app, and finally, the power supply component provides power to the LED panel and microcontroller.

Block Requirements

- Power Supply
    - Must be able to convert 120V AC from the wall to charge a 12V battery. Must be able to take output from the battery and convert to both 12V and 5V DC.
        - Requirement 1: Provide 12V +/- 0.5V and 5V +/- 0.5V after the voltage regulators.
        - Requirement 2: Provide current to operate LED panel for an extended duration (8 hours)
- LED Panel
    - Consists of 8x8 grid of 5mm colorless LED's. Responsible for properly displaying converted grayscale images from the phone app. LED Panel will also contain LED drivers, constant voltage specifically since we will wire the LEDs in parallel
        - Requirement 1: LEDs can light up properly and have individual brightness modulated based on grayscale input
        - Requirement 2: LEDs operate within safe values for both current and voltage, which generally speaking are 20-30 mA and 2-3 V respectively.
- Microcontroller
    - Able to take input from the phone app, interpret this, and send out appropriate signals to the LED panel. It should be able to filter out extraneous inputs, including ones that don't make sense or would compromise the LED Panel. Includes the bluetooth module used to communicate/receive data from the phone app.
        - Requirement 1: Can properly communicate with phone app through bluetooth module chip via UART, receiving 10 samples/second from the phone app.

        - Requirement 2: Can properly send out signals to the LED drivers on LED panel to display grayscale image from phone app
        - Requirement 3: Signals sent by microcontroller to LED panel should be signals that would not damage the LEDs in use on the panel
- Phone app
    - Able to take image inputs and translate them into grayscale outputs to be sent to the microcontroller via the bluetooth module. Includes the drawing application for users as well as a load images option to send data to the microcontroller.
        - Requirement 1: Can properly translate images into grayscale images.
        - Requirement 2: User can create a grayscale image using the app.

Risk Analysis

This riskiest part of this design is the possibility of improper use or installation of the LED components. If wires connecting LEDs to the microcontroller are not properly set up it is possible that the correct brightness will not display throughout the LED panel. For example in the case where wires are overlapping the LED light signals will not properly be sent to the correct LEDs as shorting throughout the circuit will probably cause several LEDs to be turned off. In order to avoid such a predicament it is important to install all the LEDs in a way that will keep the LEDs isolated from the rest of the LEDs.

One other part of the design which will be susceptible to problems will be the interaction between the phone application and the bluetooth microcontroller module. Since the application is responsible for acquiring most of the data, the sending of that data is crucial for the success of the project. If the connection between the module and the phone application is not processed correctly the problem of the LED showing an incorrect display becomes possible again. In order to ensure that the connection between the phone and the microcontroller is stable it will be important to create a connection stability test.

Extension Goal

Our extension goal for our project is to allow the gray scale image to be displayed on multiple LED panels. This goal compliments the main objective of our project, to have a modular design, since distribution of a single image to multiple light panels allows for easy customization of each panel display.

The requirements for this extension goal include updating the phone app to allow communication with multiple panels, and the creation of a second LED panel. This means we would require double of all components needed for the original.

Ethics

Since this is a consumer product there is a certain level of safety we must ensure when creating the device. Immediately apparent is ensuring the safety of operating the LEDs on the panel display. Improper operation of LEDs leads to electrical hazards. Careful steps must be taken when designing the project to limit/entirely remove human contact from operating LEDs.

A slightly overlooked but nonetheless important concern would be our usage of a wall outlet in our project. Since it is our primary power source, we must ensure that proper usage of said power and also the safety of the user of our product while it is in operation. Making sure to cover and secure proper wiring should ensure the user's safety.

Citation

Greene, Jay. "Spending on Christmas Decorations Remains the Same in 2018." *KCRG*, 29 Nov. 2018, www.kcrg.com/content/news/Americans-spending-the-same-on-Christmas-decorations--501601652.html.