LED Lighting for Photography

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1. Introduction

1.1 Objective

The industry of photography has an immense market and provides information about products that cannot be communicated through text. The advertising and marketing industry alone provide over 500 billion USD [1], and photography plays a great role in the effectiveness of advertisements. In the case that these photographers purchase subpar equipment, improper lighting can create a dull and listless photo, losing the appeal that a vivid image can have.

Our project is to create an affordable lighting fixture that can offer tunable lighting effects such as smooth lighting gradients, adjustable color temperature, and mobility to create dynamic lighting for stunning photographs. By designing a programmable 2D LED array, we can enable photographers to “paint with light” by utilizing the effects provided from our design.

1.2 Background

Current lighting used in photography can cost thousands of dollars, and does not easily provide the dynamic lighting needed for certain effects used in photography. This lack of mobility of the current lighting limits the abilities of the photographer, and therefore the quality of the image. Without desired effects, photos of ordinary objects stay ordinary, but with control over certain features of the lighting, these photos can become extraordinary.

We propose that a single light source can be used in place of many, high cost, immobile lights. This light fixture can be swept past an object to offer a scanning effect and produce an image with dynamic lighting; giving photographers a whole new dimension to their photography. By incorporating tunable brightness, light gradient, and color temperature, our project will allow for more versatility than many professional lights can.

1.3 High-Level Requirements

- Our design requires a cordless power source capable of lasting up to 1hr
- The LEDs must be bright enough (appx 1000 lumens) to provide sufficient lighting for photography
- The LEDs must span a color temperature range between 3200K-5600K

2. Design

2.1 Block Diagram

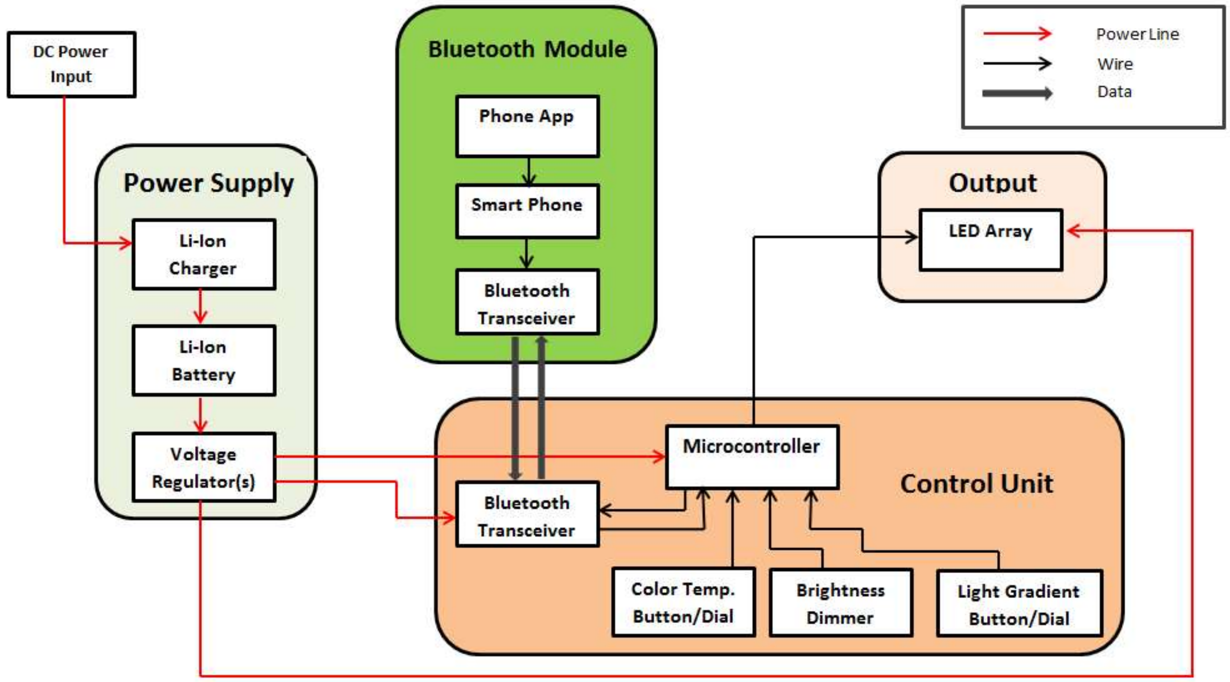

Figure 1: Block Diagram of LED Array

2.2 Physical Description

The LED array will be rectangular with the housing dimension dimensions of roughly 6 inches wide, 6 inches tall, and 3 feet long. The color temperature, brightness dimmer, and light gradient will be controlled by buttons or dials attached to the side or back of the LED array. There will also be two handles on the back of the LED to ensure better mobility for the user.

3 Functional Overview

3.1 Power Supply Module

3.1.1 DC Power Input

This unit is responsible for supplying the power to the lithium ion battery charger. The power will come from a standard 120V/60Hz DC input, and it will output to the Li-Ion battery charger.

Requirement: Must provide 120V/60Hz +/- 5% DC input to properly power the Li-Ion charger.

3.1.2 Li-Ion Charger

Power from the DC input will be sent transformed from the standard 120V/60Hz to appropriate values through the charger. This module will convert the DC input power to a useable voltage/current to charge the Li-Ion battery.

Requirement: The charger must fully charge the Li-Ion battery in under 6 hours to provide fairly quick reusability.

3.1.3 Li-Ion Battery

This is the core power of the entire system. It is the power supply to the Bluetooth receiver, microcontroller, and the output LEDs. Its output is first sent to the voltage regulators and then to the aforementioned modules. The input to this module is only necessary when recharging the Li-Ion battery.

Requirement: The battery that we will use should provide at least 20mA to each LED to provide sufficient light emission.

3.1.4 Voltage Regulator(s)

The voltage coming from the Li-Ion battery may not be at an appropriate level for each module that the battery is powering. This is the interface that protects each of the modules from too high of a voltage coming from the battery.

Requirement: The regulator should provide a steady voltage level within +/- 10%.

3.2 Control Unit Module

3.2.1 Microcontroller

This is the central control unit of the entire system. It takes input from three user options: Color Temperature, Brightness, and Light Gradient coming from the smartphone app and physical dials on the housing of the unit. Its output is sent to the LED array to adjust the current at each LED, creating each desired effect.

Requirement: The microcontroller should be able to vary the input current from 0-20mA to allow for brightness control and gradient control.

3.2.2 Bluetooth Transceiver

To communicate between the smartphone and the microcontroller wirelessly, our design will utilize Bluetooth communication. This module receives the desired input from the phone app and relays current values back to the phone from the microcontroller.

Requirement: The transceiver should be able to communicate with the smartphone from a range of 0-10 meters.

3.2.3 Color Temperature Button/Dial

This is one of the levels of control to the system by the user. By adjusting this dial up or down, the color temperature will vary accordingly. The up/down signal is sent to the microcontroller to be affected in the LED array.

Requirement: Should send a single message of up or down to vary the color temperature between 3200K-5600K.

3.2.4 Brightness Dimmer

This is another level of control by the user. This allows the overall brightness of each LED to be adjusted, allowing for more or less output optical power. The up/down signal is sent to the microcontroller as well.

Requirement: Should send a single message of up or down to vary the brightness by adjusting the current to the LEDs between 0-20mA.

3.2.5 Light Gradient Button/Dial

This is the final level of control from the user. It allows the position of the gradient through the 2D array to be shifted up or down. The up/down signal is sent to the microcontroller as well.

Requirement: Should send an up/down signal to the microcontroller to move the position of the gradient from one end of the array to the other (0-3 feet).

3.3 Bluetooth Module

3.3.1 Phone App

Although there is a physical interface on the housing unit, this is a second interface between the user and the LED array. It allows for the same control as the physical dials, but is sent wirelessly via Bluetooth. The app communicates with the smart phone, sending relevant data such as up/down signals to be sent by the Bluetooth transceiver.

Requirement: Compatibility with IOS devices

3.3.2 Smart Phone

This is the simply the hardware connecting the phone application to the Bluetooth transceiver. It takes input from the mobile app, and relays the signal to the Bluetooth transceiver.

Requirement: Should send the data to the LED array with minimal latency (between 100-500ms).

3.3.3 Bluetooth Transceiver

Similar to the transceiver in the Control Unit, this is the communication hub on the phone itself, sending up/down signals, and receiving the current values of the system.

Requirement: The transceiver should be able to communicate with the smartphone from a range of 0-10 meters.

3.4 Output - LED Array

This is the output of the system, receiving input signals from the microcontroller and transforming them into visual effects in the LEDs.

Requirement: Maximum brightness of array is 1000 lumens +/- 10%.

3.5 Risk Analysis

The component of our project that poses the most risk to being successful is the Bluetooth interface. It must be simple to use, reliable, and function within an acceptable range.

Ensuring a simple interface means connecting to the light from a mobile device feels familiar and requires few steps. Having control from a mobile device only helps if it is as convenient to use as the physical controls. This is a challenge because a lot of complexity has to be abstracted away, and users are unpredictable with differing opinions about what is easy to use.

The reliability of the connection is also important. The software running on the phone must not cause disconnects. The Bluetooth connection should also be stable within an acceptable range of ~10m. This poses a significant challenge in a couple ways. It requires a well-implemented antenna design. It also needs thorough testing in a variety of situations to sufficiently determine reliability.

4. Ethics and Safety

The biggest safety concerns for our project lie with including a lithium-ion battery. Due to the high energy density of lithium-ion cells, a failure can be very energetic. The battery must be protected from short circuiting, overheating, overcharging, and physical damage. [2] This will require temperature detection, charging/power circuitry that prevents the voltage and current from exceeding safe levels, and careful design of the housing for the battery cells.

One ethical issue that we might run into is unintentionally copying the design of an existing product. There are many designs already for battery powered LED lights. We must do research as we go to prevent our final design suffering from intellectual property issues as per part 9 of the IEEE code of ethics which says "to avoid injuring others, their property, reputation, or employment by false or malicious action." [3]

We must also be responsible in developing the mobile device software. Accessing only what is necessary on a device is important to the security of the user. Part 1 of the IEEE code of ethics instructs "to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment." [3] We will develop software such that we don't provide a way for somebody with malicious intent to access sensitive information.

References

[1] "Industry statistics, advertising, Branding & marketing business statistics analysis - Plunkett research, Ltd," in Plunkett Research, Ltd., Plunkett Research, 2015. [Online]. Available: http://www.plunkettresearch.com/statistics/advertising-branding-industry-market-research/. Accessed: Feb. 9, 2017.

[2] T. R. Long, M. Kahn, and C. Mikolajczak, "Lithium-ion battery hazards," in SFPE.org. [Online]. Available: http://www.sfpe.org/page/2012_Q4_2. Accessed: Feb. 9, 2017.

[3] "IEEE code of ethics," in IEEE.org, 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. Accessed: Feb. 9, 2017.