Motorized Remote-Operated Track Lighting System

Team 80
University of Illinois at Urbana-Champaign ECE 445
Pratik Ainapure (painap2), Adithya Bellary (bellary2), Ethan Hickman (ehickma2)
TA: Zhen Qin
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1. Introduction

1.1 Objective and Background

Goals

Current lighting solutions for home, museum, and studio use are often static systems. While they can be useful in fixed positions in fixed environments, if the environment they are meant for use in is rearranged regularly, manually adjusting the lighting solution is a frustrating and potentially dangerous process.

Functions

We propose a track light style system in which multiple lights can be controlled remotely. The degrees of freedom available to each each light unit will allow them to move left and right along a shared linear track, and to pan the bulb mount 360 degrees, and tilt the light through a range from 0 degrees (beam straight down) to 90 degrees (beam horizontal). This product should give artists, gallery owners, and homeowners the ability to change focuses of their lighting solutions on demand.

Benefits

This product will make arranging lighting in a space simpler. The user will not need to modify the lighting configurations manually, risking burns from hot bulbs, electrical shock or falls from high ladders. The user will be able to move individual light units along the track and change the direction the light bulb is shining through a cell phone application communicating with the light system over Bluetooth.

Features

Ease of use is the most important marketable aspect of this project. Our remotely controlled system will mitigate much of the physical hassle of manually iterating on a lighting setup. In turn, this will bring dynamic lighting solutions to users who may be physically unable to balance on a ladder and reach above their heads. In addition, this lighting solution allows the user to view the changes they are making to the lighting in a space from the vantage point that viewers, customers, or themselves as artists will have of the illuminated subject.

1.2 High Level Requirements

For this system to be be successful, there are several requirements which must be fulfilled.

The most important requirement is that the light beams can be controlled to pan and tilt. The ranges for the pan and tilt will be controlled through two servo systems available for purchase in order to alleviate some of the mechanical complexity of integrating motion in two axes in a small form factor. These mounts should provide more than enough flexibility for 360 degree panning and at least 90 degree tilting to pointing the light anywhere in the range of straight down to horizontal. These systems are compatible with standard servo sizes, so we can select units as necessary to compensate for the torque of supporting the light fixture. The tilt system is designed to support cameras up to 2 pounds, far more than the average LED bulb weight of about 0.4 pounds [1]. This gives us leeway in terms of weight for a mount for the bulb.

It also must be fully controllable remotely. To implement this, we currently intend to interface via cellphone app with a master bluetooth receiver mounted at one end of the track system [3]. This bluetooth module will act as a master to slave modules on each light unit. This will allow the user to control linear motion of units along the track as well as interact with the pan and tilt controls on each unit.

In addition, The user must be able to connect and be able to control a light cart seamlessly within 30 seconds of opening and configuring the connection to the correct track system.

2. Design

2.1 Block Diagram

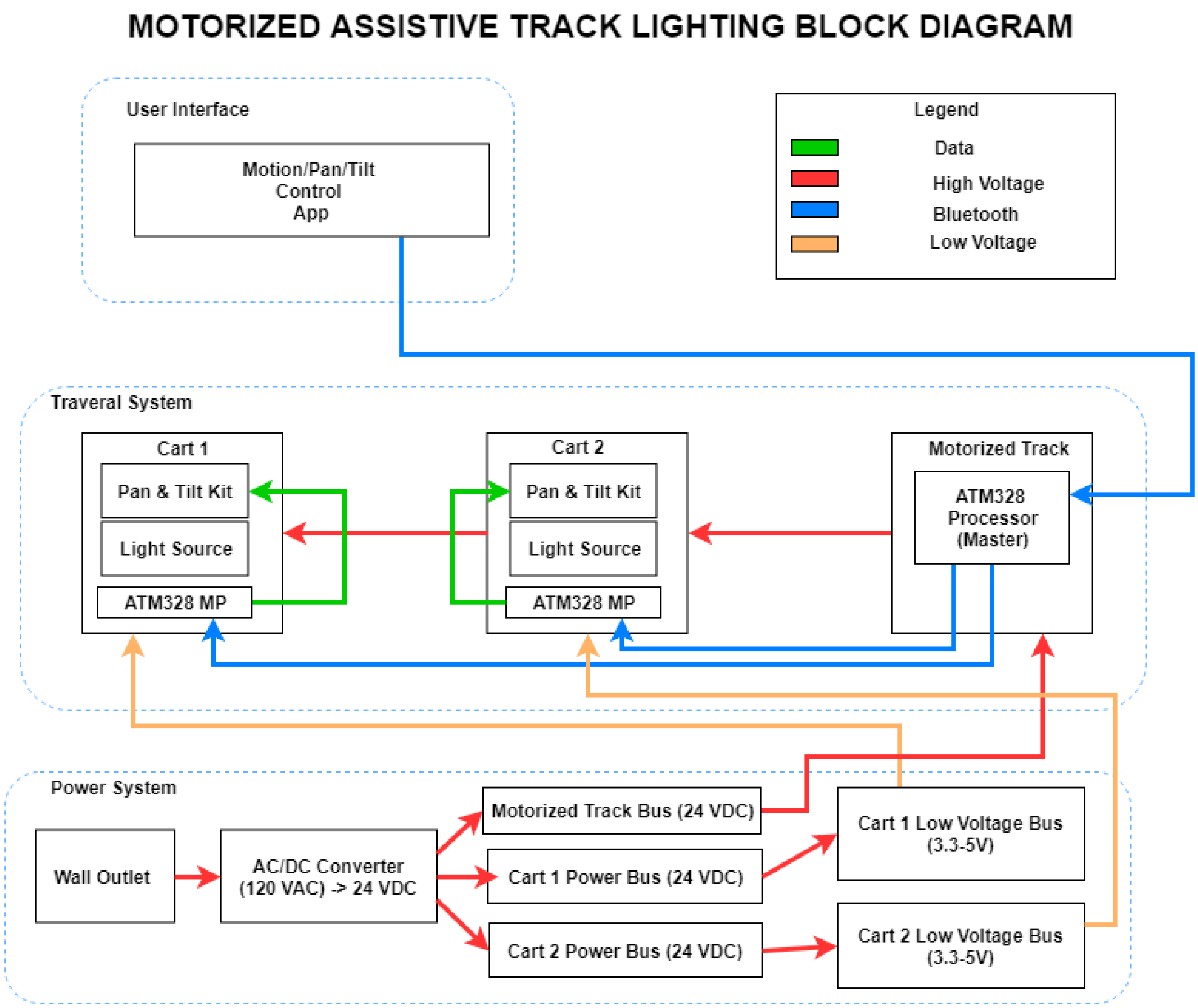

Figure 1: Block diagram for the proposed system

2.2 Block Descriptions

User Interface App

The user interface app is the high level communication method that will allow the user to directly communicate with the motorized track lighting system. It will be operated through an IOS or Android device that will allow the user to move a specific light cart in a lateral direction, as well as pan and tilt the light source. The configuration data will be transmitted to a master AT328 processor that will be attached to the traversal sub-system. For this system to be functional as intended, it will need to be able to allow the user to configure the light source near real time to get to the desired end position.

Traversal Module

The traversal system will be responsible for the lateral motion of the light carts within the system. This sub-system will provide form factor to allow for forward and backward motion for each light cart. For the purposes of this design build, two carts will be configured to work on the same rail with the flexibility to extend this system with additional light sources. The traversal system will be directly powered by the converted 24 VDC source coming from the power sub-system. This voltage will be distributed to each cart connected to the traversal system which will ensure constant power is delivered to each light cart.

The main form of communication for the traversal system is a master AT328 processor that will be utilized as the receiver of the user interface app. The data transmitted to this processor will be used to determine which cart needs to be moved along the rail. The final product will allow for one cart to move laterally at a time to minimize the complexity and a higher risk of collisions between carts.

The data relevant to the light carts such as pan and tilt orientation will be transmitted from this processor to the specific cart that the data pertains to. This data will be received by a respective AT328 processor on the light cart which will provide the relevant data to drive the pan and tilt kits into the appropriate orientation. To power the low voltage peripherals, a low voltage bus bar will be created to step down the DC voltage to 5 volts. This will be done in each respective cart on their PCB.

Power Sub-System

The power sub-system will be completely responsible for all the voltage conversion and regulation for this system. The main power unit, which is responsible for converting 120 VAC to 24 VDC will be mounted to one end of the motorized track where it will remain stationary, but still be in range to provide power to all components within the traversal sub-system. This sub-system also encapsulates the step down of voltage from 24 VDC to 5 VDC to power low voltage peripherals that will be utilized in all of the light carts. This will be done locally on each light cart to minimize power loss over long distances.

A functioning sub-system will ensure constant connection is maintained to all of the light carts within the traversal system. Since the novelty of the design rests on its ability to move based on the user's desire, it's imperative power loss to a light cart does not happen.

2.3 Risk Analysis

One part of the project which we foresee being difficult to implement is enabling the light bulbs on the units to pan around its axis 360 degrees as well as tilt in the range from pointing down to pointing horizontally. This will be tough because we need to incorporate a high degree of mechanical complexity in a small size in each light module. There are multiple moving parts that we need to make sure work well together. Incorporating this movement into the project is important because it plays a major role in accomplishing the goal we outlined in the introduction. Therefore, we need to ensure that this functionality is present in the final system that we demonstrate. We worked towards simplifying this aspect of the project by using intermediate components such as pan and tilt kits [2] that are designed to actuate this specific type of movement. We then need to integrate these parts into the design of the light units such that they can be controlled reliably and to a sufficient degree of precision.

3. Ethics and Safety

Ethics

We understand that there are some safety hazards regarding this project, so we will ensure that these potential issues are accounted for through careful planning and rigorous testing. Safety is our utmost concern and we take it seriously. We will also be honest in stating the functionality as well as limits of this project when marketing it to any potential end-users. We will not mislead the user into thinking this project can do something is realistically cannot. If issues of any sorts arise throughout the developmental or product phase of this project, we will rectify them as soon as possible to limit any potential damage to individuals' health or reputation.

Safety

Since we are going to be pulling 120VAC from the wall outlet, there could be electrical hazards associated with this project. We will be using a transformer to convert the 120VAC to 24VDC at the entry point to the power subsystem of our project. We will need to be careful when dealing with this conversion, and take all necessary precautions such as undergoing rigorous testing prior to continuing to build and test our designs. We anticipate being able to power LED lighting with the 24VDC power, or stepping it down further.

We are also dealing with lightbulbs, so there is a possibility of a fire hazard as the light dissipates heat. We will employ safety fallbacks to ensure that the bulbs to do not overheat. The track as a whole will be mounted to the ceiling, and the individual light modules mounted to the track itself, so it is important that we make these connections very secure to avoid any risk of any component falling down and potentially injuring anyone below the fixture.

References

[1]RobAid. (2019). *Power consumption and environmental impact of light bulbs | RobAid*. [online] Available at: http://www.robaid.com/gadgets/power-consumption-and-environmental-impact-of-light-bulbs.htm [Accessed 7 Feb. 2019].

[2] Servocity.com. (2019). *DDT500 Tilt Kit*. [online] Available at: https://www.servocity.com/ddt500 [Accessed 7 Feb. 2019].

[3] "Bluetooth Basics - How Bluetooth Works: Applications and Advantages," *ElProCus - Electronic Projects for Engineering Students*, 08-Nov-2018. [Online]. Available: https://www.elprocus.com/how-does-bluetooth-work/. [Accessed: 07-Feb-2019].