Robotic Lamp

Team 82

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1 Introduction

1.1 Objective

Home automation continues to be on the forefront of technological advancement in 2016 and in 2017. While we have seen software interaction, such as Google Assistant, Siri, and Alexa, and we have seen automation in the form of smart lighting, thermostats, and more, we have yet to see many products that bring automation and interaction together. Specifically, we wanted to look at the office setting - lamps. We spend a lot of time at our office desks working on our computers, scribbling on our papers, and 46% of that time is spent after daylight hours[1]. While lighting in the office typically is through the use of lamps, these lamps are stationary, heavy, out of reach, and take effort to move around when we need them to, especially for those that are moving from one area of the table to another. This can be an annoyance for many office workers - constantly having to move lamps for their intended needs.

Our solution - a robotic lamp - aims to provide automated interactivity for anyone who spends their time at the office. The robotic lamp provides automation - turning itself on as soon as you are near it, and can set the tone of light based on the time of day. It also provides interactivity - following your hands as you write and work, to provide optimal lighting on your workspace.

1.2 Background

There are currently no commercial robotic lamps on the market, but rather only “smart lighting” (such as Philips Hue) and lamps that are easy to adjust. There are many “do it yourself” projects online that have created a robotic lamp, but are not feasible products, as they use expensive, using unnecessary technology such as Arduino variants [2]. Lamps are currently lacking functionality, and a robotic lamp is what many people are looking for [3]. We want to provide a cost-effective solution, while providing fullness of interactivity and automation.

We took inspiration from a Robotics project done at MIT a few years ago [4][5], which uses OpenCV and Machine Learning to provide the user an interactive desk assistant in the form of a robotic lamp, which keeps the user engaged in their work. The lamp adjusts the gestures based on the user’s behavior and mood patterns and has additional functionality such as changing the temperature/color of the light as well. We wanted to use the research done and make a cost-friendly interactive robotic lamp assistant for the users.

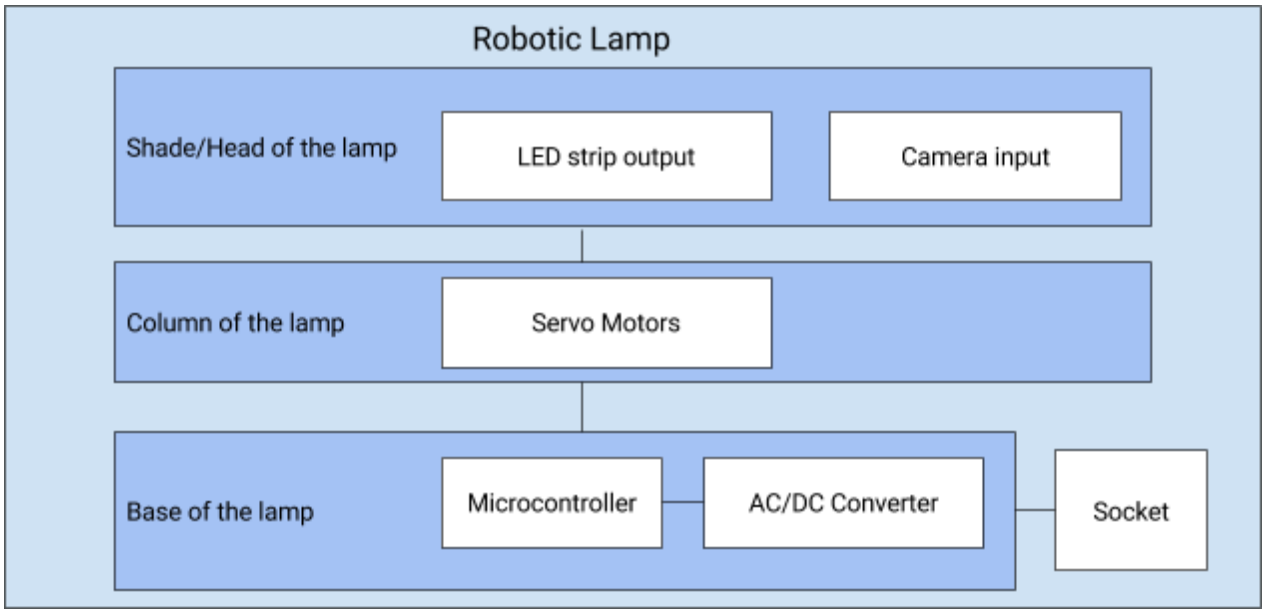
1.3 High-level requirements list

- The full cost of constructing the robotic lamp will be under $130.
- The lamp must interact with a single person within a 5 foot distance, while never coming into contact with the individual’s arm or hand.

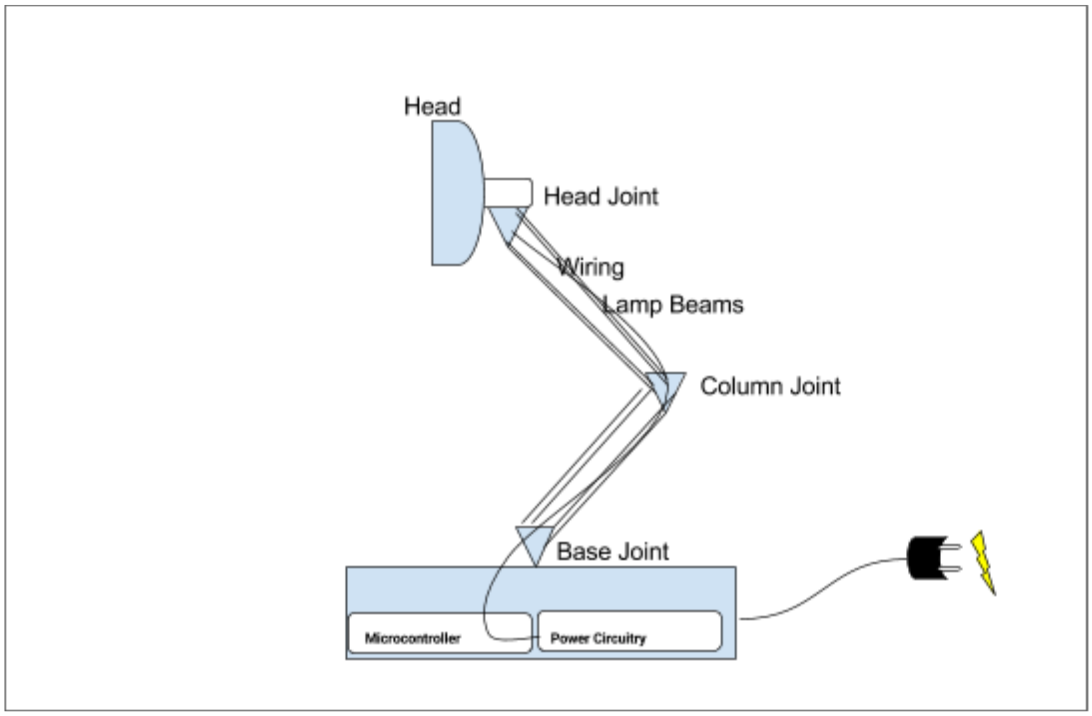
- There must be a kill-switch that would immediately shut off all mechanical and electrical functions within 1 second of the command to prevent damage and harm

2 Design

2.1 Block Diagram



2.2 Physical Design



2.2 Functional Overview

2.2.1 LED Array

Instead of one big bulb as used in conventional light bulbs, we plan to use an LED strip that will be connected to a variable resistor to control the temperature of the light emitted by the lamp head. This part is controlled by the microcontroller and is connected to it using wires which pass through/around the lamp arm.

Requirement 1: The LED strip should be power efficient enough to be powered by the microcontroller.
Requirement 2: The LED strip should have multiple temperature levels.

2.2.2 Camera Module

The camera module we plan to use is a VGA Camera Module used with Arduinos/Raspberry Pi to get input from the user for the Computer Vision part. We plan to use gesture recognition based on contour mapping and edge detection which can be achieved through both RGB as well as grayscale cameras.

Requirement 1: The camera module should be capable of recording video.
Requirement 2: The camera should have resolution high enough so that the CV algorithm can differentiate between the user and the background, but also low enough so that the computation is within the limitations of the processor used.

2.2.3 Lamp Beams

The lamp beams support the lamp head and also support the wires that run from the base to the head. The beams are 3D printed according to the specifications depending on the weight of the head.

Requirements: The beams will have 70-80% infill density to make the beams strong enough to support the lamp, but at the same time are light enough for the servo motors to move.

2.2.4 Joints

The lamp arm will have joints which will have servos to provide movement in the arm based on the response from the microcontroller. There will be 3 joints (head, column and base) which will be controlled by the microcontroller independent of each other.

Requirement: The servo motors should be powerful enough to move the weight of the columns and the lamp head.

2.2.5 Power module

This module supplies power to the microcontroller which in turn powers and controls the servos and the lamp head LEDs. This module will be responsible for converting AC to DC for the LED strip as well as for the servo motors.

Requirement: The voltage and current should be within the acceptable limits of the microcontroller , LED strip and the servos so that there is enough power for the whole system without any overheating.

2.2.6 Block Requirements

Block Name	**Requirements**
LED Array	• Maximum 5V @ 120mA draw per 2.5" strip segment (all LEDs on full brightness) • 5VDC power requirement (do not exceed 6VDC) - no polarity protection
Camera Module	• High-resolving power: 640x480 • Video Format: 24bit RGB • Interface: USB Frame • Rate:320x240 up to 30 frame/sec(cif) 640x480 up to 15 frame/sec(VGA) Sensor size:3.64mm
Lamp Beams (Dual Struts)	• Able to sustain 2lbs on weight force
Power Circuit	• AC 110-240V To DC 12V 1.5A Power Supply
Microcontroller	• 32-bit or 64-bit processor that OpenCV • supports (ideally an Intel CPU but can even work on other processors • C compiler

2.2.7 Risk Analysis

The computer vision part will be the most difficult as well as the riskiest part of our project. The computer vision part requires a lot of computational power and is also prone to a lot of error. This is why, we will need to come up with a few techniques for gesture recognition to decide the response from the microcontroller. We plan to use existing OpenCV libraries that detect hand and fingers, however if the error margin is too much for object detection on the background, we can use contour mapping or contrast detection to detect the gestures.

The servos and the robotic arm could be difficult to implement since the 3D printed arms need to support the weight of the lamp head as well as allow movement. We can strengthen the arms by printing them at >70% fill density, however this would increase the weight and would require more powerful servo motors as compared to the ones we would need for ~<50% fill density 3D prints.

3 Ethics and Safety

There are a lot of ethical issues and safety issues that will come up with a mechanical, robotic lamp. To highlight one of the most severe issues of this decade - privacy. We want to keep the lamp functioning as robotic rather than “smart”. As it states in IEEE Ethic #8: “to treat fairly all persons and to not engage in acts of discrimination...” [6]. As spying on cameras have been a bigger problem for personal privacy, we want to prevent engagement in personal and discriminatory acts that may be possible by spying through the lamp’s camera. To prevent this, we will provide a mechanical cover on the camera when it is not being used, so it will be obvious if the camera is in use or not.

We also want to emphasize and put efforts towards safety and preventing physical harm, an important IEEE Ethic, #9: “to avoid injuring others, their property...” [6]. As much effort as could to prevent mechanical and electrical malfunction of a robotic lamp, we want to provide a kill-switch that will quickly turn off the robotic lamp and prevent additional functionality after the switch (until being turned back on). We will also provide guidelines on the area that the lamp may move, so users will be informed of potential injury or destruction if something were to get in the vicinity of the lamp. Additionally, since the lamp will be tracking the user’s motions through the use of arm and hand, we will add additional countermeasures so that the lamp will never physically touch the arm or hand.

Additionally, since we will be working with many pre-built parts such as servos, LED arrays, and a microprocessor, we will abide IEEE Ethic #6: “to undertake technological tasks for others only if qualified by training or experience...” [6]. We will not take apart these parts and tamper with them unless we have read the documentation, safety guidelines, and all other paperwork regarding these parts. We will follow instructions on how to properly use these parts.

Safety is one of the most important priorities of this robotic lamp, as stated in IEEE Ethic #1: “to accept responsibility in making decisions consistent with the safety, health, and welfare of the public...”. While we work with many electrical components such as the LEDs, we are aware that these parts will have many limiting factors. This includes particular Voltage and Current regulations. For example, the Voltage of a group of GaN LEDs is an average of 3.6 volts and a maximum of 4.0 volts [7]. Failure to follow regulations such as these will result in blowing out LEDs, or potentially worse. We will abide by each component’s standards, and implement Voltage and Current regulators where necessary.

We will pay careful attention in regulations regarding the servos we use - maximum torque that each can push, how to properly construct the lamp with them, and to prevent harm if a malfunction were to occur.

References

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