Music Detecting Light System

Team 72 - Francis Mui, Ran Wang, and Alfredo Sanchez

ECE 445 Project Proposal - Spring 2020

TA: Ruhao Xia

1. INTRODUCTION

1.1 Objective

The system objective is for the light patterns to change based on the music detected and on the user's chosen settings. For example, when used in a party and a strong music is detected, the lights are supposed to react to the "mood" of the music, showing strong synchronized beats, with fast changing, enthusiastic color patterns. When in personal use, such as when the user is playing jazz music, the lights change to a colder, background color to reflect the genre of the music, creating a more immersive atmosphere. So if the rhythm, genre and change of pace of the music is accurately reflected and the user's preferences are met, the system is considered successful.

1.2 Background

Lights and music are two features that are very powerful in providing entertainment. For example, party hosts often provide rock music and warm-color lighting to improve the atmosphere. Also, musicians would sometimes relate a piece of classical or jazz music to a specific color. The problem is the colors and the music itself are often separated. A system providing synchronous lighting to the music would be an interesting solution for individuals who frequently listen to music and want a matching atmospheric lighting. This will also extend to people who host home parties and are looking for a way to make it more exciting or for people who desire to feel more immersed when listening to any kind of music. The key point is that people will be able to create a synchronous ambience combining both music and lights.

1.3 High Level Requirements

1.3.1. Detecting and recognizing the music pitch.

The high level goal for this system is for the light patterns to change based on the music detected. In order to do that the system must detect the type of music that is being played and classify it in order to form the proper output, using parameters such as genre, chord progression, frequency, and strong beats.

1.3.2. Controlling lights.

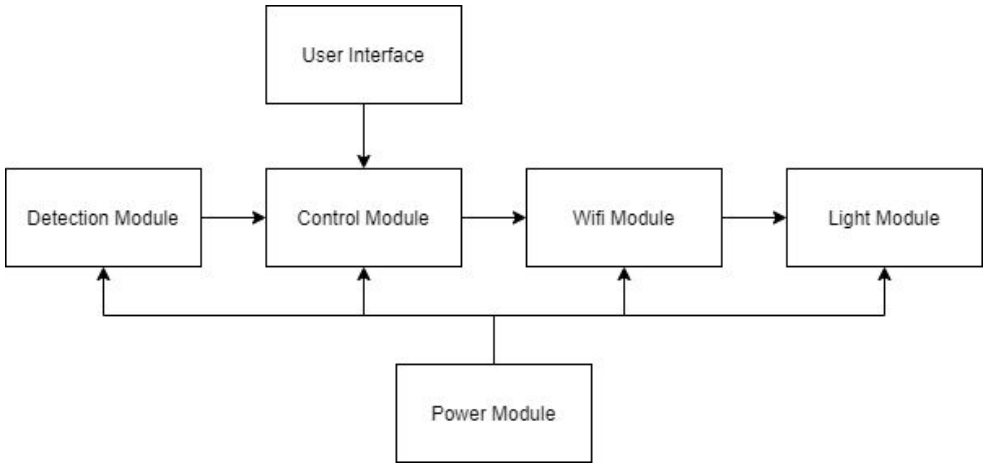
The other part of the main goal of the project is the lights being able to change. The only way of doing that is by controlling the pattern of the lights, so the system must have total control of the light outputs.

1.3.3. User choosing preset patterns.

The project must also have some user interface software so the user can choose to use either a preset light pattern or one that is custom set by the user even without having any music playing.

2. DESIGN

2.1 Block Diagram and Module Explanation



2.1.1 Detection Module

This module contains a microphone to record the analog audio signal from the room where it's installed, an amplifier to increase its strength, a digitizer to perform an analog-to-digital conversion, and a digital filter to preliminarily eliminate the background noises recorded. Recognition of the music is performed in the recognition module followed.

2.1.2 Control Module

This module is the part that is in charge of recognizing the music, receiving user commands from the user interface, and controlling the light module accordingly. After the microprocessor receives the audio signal, it performs the adaptive noise cancellation, audio fingerprinting algorithm and pitch detection to recognize the music's genre, frequency and strong beats. After the recognition, it loads the matching preset light

pattern, along with potential user commands to change preferred patterns (explained later), and sends control signal to the Wifi module.

2.1.3 Wifi Module

Added to enable remote connection between the control module and light module. Since wiring the lights directly with the control module can pose a lot of problems when physically setting up the system, remote controlling will allow more flexibility.

2.1.4 Light Module

Multicolor LED light bands to be set up around the room and perform the desired task: a matching lighting to the music being played. Receives digital control signals through the Wifi module and changes the colors accordingly.

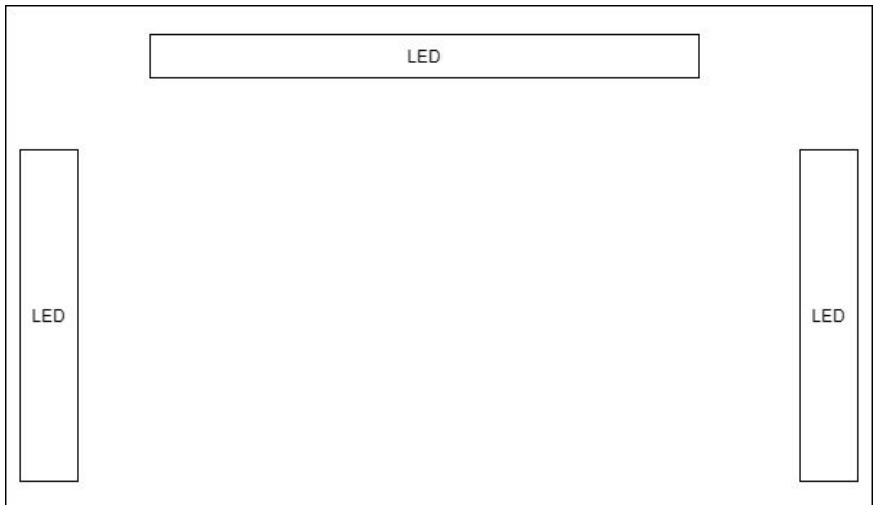
2.1.5 User Interface

Personal computer connected to the control module through a USB port. The implementation of a laptop app for the user to choose their preferred light colors and patterns, to switch between personal mode (for music appreciation, etc.; gradual change, colder colors) and party mode (for enthusiastic music played in a party; emphasizes strong beat effects), and to customize other settings such as brightness and favorite color, is necessary.

2.1.6 Power Module

Contains a rechargeable battery that draws power from the wall outlet, and a power distribution unit to power the other modules from the battery. Since the system is designed to allow a convenient movement and installment for the user when looking for entertainment, a central power module would be preferable than plugging modules in the outlet separately.

2.2 Physical Design and Explanation



The microphone is installed near the music player to reduce the noise received. LED light bands are installed around the room and on the ceiling to create light patterns. The control, Wifi and user interface modules can be installed at any convenient places at will, and does not interfere much with the users when in use. (for example, in a crowded party)

2.3 Functional Overview and Interface

2.3.1 Functional Overview

The final goal of this system is to create a matching lighting atmosphere to the music being played, and to the user's preferences. In order to achieve this,

1) It should accurately recognize the music and the time node at which it's played, even in a relatively noisy background.
2) Since it needs to reflect the genre and beats of the music being played, and change to different light patterns when the music is switched, it is required to perform with a low latency.
3) The LED lights must correctly respond to the control signals, and display various light patterns and beats at various rates as desired.
4) Another feature is the user interface. The user is allowed to choose which preset light patterns to use, and customize other lighting conditions to his own preference.
5) Lastly, it must be convenient for the user to remove, move and install, and doesn't take too much space.

2.3.2 Interface

The most important interface of the system is the user interface module that allows the user to choose the preferred light patterns and mode. This interface is achieved using a PC app that sends commands through a USB port to the control module. Another

interface would be a switch to power off the entire system when not in use or the system needs to be moved.

2.4 Block Requirements

2.4.1 Detection Module

The Detection Module will need to be able to read the audio signal, amplify it and convert it from AC to DC, and filter out anything that is not the music, and send this new amplified signal to the Control Module. This needs to be active while the machine is on at all times, and needs to quickly identify when the song has changed. The microphone itself will need 12V to activate.

2.4.2 Control Module

The Control Module needs to be able to read the signal acquired from the Detection Module and convert it into a signal which accurately conveys the genre, chord progression, frequency and strong beats. It then needs to use these parameters to pick out the appropriate light patterns, either from the preset list or from one obtained from the User Interface, and send it to the Wifi Module. We intend to use either a microcontroller of, if we need a more powerful chip, a raspberry pi. Much like the Detection Module, this needs to be active at all times to identify the song, but will only need to send outputs to the Wifi Module when the light is turned on. Both of which require the Power Module to provide approximately 5V of power, +- 0.5V

2.4.3 Wifi Module

The Wifi Module will need to receive the signal from the Control Module and immediately send the signal to the light Module. This will only activate when we need the lights to turn on, and otherwise will block inputs. This needs to be powered by the Power Module with up between 1.8 and 5 V.

2.4.4 Light Module

The Light Module will need to receive the signal from the Wifi Module and output the signal as varying lights. They will only turn on when they receive inputs from the Wifi Module This needs to be powered by the Power Module with 12 V at 0.6 A per meter of LEDs.

2.4.5 User Interface

The User Interface needs to have sliders/buttons that determine how active a person would want their lights to be, from whether they want the colors to change dramatically for party settings to changing gradually for personal settings or for concerts. This would also have options to place emphasis on certain colors or brightness. This

would come with presets for party and personal use, and this signal would be outputted to the Control Module to determine what color patterns would be most appropriate.

2.4.6 Power Module

The Power Module needs to be able to power the Detection, Control, Wifi, and Light Module. This will need to provide power for at least 3 hours so that the system can stay on during an entire concert or the majority of a party.

2.5 Risk Analysis

One of the larger risks is finding the appropriate filter to eliminate background noise efficiently and effectively. While we have many possible solutions, such as using the least mean square algorithm to adaptively reduce background noise levels, or using audio fingerprinting, we are not sure how much success each one will provide, especially if the music volume becomes comparable to the background noise such as during a party.

Another risk comes from the Control Module, which will need to accurately output key characteristics of a song. We can use machine learning algorithms or predefined settings to determine each characteristic, but both may require a large amount of memory and power to function well. This is part of the reason why we are debating whether or not to switch to a raspberry pi instead of a microcontroller. The extra storage will also help for storing and modifying light patterns, which may also take up a lot of space.

3. ETHICS AND SAFETY

The general goal of both the IEEE Code of Ethics [1] and the ACM Code of Ethics [2] is to ensure quality without either intentionally or unintentionally causing harm. Our design does not appear to break any laws; the device will record audio only for the purposes of creating lights, and will not invade anyone's privacy. The only wireless connections are made via bluetooth, so there is little to no possibility of invading personal privacy or interfering with other signals.

Every subsystem aside from the lights and the microphone are contained within one compartment, which receives controlled inputs that would not cause overheating or other damage to the subsystems. The lights and microphone would be similar to ones you have at a normal home, so the ethical implications of those would be comparable as well. Finally, the lights are LED so they don't require much power and create little risk.

Overall, we believe that we are following both Codes of Ethics, as we are not breaching any regulations or standards. We will keep careful note to prevent our primary controller from overheating, but otherwise no safety concerns or breaches of privacy arise.

REFERENCES

[1] "IEEE Code of Ethics," *IEEE*, Jun-2019. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 12-Feb-2020].

[2] "Code of Ethics," *Code of Ethics*, 22-Jun-2018. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 12-Feb-2020]