PoV Music Visualizer

Team - Adam Belkhadir, Alex Dutrow, John Tran TA: Sam Sagan
ECE 445: Project proposal Fall 2017

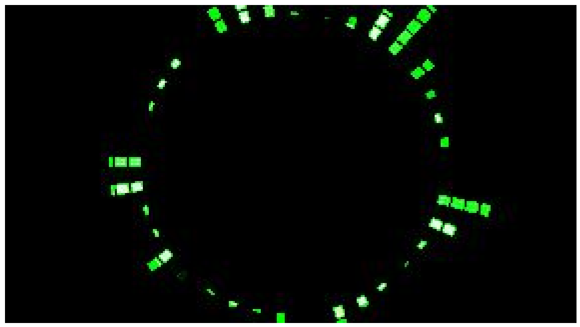

Figure 1: An example of a circular music visualizer

1. Introduction

1.1 Objective

Problem Statement: Circular music visualizers, as shown in Figure (1), have recently become popular in the entertainment and music scene for their unique take on music visualization. Creating one is easy on a computer or an HD TV due to the high pixel count and large computation power. However, many light fixtures used by hobbyists / artists / entertainment companies use low resolution square dot pixel displays to visualize their music. This causes jagged edges on the frequency bins of a circular music display. Anti-aliasing filters can fix this issue but the end result looks messy and unprofessional.

Solution: We hope to create a Persistence of Vision display that can run a circular music visualizer. The idea is that spinning a LED bar around at a high rate we will be able to display the visualizer cleanly and fluidly without the need of a pixelated display.

1.2 Background

PoV displays have been done many times before and they cover a wide range of functionalities. They have been used to generate 3D images, clocks or even display messages. Aliasing is a direct artifact of the resolution of a display and creates the commonly referred "jaggies" that appear on an image at a certain resolution. According to NVIDIA the only way to remedy aliasing is "is to create the effect of having more pixels on the screen" [1]. With a static dot matrix you can't do this unless you create a blending effect between the edges of the image by utilizing more pixels. Utilizing our PoV display allows us to remedy this aliasing effect without the need or utilizing more processing power for our display. Our product is interesting to consumers as it allows the creation of any sort of image to render while captivating audiences with the fact that the image is created with a minimal amount of display elements on a rotating PCB.

1.3 High Level Requirements

- Motor must work and spin at a constant speed of 900 RPM with a -/+ 5% delta to ensure stable framerates.
- LEDs must change outputs within 1 ms to keep up with the spin of the system to generate a working display.
- Microcontroller must have a clock speed of at least 3 MHz to compute the spectrum of the music and interact with the LEDs.

2. Design

Our block diagram consists of 5 modules: power supply, motor system, control unit, audio interface, and the LED display. The whole design will be powered by an AC to DC power supply with 12 and 5 volt outputs. The 12 volt rail will provide power to the motor system exclusively while the 5 volt rail will supply the other circuitry such as the control unit, audio interface and the LED display. The motor system will be controlled to maintain a constant speed and to provide a timing for the microcontroller and LEDs to go off of. We will use a microcontroller to interface with the motor controller, LED drivers, and to process the audio signal. The LEDs will be controlled according to the audio and motor speed while the motor will be controlled purely by the tachometer.

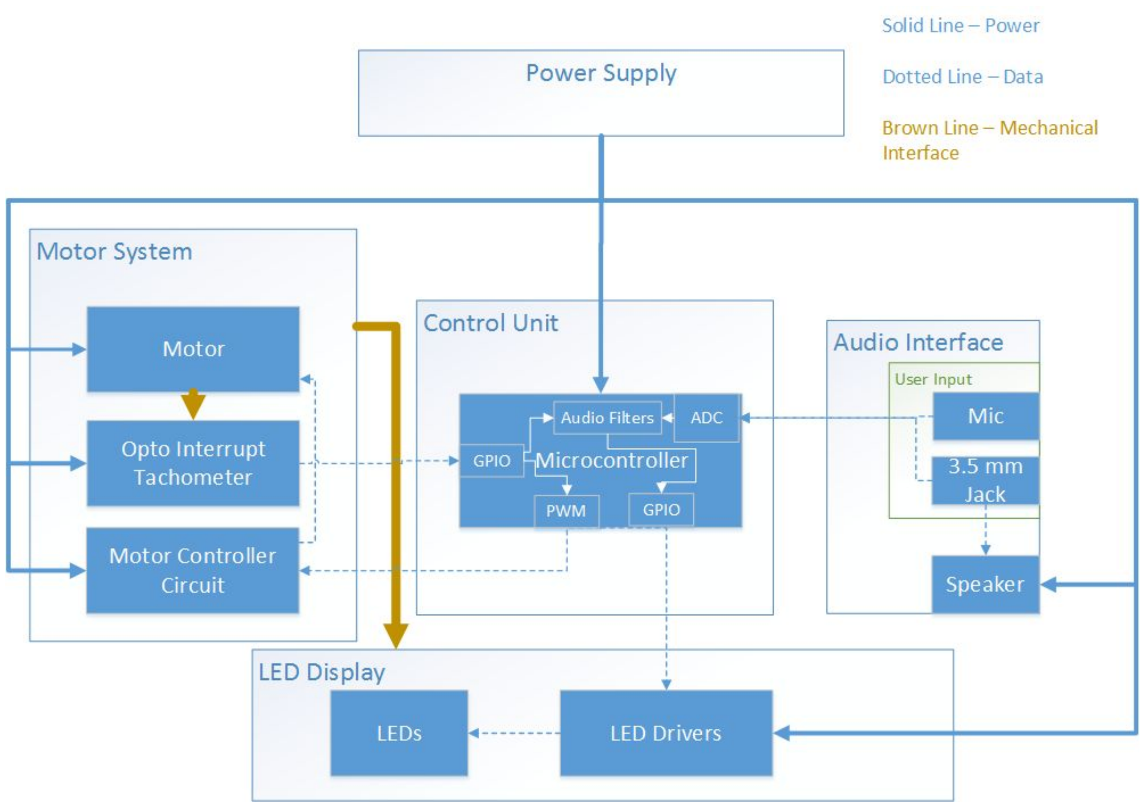

Figure 2: Block Diagram of the system

2.1 Power Supply

The power supply is often a necessary and important component in most projects. Our project will need a 12 volt supply for the motor system and a 5 volt supply for all other subsystems. We want to ensure that the motor power and the LED / micro / audio power are isolated from each other. To do this we decided on using a linear multi channel power supply that can give both 5 and 12 volts. The power supply is the most crucial component in our system as without it, we can't satisfy any of our requirements as they would not be able to operate.

Requirement: Power supply should have multiple voltage railings to supply different sections of our project. Power supply needs a max power rating of at least 60 Watts and a min max current rating of 3 Amps.

2.2 Motor System

Motor: A DC brushed or brushless motor to act as the main driving element to spin the LED bar. It will be mechanically coupled to the PCB and the tachometer. If the motor does not operate properly then we would not be able to fulfil our first requirement.
Tachometer: The tachometer will be used to gauge the speed of the motor. This signal will be fed to the microcontroller for calculating the current speed. If this does not operate correctly we will not be able to accurately measure the speed of our motor and move on to controlling it and therefor we would not be able to meet our first requirement.
Motor controller: The motor controller will adjust the speed of the motor according to a PWM pulse generated by the microcontroller. If this does not operate correctly we will not be able to control the speed of our motor within the required limits and therefore would not meet our first requirement.

Requirement: The motor must be able to spin consistently around 900 RPM in order to match 30FPS for dual blades.

2.3 Control Unit

Microcontroller: The microcontroller is the central hub of the project. The controller will generate the control pulses for the motor control circuit as well as generate the spectrogram of the music. If the microcontroller does not operate fast enough then we will not be able to successfully control our motor or process our input signal fast enough to alter our LED display. So if this doesn't operate properly, we will not be able to satisfy any of our requirements.

Requirement: The microcontroller must be clocked at least 16MHz to insure that control signals are processed quickly enough.

2.4 LED Display

LEDs: RGB LEDs will be used to display the spectrogram and will be driven by the LED driver. These LEDs will need to be able to alter their colors within a reasonable time period in order to fulfil our second requirement.
LED driver: The LED driver will communicate with the main microcontroller and drive the LEDs. The LED drivers will need to be able to send signals at a fast enough rate in order to fulfil our second requirement.

Requirement: To have 16 frequency bins on the display we should be able to change the colors on the LEDs in under 1.04 ms. (1/(60 half revolutions per second) * 1/16 bins per half rotation).

2.5 Audio Interface to Microcontroller

DAC: The DAC will be used to sample the audio signal from the user input. The audio spectrum ranges from 20Hz to 20KHz. However, a majority of people can only hear from 20Hz to 16-17KHz. For this reason we will sample at a rate greater than 32 KHz in order to satisfy nyquist criterion. However to get a good signal we propose to sample at 160 KHz or 10 times the bandwidth. If the DAC is not able to sample the signal at a fast enough rate then we may run into microcontroller processing speed issues and therefore would not be able to fulfil our second or third requirements.

Requirements: This component can often be found inside microcontrollers. We require that the micro we use has a sampling rate of at least 32 KS/s.

2.6 Risk Analysis

The microcontroller is the component that would probably cause the most problems down the line. This is because the microcontroller controls almost everything within our design including the DAC, the audio filtering, controlling the motor, and timing the LEDs. This leaves our project heavily coupled between each subsystem because they each depend on one another for input. For example, the LED bar depends on motor speed and the music and the motor controller and music processing will often compete for computation resources. To mitigate this we have decided that we should program the microcontroller for each subsystem individually. After having the three separate systems working we will then start interfacing them together. This will be done along with a verification process that will test each subsystem one at a time. Once we are able to verify that one subsystem works, we will verify the next sequential subsystem with our designed interconnections until we have completely verified the entire system. This form of modular verification should allow us to efficiently address areas of failure which will help reduce our overall debugging process.

3. Ethics and Safety

Having considered the scope of our project and having read the IEEE Code of Ethics we can say for sure that there are a few ethical codes that should be addressed.

#1 of the IEEE Code of Ethics states: “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” [2]. Our product is going to be using strobing lights, though they may not be too intense, it is important to consider any audience members that are prone to epilepsy and seizures and warn them promptly. Also, our final product will likely be rotating at a significant speed and thus could cause harm to anyone who comes into contact with the rotating member and so a warning should be administered. Finally, our product’s power supply will be plugged into a wall outlet and is in contact with a large source of power and could cause harm to anyone who operates the device improperly and so a warning should be administered.

#7 of the IEE Code of Ethics states: “To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others” [2]. The important portion to take from this is that we should properly credit the contributions of others. Persistence of Vision screens have been done many times in the past be it in this class or online. It is important to consider that our system should stay unique and if outside documentation is utilized that we credit the source appropriately.

#9 of the IEE Code of Ethics states: “To avoid injuring others, their property, reputation, or employment by false or malicious action” [2]. This is a crucial point of consideration in our final product. As discussed previously, our product has the potential to cause physical harm to others. It is important that during the implementation of our project that we incorporate appropriate safety standards. In order to prevent the occurrence of someone coming in contact with the spinning member of our project we are likely to implement a safeguard in a similar sense to how the department of labor requires safeguarding for rotating parts [3]. Another thing to take into consideration is proper housing of the power supply as it is plugged into a wall outlet and therefore could cause significant harm to others if improper contact is made. One final important factor when considering safety is to ensure that the power supply that we choose meets the appropriate safety standards and has the necessary safety marks [4].

References

[1]Nvidia (2017). High-Resolution Antialiasing (HRAA). [Online].Available:http://www.nvidia.com/object/feature_hraa.html [Accessed: 7- Feb- 2017]

[2]IEEE (2017). IEEE Code of Ethics. [Online].Available:http://www.ieee.org/about/corporate/governance/p7-8.html [Accessed: 1- Feb- 2017].

[3]OSHA (2017).General requirements for all machines. [Online].Available:https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9836 [Accessed: 1- Feb- 2016].

[4]CUI(2017).Power Supply Safety Standards, Agencies and Marks. [Online].Available:http://www.cui.com/catalog/resource/power-supply-safety-standards-agencies-and-marks.pdf [Accessed: 1- Feb- 2016].