UCF Senior Design 1

Initial project document

See the Sound

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Group #3

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Narrative

Art is an inherent part of the human condition. Prehistoric cave paintings, and portable art, including musical instruments, sculptures, and paintings date back to our prehistory, as far back as one hundred thousand years ago. The fact that the oldest musical instrument, a flute[10], predates the invention of the wheel is a profound realization about what it means to be human. Today, art has become so widely recognized and valued as a good (and even a necessity), that some of the most recognizable and influential people in our society are artists.

Despite this, there are still certain forms of art that certain demographics are unable to experience and ultimately enjoy. For example, the deaf are obviously unable to perceive and enjoy music the same way the hearing can. The goal of this project is to make a device that can take a musical input and transform it into a visible, loyal, visual representation of the music. This device will transform the pitch part of the music directly into color, as well as using the volume of the sound to determine the brightness of the display. Finally, we intend to include a third dimension, transforming the timbre or harmonic "shape" into a visible pattern.

The idea of attempting to connect visualization to music can be dated to the early 1900s, when neuropsychiatrists Pierre Janet, Jean-Marie Carchot, and others tested LSM (Light Sound Meditation) on patients, which would induce a hypnotic state of audiovisuals that was tested by EEG[2]. Although it was only used as a therapeutic method for those with mental illnesses, it shows that the brain has the capability of translating and transducing various sounds to various lights and/or colors.

Moving into the 1960s was the combination of psychedelic drugs and music to have audio-visual hallucinations. Psychedelic music was a result of reform and going against the conformities of society. Psychedelics created a 'trance' with various notes of music making alterations in the visuals individuals experienced. As a result of psychedelics having drastic effects on the user's body, a new initiative was to try mediation with art and music[3, 4].

Thomas Edison's phonograph in 1857 and Nikola Tesla's wireless radio invention in 1893 were both revolutionary to the foundations of audiovisuals. An invention to assist with converting this analog wave to something humans can see is the Analog-to-Digital Converter (ADC). This device will allow for a simple, lightweight and cost-effective manner to convert analog sound data into digital information for analysis and conversion[5].

Digital light processing (DLP) is a relatively recent concept by Texas Instruments in 1993 where micromirrors are manipulated by digital authority, which allowed for mini projectors and personal computers. It uses Digital Micromirror Devices (DMDs) for projecting images onto objects. It is used for both front and rear projection devices and is in the form of a microchip. In the DMD chip is millions of microscopic mirrors that can be rotated. To have colors show on a screen, there is a color wheel of RGB placed in between light and the DMD. While deciding which design would be the most efficient for our project, we chose DLPs over Liquid Crystal Displays (LCDs) and Liquid Crystal on Silicon (LCoS) because it is simpler to design, much cheaper, and much more reliable[6,7, 8, 9].

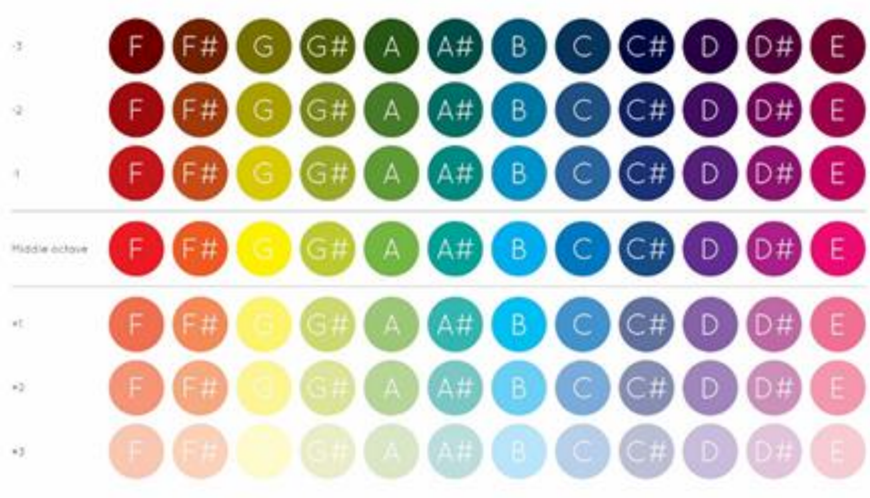
There are plenty of devices that create something resembling a true visualization of music, like popular speakers with colored LEDs (like the JBL Pulse) who illuminate specifically according to volume, or music visualizing software out there such as Spectrum Music Visualizer, who can identify the tempo of the music and make pre-determined images move according to that beat, creating the illusion of music visualization. Our device is unique in that it creates “true” music visualization by tailoring the experience specifically to the tune it registers.

Requirements

In a simplified explanation, this product will showcase a visual that is correlated to the sound of music customers intend to play. It can work with any smartphone via Bluetooth, thus it can work with any streaming service. It will convert and display any musical data into visual display in real-time.

The system should be able to display operate at a frame rate of up to 30Hz, so that it may be registered as video by the brain. This display must be bright enough to illuminate through a translucent screen and still be visible, so we’ll need a projection intensity of about 1000 Lumens. This device will have a video resolution of at least 1080p. The entire device will fit inside a space of no more than 8 cubic feet (2’x2’x2’) and weigh no more than 15 pounds. The viewing screen will be a two-dimensional square 12”x12”.

The nuance is with assigning colors to sound frequencies. Because music scales are cyclical (that is, each octave note is double the frequency of the next), we will be able to assign colors directly to notes for color representation. We intend to use Neil Harbisson’s Sonochromatic Music Scale[1] to assign colors, so in this instance Red (~450nm light) would be used to represent middle F (~174.6 Hz), Green would correspond to middle A (220 Hz). The true value of each displayed color will be calculated and converted using the color system HSV, which directly correlates to RGB. We expect our device to have a listening regime in the full bandwidth of the audible spectrum that is typically used in music (from about 20Hz to about 8kHz). Our software needs to be fairly accurate in identifying each frequency within a couple of Hz. We are setting a sensitivity requirement 75%, meaning the device must be able to identify at least 75% of the frequencies it receives at any given time (within a couple of Hz).



Harbisson's Pure Sonochromatic Music Scale is a non-logarithmic scale based on the transposition of light frequencies to sound frequencies, which is used to convert visible color into an audible tone

The true creative difficulty of this project is designing the shapes and patterns being displayed by the DMD. As previously mentioned, we want to have a framerate of about 30Hz. We intend the display itself to consist of geometrical shapes whose size and "smoothness" will vary depending on the volume and harmonic composition of the music itself. The form of the designs and patterns to be displayed have yet to be designed, but the contrast ratio of the display from pure white to black must be at least 4.5:1 to ensure that the experience is actually visible to most of the populous.

Lastly, for purposes of demonstration, our device will display the visuals in real-time with audible music. This means we need to include a speaker of reasonably good quality for output. Due to the nature of this project being an optical device, we aren't incredibly concerned with the fidelity of the speaker, but the speaker/amplifier system should consume less than 50 watts of power from the whole device.

This project requires the employment and integration of a complex optical setup, electrical components to receive data and power the optics, computer software to analyze the information and control the optics. The electrical components include a Bluetooth receiver which we will purchase to receive the music data we choose to analyze, and a PCB to hold all of our circuitry. This device will require three laser diodes or RGB LEDs. The light source will illuminate an electronic Digital Micromirror Display (DMD) chip which will be programmed to create the shapes and patterns for the display.

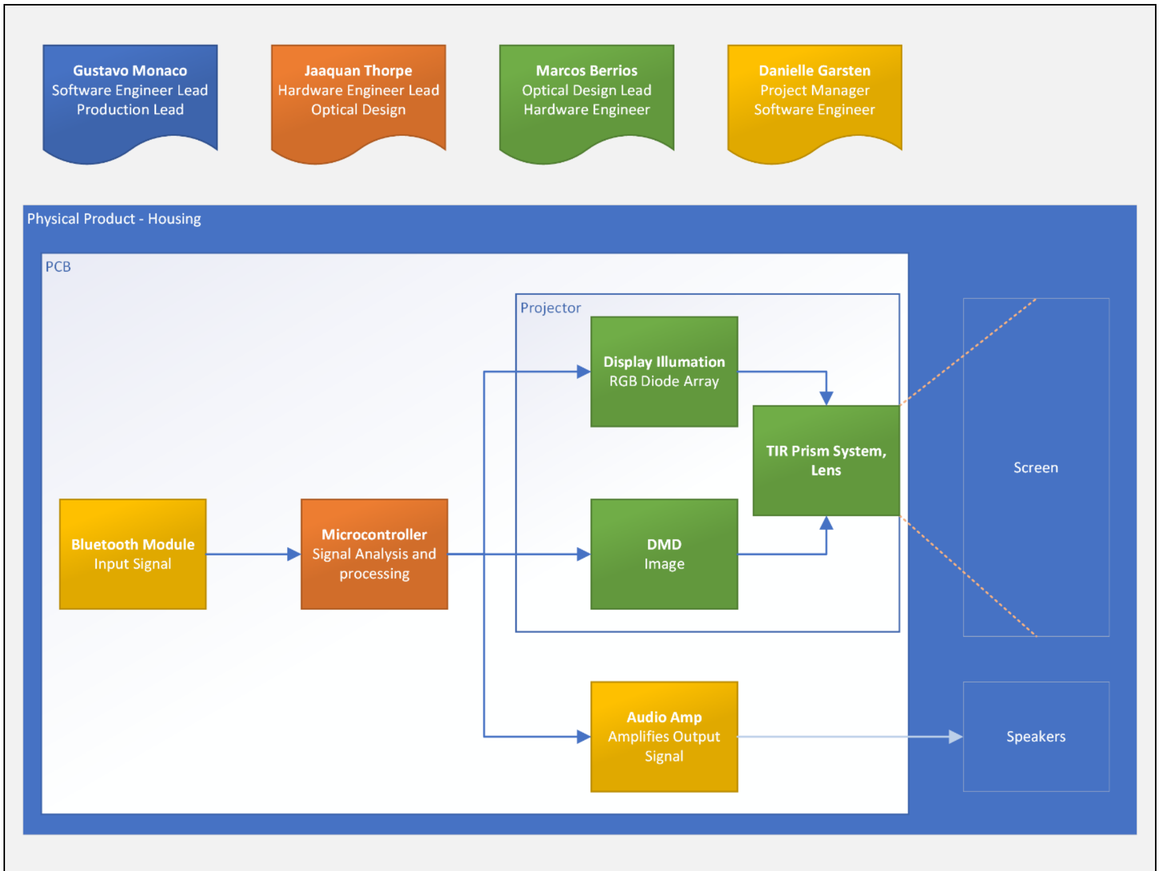
Marketing Requirements met	Engineering Requirements	Justifications
9	The product should have a weight less than 15 lbs	15 lbs is easily lifted with or without assistance
1, 4	It should have a display resolution of 1080p	1080p is widely accepted as high resolution
1, 4	The display's contrast Ratio should meet 4.5:1	Easily discernible to the naked eye
1, 4	The display's framerate should not fall below 30Hz	30Hz is a common basic video framerate
7, 2	The product should not occupy a volume greater than 8 ft^3	This is an easy table-top size
1, 3	The delay between audio output and visual display should not exceed 500ms	If the delay between sight and sound is too great, it will be disorienting
9	It should cost less than $500 to produce	This is a constraint
5	Bluetooth capability	Bluetooth connection is available on all smartphones

Marketing Requirements

1. The system should be visually engaging/immersive
2. The system can be shared with friends and family alike
3. The system should have excellent sound sensitivity
4. The system should have a high resolution display
5. The system should be easy to use.
6. The system should have low cost.
7. The system should have a low spatial footprint on an average living room.
8. The system should have an average low carbon footprint.
9. The system should be lightweight

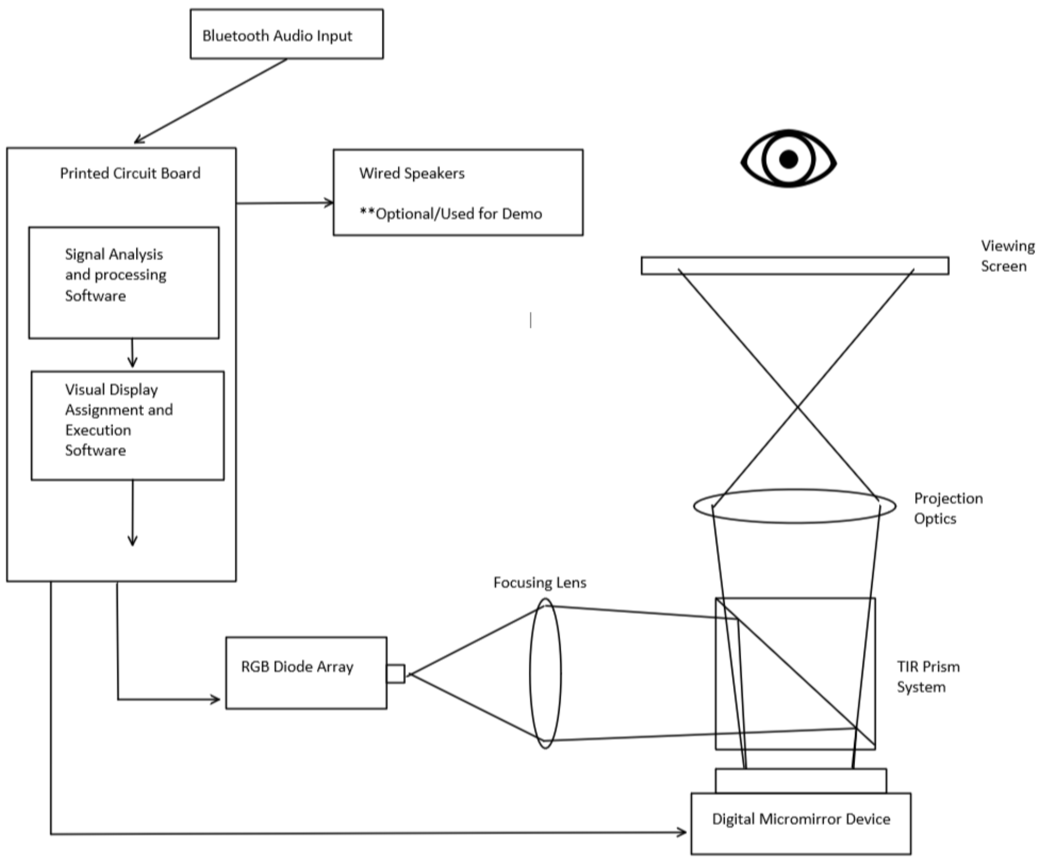
Block Diagrams

Hardware Block Diagram



Block Description	Assigned To	Block Status
Physical Product – Housing/Case	Gustavo Monaco	Research / Not Acquired
Bluetooth Module – Input Signal	Danielle Garsten	Research / Not Acquired
Microcontroller – Signal Analysis and Processing	Jaaquan Thorpe	Research / Not Acquired
Display Illumination – RGB Diode Array	Marcos Berrios	Research / Not Acquired
Digital Micromirror Devices – Image	Marcos Berrios	Research / Not Acquired
TIR Prism System and Lens	Marcos Berrios	Research / Not Acquired
Audio Amp – Amplifies Output Signal for Speakers	Danielle Garsten	Research / Not Acquired
Screen and Speakers – Output Channels	Gustavo Monaco	Research / Not Acquired

Optical Setup Schematic



Rough sketch/rendering of the expected optical components needed to achieve a successful prototype

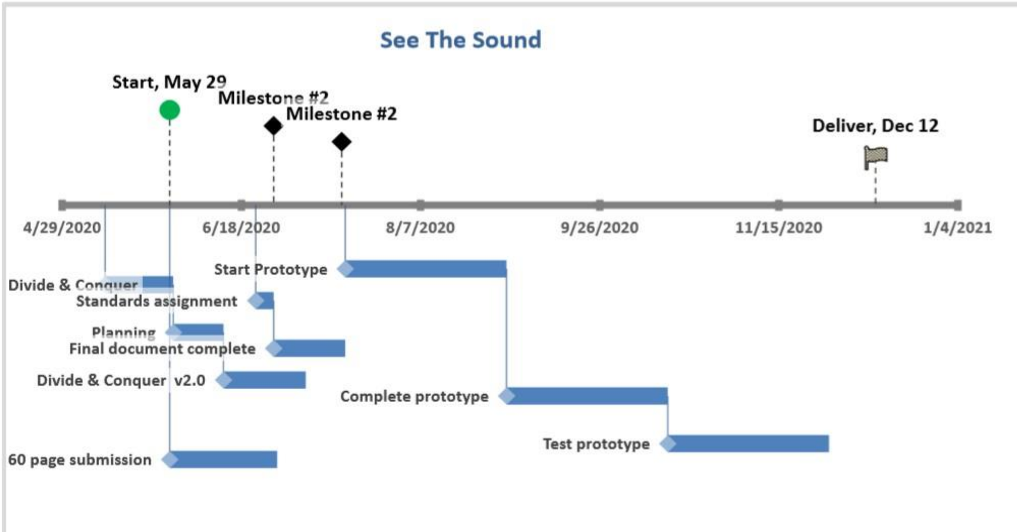
See The Sound

Project Budget

INCOME	Budget	Actual	Difference
Internal Funding			
Group Budget	$750	$500	(250)
Other			-
Total Internal Income	**750**	**500**	**(250)**
External Funding/Other			
Donations		$500	500
Other			-
Total External Income	**-**	**500**	**500**
Total INCOME	**750**	**1,000**	**250**

EXPENSES	Budget	Actual	Difference
Hardware			
PCB Board Kit	$50	$18	32
DLP projector	$200	$118	82
Bluetooth Audio Adapter	$25	$25	-
Projector screen w/stand	$50	$50	-
PWM signal & Pulse function generator	$20	$12	8
DLP Chips	$300	$250	50
Semiconductor Laser Diode	$50	$25	25
Linear Optical Polarizer	$50	$20	30
Subtotal	**745**	**518**	227
Software			
Online Subscriptions	$100	$0	100
Subtotal	**100**	**-**	100
Total EXPENSES	**845**	**518**	**327**
NET (Income - Expenses)	**(95)**	**482**	**(577)**

Project Milestone



Tasks

Start	End	Days	Label	Vert. Position	Vert. Line
5/11/2020	5/29/2020	19	Divide & Conquer	-25	-25
5/30/2020	6/12/2020	14	Planning	-40	-15
6/13/2020	7/5/2020	23	Divide & Conquer v2.0	-55	-15
5/29/2020	6/27/2020	30	60 page submission	-80	-80
6/22/2020	6/26/2020	5	Standards assignment	-30	-30
6/27/2020	7/16/2020	20	Final document complete	-45	-15
7/17/2020	8/30/2020	45	Start Prototype	-20	-20
8/31/2020	10/14/2020	45	Complete prototype	-60	-40
10/15/2020	11/28/2020	45	Test prototype	-75	-15
11/29/2020	12/12/2020	14	Final Presentations		

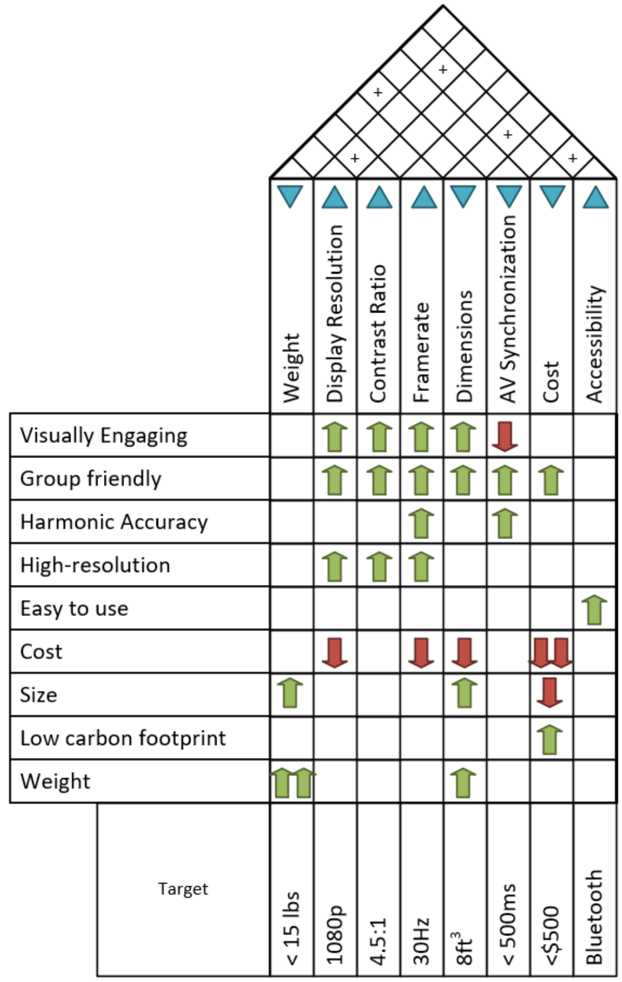
Milestones

Date	Label	Position
5/29/2020	Start, May 29	30
6/27/2020	Milestone #1	25
7/16/2020	Milestone #2	20
12/12/2020	Deliver, Dec 12	15

House of Quality

Correlation matrix	
+ +	Strong positive
+	Positive
–	Negative
– –	Strong negative
	Not correlated

Relationship matrix	
⇧ ⇧	Strong
⇧	Medium
⇩	Weak
	No assignment



Bibliography

[1] Neil Habrisson's Color Scale: http://iancdesign.blogspot.com/2013/02/sonochromatic-scale-chord-structure.html

[2] Interacting with Presence: HCI and the Sense of Presence in Compute https://books.google.com/books?id=HQruCAAAQBAJ&pg=PA107&lpg=PA107&dq=lsm+pierre+janet&source=bl&ots=pRGk0w-BCk&sig=ACfU3U25s7F2r-no9Xw7dBuR1kj258c0wA&hl=en&sa=X&ved=2ahUKEwjd352BlcrpAhUNm-AKHV6FCnIQ6AEwA3oECAcQAQ#v=onepage&q=lsm%20pierre%20janet&f=false

[3] This is Your Brain on LSD and Music https://beckleyfoundation.org/2017/03/29/this-is-your-brain-on-lsd-and-music/

[4] Origin and Evolution of Psychedelic Music https://medium.com/@susanbhairston/origin-and-evolution-of-psychedelic-music-287a1b5708f8

[5] Audio-Visual Entrainment: History, Physiology & Clinical Studies https://www.aapb.org/files/news/Entrainment.pdf

[6] Sound https://processing.org/tutorials/sound/

[7] Light: Electromagnetic waves, the electromagnetic spectrum and photons https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/a/light-and-the-electromagnetic-spectrum

[8] Digital Light Processing https://www.sciencedirect.com/topics/engineering/digital-light-processing

[9] TI DLP® technology http://www.ti.com/dlp-chip/overview.html

[10] Prehistoric Flutes https://www.bbc.com/news/science-environment-18196349#:~:text=Researchers%20have%20identified%20what%20they,by%20modern%20humans%20%2D%20Homo%20sapiens.