Department of Computer Science & Engineering
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Architectural Design Specification
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Resonance
LTunes

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Revision History

Revision	Date	Author(s)	Description
0.1	11.02.2019	AD	document creation
0.2	11.06.2019	AY, AD	complete draft
1.0	11.08.2019	AY, AD	official release
1.1	05.10.2020	AY	added design review requests

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1 Introduction

This section describes the purpose, use and intended user audience for the 'L-Tunes' laser harp instrument. L-Tunes is a laser-based digital instrument that uses laser signals and converts them to MIDI signals that trigger a musical note when the laser is blocked or obstructed. The device can be used to play sounds from different instruments like harp, guitar, piano, etc. with presets and parameters to emulate other instruments and sounds. Users of L-Tunes will be able to play the device like an instrument and even create new sounds via built in sound generators. This product is intended for anyone, but particularly musicians, harp-enthusiasts, and children.

The L-Tunes laser harp should be used to play sounds like a harp, piano, etc. along with being versatile MIDI device than can be used to trigger sounds in a DAW (Digital Audio Workstation).

This device can be used by anyone, however the device is intended to be used by musicians, harp-enthusiasts, and young children. This device is designed for anyone looking for an alternative to a real harp with strings.

2 System Overview

Laser Harp consists of four layers. The first layer is the power system, which is going to act as a power source for the device and consists of battery or similar power source. Second layer is frames and components which consists of laser beams, receptors, mister and speaker. Receptors are going to identify the interference in the laser beam and send the signal towards MIDI converter. Mister is being used for visibility whereas speakers are for audio output. Then, we have MIDI converter which is going to receive signals from the receptors and encode those signals as MIDI signals. Finally, the last layer is the sound module which is going to decode the MIDI signals, pass the resulting outcome to fluid synth which in turn sends the audio signals to speakers via sound card.

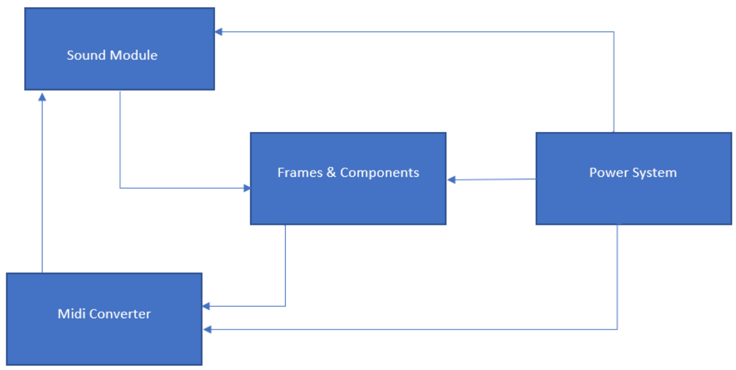

Figure 1: Laser Harp Architectural Layer Diagram

2.1 Power System

The whole product is built around its CPU, raspberry pi. It is going to act as a power source for the whole device. The raspberry pi is going to have a cable that can be plugged in to any external outlet.

2.2 Frames and Components

Users of the laser harp are going to interact with device using this layer. This layer is going to provide the users with visual and audio output in addition to ways to play the instrument. It consists of laser and receptors, fogger, a touchscreen and speakers. Lasers acts as the input medium in the device. Receptors are going to identify the break in the laser beams and transmit the resulting signal towards MIDI converter to be encoded. Lasers are not visible in broad daylight, so in order to overcome that mister is being used for visibility and is lodged at the base of the harp. Speakers are the way audience are going to hear the resulting audio. It will receive input from sound card form the sound module layer. It will be high quality speaker, able to play multiple range of audio clearly. There will also be a 6-inch touchscreen display to toggle between presets and adjust sound effects such as gain and reverb.

2.3 MIDI converter

This layer is connected to the receptors of the frame and components layer. The interference signal caught by those receptors is changed into MIDI signal by MIDI encoder subsystem lodged in the layer. It is will housed inside a teensy micro controller or the raspberry pi.

2.4 Sound Module

This layer is associated with reading the MIDI signals and converting it into audio signals required for the speaker to give out proper audio output. This consists of three subsystems MIDI decoder, fluid synth and sound card. MIDI decoder changes the signals from the MIDI encoder and passes it on to fluid synth. Fluid synth which is enclosed in the raspberry pi is a software that allows the user to control speed, frequency and other characteristics of sound to be produced. Sound card comprises of drivers that enable the raspberry pi to generate audio output.

3 Subsystem Definitions & Data Flow

There are 9 components in our laser harp instrument. These components are referred as subsystems which combine to give definition to the layers discussed above.

The Power System layer consists of single subsystem, Battery. It is main power source for all the components of the instrument. It will be comprised of single or combination of multiple 12V DC batteries. This subsystem will be place in the base of the instrument, will be wired to each component.

The Frames Component system is comprised of four subsystems Lasers Receptors, Mister, Touchscreen Display and Speaker. Lasers Receptors will be combination of multiple laser diodes positioned directly above the photo resistors, which will create laser beams. The interference of laser beams will be detected by the receptors and the resulting signals is sent to MIDI encoder. Mister acts as an individual unit and does not communicate with any other components whereas speakers get its input from the sound card of the sound module layer. There will also be a 6-inch touchscreen display at the front center of the frame. It is used for presets control and adjust sound effects such as gain and reverb.

The MIDI converter layers consists of single component i.e. MIDI encoder. The encoder is likely to be housed in a teensy microcontroller which takes the signals passed on by the receptors and changes it into MIDI signals. Those MIDI signals are forwarded towards MIDI decoder of sound module.

The sound module layer contains three components. MIDI Decoders gets MIDI signals from the MIDI encoder. It interprets those signals, and which is fed into fluidsynth software. It allows the users to manipulate the frequency, depth, dampness, speed, etc. of the incoming signals. The resulting sound is in turn passed onto speakers for audio output via sound card.

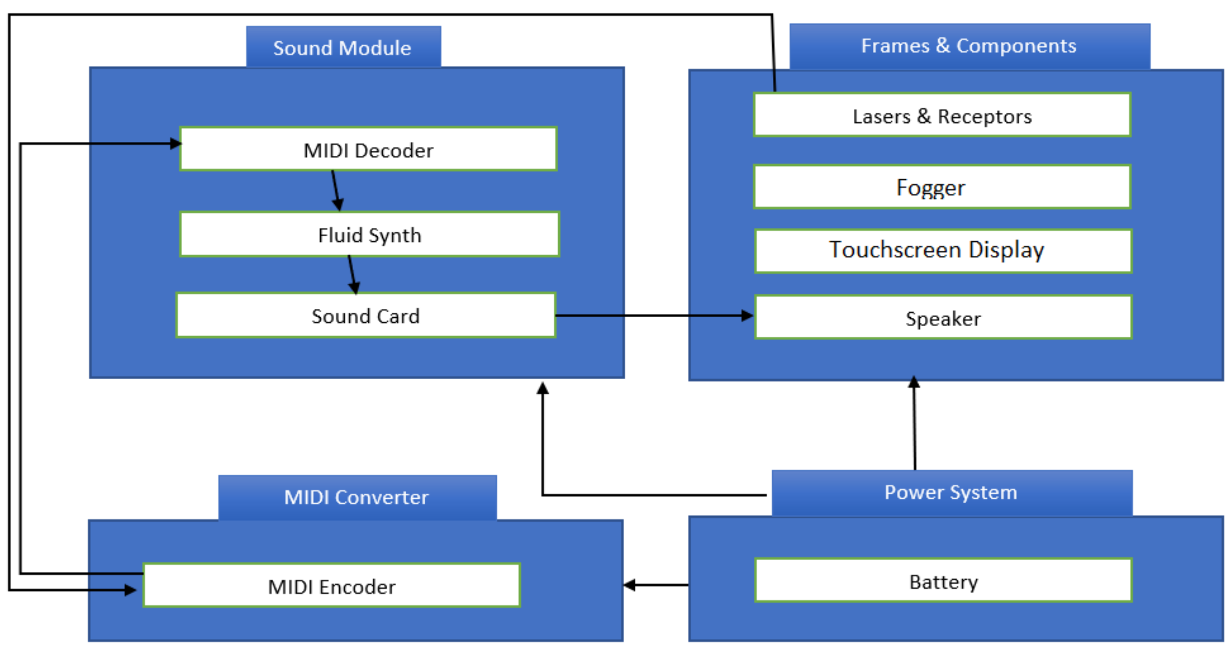

Figure 2: A simple data flow diagram

4 Power System Layer Subsystems

The details about the subsystem included in the power layer are discussed below. We are opting to go with centralizing the raspberry pi as the main power source. It will sort of act as a power source to all the other components and it itself is powered by plugging to an external outlet.

4.1 Raspberry Pi

Raspberry Pi is the only subsystem component included in this layer. It will act as the power source for all the components. It will be connected to other components via wires and cables.

4.1.1 Assumptions

The Raspberry Pi will be able to provide enough power to run all the components of the instrument for a reasonable amount time without difficulties. It will have access to external outlet to power itself.

4.1.2 Responsibilities

It is responsible for providing adequate power to all the components of the device.

4.1.3 Subsystem Interfaces

Input and output for the Raspberry Pi subsystem are mentioned below.

Table 2: Subsystem interfaces

ID	Description	Inputs	Outputs
#xx	Raspberry Pi	120V outlet	2A DC Power

5 Frame and Component Layer Subsystems

Frames and components make up the external outlook of the device. Furthermore, it is the layer that allows the user to interact with the device. It consists of three subsystems which include laser and receptors, mister and speakers.

5.1 Laser and receptors

This subsystem comprises of laser beams and receptors to detect the interference for the same. It consists of laser diodes pointed towards the photo resistors. The receptors will not only detect the breaking of the beam, but also the number or note of the beam interfered. This information is then transferred to MIDI encoder for further analysis.

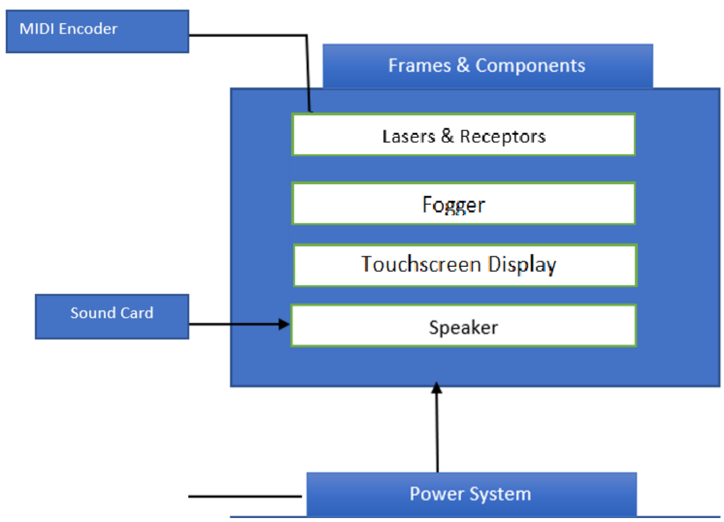

Figure 3: Laser and Receptors subsystem description diagram

5.1.1 Assumptions

It is assumed that laser diodes are properly placed in position with respect to resistors. All the laser diodes are functioning properly, and no external factors are causing the interference other than the user.

5.1.2 Responsibilities

It is responsible for production of laser beams as well as recording of the breakage of laser beams. Furthermore, it should transmit those records to MIDI encoder.

5.1.3 Subsystem Interfaces

An external power supply is connected to the subsystem using breadboard or hookup wires.

A USB to MIDI cable is used to connect the subsystem to encoder.

Table 3: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Laser Diodes	Power supply	Laser beams
#02	Receptors	Interference	Signals
#03	MIDI Interface	Signals	Event Messages

5.2 Fogger

It consists of a mini vape model that will be produce fog or vape which enhances the visibility of the lasers. It will take power source from Raspberry Pi. It will use the power to convert vape juice inside of it to fog.

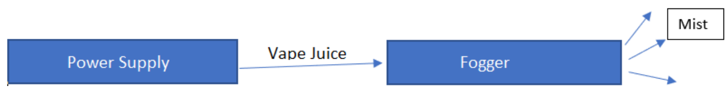

Figure 4: Laser and Receptors subsystem description diagram

5.2.1 Assumptions

It is assumed that there is enough vape juice inside the fogger and adequate power supply.

5.2.2 Responsibilities

It is responsible for emitting fog or mist which will be used to make the lasers visible to naked eye in well-lit room.

5.2.3 Subsystem Interfaces

Power is given to the mister through Raspberry Pi.

Fogger takes input from the vape juice which is converted into mist.

Table 4: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Fogger	Vape juice	Mist

5.3 Speaker system

It consists of single or multiple speakers which will be hooked up to the sound module. It will give the audio output for any presets or interference created by the user.

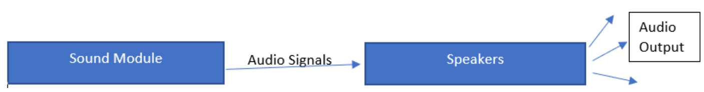

Figure 5: Laser and Receptors subsystem description diagram

5.3.1 Assumptions

Speakers are fairly new and the device is played in quiet place so as to ensure that there is no background noise.

5.3.2 Responsibilities

It is responsible for producing clear audio output.

5.3.3 Subsystem Interfaces

It receives the signals from the sound module and produces the resulting audio output based on the signals fed to it.

Table 5: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Speakers	Audio Signals	Audio Output

5.4 Touchscreen Display

It consists of a 6" inch touchscreen monitor that is used for toggling between presets and changing the settings. It is also useful for viewing the current settings and preset. The UI is based on Kiwi UI for the display.

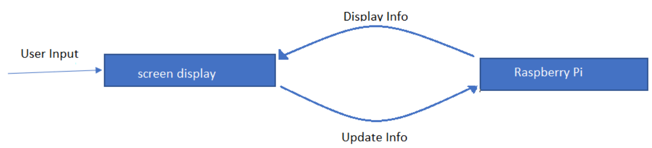

Figure 6: Laser and Receptors subsystem description diagram

5.4.1 Assumptions

It is powered by the Raspberry Pi and it can take inputs from the screen display.

5.4.2 Responsibilities

It is responsible for toggling between presets and changing the settings.

5.4.3 Subsystem Interfaces

It is connected directly to the Raspberry Pi via a USB-C cable.

It displays the information on the screen and also takes input from user through the same screen

Table 6: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Touchscreen Display	Raspberry Pi	display info
#01	Touchscreen Display	user input	update info

6 MIDI Layer Subsystems

The MIDI converter layers consists of single component i.e. MIDI encoder. The encoder takes the signals passed on by the receptors and changes it into MIDI signals. Those MIDI signals are forwarded towards MIDI decoder of sound module.

6.1 MIDI encoder

The MIDI encoder gets the signal from the laser receptors, converts it to MIDI data and sends to the Raspberry Pi for the output. This converts the laser receptor signals to MIDI data in order to convert it to sound data.

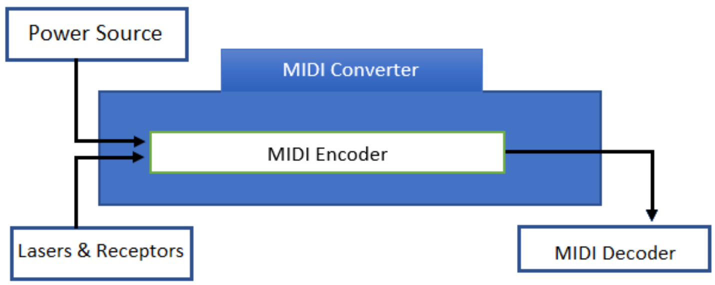

Figure 7: MIDI encoder subsystem diagram

6.1.1 Assumptions

The MIDI encoder is connected to the Pi and the laser receptors via cable. It also has a built-in software that converts the data automatically.

6.1.2 Responsibilities

The laser receptors, when it detects an interference, sends signal to the MIDI encoder. Here, the encoder converts the signal data it received to a MIDI data so it can be manipulated to different sounds with the sound modules.

6.1.3 Subsystem Interfaces

It receives the laser signals and converts it into MIDI signals which it sends to the pi.

Table 7: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	MIDI Encoder	Laser Signals	MIDI signals

7 Sound Modules Layer Subsystems

This layer is associated with reading the MIDI signals and converting it into audio signals required for the speaker to give out proper audio output. This consists of three subsystems MIDI decoder, fluidsynth and sound card.

7.1 MIDI decoder

MIDI decoder is a driver that gets the MIDI signals to the raspberry pi. It is a bridge software that transfers the encoded data for processing by fluidsynth.

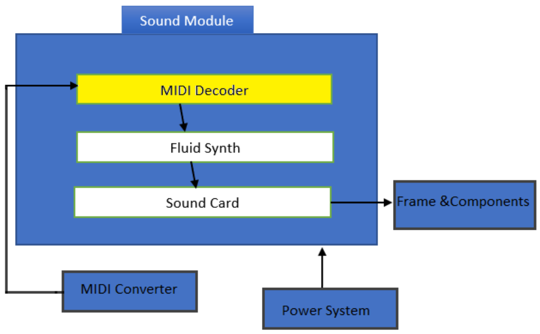

Figure 8: MIDI decoder subsystem diagram

7.1.1 Assumptions

The drivers are compatible with the raspberry pi OS.

7.1.2 Responsibilities

The drivers should successfully decode the MIDI data signals to be able to be processed by the fluidsynth software. There should be no loss of data.

7.1.3 Subsystem Interfaces

The MIDI decoder drivers are software drivers downloaded to the raspberry pi OS. It doesn't have any sub-system inside it

7.2 FluidSynth

FluidSynth is a real-time software synthesizer based on the SoundFont 2 specifications and has reached widespread distribution. It converts the MIDI signals to produce desired sound waves.

7.2.1 Assumptions

The software already has default preset sounds built-in. It also has the functionality manipulate the sound to produce various sound effects. Also it is free, open source and easy to use.

7.2.2 Responsibilities

The software is used to convert MIDI signals to sound waves. It should have multiple different sound effects and create a wide range of sound octaves in different formats.

7.2.3 Subsystem Interfaces

The software is downloaded and installed into the raspberry pi. It is supported by the raspberry pi OS.

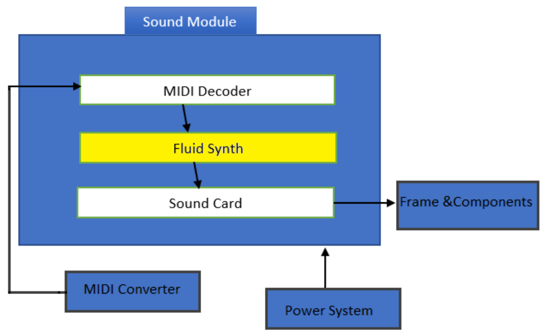

Figure 9: FluidSynth subsystem diagram

7.3 Sound Card

The sound card is integrated into the raspberry pi as drivers. It converts the data outputted by FluidSynth to sound data which is released through the speaker as the final output.

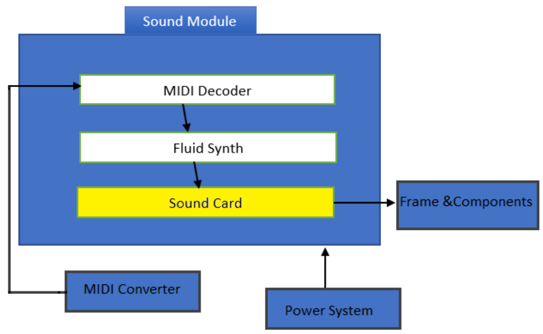

Figure 10: Sound Card subsystem diagram

7.3.1 Assumptions

The sound card drivers are already built-in and integrated to the raspberry pi.

7.3.2 Responsibilities

The sound card should handle decent amount of data set. It should be able to produce a wide variety of sound data with different wavelengths.

7.3.3 Subsystem Interfaces

The sound card drivers are built-in software built-in to the raspberry pi OS. It doesn't have any subsystem inside it.