DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

SYSTEM REQUIREMENTS SPECIFICATION
CSE 4316: SENIOR DESIGN I
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RESONANCE
PROJECT LTUNES

AMIR DHUNGANA
ANISH YONJAN
NIKHIL PUROHIT
RABINSON SHRESTHA
RAUL JIMENEZ
ROBERTO TORRES

Revision History

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1 Product Concept

This section describes the purpose, use and intended user audience for the L-Tunes laser harp. L-Tunes is a laser-based digital instrument and MIDI device that uses lasers to trigger a note when the laser is blocked or obstructed. The device can be used to play sounds like an harp, 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.

1.1 Purpose and Use

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

1.2 Intended Audience

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. Users who are unable to play a harp due to physical ailments such as carpal tunnel, as the device does not require any pressure to be applied to trigger sound.

Figure 1: laser harp conceptual drawing

2 Product Description

This section provides the reader with an overview of L-Tunes, a laser harp. The primary operational aspects of the product, from the perspective of end users, maintainers and administrators, are defined here. The key features and functions found in the product, as well as critical user interactions and user interfaces are described in detail.

2.1 Features & Functions

The product generates sounds when a user obstructs the laser with their hand. The harp can also play other instruments by pressing the â>â (arrow) button on the sound bank section. The harp can be used to play user generated sounds via the built in wave generators by first cycling through the sound bank, then by tinkering with the the ADSR sliders and wave cycle sliders to change the character of the sound that the two wave generators create in parallel.

The product does not function without a charged battery or power. The product does not play sounds beyond the sound bank. The product primarily composed of [insert elements composing the product here].

The product looks like a smaller sized harp so that it is mobile (see Figure 1) [insert figure 1 here]. [specify the components here]. The product does not require any external elements how it can be used with a computer as a MIDI device, for example as an input source in a DAW (Digital Audio Workstation).

2.2 External Inputs & Outputs

No external data is required to flow into the device from external software for it to be used, as it has built in sounds and presets that can be selected by the user on the device itself. However, if the user chooses to use the product as a MIDI device then they need a computer with a DAW (Digital Audio Workstation) installed on it to be able to use the device as an input source for triggering audio playback. [insert table / diagram to show how to use the device as a MIDI device with an external computer/DAW]

2.3 Product Interfaces

The device will feature a digital interface of sliders and buttons to control the device. The device will have a plug to power the device on and off, and a slider to control the volume, along with two sections of parameters for additional functionality. The first section will feature a screen that displays the instrument preset being used, with a button to change the preset. The second section will feature the audio synthesis portion of the device with (4) sliders to control the attack, decay, release and sustain of the sound and (4) buttons for the (2) wave generators that all one to cycle between sine, sawtooth, square, and triangle waves. [insert diagram of devices controls in the future]

3 Customer Requirements

The nature of this product lends itself to creativity and flexibility in the requirements gathering process. Throughout the process, thought was given to the purpose and eventual use of the laser harp. Keeping in mind that the end users will be young middle school to high school students who are interested in STEM, we created the following Customer Requirements.

3.1 Product shall use visible laser beams

3.1.1 Description

The product shall use laser beams that, when broken/interrupted, will signal the device to produce a tone. An array of laser diodes will be arranged across the top of the device and shine down onto photo-resistors that will detect the breaks and relay that information to an onboard microcontroller. The beams shall be made visible through the use of a fogger that allows the laser beam to reflect and appear to shine.

3.1.2 Source

Customer: Dr. McMurrough

3.1.3 Constraints

We will be limited to the type and number of components that can be connected to a single microcontroller.

3.1.4 Standards

N/A

3.1.5 Priority

Critical

3.2 Built-In Speakers

3.2.1 Description

The product shall have speakers to generate the tones/sounds. These speakers shall be connected to the onboard software synthesizer that controls the sound generation and will be located on the base of the device.

3.2.2 Source

Development Team

3.2.3 Constraints

Space will be a constraint as the base will be of limited size.

3.2.4 Standards

N/A

3.2.5 Priority

Critical

3.3 Polyphony

3.3.1 Description

The onboard synthesizer shall have the ability to take the input of two or more laser beams at the same time and output the combined tone to play from the speakers.

3.3.2 Source

Development Team

3.3.3 Constraints

We will be limited by the capabilities of the software synthesizer we use, which will the maximum number of voices the synth allows.

3.3.4 Standards

N/A

3.3.5 Priority

High

3.4 MIDI Device

3.4.1 Description

The device shall have the ability to be used as a MIDI device. The device shall be able to connect via USB or a MIDI connector to a MIDI Synthesizer for sound generation. The output of the device shall be a serial MIDI signal.

3.4.2 Source

Customer: Dr. McMurrough

3.4.3 Constraints

We will be constrained by the existing protocol for serialized MIDI signals.

3.4.4 Standards

MIDI 1.0

3.4.5 Priority

High

3.5 Ease of Use

3.5.1 Description

The device shall be easy to play and generate sounds in an intuitive manner. Given that this product will be used for outreach and as a tool to keep kids interested in STEM, the product should be intuitive, quick to learn, and easy to use.

3.5.2 Source

Customer: Dr. McMurrough

3.5.3 Constraints

The ease of use will be evaluated with middle to high school students in mind. The device must not be too cumbersome or complex for the typical child in that age group.

3.5.4 Standards

N/A

3.5.5 Priority

High

3.6 Portability

3.6.1 Description

The product shall be portable for use in remote outreach events. The product shall be light enough to be carried by a single person. The product will be powered by a power source to eliminate the need for an outlet. The product shall have a handle for ease of carrying.

3.6.2 Source

Development Team

3.6.3 Constraints

A max weight of 50 lbs must not be exceeded.

3.6.4 Standards

OSHA recommendations

3.6.5 Priority

Moderate

3.7 Configurable

3.7.1 Description

The device shall have the ability to be configured to adjust certain settings. Settings that must be configurable include: volume, pitch, attack, sustain, release, etc. These settings will be configured using controls on the base of the device.

3.7.2 Source

Customer: Dr. McMurrough

3.7.3 Constraints

Existing devices shall serve as guides for how and what can be configured.

3.7.4 Standards

N/A

3.7.5 Priority

Moderate

3.8 Preset Instrument Sounds

3.8.1 Description

The MIDI Synthesizer shall be preloaded with preset configurations to emulate certain instruments. Instruments to emulate include: Harp, Piano, Guitar, Flute, more.

3.8.2 Source

Customer: Dr. McMurrough

3.8.3 Constraints

We must accurately simulate the instruments we select. A user must be able to tell which instrument is being played.

3.8.4 Standards

N/A

3.8.5 Priority

Moderate

3.9 Visual Requirement

3.9.1 Description

The device shall be visually appealing. The device shall not contain any exposed wiring and should have some sort of finish to look good.

3.9.2 Source

Development Team

3.9.3 Constraints

If the device is made of wood, the wood must be painted and varnished. Electronic components, other than controls and displays, must not be visible. Generally, the device should look like something you would want to use.

3.9.4 Standards

N/A

3.9.5 Priority

Moderate

3.10 Audio Output External Output

3.10.1 Description

The device shall play audio internally and also offer external output options to play audio on external speakers.

3.10.2 Source

Development Team

3.10.3 Constraints

The output is constrained by the sound card capabilities and output options it has.

3.10.4 Standards

N/A

3.10.5 Priority

Critical

3.11 Power and Volume

3.11.1 Description

The device will have a volume slider to control the output gain.

3.11.2 Source

Development Team

3.11.3 Constraints

N/A

3.11.4 Standards

The device shall be able to run off a 12 V power supply.

3.11.5 Priority

Critical

3.12 Design

3.12.1 Description

The device shall look like a harp.

3.12.2 Source

Customer: Dr. McMurrough

3.12.3 Constraints

The design is constrained by what we can feasibly manufacture and 3D print.

3.12.4 Standards

N/A

3.12.5 Priority

Critical

3.13 Design Robustness

3.13.1 Description

The device shall stand upright without the need for external support.

3.13.2 Source

Development Team

3.13.3 Constraints

The device needs to be stable while also having a design that is aesthetically pleasing.

3.13.4 Standards

N/A

3.13.5 Priority

Moderate

3.14 Mass

3.14.1 Description

The device shall not weigh over 50 pounds.

3.14.2 Source

Development Team

3.14.3 Constraints

The device cannot be too heavy as it needs to be portable.

3.14.4 Standards

N/A

3.14.5 Priority

High

3.15 Speakers Controls

3.15.1 Description

The device shall have the speakers and controls at the base of the base of the device.

3.15.2 Source

Development Team

3.15.3 Constraints

The base of the device is where the internals will be kept, which also has the most room for controls that affect the device.

3.15.4 Standards

N/A

3.15.5 Priority

High

4 Packaging Requirements

This section will contain packaging requirements on how the laser harp will be delivered to the end-user. These requirements specify how the user will assemble the laser harp and ensure that the user will be able to play sounds when they start up the system. There will be pre-installed software on the micro-controller which produces sounds.

4.1 Assembly Documentation

4.1.1 Description

The system shall be delivered with schematics to 3-D print and assemble the system.

4.1.2 Source

Development Team

4.1.3 Constraints

These schematics will be in PDF format available online. These instructions will be in english.

4.1.4 Standards

N/A

4.1.5 Priority

Moderate

4.2 Sound Software

4.2.1 Description

The system will be delivered with pre-installed software on micro-controller.

4.2.2 Source

Development Team

4.2.3 Constraints

We will assume that sufficient memory is available to run program.

4.2.4 Standards

N/A

4.2.5 Priority

High

5 Performance Requirements

In this section, the performance of the Laser Harp is evaluated. It is very crucial that the laser harp lives up to the standard, the customer expects it to. Response time, startup time, reliability, etc. are some of the factors that are being evaluated to define the performance of the product.

5.1 The device shall have a maximum setup time of 5 minutes.

5.1.1 Description

The time taken to set up the equipment should be less than 5 minutes. The process includes wiring the necessary components, aligning the laser diodes to photoresistors if not already done, and connecting to power source.

5.1.2 Source

Team

5.1.3 Constraints

Most of the components should already be wired and in position i.e. no breadboard connections required and laser diodes and photoresistors should be already on the frame, so that not a lot work is needed to align the parts in the correct place. There must be an appropriate power source nearby.

5.1.4 Standards

N/A

5.1.5 Priority

Medium

5.2 The device shall startup and fully boot within 30 seconds.

5.2.1 Description

Once the all the components of the device are setup, the device should take no longer than 30 seconds to be fully operational. Users should be able to see the lasers and play sound by interfering the laser beams.

5.2.2 Source

Team

5.2.3 Constraints

All components should be in place and the laser diodes should be pointed towards the photoresistors.

5.2.4 Standards

N/A

5.2.5 Priority

Medium

5.3 The device shall be able to play audio to stereo.

5.3.1 Description

The audio output should be able to be redirected towards stereo. Instead of piezo speaker, the audio should come out of stereo without any difficulty.

5.3.2 Source

Team

5.3.3 Constraints

The device should be fully operational and necessary outputs must be visible.

5.3.4 Standards

N/A

5.3.5 Priority

Low

5.4 The device should have very low latency between the laser being triggered and resulting audio playback.

5.4.1 Description

Once the laser beam is interfered, there should be no or minimal delay in the resulting audio. The sound should vary with respect to the laser that is being triggered. The time taken to hear audio should be less than 100 milliseconds.

5.4.2 Source

Team

5.4.3 Constraints

The device should be fully operational, and it should be connected to necessary audio output. No other devices should be playing nearby.

5.4.4 Standards

N/A

5.4.5 Priority

High

5.5 The device should be reliable and should not crash during use.

5.5.1 Description

The device should not crash or turn off by itself unless the power source is removed. If adequate power supply is provided and all the parts not corroded, the device should run for few hours without crashing.

5.5.2 Source

Team

5.5.3 Constraints

All the parts should be in good condition. All the connection should be tight and insulated from any external factors. There should be a constant power source.

5.5.4 Standards

IEEE 1413.1-2002

5.5.5 Priority

High

6 Safety Requirements

The laser harp project deals with lasers which can damage the eyes and be hazardous if we are not careful. There are also wires, mister, speakers and power source that is needed to be handled carefully.

6.1 The lasers on the device should be put in a way they do not point towards anyoneÂs eyes

6.1.1 Description

The lasers mounted on the product should be fixed and immovable. It should in no way be pointed anywhere else but the receiving sensors. It should not diverge from the path at any angle.

6.1.2 Source

CSE Senior Design laboratory policy

6.1.3 Constraints

The laser pointers will be made immovable and fixed to a certain place to minimize risks and will be in compliance with the ANSI Z136 standards.

6.1.4 Standards

ANSI Z136.1 â Safe use of lasers

6.1.5 Priority

Critical

6.2 The laser should only point to the receiving sensor.

6.2.1 Description

The lasers should in no way be pointed anywhere else but the receiving sensors. It should be a straight path from the laser pointer to the sensors.

6.2.2 Source

CSE Senior Design laboratory policy

6.2.3 Constraints

The lasers will be in compliance with the ANSI Z136 standards.

6.2.4 Standards

ANSI Z136.1 â Safe use of lasers

6.2.5 Priority

Critical

6.3 The device and all the internal parts should be enclosed.

6.3.1 Description

The internal components i.e. Arduino, speakers, wires, etc. should all be enclosed in a main box/frame so that they are protected from the outside interference.

6.3.2 Source

CSE Senior Design laboratory policy

6.3.3 Constraints

The external structure will not be authorized to be taken apart by anyone except the instructor and project members.

6.3.4 Standards

Occupational Safety and Health Standards

6.3.5 Priority

Critical

6.4 The mister should not damage any internal components.

6.4.1 Description

The mister should be on the outside part of the product and should not affect/harm any internal components.

6.4.2 Source

CSE Senior Design laboratory policy

6.4.3 Constraints

mister will only be used only when needed in limited amount by authorized personnel.

6.4.4 Standards

Occupational Safety and Health Standards

6.4.5 Priority

Critical

6.5 The mister should not cause health problems.

6.5.1 Description

The mister should be safe to use and should not cause any health problems to anyone.

6.5.2 Source

CSE Senior Design laboratory policy

6.5.3 Constraints

mister will only be used only when needed in limited amount by authorized personnel.

6.5.4 Standards

Occupational Safety and Health Standards

6.5.5 Priority

Critical

6.6 The external wires should be properly insulated on the device.

6.6.1 Description

All of the wires should be properly insulated. They should be in compliance with all the requirements specified in the National Electric Code.

6.6.2 Source

CSE Senior Design laboratory policy

6.6.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.6.4 Standards

NFPA 70

6.6.5 Priority

Critical

6.7 The physical device shall be structurally firm about its base.

6.7.1 Description

The whole product should be firm and stable upright. It should not be able to be easily tipped when upright. It should also be sturdy enough.

6.7.2 Source

CSE Senior Design laboratory policy

6.7.3 Constraints

The device will only be used by team members and the professor.

6.7.4 Standards

Occupational Safety and Health Standards

6.7.5 Priority

Critical

7 Maintenance & Support Requirements

The laser harp project is planned to use lasers and mistifier. Maintenance is required to check if all the components are working properly and are in compliance with the standards.

7.1 Update documentation with each additional feature

7.1.1 Description

The product document should be updated every time there is a change/upgrade in the equipment.

7.1.2 Source

CSE Senior Design laboratory policy

7.1.3 Constraints

The upgrades and changes can only be done by authorized personnel.

7.1.4 Standards

ANSI Z136.1 â Safe use of lasers
NFPA 70
Occupational Safety and Health Standards

7.1.5 Priority

Moderate

7.2 The product will be tested for errors and failure every 3 months.

7.2.1 Description

The lasers, mistifier and other internal components will be tested for potential failure every 3 months.

7.2.2 Source

CSE Senior Design laboratory policy

7.2.3 Constraints

None

7.2.4 Standards

ANSI Z136.1 â Safe use of lasers
NFPA 70
Occupational Safety and Health Standards

7.2.5 Priority

Critical

7.3 There should be authorized personnel(team member or professor) at the side every time the product is used.

7.3.1 Description

Every time the product is used there should be a professional present in the area for safety and support assistance.

7.3.2 Source

CSE Senior Design laboratory policy

7.3.3 CONSTRAINTS

None

7.3.4 STANDARDS

Occupational Safety and Health Standards

7.3.5 PRIORITY

Moderate

8 Other Requirements

Since the system will be used by kids and is intended to be highly interactive with kids we must take into account the safety and tailor the system to kids. We must have safe product. Additionally, since we are using a microcontroller we must use a programming language that is acceptable and understandable for the microncontroller. We currently do not have plans for modularity or extensibility. Since most microcontroller use C and C++ for their programming we must use C and C++ for the control language of the system.

8.1 Sharp Edges Mitigation

8.1.1 Description

The physical device should not have any sharp edges that can be hazardous.

8.1.2 Source

Development team

8.1.3 Constraints

Materials that we use will be sanded down and rounded down to ensure mitigation of hazard

8.1.4 Standards

N/A

8.1.5 Priority

Moderate

8.2 Operating System Requirement

8.2.1 Description

The software developed for the microcontroller shall be runnable on unix based system.

8.2.2 Source

Development team

8.2.3 Constraints

We cannot use microntroller which are not unix based, and don't have digital pins.

8.2.4 Standards

Follow coding standards for C++ as noted by the gcc compiler and arduino standards.

8.2.5 Priority

High

9 Future Items

In this last section, you will reiterate all requirements that are listed as priority 5. This is repetitive, but necessary as a concise statement of features/functions that were considered/discussed and documented herein, but will NOT be addressed in the prototype version of the product due to constraints of budget, time, skills, technology, feasibility analysis, etc. Use the following format for this section. Our future requirements mostly be software enhancements that will improve the experience of the user when using the system. These requirements will be addressed once all other requirements have been met.

9.1 Loading Presets from Mobile Application

9.1.1 Description

The device should be able to play user presets within 5 seconds of uploading in the app.

9.1.2 Source

Development Team

9.1.3 Constraints

The user must be within close proximity of the device. The user must also be able to connect via bluetooth to the device.

9.1.4 Standards

802.11 Bluetooth protocol.

9.1.5 Priority

Future

9.2 Time of Flight Sensors

9.2.1 Description

The system shall use time of flight sensors to adjust output of sound.

9.2.2 Source

Development Team

9.2.3 Constraints

Time of flight sensors are typically invisible to finding one with visible light will be difficult.

9.2.4 Standards

N/A

9.2.5 Priority

Future

9.3 Bluetooth Connectivity

9.3.1 Description

The system shall be able to connect to Bluetooth speakers for audio output.

9.3.2 Source

Development Team

9.3.3 Constraints

Speakers must be within close proximity to the device or phone device.

9.3.4 Standards

802.11 Bluetooth protocol

9.3.5 Priority

Future

9.4 User Sounds

9.4.1 Description

The application shall be able to upload sound files to device.

9.4.2 Source

Development Team

9.4.3 Constraints

The system shall be able to intake sound files from the mobile application and play those sounds. The system must have sufficient capacity to store these sound files.

9.4.4 Standards

802.11 Bluetooth protocol

9.4.5 Priority

Future

9.5 Configurability from Mobile application

9.5.1 Description

Mobile app will be used to configure the device and expand functionality.

9.5.2 Source

Development Team

9.5.3 Constraints

The system will require a configuration file. Assume that Bluetooth is lossless and all packets get delivered.

9.5.4 Standards

802.11 Bluetooth protocol

9.5.5 Priority

Future

9.6 Individual Laser Control

9.6.1 Description

Individual lasers shall be able to be turned off and on based on preset

9.6.2 Source

Development Team

9.6.3 Constraints

The circuit must work without loss to cut power to laser.

9.6.4 Standards

N/A

9.6.5 Priority

Future

9.7 Physical Control Mechanisms for Sounds

9.7.1 Description

The product shall have physical controls for: Attack, Decay, Sustain, Release, Volume, High-pass/Low-pass filters.

9.7.2 Source

Development Team

9.7.3 Constraints

The physical controls will eventually weardown.

9.7.4 Standards

N/A

9.7.5 Priority

Future

9.8 Preset Display

9.8.1 Description

Presets for the instrument will be configured on the device using a button/knob and displayed on the screen

9.8.2 Source

Development Team

9.8.3 Constraints

The display will need to be dynamic (capable of switching images). Assume that display is powered with same power source as laser.

9.8.4 Standards

N/A

9.8.5 Priority

Future

9.9 Custom Preset

9.9.1 Description

On custom preset the device shall display "custom".

9.9.2 Source

Development Team

9.9.3 Constraints

The display must be large enough to display the word custom.

9.9.4 Standards

N/A

9.9.5 Priority

Future

9.10 Octave Control

9.10.1 Description

The device shall have digital buttons to play lower or higher octaves.

9.10.2 Source

Development Team

9.10.3 Constraints

The device must be able to play various pitches of sound, and hence it needs to be able to change octaves on the fly.

9.10.4 Standards

N/A

9.10.5 Priority

High

9.11 The device should have a main power button.

9.11.1 Description

The product should have a main power button to turn on/off the whole thing. In case that something goes wrong the main power button can be used to shut it down completely.

9.11.2 Source

CSE Senior Design laboratory policy

9.11.3 Constraints

The equipment can only be used by authorized personnel.

9.11.4 Standards

Occupational Safety and Health Standards.

9.11.5 Priority

Critical

REFERENCES