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

PROJECT CHARTER
CSE 4316: SENIOR DESIGN I
FALL 2019

LIGHT LUTHIERS
LASER HARP

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Revision History

Revision	Date	Author(s)	Description
0.1	10.01.2019	SS	document creation
0.2	10.05.2019	LL	complete draft
1.0	10.20.2019	LL	official release
1.1	10.31.2019	MM	added customer change requests
2.0	12.11.2019	SS, ML	Final revised version

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1 Vision

STEM is a very broad field, and it may not be the most appealing to students due to a lack of knowledge of the great things that can be achieved by those who opt for a STEM career path. We plan to make a STEM career more appealing to those who may not fully understand the near limitless potential that this line of work provides. Computer Science and Engineering can seem pretty abstract and potentially not very appealing. We want to change that. Our team strives to show how cool this field can Look and Sound.

2 Mission

We are building a string instrument, that instead of strings, will have lasers that when you break the line of light, it will make the corresponding tone from different instruments like a string. This will act as a showcase to convey the kind of fun and creative DIY projects that can be completed. The instrument will be built in a compact design with everything in a all in one device for portability and built with easy to understand controls. This device will be easy to use to be able to connect with as many age groups as possible.

3 Success Criteria

The main goal of our project is to influence students to choose a STEM major, however it is impossible to gauge this and quantify it into a time frame, so we have not done so.

Upon completion of the prototype system, we want to see the following indicators of success:

- We are able to play a complete song to demo for classrooms.
- The instrument has the ability to play a voice.
- We have the product be better than the other two teams working on this project.
- We have not gone over our budget of $800 to complete the project.
- Able to see laser beams while ambient light present

Long term indicators of success upon completion of the prototype system include:

- All systems functioning correctly and device can be used as intended.
- The device can support multiple voices to be played.
- The product is frequently used for its purpose, being demoed for students, while retaining full functionality.
- Having influenced students in any capacity to opt for a career in STEM.
- Inspire musicians to use more electronics instruments in their music.
- If the product is a success, subsequent iterations for the production of the device will cost less with every production cycle.
- Users are able to perform simple troubleshooting using the user manual.

4 BACKGROUND

This project is about a group of UTA engineers coming together to build a functioning electronic device from simple individual components. This device will then be used later to show potential future engineers what they can be made with the skills and knowledge that they will learn while they attend UTA. The ultimate goal of this is to convince more people to take a career in STEM oriented fields.

This project will also show off the potential and skills of students who complete the UTA engineering curriculum. When this project is completed, it will help draw new students to the school just as sports teams draw new students.

A laser harp is electronic instrument that uses lasers as a means to receive input from the musician and plays a corresponding musical note depending on the laser touched. Laser harps are frequently used to play electronic music, such as electro jazz and EDM. The laser harp is a relatively recent invention when compared to most instruments, being invented in 1975 by Geoffrey Rose and Bernard Szajner, and being popularized by Jean-Michel Jarre in 1981. The lights and the music typically played by a laser harp help give it a sensation of futurism. The laser harp is also a relatively uncommon instrument, as it is functionally identical in output with a electronic keyboard, with each input is programmed to a specific note. The electronic keyboard is more widespread because is uses a traditional piano keyboard as an interface, while the laser harp input is solely unique to it.

For these reasons, most people will see the laser harp as something unique and interesting, something that they wouldn't see in their normal day-to-day lives. This is why UTA has decided that this instrument should be used to present the UTA engineering department in a fun and exciting way.

5 RELATED WORK

There are plenty of companies that produce and operate lasers for a live setting; Kvant [2], Able [1], and NRG. They offer fans of laser beams that can pan/tilt, rotate, and even do projection. There is no company I have found that offers a laser rig that operates as a musical instrument. Even if we chose to use one of these projects to build off of, ignoring licensing for the moment, they range in price from 2,000 to 4,000 USD which is out of our budget.

Our team plans on making a 13 string, one octave of the chromatic scale, frameless Laser Harp with built in speakers. If we have time we hope to have a 1/4' cable out to plug into external speakers, multiple voices, and midi, which is used to operate external synthesizers, over USB. There are a number of prototypes available on the DIY site Instructables. They do not operate on the scale that we hope to achieve. The Upright Framed Harp [4] has many of the features we are looking for except that it is missing the 13th string, the octave of the lowest string. It also has a frame and our team plans on building our harp to be frameless. That being said this harp does contain built in speakers, and it accomplishes some of our stretch goals such as having multiple voices and having an audio cable out which can be plugged into external speakers. The same creator also has a similar 13 string harp that is frameless [3] with midi out instead of internal speakers, but is lacking the multiple voices and audio out capabilities. Another 13 string frameless harp [5] does midi out which isn't in our requirements but is something we are looking into accomplishing.

In conclusion, there are not any large scale companies making this type of instrument, and there are not any enthusiasts that have made something to the scale that we hope to achieve. The three Instructables explicitly mentioned above will make nice references that our team can use to build off of. By using ideas from these projects we can start designing our own, picking the features that we like and adding in the features we need to meet our requirements list. We will also be able to use to get an idea of the budget and required time for our project.

6 System Overview

The system will be build from the ground up using an embedded systems approach. The system needs to fulfill some basic requirements as provided by the sponsor. These are as follows: 13 full strings to fit full chromatic scale, easily portable, built-in speakers, at-least one knob, volume knob, range knob, lasers visible in low-light settings. Other optional requirements are: a quarter inch output, MIDI over USB and a distortion knob. The basic working principle is as follows: we will have 13 laser emitters emanating from an Arduino micro-controller. The 13 lasers represent the 13 strings of a chromatic scale. Once the laser breaks contact from the user's fingers, the length at which the the laser is broken is recorded by the light sensor. This is converted to the Harp tune it was supposed to play. The system is supposed to be easily portable, and hence will contain two speakers on either side of the device, so that the device is portable and self-contained musical instrument. The front side the device will have a knob to adjust the output volume. The lasers will have to be visible in low-light settings such as semi-dark room. Digital filters will be applied to the input data so we can remove ambient light from the data. The device will also contain a voice knob which can be used to change voices from harp to another device such a piano. A range knob will be used to determine the output range of the frequencies played by the instrument. The instrument will contain a digital output that can output digital voice over a quarter inch output.

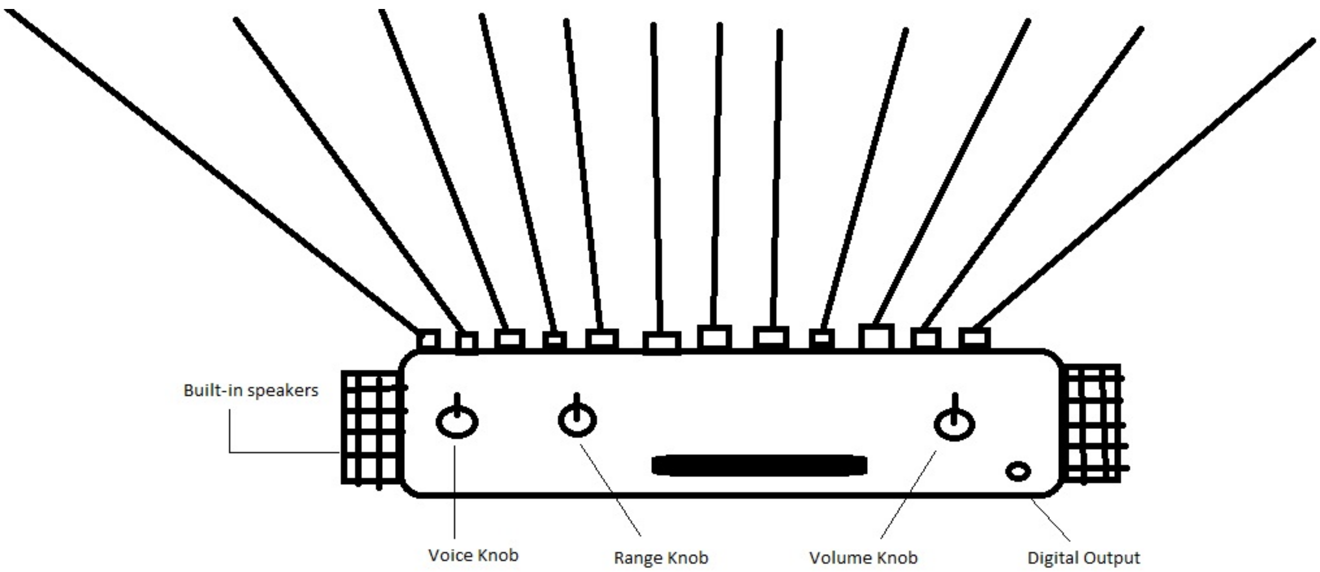

Figure 1: Initial System Design

7 Roles & Responsibilities

The primary stakeholders on the project are the team members: Sidharth Banerjee, Zachery Gualandi, Mitchell Lux, Michael Morrow and Muhammad Siddiqui, and our supervising professor Dr. Shawn

Geiser. The point of contact from the sponsor will Dr. Gesier, who will oversee our project success and provide feedback to make sure we are on the right path towards making a product based on what our sponsor requires. The aforementioned team members will take on the role of computer professionals and overlook areas of their sector. Sidharth, a Computer Engineer will handle the hardware programming for the micro-controller. He will use his knowledge of embedded systems to assist with the reading and interpreting data collected by the hardware, and use signal processing methods to understand the data. Mitchel, Michael and Muhammed, as strong computer scientists will design optimal code functions so that we have a low latency product. They will use their advanced knowledge of algorithms to make sure we increase our compute speed and use the least memory possible. Zachery, a software engineer, will overlook the software management and scalability of our product. This will help with long-term management of our product once we get past the initial prototype stage Throughout the project, the owner, Dr. Gesier, will remain the same. We will keep rotating our scrum master so that we each get a chance to design certain aspects of the product under different leadership. This will assist in making sure we have multiple perspectives of our product. Team members will take initiative to provide ideas at every stage of the implementation, and will not only rely upon the ideas of the scrum master.

8 Cost Proposal

Our team will be relying on the $800 provide by the CSE Depatrment and we are not expecting to get additional funding. The most amount of money will be going into the microprocessors and the shields. We will need one Arduino Mega to act as the brain of the project. One Adafruit Music Maker Shield to formulate our the sound, and we will need an audio amplifier to boost that signal. After that we will need the lasers. We will need to do some testing to see which lasers will perform best, such as whether a 520nm(green) laser or a 700nm(red) laser is better detected by our device. To this end we will need to buy a selection of different lasers to run tests on. Then the rest of the budget will be spent on small electronic components such as transitors and potentiometers.

8.1 Preliminary Budget

Item	Cost($)	Running Total($)
Ardunio Mega	30	30
Adafruit Music Maker Shield	40	70
MAX9744 20W Amplifier	25	95
2 x 20W 4 Ohm Speaker	40	135
Lasers	100	235
Small Electronics	100	335

Table 1: Preliminary Budget

8.2 Current & Pending Support

We currently only have secured funding from the Department of CSE for $800. We do not inted to seek out any more sponsors at this time.

9 Facilities & Equipment

We will require a lab/work area. We plan to utilize the Senior Design lab at the Engineering Research Building for this purpose so we won't have to move around our prototypes too much. We will also require a 3D printer to print the housing of the product, and there are many present in the Senior Design lab which we plan to avail. An area where lights that can be dimmed (or shut off) will be needed for testing purposes, as a laser that is safe enough for the use cases of the product may not be sufficiently bright enough to be visible in a well lit environment. We can use Arduinos, breadboards and wires present at the Engineering Research Building, along with the soldering equipment. Personal protective equipment, such as green laser safety goggles and gloves, will be purchased as needed, with a maximum of one pair of gloves and one pair of goggles per team member. Finally, we plan to utilize our team budget to purchase the following items from Amazon/Newegg (items will be added here as needed):

- laser
- mirror
- stepper motor
- speakers
- power supply
- light dependent resistors
- quarter-inch audio output jack
- MIDI jack

10 Assumptions

- We will have a suitable work space where we can leave our prototypes so different members may work on the product at different times
- We will have access to a 3D printer at the senior design lab.
- Anyone who is working on the product when lasers are involved is wearing the appropriate protective equipment. If they are not, they must take the necessary precautions to protect their eyes and skin.
- A suitable testing location will be available within the first month of production, a location where the lights can be dimmed.
- The product does not need to be hand-held, although still portable.

11 Constraints

- Final prototype demonstration must be completed by May 1st, 2020
- Total development costs must not exceed $800
- The team working to develop this device is limited to five members
- Device must be safe enough for kids to use since demonstrations will be given using this product

- Entire device must be compact so it can be portable but also big enough to meet all requirements
- Will not have access to resources immediately, could take time to set up or deliver

12 Risks

This section should contain a list of at least 5 of the most critical risks related to your project. Additionally, the probability of occurrence, size of loss, and risk exposure should be listed. For size of loss, express units as the number of days by which the project schedule would be delayed. For risk exposure, multiply the size of loss by the probability of occurrence to obtain the exposure in days. For example:

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
3D Printing: Misprints and Re-designs	0.20	10	2
Hardware Components not able to perform required function	0.15	20	3
Senior Design Lab not available for use	0.10	10	1
Initial Software has to be replaced entirely	0.15	20	3
Delays in shipping from school approved vendors	0.40	20	8
Hardware breaks or malfunctions during testing	0.20	10	2

Table 2: Overview of highest exposure project risks

13 Documentation & Reporting

13.1 Major Documentation Deliverables

13.1.1 Project Charter

The project charter will be turned in as an initial version September 30th, 2019, while the final version will be done on December 11th, 2019. During the planning period of this project, the project charter can be updated at any time if new ideas come up or something changes from the original charter. Once the final version is turned in we will not make any changes to it.

13.1.2 System Requirements Specification

The SRS document will have an initial version turned in on October 21st, 2019 and will be finalized and submitted by December 11th, 2019. This document will be updated any time new requirements are added or existing requirements are taken out of the project. This can be updated at any time before the final due date and can be done by any team member or the product owner.

13.1.3 Architectural Design Specification

The ADS document will be turned in initially on November 11th, 2019 and will be finished by December 11, 2019. This document will be written and maintained by all team members. Any changes to the architectural design will need to be updated in this document to stay concurrent with the project. This can be done up until the final copy is due.

13.1.4 Detailed Design Specification

The DDS document will be turned in and finalized on February 24, 2020. Any changes to the design of the project will need to be updated here until all final plans are made by February 24. This document can be changed anytime during the planning phase.

13.2 Recurring Sprint Items

13.2.1 Product Backlog

Tasks will be added to the product backlog based on prioritization of the features of our product. The priority list will be decided by the entire group with the approval of the product owner. Communicating through the team channel on Slack will keep team members and the product owner updated during sprints and presentations after each sprint will show our progress through the project.

13.2.2 Sprint Planning

Each sprint will be planned out by having a meeting to discuss what we think as a team we can get done in the time interval of the current sprint. The tasks for each sprint will be based on the priority list of features, schedule, and previous sprints. We will have a total of 8 sprints, each spanning a 2 week time period.

13.2.3 Sprint Goal

The sprint goal will be decided by the entire team during our pre-sprint meeting. This decision will be based on the priority list of features and how the product owner feels the direction of the project should be going. The sprint goal will also depend on the schedule of the project, since certain tasks need to be completed at certain times.

13.2.4 Sprint Backlog

Deciding the sprint backlog will be up to the team's members and the product owner. Whichever tasks they feel need to be finished in that sprint will be added to its backlog. Our sprint backlog items will be maintained by always having a written list of all backlog items and also using an easy to use software (such as Trello) to keep the backlog as up to date as possible.

13.2.5 Task Breakdown

Tasks for each sprint will be assigned voluntarily but will also be strongly influenced by each team members major and skills in the field. Although tasks might be assigned to an individual all team members will be ready to help if needed. Each team member will document time spent on each task in their engineering notebook and then logged in an Excel spreadsheet.

13.2.6 Sprint Burn Down Charts

Each team member will be responsible with creating burn down charts for each sprint, where one team member per sprint will be assigned this duty. The times used in the chart will be acquired from the backlog board of items and the logged hours spent on a task. Each chart will be a line chart like the one below:

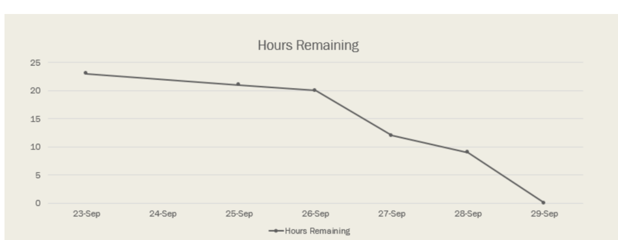

Figure 2: Example sprint burn down chart

13.2.7 Sprint Retrospective

Each sprint retrospective will be discussed in a meeting the next class lecture day after the end of the sprint. We will go over what went well and what did not so we can learn from our mistakes. As a group, we will also go over all finished tasks for that sprint so we know if anything needs to get pushed to the next one. This retrospective will be done by the Wednesday following the end of a sprint.

13.2.8 Individual Status Reports

Each member will report any updates that they have dealing with any part of the project they are working on. This will make sure everyone is on top of their work and will allow ideas to be shared about certain tasks. Each major milestone will be reported such as key features and sprint rundowns.

13.2.9 Engineering Notebooks

Engineering Notebooks will be updated at a minimum of once every meeting that occurs with the team and any other time it is necessary. We should be having at least two meeting every sprint so this should be the minimum amount for each sprint. Each team member must hold each other accountable each meeting to make sure everyone is updating regularly. We will also not be requiring a witness signature for each page used.

13.3 Closeout Materials

13.3.1 System Prototype

What will be included in the final system prototype? How and when will this be demonstrated? Will there be a Prototype Acceptance Test (PAT) with your customer? Will anything be demonstrated off-site? If so, will there be a Field Acceptance Test (FAT)? By the end of a project, we will have a portable laser harp that at minimum can play audio through built-speakers. As Dr. Gieser is the sponsor of this project, we will be demonstrating the product to him and he shall act as the PAT. FAT can be performed in classrooms while demoing the product to students.

13.3.2 Project Poster

This will be a 4 ft x 3 ft tri-fold poster that will summarize the journey of this project from conception to completion, while also showcasing how it works at a high level and it's purpose.

13.3.3 Web Page

As of now, there are no plans to make a web page. It may potentially be shown on the UTA website, a blog, or on social media.

13.3.4 Demo Video

We plan to learn to play a song of our choosing on the harp for the demo. If we were to record this, it may be a two to three minute video.

13.3.5 Source Code

We plan to use GitHub for version control, and for now the plan is to keep our code open source under the Creative Commons license. This, however, is subject to change at the team's/sponsor's discretion.

13.3.6 Source Code Documentation

Documentation will be a browse-able PDF document created by the team.

13.3.7 Hardware Schematics

To be determined

13.3.8 CAD files

We will use Solid Works to create models of the casing for the harp, which we plan to 3D print. Models will be of the STL format.

13.3.9 Installation Scripts

No software is required to use this product.

13.3.10 User Manual

We will create a video and post it to YouTube, showing how the product is to be used and what features it has.

References

[1] Able Laser Products.

[2] Kvant Laser Display Systems.

[3] Jbumstead. 13 Note MIDI Laser Harp.

[4] Jbumstead. Upright Laser Harp.

[5] Pushan Panda. Frameless Laser Harp.