Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4317: Senior Design II
Fall 2023

Melody Masters
SoundSync

Angel Aguirre
Benjamin Farmer
Patrick Ferguson
Edgar Hernandez
Adrian Ramos

Revision History

Revision	Date	Author(s)	Description
0.1	06.21.2023	AR	document creation
0.2	06.22.2023	AA, AR, PF, BF, EH	Document revision with team information
0.3	06.27.2023	AA, AR, PF, BF, EH	Complete draft V1
0.4	08.11.2023	AA, AR, PF, BF, EH	Complete draft V2
1.0	11.30.2023	AA, AR, PF, BF, EH	Final Release

CONTENTS

List of Figures

1 Problem Statement

Whether in the privacy of their own room or in a concert hall with an orchestra, musicians read music in order to keep track of where they are when playing. However, a common annoyance of this art is the need to turn a page! When a musician is playing a longer piece and needs to turn the page, it can be a distraction. If there were a way to leverage technology to remove this burden entirely, it could prove to be a useful tool for any musician who wants to concentrate on their playing, and not their page-turning. SoundSync will be the way to leverage technology in the music world by being a useful tool for removing the dependencies of physical music sheets and providing digital solutions to musicians everywhere.

When tackling this problem, we aim to consider all engineering challenges associated with it, such as creating a user-friendly and intuitive interface for musicians, being able to track the musicians playing to a scanned music sheet, and making sure we can account for errors in our detection approach. This entails leveraging advanced tracking technologies to accurately follow the musician's progress on the scanned sheet, ensuring precise synchronization between their performance and the digital score.

Moreover, our approach will be characterized by robustness and adaptability. We understand that live performances can be unpredictable, and factors like variations in tempo, dynamics, and potential errors are integral to the musical experience. As a result, we will employ sophisticated algorithms capable of dynamically adjusting to the musician's playing style and reacting to deviations, guaranteeing a fluid and responsive page-turning process.

Furthermore, the versatility of SoundSync will be a key feature. Musicians of all genres and instruments should be able to use this tool, which means accommodating various types of sheet music formats, providing customizable annotation options, and integrating with a wide range of devices such as tablets, smartphones, and electronic music stands.

By addressing these challenges, SoundSync aims to revolutionize the way musicians interact with their sheet music, enhancing their focus on the music itself and freeing them from the distractions of physical page-turning. Whether practicing alone or performing on a grand stage, musicians can fully immerse themselves in their craft, knowing that SoundSync has their sheet music needs covered.

2 Methodology

The Melody Masters intend to solve this problem by developing a web service that can be paired with mobile devices to replace physical sheet music entirely. This application will be capable of scanning physical sheet music and storing it in an account for the user, listening to the user's live playing, following along with the user on the sheet music, and automatically turning the page when appropriate. It will accomplish these features with a complex system of subsystems all working in unison to create the ultimate experience. The different subsystems will communicate and transfer information between their layers based on user input and optimize the information for seamless integration into the overall system. Each subsystem will handle their dedicated tasks and process the information to keep the system flowing and running efficiently.

3 Value Proposition

One of the benefits of a musical product is that there are millions - possibly billions - of people who have played an instrument at least once in their life. The demand for a product that can make learning easier, make high-stakes concerts less risky, and even make organizing your music sheets a breeze will undoubtedly be apparent. The overall utility of SoundSync will be its uniqueness of a do-it-all-in-one experience that will give a better experience than any other web-app currently out in the market. The many features that SoundSync offers are scattered throughout the market and require to have a minimum of 2 separate apps to have all the features that SoundSync will provide. Sponsors will benefit

greatly from this development as the digital world has quickly taken over the physical world and many users prefer the digital solution on a screen rather than having to carry many pages of music or books everywhere they go.

4 Development Milestones

- Project Charter first draft - June 2023
- System Requirements Specification - July 2023
- Architectural Design Specification - July 2023
- Demonstration of <Note identification> - August 2023
- Detailed Design Specification - September
- Demonstration of <page turning/sliding> - September
- Demonstration of <note duration/tempo> - October
- Demonstration of <key signature/ different tuning> - November
- Demonstration of <tempo changes/dynamics and accuracy> - December
- Final Project Demonstration - December

5 Background

Performing music is a complex and skillful endeavor that demands a substantial investment of time and effort to master effectively. When tackling a new musical piece, musicians encounter a range of challenges that contribute to the learning process. One of these challenges involves repeatedly engaging with the sheet music, meticulously analyzing and executing its different techniques.

Furthermore, an often-overlooked aspect of musical performance involves seamlessly transitioning between pages of sheet music. Musicians must memorize not only the intricacies of the music itself but also the page turns, ensuring a fluid continuation of the performance without disruptive pauses. This requirement extends the time needed to learn a new piece, as musicians must allocate additional mental resources to managing the physical act of page turning while simultaneously playing.

SoundSync is innovative Service designed to address these challenges. SoundSync emerges as a technological solution developed to change the way musicians approach learning and performing music. This web-app functions as a virtual partner, synchronizing with the user's musical progress through the sheet music displayed on-screen. By aligning with the musician's tempo, SoundSync enables uninterrupted playing, empowering users to navigate the musical composition at their preferred pace.

Unlike existing applications that generate sheet music based on audio input or play pre-recorded musical pieces, SoundSync's primary objective prides itself in its commitment to create an immersive and focused learning experience. Musicians are granted the freedom to concentrate only on reading and playing music, unburdened by the need to manipulate physical sheet music or divert attention to page-turning logistics.

The development of SoundSync is rooted in a deep understanding of the challenges faced by musicians, emphasized by the heartfelt passion shared by its sponsorâa music enthusiast eager to expand their skills and explore new melodies. For the passionate community of music lovers, SoundSync presents an opportunity to engage with their craft without the burden of physical sheet music or the disruptive task of page turning. Instead, they can devote themselves entirely to the joy of mastering a new musical piece, enhancing their musical talent and forming a deeper connection to the music.

In essence, SoundSync transcends the traditional music learning methods by introducing technology to empower musicians. Through its innovative approach, it paves the way for an unforgettable and immersive musical experience.

6 Related Work

SoundSync aims to enhance the music learning experience by improving upon existing app features available in the market. It will implement features from Android and iOS music apps and combine them into one single web-app. SoundSync will accomplish five main objectives: accurate music note tracking based on speed and precision, music scanning to add to the library of music for the user to play, accuracy tracking for the user to follow along and get a percentage based on how well they matched the music, music library for the user to have a variety of music to choose from ,and seamless manual page turning facilitated by a pedal. These functions distinguishes SoundSync from the array of music-related apps available today. Currently, the app market has been divided into separate categories, with some apps specializing in music tracking while others cater to musical libraries. This division presents a limitation for users who are looking for a single app with multiple functionalities. SoundSync is working to bridge this gap, offering users a unified platform that combines these two critical aspects of music practice. Moreover, SoundSync allows users to easily integrate new pieces of music into their practice routine. By enabling users to import and play along with their preferred music, SoundSync encourages musicians to engage with a diverse selection and explore their creativity.

Some current market products that are available for seperate purchase include the PageFlip Firefly, which is a bluetooth/usb device that will connect to the device the user is using and is compatible with

all current modern OS (MAC, Windows, iOS, Android, Linux) but this type of connectivity is expensive for the average consumer [5]. Another limitation for users is having too many apps for one subject. The frustration of multitasking between apps with no cross data transfer or seamless transition can be too much of a hassle for some users. The MusicReader, PlayScore 2 Sheet Music Scanner, RemoFinger S, SM Music Reader and Sheet Music reader are five separate apps that perform the same functions as SoundSync. These apps display music sheets, read music notes and articulation, and music page turner with compatibility of using an optional pedal. This can become an inconvenience to many users having to switch to different apps and lose their concentration in the music. [1], [2], [3], [4]

7 System Overview

Our team's solution to the problem will be to create a web application that handles the page turning automatically. Additionally, since the application will have to recognize the music the user is playing, we will implement an extra feature to return the user's accuracy for a given song. This will streamline the user's experience and provide feedback to help them improve their playing. The general process is illustrated in the following diagram.

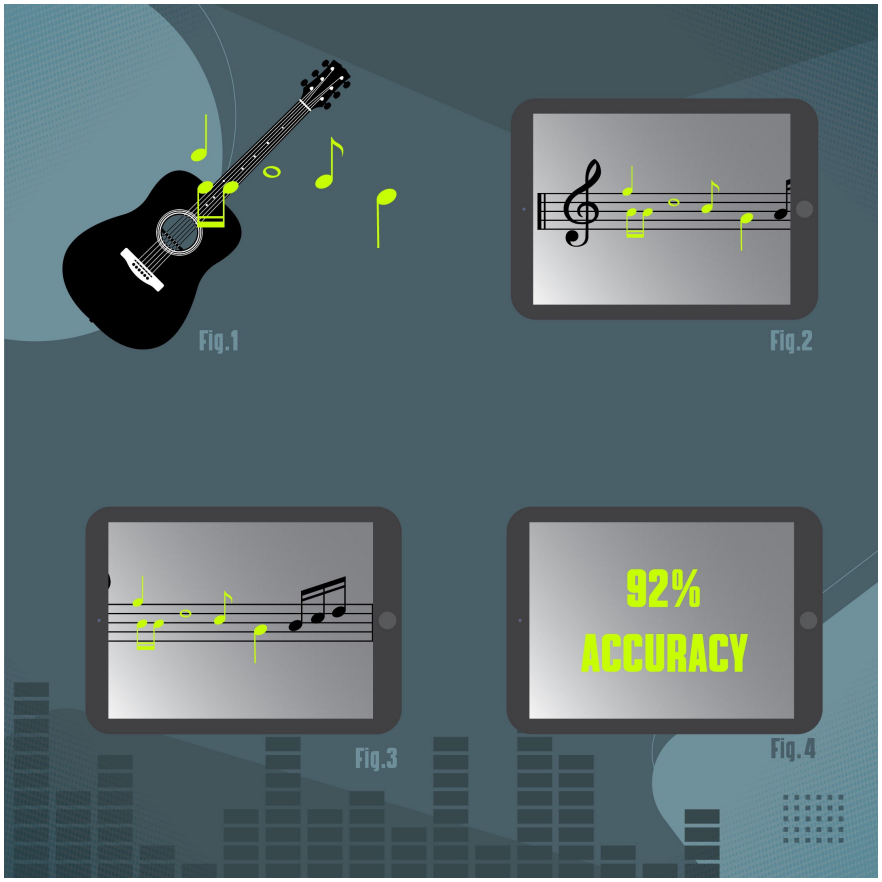


Fig.1) The user plays a song on their instrument. They will have their mobile device nearby with SoundSync open.

Fig.2) SoundSync will receive the music as an input, and match it to a stored set of sheet music. The web application will keep track of which notes have been played, illustrated by the green music notes.

Fig.3) Once the user approaches the end of each section of sheet music, SoundSync will display the next unplayed notes, illustrated by the black music notes.

Fig.4) If requested by the user, SoundSync will also keep track of how well the input music matched with the expected stored music. Based on this, as well as the timing, it will provide the user an accuracy score to keep track of improvement.

8 Roles & Responsibilities

On behalf of the CSE department, Dr.Gieser will be our sponsor. All five team members are in contact with him, and the entire team will be present during sponsor feedback meetings. While working on the project, the following tasks will be the responsibility of the whole team:

- Documentation - This includes the project charter, sprint plans and reviews, and keeping up with engineering notebooks. The former three will be done during team meetings, and the notebooks will be filled out individually.
- General Research - This includes familiarizing ourselves with relevant topics such as music theory and app development tools.
- Presentations - Team members will rotate speaking roles for sprint presentations.

Separately from the team tasks, individual team members will be responsible for the following:

- Angel Aguirre - focus on hardware research and implementation, software contributions
- Benjamin Farmer - focus on software research and development, product testing
- Patrick Ferguson - focus on software research and development, development tools research
- Edgar Hernandez - focus on hardware research and implementation, software contributions, team graphics
- Adrian Ramos - Scrum Master, software research and development

It is also worth noting that these roles are somewhat fluid as we will be collaborating on most components of the project.

9 Cost Proposal

The budget for this project is $800. The majority of this will go towards the hardware components required for testing and use of the application. The main components will be the instrument and microphone, a USB audio interface for communicating with the web-app and all the corresponding cables, and an additional tablet for testing.

9.1 Preliminary Budget

Line Item	Cost
Instrument	$200.00
USB audio interface	$150.00
Backup pedal	$100.00
Microphone	$50.00
Tablet	$300.00

Table 1: Overview of preliminary budget for SoundSync

9.2 Current & Pending Support

Our $800 budget will be provided by the UTA CSE department.

10 Facilities & Equipment

For facilities we will use the music rooms located on the first floor of the UTA library. They are available Sunday through Monday from 9am to 9pm. The rooms are reserved by appointment so in order to perform testing there we will have to make sure to take a spot at least the week before. Music can be played there and with UTA-provided tablets, we can test to see if our web-app is working. If the music rooms don't have enough sound proofing then we will buy and bring some foam sound proof pads. We will know after the first testing session if this will be necessary based on how much noise shows up in the recordings. We will also need some hardware components for our web-app. For the instrument, we have decided on a guitar. Specifically, we will be using an electric guitar to have the option of directly inputting sound data to our audio interface rather than recording it with a microphone. This will pick up less environment noise. The audio interface we are using is designed for use with mobile devices through a USB-C port, so we will be able to connect it to the tablet through a USB-C to USB-C cable. The guitar will be connected to the audio interface through a standard 1/4" TS cable. Should we not have access to the interface for any reason (for example, if the team member in possession of it cannot make it to testing), then the device microphone should be sufficient for general testing as long as it is held close to the guitar and environment noise is limited. This will allow the team to more easily debug and apply fixes during testing. Aside from this, since this is mainly a software-based project, we do not expect to need any other hardware or special facilities.

11 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- There will be an adequate music library to help us interpret musical notes on the software side.
- An open senior design lab will be available during senior design 2 for us to test our app.
- React native will be a good web design environment and the depreciated functions wont be too intrusive.
- Any music library we use will be compatible with JavaScript.
- Our group will have a good understanding of music theory allowing us to properly model it in the software environment by the time senior design 2 starts.
- A group member will be able to play an instrument or have someone outside the group play an instrument.
- We will be able to use the sound provided by the ADC analog converter.

12 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by December 2nd, 2023
- Project members must have an individual play on a real instrument to measure speed an accuracy metrics
- Resources needed for build may be out of stock due to chip shortage or other constraints caused by pandemic

- Total development costs must not exceed $800
- Learning of music theory and musical instruments on a foundational level to begin implementaion of app based features

13 Risks

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)
Delay of Music theory concept grasp	0.20	5	1
Delays in shipping from online vendors	0.30	5	1.5
Finding an instrument player for testing	.25	5	1.25
ADC or pedal not available for testing	.50	14	7
Web-app failure/Major Bugs	.75	10	7.5
Device port errors and issues	.20	7	1.4

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The initial project charter will be completed by the end of sprint 1. The charter will be reviewed at the end of every sprint.

14.1.2 System Requirements Specification

Starting in sprint 2, we will have a formal meeting to discuss the specific system requirements. This document will be updated as sprints go forth.

14.1.3 Architectural Design Specification

Starting in sprint 3, we will create an initial architectural design specification document. We will review this as sprints go forth.

14.1.4 Detailed Design Specification

Starting in sprint 4, We will create a Detailed Design Specification. This document may be updated in senior design 2 if we find some parts are not up to par.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added from the SRS based on how essential they are for our web-app to function and perform it primary purpose. Items will be prioritized based on a numbering system of importance. The most important features being completed first. The decision to prioritize tasks will be a group decision. We are using Trello to keep track of tasks and who doing what.

14.2.2 Sprint Planning

Each sprint will be planned based on what we need to get done and what we will need for the next sprint to continue without being held back. There will be 8 sprints in total.

14.2.3 Sprint Goal

The group will decide the sprint goal. We will begin involving the customer around senior design 2 when we have actual software for them to use.

14.2.4 Sprint Backlog

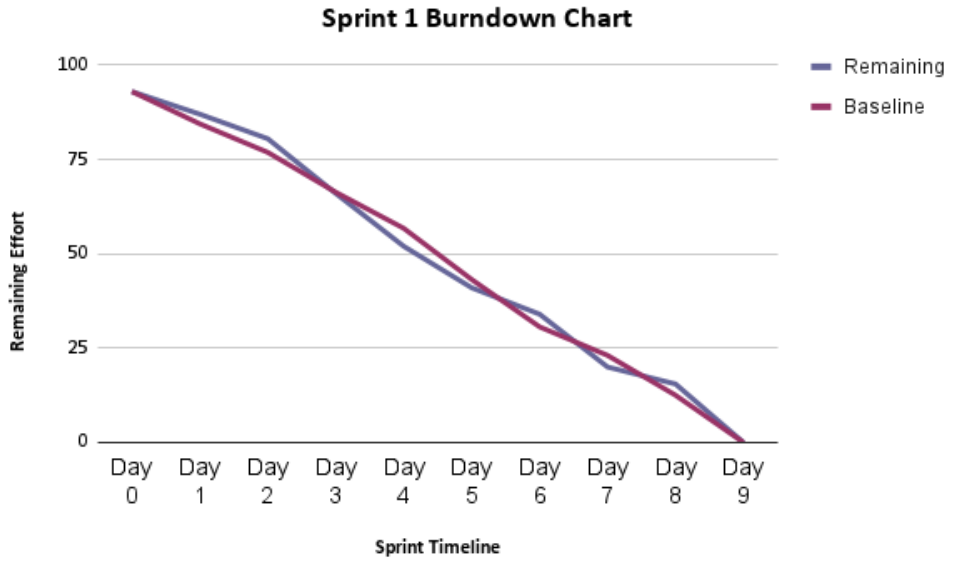
We decide as a group which items will go on the sprint backlog. The backlog will be maintained by checking it every Friday and marking what items have been completed.

14.2.5 Task Breakdown

Tasks will be claimed voluntarily first and if tasks need to be assigned the sprint master will assign tasks. Time spend on tasks will be documented through engineering notebook.

14.2.6 Sprint Burn Down Charts

The sprint burn down chart will be a group effort created by all members. All members should keep a running total of the hours put into the project creation. The burn down chart will be in a line graph format that will use the projected hours from the sprint outline to actual committed hours during the sprint.



	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Remaining Effort	93	87	80.5	66	52	41	34	20	15.5	0
Baseline Effort	93	84.44	76.88	66.32	56.76	43.2	30.64	23.08	12.52	0

Figure 1: Sprint 1 Burn Down Chart

14.2.7 Sprint Retrospective

The team will meet on Friday's after the sprint to discuss what needs to be worked on during the next sprint, issues we ran into, what tasks didn't get completed, and how we will complete them during the next sprint.

14.2.8 Individual Status Reports

Individual status reports will be delivered bi-weekly and should include the progress made toward the research and development of the web-app and pedal. Key items will include the hours committed toward research and development.

14.2.9 Engineering Notebooks

Engineering notebooks will be updated as needed per member and will be checked on a bi-weekly basis. There is no minimum amount of pages set per sprint as long as entries to the notebook are to improve knowledge for project completion. No signatures are required for pages.

14.3 Closeout Materials

14.3.1 System Prototype

The final prototype will include a device that inputs an analog signal and outputs a digital signal to a web-app, which can then use this signal to follow along with a previously scanned piece of sheet music, flipping the pages when the user approaches the end of the current one. The final system prototype will be demonstrated at the end of Senior Design II, in December.

14.3.2 Web Page

The project web page will include all the information about what the web-app does. This will include music page scanning, and music page turning. This web page will only be available to the senior instructor and the group until the web-app is ready to launch. The website will most likely be updated near closeout.

14.3.3 Demo Video

The demo video will show the actual music page being turned along with it accuracy score as music is being played. We may include B-reel footage if the demo video is too long. The video will probably be 10 minutes long at the most and will include the music page turning, music tracking, and music note identification

14.3.4 Source Code

Our source code will be maintained with GitHub. The source code may be provided to the customer if we deem it necessary for them to have it. We are still deciding if the web-app will be open source, we will know more as we get near the end. Licenses for any library we use will be provided.

14.3.5 Source Code Documentation

14.3.6 Hardware Schematics

No diagram or schematics needed.

14.3.7 Installation Scripts

No installation scripts will be needed.

14.3.8 User Manual

The customer will not need a digital user manual with set up steps. No video is needed. The manual will consist of web-app instructions for usage and features/capabilities.

REFERENCES

[1] Remofinger s page turner for digital sheet music, 2016.

[2] The best score-reading apps for classical musicians, 2020.

[3] The only music solution you'll need, 2020.

[4] Janet Ingber. A review of two sheet music apps: Sm music reader and sheet music scanner, 2022.

[5] Justin Lin. Pageflip firefly bluetooth/usb page turner review, 2017.