Guitar Learning Tool and Feedback System

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Introduction

1. Objective

The ability to play an instrument is something that everyone has desired to do at some point in their lives. Whether it is due to a lack of time or motivation, it simply requires way too much effort for the average person to ever actually learn one. The guitar is one of the most popular instruments in the world today, yet learning how to play it is still much too difficult. When you do begin to learn, there are few quantifiable resources at your disposal to truly know if you are improving or not.

Our project looks to tackle that problem. By synthesizing sheet music into a measure-by-measure breakdown, the user will be able to practice individual measures or sections at a time and receive instant feedback on their performance. This system will greatly accelerate the learning process, as users can receive detailed information on where they are playing well and where they are struggling to perform. By repeatedly practicing difficult sections, they will build the muscle memory and comfort needed to play a guitar well.

2. Background

While there are several tools out there similar to our design to teach people how to play guitar, we noticed that they were all either tethered to some sort of iOS/Android app, or designed in a way that was uncomfortable for the player to see what the correct notes to be played were. When the LEDs are situated along the fretboard underneath the strings, the user has to crane their neck over the guitar to see where to put their fingers. By placing the LEDs on top of the fretboard where they are easily visible, they will learn to play the correct strings by the feel of them rather than just placing their fingers wherever the lights are.

The other issue with current systems that arise is the lack of sectional playback. By having a simple LCD user interface displaying the current measure of the song, the user can focus on the experience of playing the guitar itself rather than trying to react to notes flying across their small phone screen. By allowing variation of tempo and measure length sequences, the user can immediately progress to more difficult versions of the song that they are playing. We believe that this system is much more helpful and viable in learning how to play the guitar as effectively as possible.

3. *Physical Design*

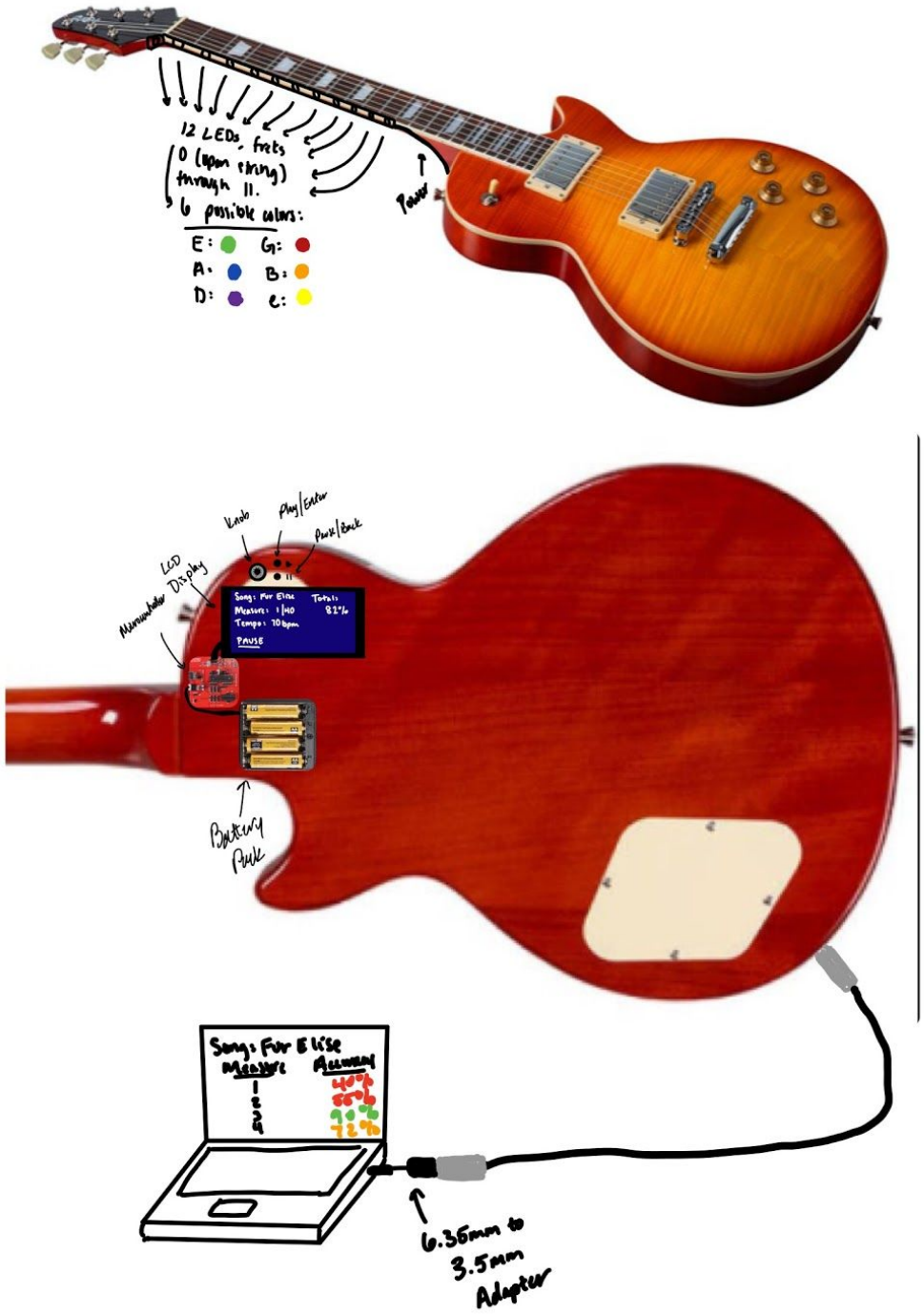

Figure 1: Physical Design

4. High-Level Requirements List

- System must provide meaningful accuracy feedback as a percentage score for each measure played to aid users in guitar playing improvement.
- System must provide real time and easily interpreted instructions for playing a song through 12 visual LEDs along the top side of the 12 lowest frets and 6 colors per LED corresponding to each string on the guitar.
- System must allow users to choose from at least 20 songs to practice.

Design

1. Block Diagram

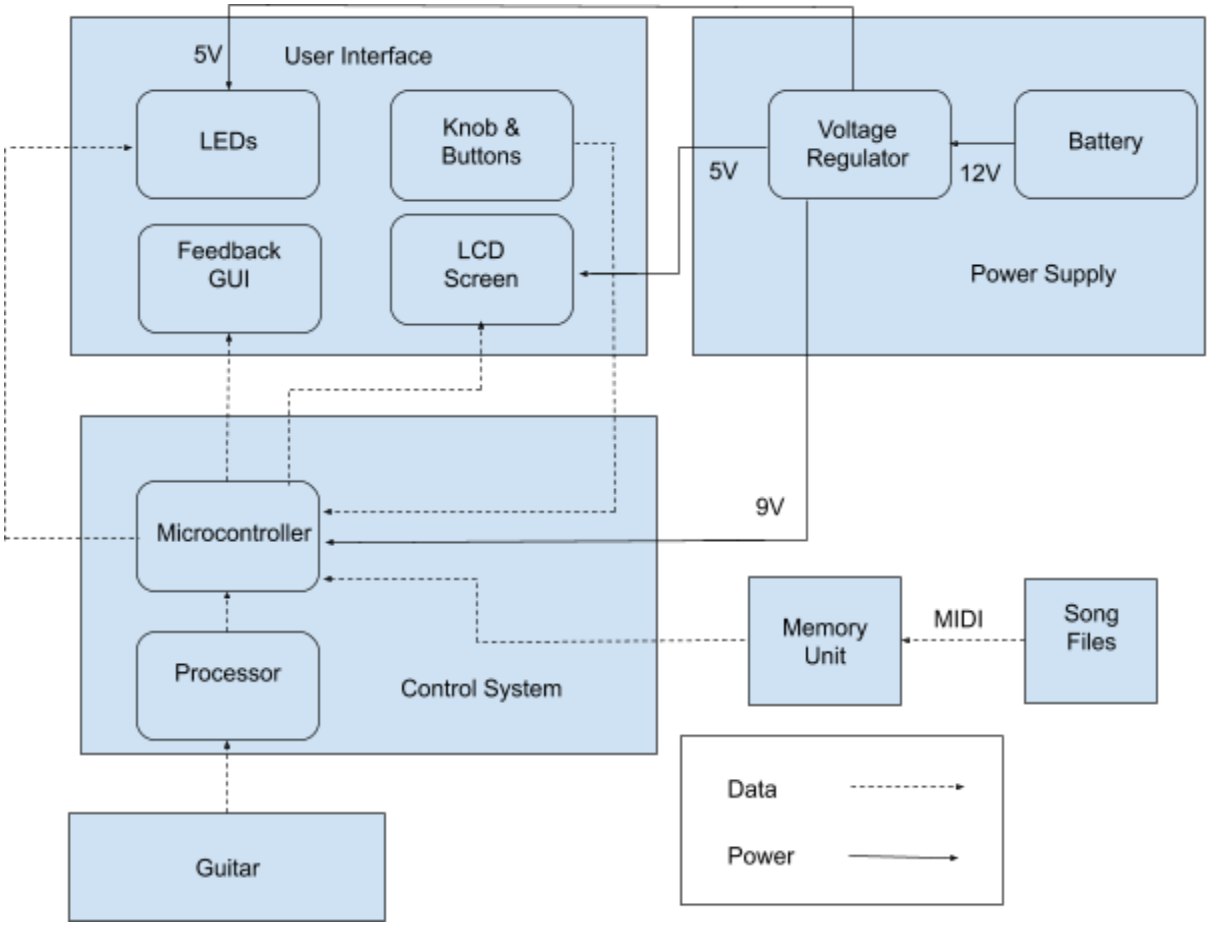

Figure 2: Block Diagram

This is the proposed block diagram for our project. We decided to go with a simpler hardware implementation, as we wanted the focus of the project to be the user feedback experience. By having a small LCD screen with an accompanying menu and a basic scroll wheel with enter and back buttons, the user is able to select different songs and varying settings for playback. The connection from the guitar to the 'processor' (i.e. computer) allows the

accompanying software to detect what note is being played in synchronization with the displayed sequence from the LEDs, to determine how accurately that sequence was played. We believe this design maximizes learnability while minimizing confusion, allowing for a simple and easy playing process.

2. Functional Overview

2.1 Power Supply

The power supply provides power to the LEDs, LCD screen, and microcontroller. This supply incorporates a battery pack with voltage regulators for the different component requirements.

- **2.1.1 Battery**
    - The battery pack provides sufficient voltage and current for all components.
- **2.1.2 Voltage Regulator**
    - The voltage regulator maintains the battery output at each necessary voltage for the various components.

2.2 User Interface

The user interface provides the user the ability to select a song, receive instructions on how to play it through color coded LED's, and receive feedback on how well the user played the song.

- **2.2.1 Knob, Button Input**
    - The knobs and buttons will allow the user to select from a list of songs and the skill level/tempo the user would like to play on. It also provides a method to pause, rewind, or forward a song.
- **2.2.2 LCD Screen**
    - The LCD screen will provide the user with a visual queue of the currently selected song, skill level and measure.
- **2.2.3 LEDs**
    - An LED will be placed along each fret and will be color coded to show which note should be played at the fret.
- **2.2.4 Feedback GUI**
    - The Feedback GUI will be an application displayed on the user's computer that allows them to receive feedback on how well the user played during each measure. This feedback will be provided as a percentage of how the user's measure compares to the original measure.

2.3 Control System

The control system will serve as the central point for all communication and data transfer between components.

- **2.3.1 Microcontroller**
    - The Microcontroller will receive input from the guitar, memory unit, and buttons. These inputs will then be translated to output as instructions on the LED's, Feedback on the GUI, and song/measure/tempo status on the LCD screen.
- **2.3.2 Processor**
    - The processor will receive input from the guitar while the user is playing, and convert this input into MIDI format to compare with the original song.

2.4 Memory Unit

The memory unit will convert and store multiple songs into MIDI format. The user will then be allowed to select from this list of songs with the user interface.

3. Block Requirements

3.1 Power Supply

- Requirement 1: The voltage regulator must provide 5V +/- 5% to the LEDs and 9V +/- 5% to the microcontroller from a 12V +/- 5% battery input.
- Requirement 2: The battery system must be capable of providing maximum total current of 900 mA at 12V +/- 5% for minimum 3 hours.

3.2 User Interface

- Requirement 1: UI provides 0 to 100% accuracy statistics with a maximum error of 5% for every measure played.
- Requirement 2: User must be able to pause the song at any time and use the knob to move to any measure.

3.3 Control System

- Requirement 1: Must be able to process the user's guitar output with 95% accuracy and process an accuracy metric.
- Requirement 2: Must be able to fetch song data and convert to an LED sequence with minimal delay to allow the user to play the measure according to the tempo selected.

3.4 Memory Unit

- Requirement 1: Ability to convert a sheet music PDF or PNG file of singular notes into a MIDI file with 95% accuracy.

- Requirement 2: MIDI files must use < 10 KB for every minute of a song to ensure that approximately 30 songs can be stored on 1MB of data.

4. Risk Analysis

The component that poses the greatest risk for successful completion of this project is the control system block, which contains the microcontroller and processor. The basis of our project is to allow a user to self learn to play the guitar through visual instructions and feedback. This block will be responsible for providing this essential aspect of the project. Input will be received from the user through the knob and buttons. This input will then be used by the microcontroller to fetch data on the song, tempo and measure that the user would like to play. The microcontroller must also convert this data into visual instructions that the user will use to learn the song. While the user is playing, input from the guitar will also need to be processed to provide meaningful feedback. There will be a lot of data transfer that will take place in the process. Therefore, we must ensure that the microcontroller and processor will be able to efficiently and accurately process the data received into its appropriate outputs.

Another component of risk may be the power supply. With many components requiring power and at varying voltages, the energy and voltage regulation required may be difficult to store on the physical guitar when considering size and weight. Also the power supply needs to remain within suitable temperatures for the electronics and the user's safety.

Ethics & Safety

The only safety concern that involves our project concerns the power and hardware of it. Since we are using a mobile battery pack to power the systems aboard the guitar, we must watch out for potential overheating. If the battery pack's heat becomes an issue, we must look into creating a safe comfortable harness to protect the user. After consulting the IEEE and ACM Codes of Ethics, we are not aware of any ethical issues that may arise with our project at this time. We are simply looking to make a fun and accessible tool for all people to be able to learn to play the guitar with.