Guitar Learning and Feedback Tool

ECE 445 Design Document

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Introduction

1.1 Objective

Many people have had the desire to learn how to play the guitar at some point in their lives. For some, the large amount of time and effort required to even master the basics can serve as a barrier to entry to the musical world. The guitar is an incredibly popular example of one of these instruments. While there are some popular pieces of technology already in existence to help you get started like Yousician and Fret Zealot, there are a couple of issues with both of these systems that we believe can be fixed.

Our project looks to address 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.

1.2 Background

While systems like Yousician and Fret Zealot have proven to be successful with some people, we believe both of these have some faults and would not be as beneficial to the learning process as our proposed system. Fret Zealot is only available on your phone and has the lights atop the fretboard itself, underneath the strings. When the LEDs are situated this way, the user has to crane their neck over the guitar to see where to put their fingers. By placing the LEDs on the side of the fretboard where they are easily visible (see *Figure 1* below), they will learn to play the correct strings by learning to feel where individual strings are in accordance with the lights rather than just placing their fingers wherever it lights up. In Yousician's case, they require a connection to a PC, Tablet, or Smartphone app (including a paid subscription) and record the user's input via a microphone to determine accuracy. This is a problem because not only is it expensive, but it is not as accurate as having a hardlined connection to a computer. By developing a more reliable system with a one-time purchase, we find this to be superior to what Yousician offers.

The other issue with current systems that arise with both of these platforms 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. An approach similar to the game 'Simon' where the lights display the sequences and the user plays them back would be best, as they are developing the habit of playing sequences of notes instead of reacting to lights coming up as quickly as possible.

1.3 High-Level Requirements

I. System must provide meaningful accuracy feedback as a percentage score for each measure played to aid users in guitar playing improvement.
II. Must be able to fetch song data and convert to an LED sequence with < 30sec delay to allow the user to play the song.
III. System must allow the user to incrementally increase the difficulty by changing the tempo of the notes to be played, and the amount of measures to play in a given sequence.

Design

2.1 Block Diagram

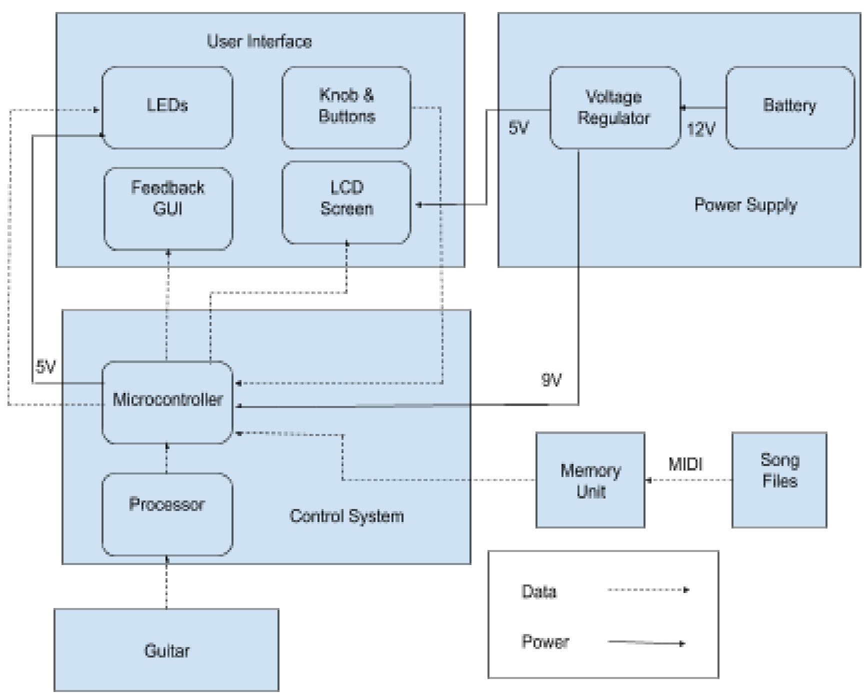

Figure 1: Block Diagram

2.2 Physical Design

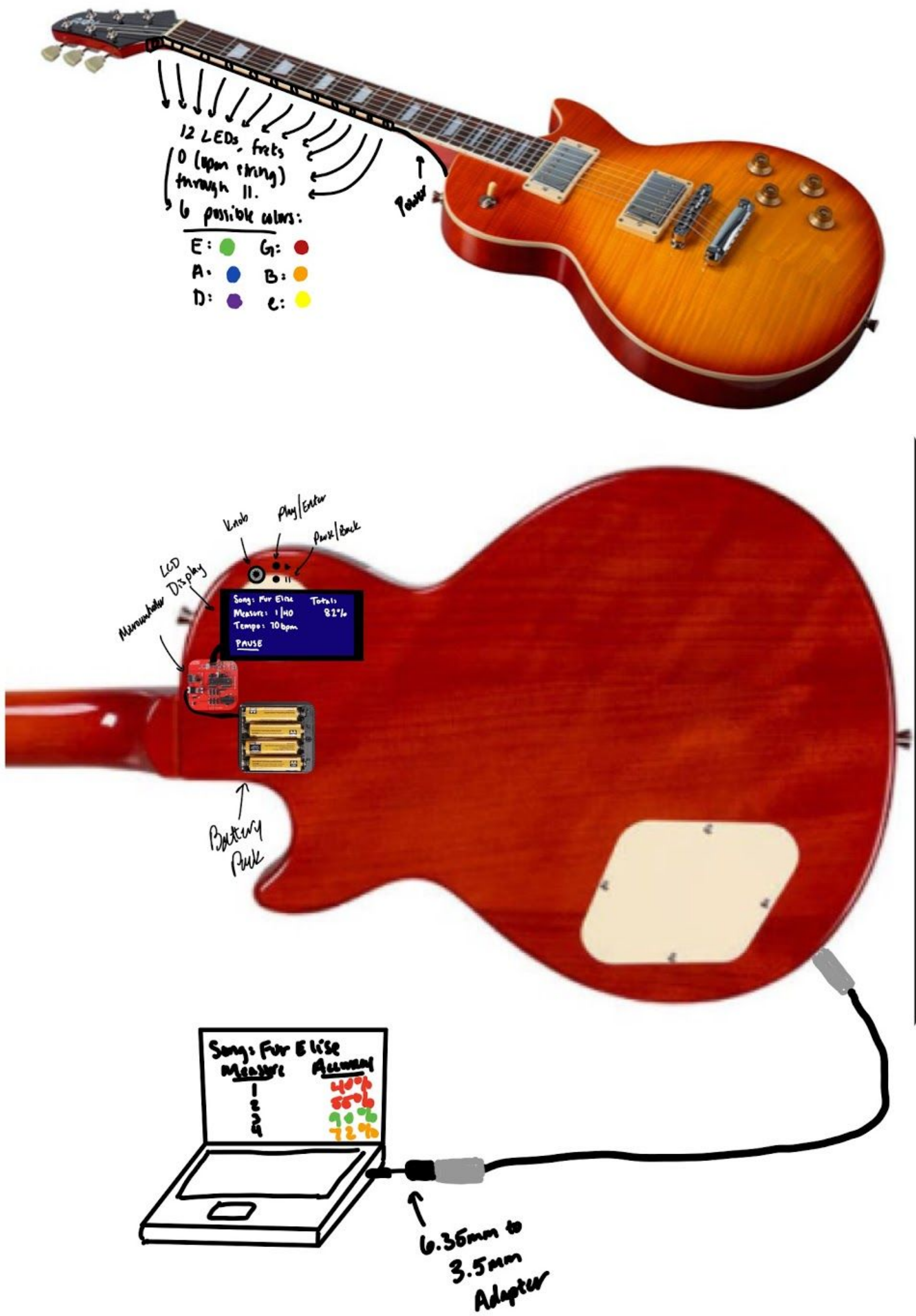

Figure 2: Physical Design

2.3 Subsystem Descriptions

2.3.1: User Interface

I. 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.

II. Parts Needed:

A. Knob & Buttons: 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 fast-forward a song.

B. LEDS: An LED will be placed along each fret and will be color coded to show which string should be played on that fret.

C. LCD Screen: The LCD screen will provide the user with a visual queue of the currently selected song, skill level and measure.

D. 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.

III. Circuit schematics, simulations, calculations, measurements, flow charts, mechanical diagram:

2.3.2: Power Supply

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

II. Parts Needed:

A. Battery:

B. Voltage Regulator:

III. Circuit schematics, simulations, calculations, measurements, flow charts, mechanical diagram:

2.3.3: Control System

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

II. Parts Needed:

A. 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.

B. 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.

III. *Circuit schematics, simulations, calculations, measurements, flow charts, mechanical diagram:*

Requirement	Verification
1. 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. These LEDs must match >95% of the actual song sheet used.	At all tempos a song will be “played” using the LEDs while one of us will record the fret and string of each note displayed. This will then be compared with the actual song to get an accuracy percentage.
2. System is able to detect correct notes with >90% accuracy and able to compile these into a meaningful feedback metric in the form of a percentage score for each measure and entire song	To verify if notes are being detected correctly, individual notes will be played and the note that it is classified as will be compared to the actual note played.
3. System must allow the user to incrementally increase the difficulty by changing the tempo of the notes to be played, and the amount of measures to play in a given sequence.	While a song is playing, the user can press one of the buttons to pause the song, change the tempo or current measure sequence length for playback with the knobs, and resume playing.

Figure 3: Requirements & Verifications Table

Control System Verification

Requirement	Verification
1. Must be able to fetch song data and convert to an LED sequence with < 30sec delay to allow the user to play the song.	Send output signal when song data is being fetched and use an oscilloscope to measure the time it takes for the processing to finish.
2. Ability to convert a sheet music image file of singular notes into a MIDI file with 95% accuracy.	Write a script to convert the MIDI file to their actual note names, and check it against the sheet music.
3. MIDI file can be converted to LED array with 100% accuracy.	We can compare the output of the script from the previous verification to the lights emitting from the fretboard to determine accuracy.
4. A note being played on the guitar can be detected by the processor with >90% accuracy to determine if the user played the correct note.	Strum one note at a time on the guitar and look at the output of the processor's detected note.

Figure 4: R&V Table for Control System Block

2.4 Tolerance Analysis

The differences in frequencies from adjacent notes on a string can be very large or very small, depending on what octave we are playing. For the 12 frets we will be using, there is a minimum difference of 4.9Hz (E string fret 1 → E string fret 2) to 34.92Hz (e string fret 11 → e string fret 12). Because of this, we will need a **maximum error of 2Hz in either direction** to be able to determine the correct note being played by the guitar. For a minimum frequency of 82.41Hz, this means we can have a valid range if the note detected is from 80.41Hz - 84.41Hz, or a maximum error of:

$$\frac{|84.41 - 82.41|}{82.41} * 100 = 2.43\% \text{ error}$$

from the processor in order to be confident that our processor is getting the right note from the guitar.