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Team A2: SuperFret

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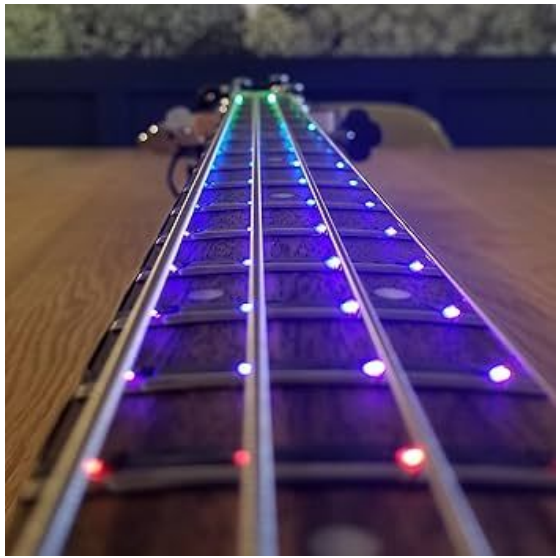
Use Case

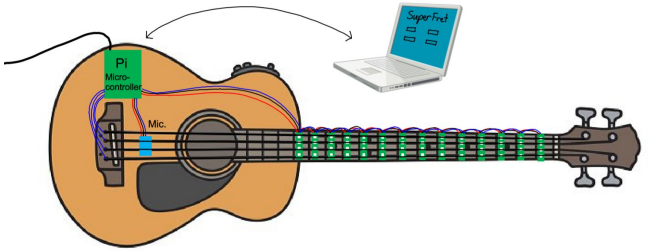
When trying to learn guitar, beginners face challenges trying to learn how to finger notes and maintain rhythm



The SuperFret system shall:

1. ***Visually indicate notes***
2. ***Detect finger positions***
3. ***Facilitate learning scales***
4. ***Provide feedback***
5. ***Be intuitive to use***

Design Requirements



Hardware

- ≥ 56 individually addressable LEDs (14 frets, 4 strings).
  - ***"Visually indicate notes"***
- Can light up ⅔ of LEDs at half brightness
  - ***"Facilitate learning scales"***
- Audibly (~60bB) indicate target tempo
  - ***"Be intuitive to use"***
- < 1 mA through body max (based on IEC 60479-1)

Firmware

- <50ms latency from strum to LED response
  - ***"Visually indicate notes & Provide feedback"***
- Support 100 beats per minute and down to 1/8th notes

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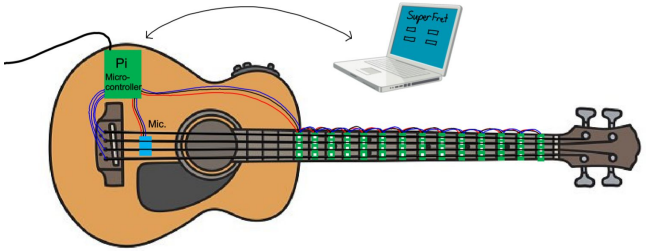
Design Requirements



Web Application:

- Start and stop routines on the guitar
- Add up to 1GB of user's own MIDI files
- Display practice statistics (rhythm score, accuracy score)
  - ***"Provide feedback"***
- < 0.25 second network delay

System Accuracy

- 99% accuracy for detecting finger placement and strumming
  - ***"Detect finger positions"***
- 100% accuracy for lighting up the correct LED(s) for a note or scale

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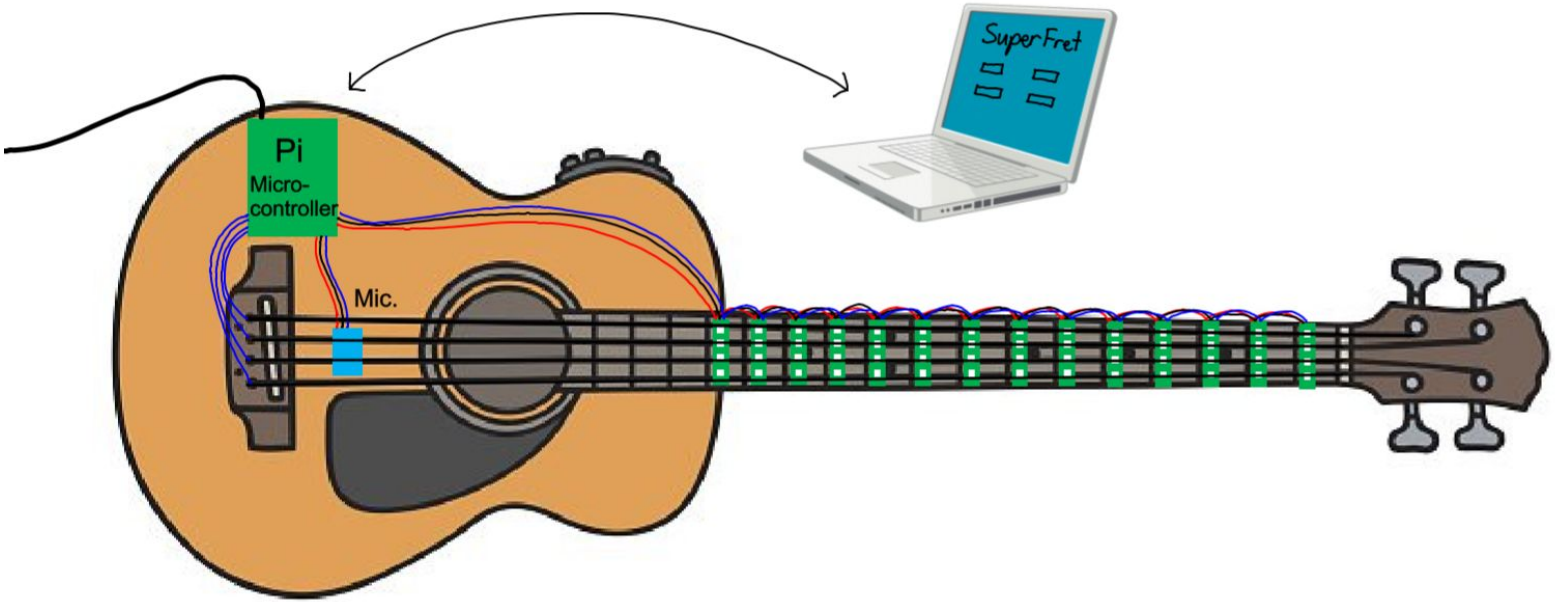
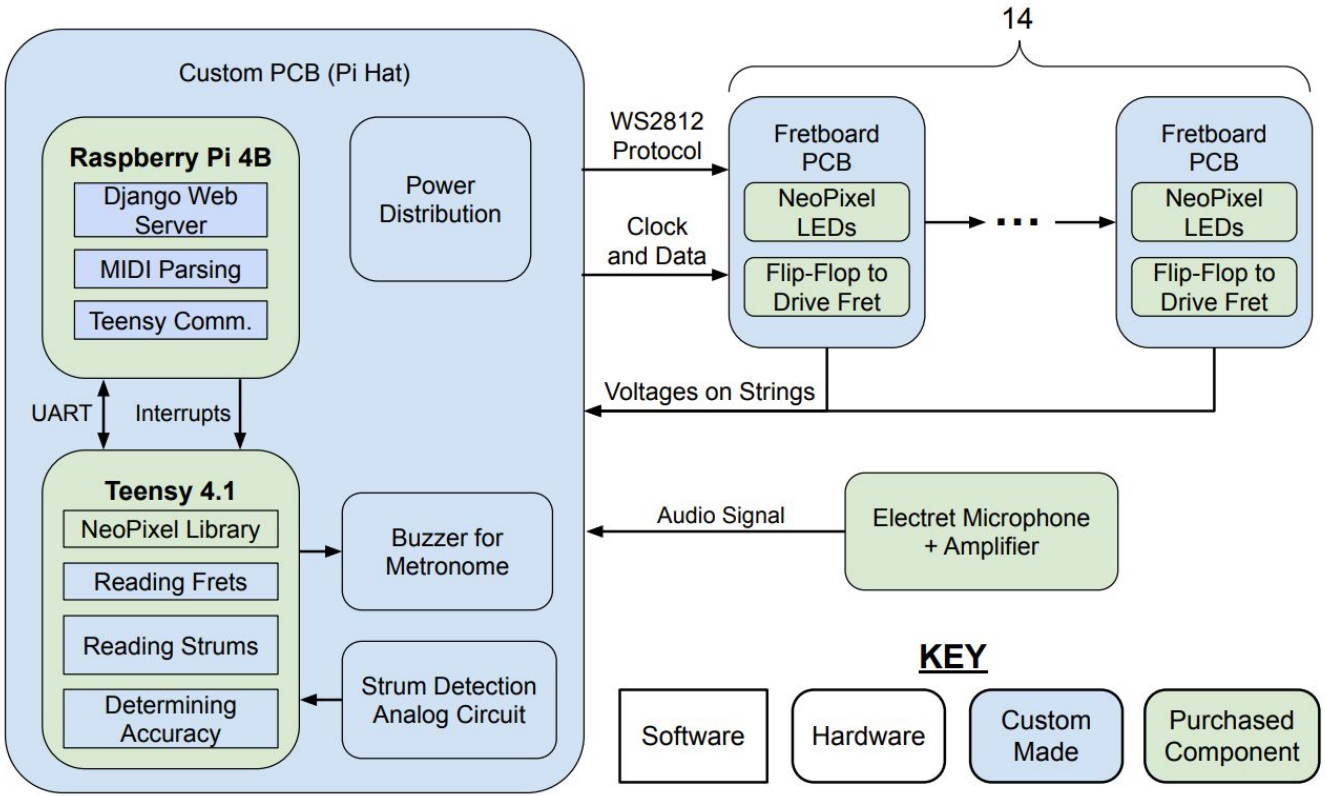
Solution Approach



Overall Block Diagram



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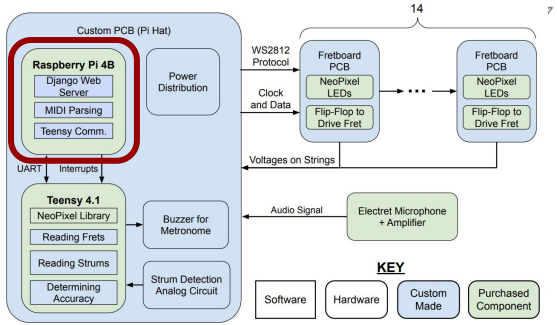
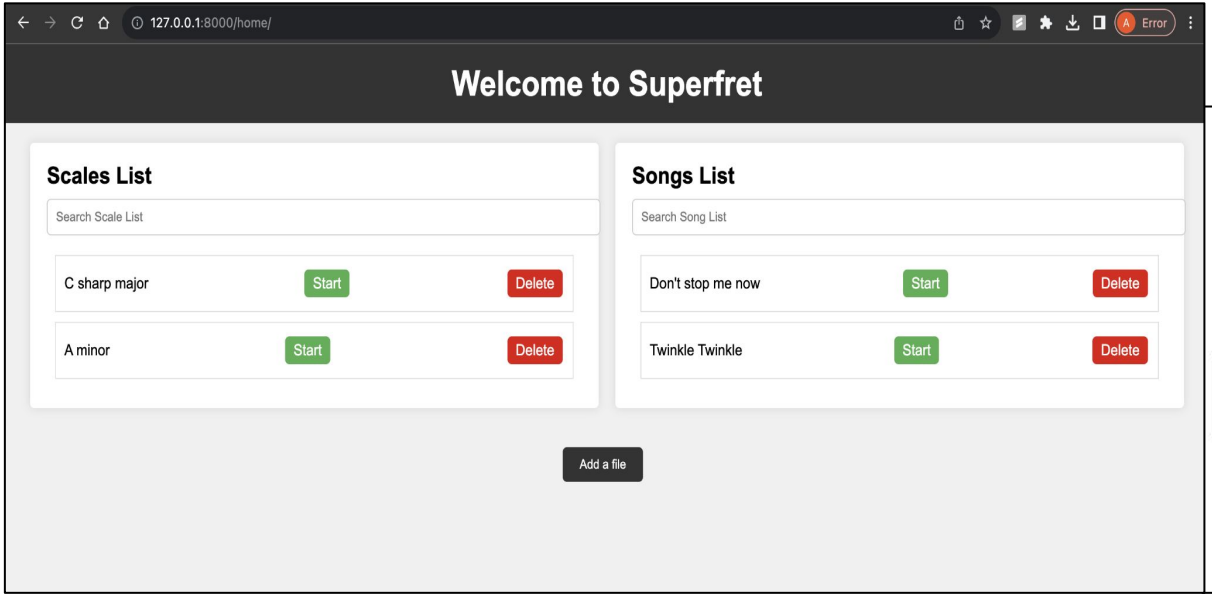
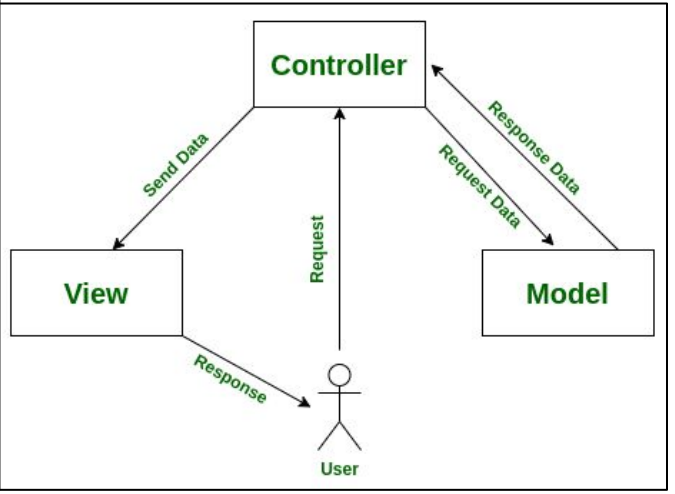
Implementation - Web Application







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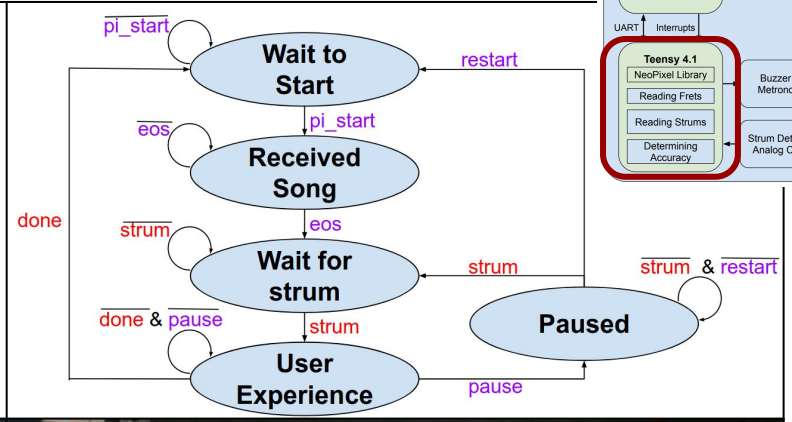
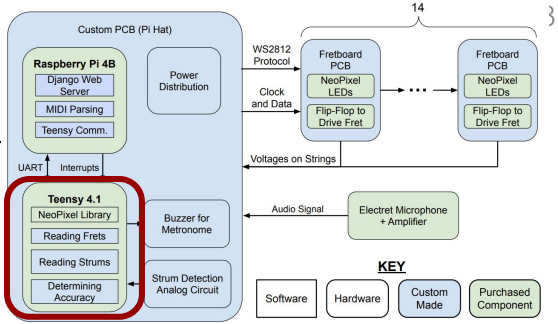
Implementation - Microcontroller

4D 54 68 64 **(MThd)**
00 00 00 06
00 01 (format 1 = one or more simultaneous tracks)
00 03 **(3 tracks)**
01 80 **(0x180 = 384 ticks/quarter note)**

4D 54 72 6B **(MTrk)**
00 00 01 D2 **(Chunk length 0x01D2 = 466 bytes follow)**
00
FF 58 04 04 02 18 08 **(time signature)**
00
FF 51 03 08 52 AE **(tempo = 0x0852AE = 545,454 us/beat ⇒ 2.1812 seconds / measure ⇐⇒ 110 BPM)**
00
FF 03 15 45 6C 65 63 2E 20 50 69 61 6E 6F 20 28 43 6C 61 73 73 69 63 29 **(Elec. Piano (Classic)) - sky blue**
00
C0 00 **(Program Change on ch 0)**
00 **(0 delta MIDI ticks)**
90 3C 32 **(0x90 = Note ON event, 0x3C = Note 60 (C4), 0x32 = 50 velocity)**
81 40 (Variable length encoding **1000|0001 0100|0000 ⇒ 00000011000000 = 192 ticks)**
80 3C 00 **(0x80 = Note OFF event, 0x3C = Note 60 (C4))**

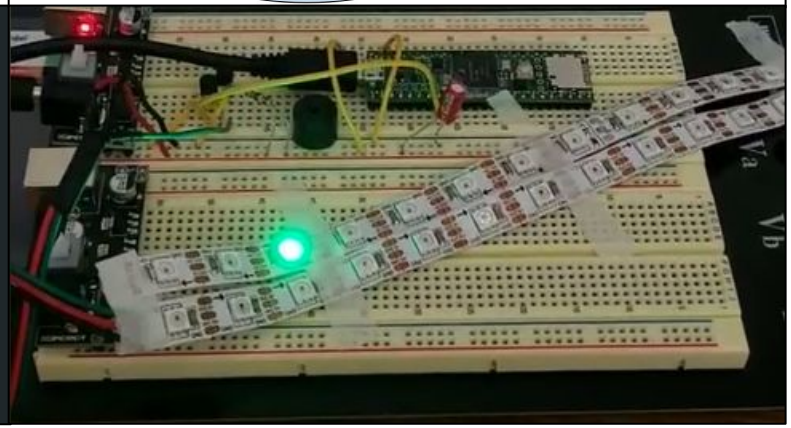





```
void parseMIDI() {
  int NUM_BYTES = sizeof(MIDI);

  bool parsed_MThd = false;
  uint32_t bytes_in_MThd_header = 0;
  bool parsed_bytes_in_MThd_header = false;
  bool parsed_bytes_in_MTrk_header = false;
  bool parsed_ticks_per_quarter_note = false;
  bool parsed_MTrk = false;
  uint32_t bytes_in_MTrk_header = 0;

  NUM_NOTES_FOUND = 0;
  MICROSECONDS_PER_BEAT = 500'000;  // default
  TICKS_PER_QUARTER_NOTE = 48;      // default
```



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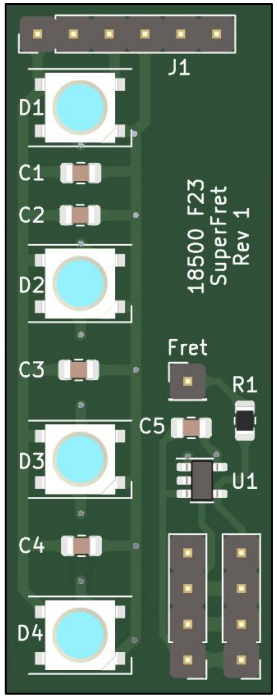
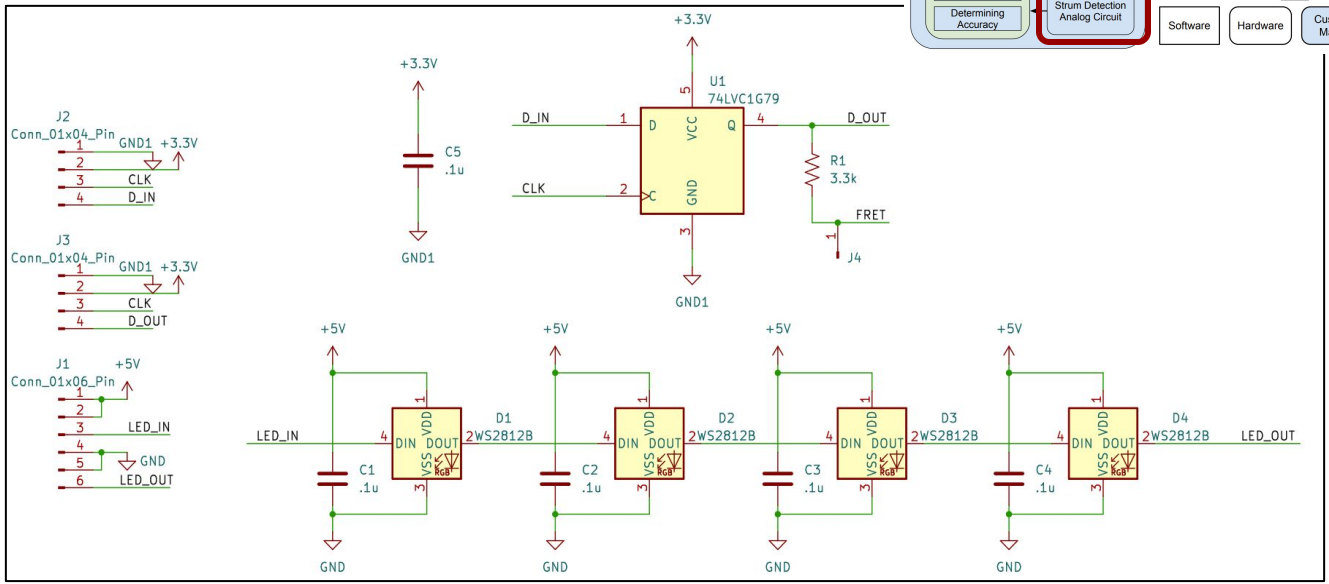
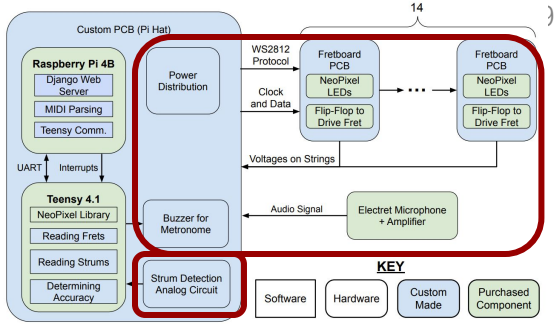
Implementation - Hardware







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Testing, Verification, and Validation

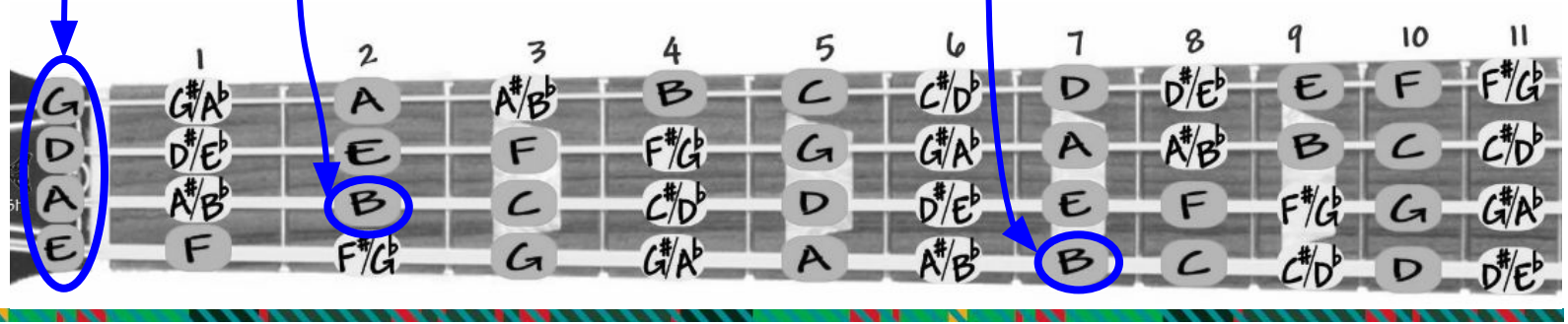
Latency	Hardware: Oscilloscope to measure delay between stimuli, such time from strumming to LEDs being written to Webapp: Measure one-way latency using time stamped requests
Accuracy	Strums: Play 100 1/8th notes at 100 BPM on each string and record the ambient sound level. Finger Placement: Place a finger on each combination of string and fret position and monitor serial port. LEDs: Light up each LED white and verify that the proper LED lights up. Verify current when illuminating all LEDs white at 50% brightness is <1.5A
User Experience	Have users evaluate categories on scales from 1 to 5 to create a quantitative metric Webapp: Intuitive interface, easy to read statistics, intuitive uploading of songs, etc Hardware: Comfortability, effectiveness of LEDs, volume and pitch of metronome

Risks Mitigated

- Lack of web app experience. Switching from Flask to Django
- Understanding MIDI files

New Challenges

- Detecting open strings
  - There is no fret-string contact
- Multiple ways to play the same note
  - How to choose where to instruct the user to play?



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Project Management