Haptic Piano Instructional Gloves

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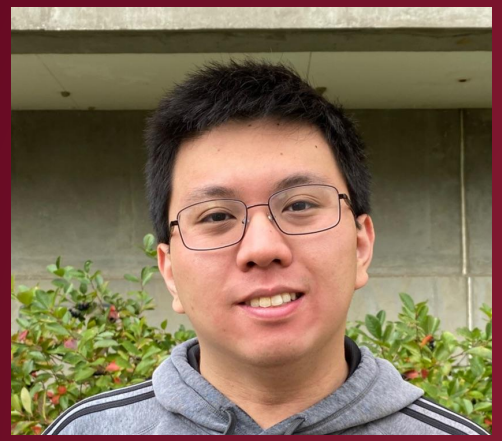
Team 11



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Problem Statement

Piano is notoriously difficult to learn for a number of reasons:

- Sheet music does not show the correct fingerings corresponding to which keys to press.
- Sheet music also requires a large amount of memorization and music theory background.
- A great deal of time, effort, and patience is required.

Due to these reasons, especially for beginners, piano can be a daunting instrument to learn. The mental processing between knowing which keys to press and in what order requires intuition. The memorization and music theory required to learn piano can be argued to suck the fun out of the instrument.

Existing Solutions

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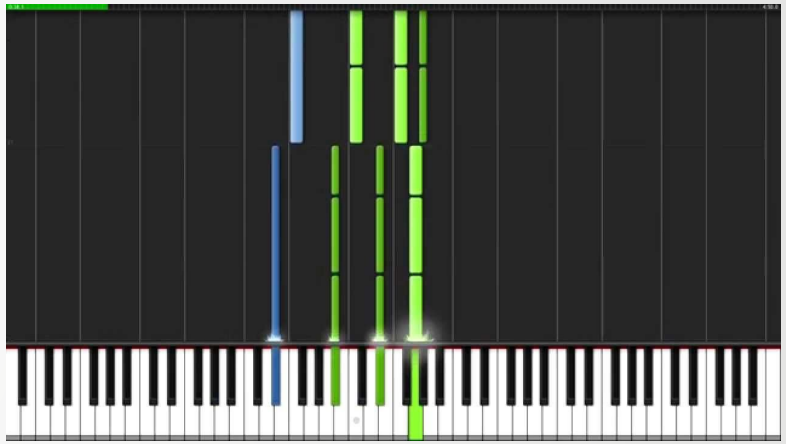
Piano Teaching Software

Synthesia is a computer application that highlights what specific piano keys should be pressed and for how long using MIDI information. This is a visual and music sheet free way of learning piano.



- Does not display information on physical keyboard
- Requires the pianist to look at both screen and keyboard at the same time
- Does not incorporate feedback
- Does not allow for passive form of learning

Piano Visualizer

There have been products made that help piano players see what keys they should press while playing. This specific product also includes a display that illustrates both the keys that need to be presses as well as the piano notes.

- Does not incorporate haptic feedback
- Does not allow for passive form of learning

Uses Synthesia Software to display correct notes.
https://www.youtube.com/watch?v=IZgYViHcXdM

Haptic Piano Gloves at GIT

The PianoTouch project was developed at Georgia Institute of Technology and consists of haptic vibration gloves and a tablet screen that enable a user to learn the piano individually at their own pace and without the need and expense of a music teacher.

- Does not show the fingerings for more advanced playing
- Intended for muscle therapy, not learning instrument
- Does not incorporate feedback
- Does not display information on physical keyboard
- Seems bulky
- Not sure if accepts MIDI or is pre-programmed

Our Solution

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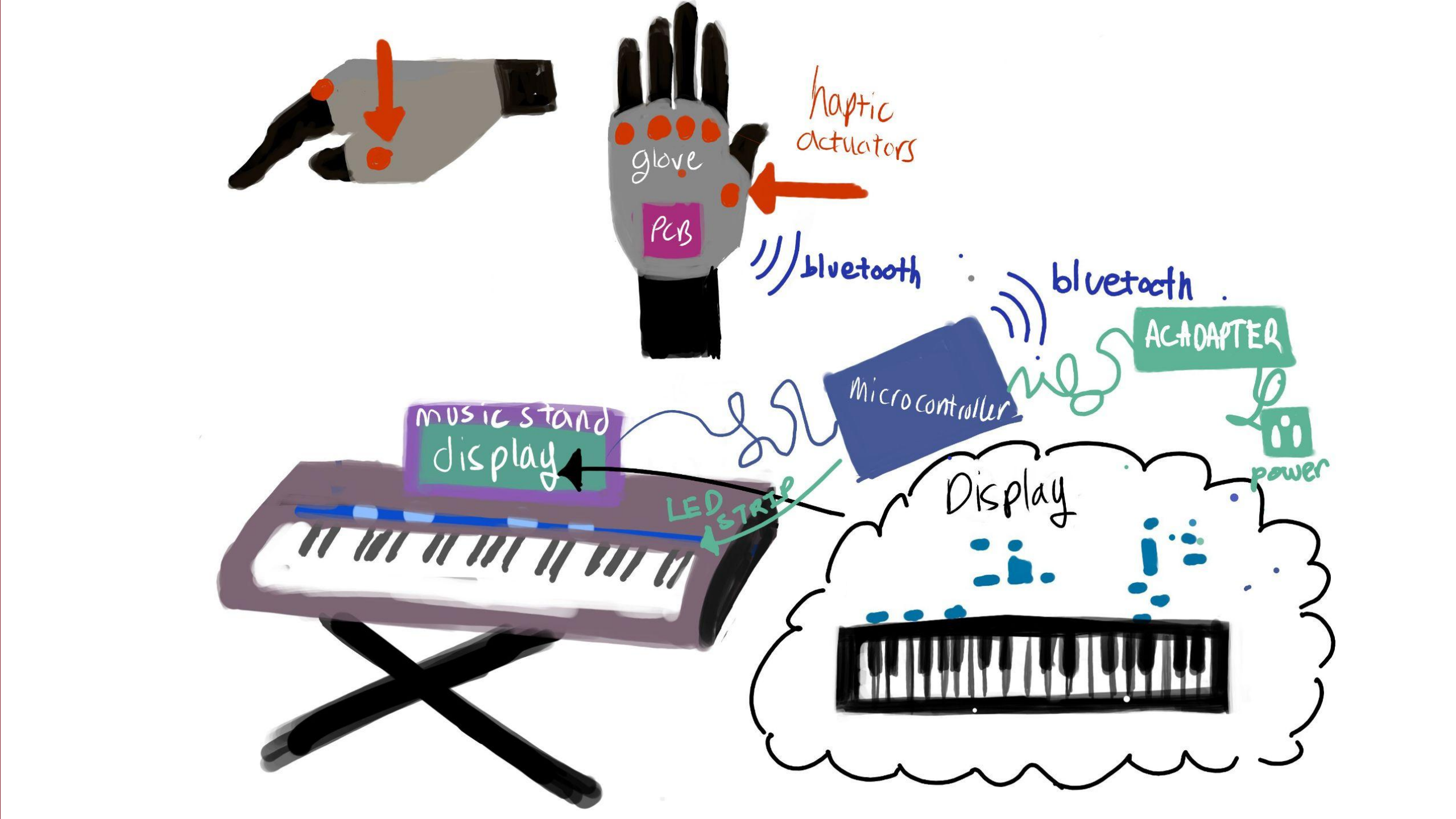
Haptic Piano Glove

Our solution will address these issues by engaging multiple of the pianists' senses in real time whilst playing a song--namely touch, vision and sound--to not only tell the pianist how to play a song, but also provide the pianist feedback on his/her playing. Additionally, these gloves also help pianist learn while not actively playing the piano.


glove
PCB
haptic actuators
bluetooth
bluetooth
AC ADAPTER
microcontroller
music stand display
LED STRIP
power
Display

Preliminary Design

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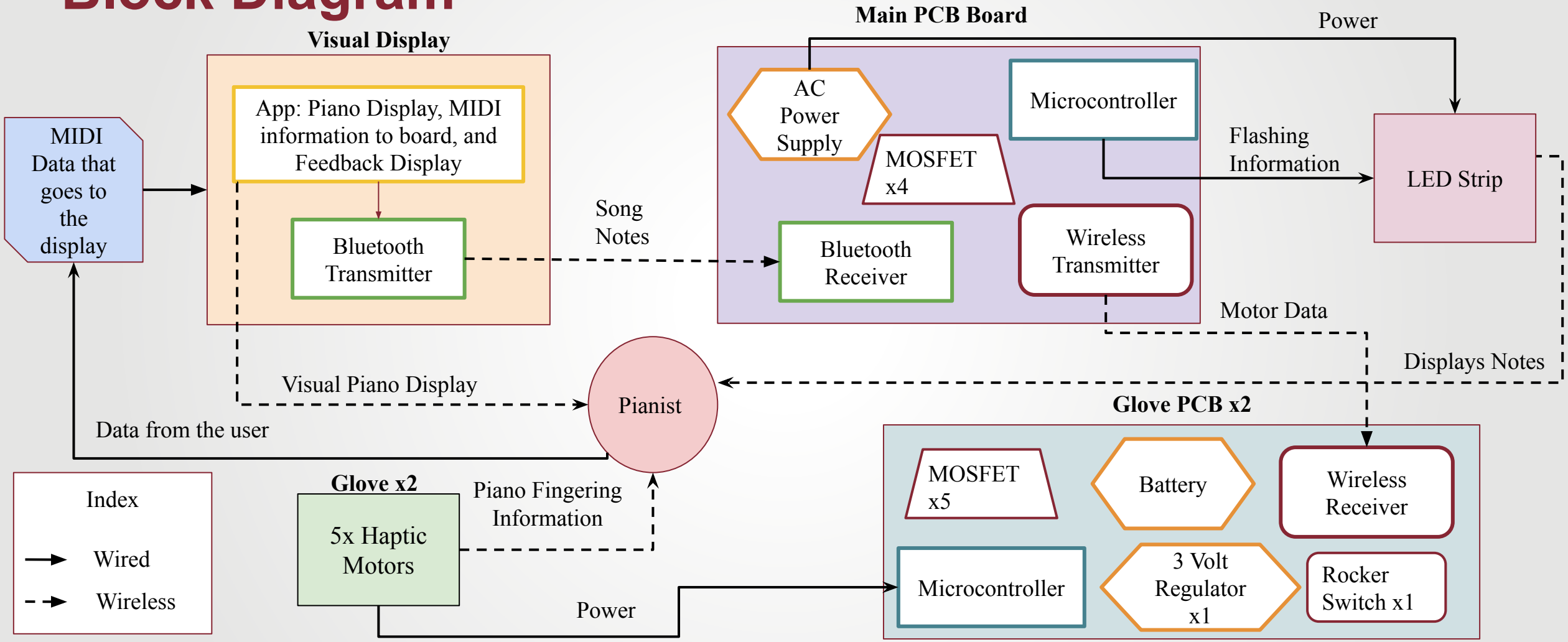
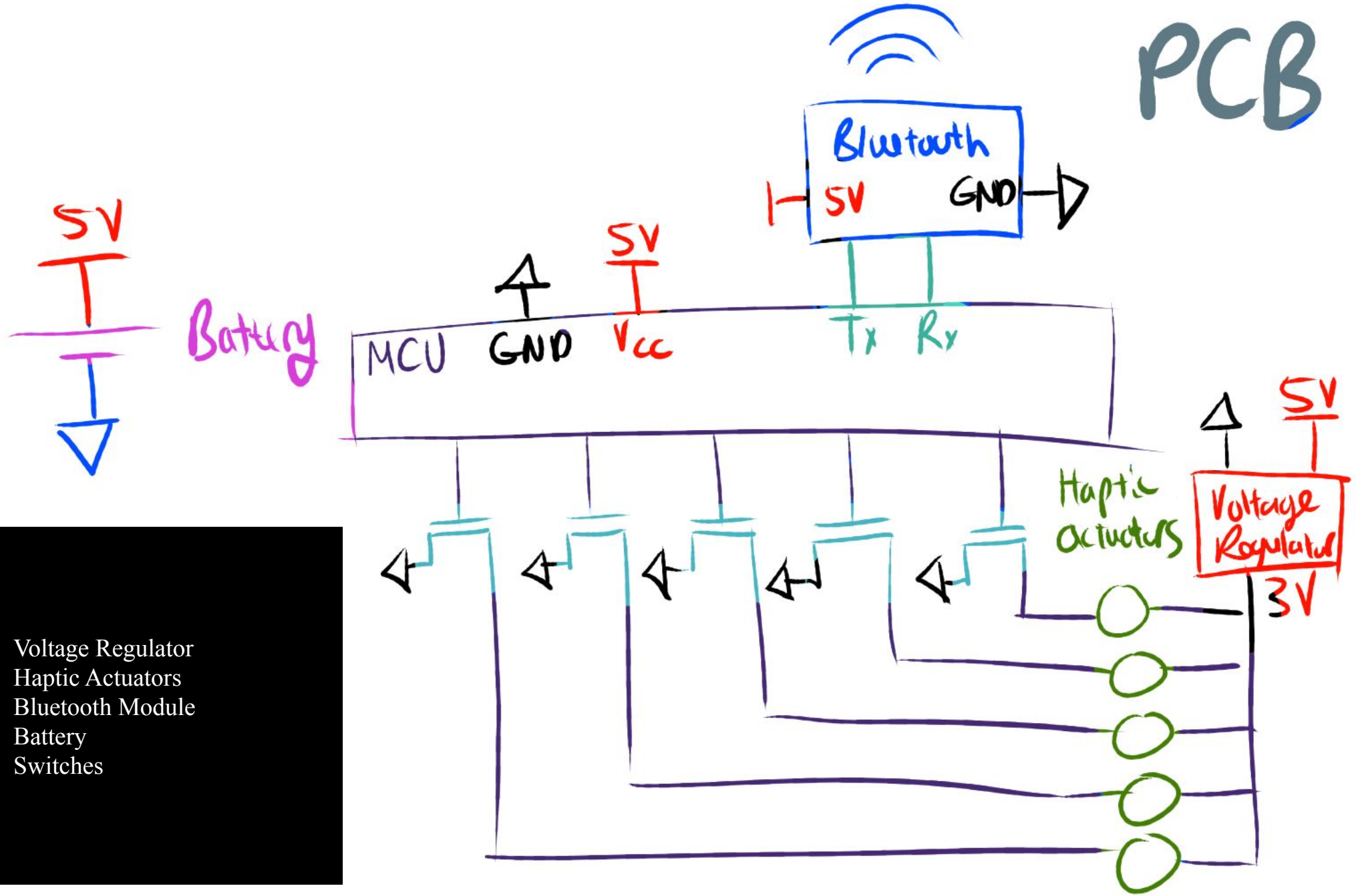
Block Diagram





1. Voltage Regulator
2. Haptic Actuators
3. Bluetooth Module
4. Battery
5. Switches

Software Block Diagram

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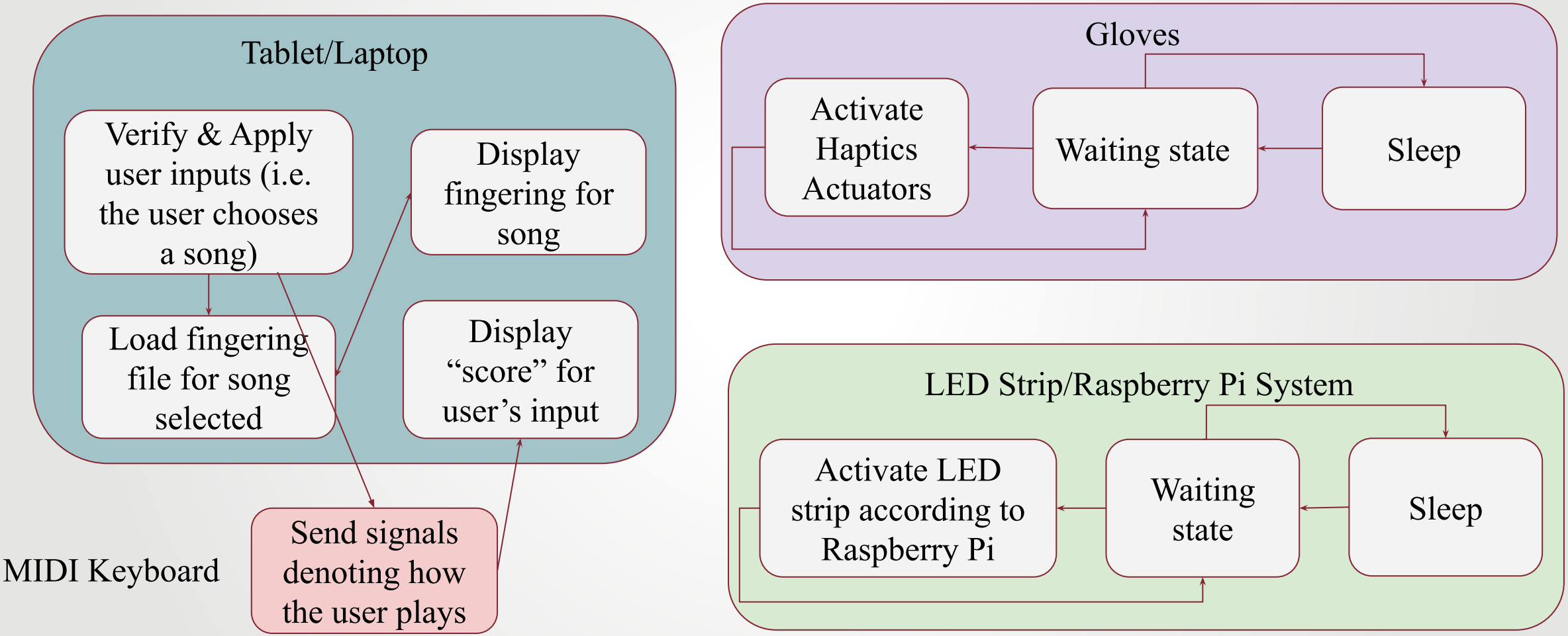
Software Block Diagram



Preliminary Components (For Entire System Not Just MDR)

- MIDI Piano
- 2 Gloves
- 10 Haptic Vibration Motors
- Visual Display (Strip LEDS and Computer Screen)
- PCBs:
  - 1 PCB on each glove
  - 1 PCB to control LEDs and to send data to the gloves
- 3 Bluetooth Modules
- Power Supply

Comparison of Solutions

	Haptic Sensors	Feedback	LED Keyboard Display	No Sheet Music	Muscle Memory (Passive Learning)
Piano Teaching Software Synthesia					
Piano Visualizer					
PianoTouch					
Our Solution					

Preliminary Cost Estimation

Component	Quantity	Cost
MIDI Piano Keyboard	1	$0.00
Gloves	2 Sets (2 different styles for prototyping)	$29.16
Haptic Vibration Actuators	10 (1 for each finger)	$21.50
Visual Display: 1. Strip LEDs 2. Computer or Use of Tablet	• LEDs for each key (63) • 1 Computer or Use of a Tablet	$15.00
Bluetooth Serial Module	2 (One for each glove) and 1 for the main PCB	$56.89
Power Supply	6 coin batteries and an AC Wall Adapter	$17.70
PCBs	4 (one for each glove and main PCB, the third is accounting for potential errors on our first design)	$160
Total		$300.15

Preliminary Goals, Specifications & Testing Plans

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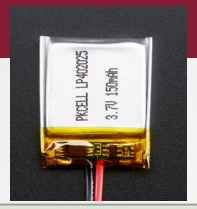
System Specifications + Testing Plan

The gloves shall neither hinder the player's ability to bend his/her joints nor bring discomfort to the user.	Demonstration; We will test by independently bending each joint on our hand, and checking if each joint bends freely Inspection; we will get feedback from multiple users on how the gloves feel
The system shall be robust enough to fit midi pianos of different sizes.	Inspection
The system shall provide the pianist with real-time haptic feedback indicating which finger the pianist must use	Demonstration; we shall demonstrate that the actuators vibrate
The system shall provide the pianist with real-time visual feedback indicating which keys to press	Inspection
The system shall provide the pianist with real-time auditory feedback on his/her playing	Inspection
The system shall not have more than 100 ms of latency between components	Analysis; we will add probes to test latency via a logic analyzer and check if responses are less than 100 ms apart.

System Specifications + Testing Plan

The gloves should have a range of at least 5m.	Demonstration; We move the gloves away from the bluetooth source at intervals of 1m. Then, we wait for 10 haptic signals to be sent through from the computer to the gloves via bluetooth. We may use a testing circuit with an LED to track if the bluetooth is working at that distance.
The gloves shall have a battery life of at least 1 hour if rechargeable The gloves shall have a battery life of at least 6 hours if non-rechargeable	Demonstration; we use the gloves for on battery from full charge and see how long it lasts. We will be continuously playing a song.

Battery Choice



	Lithium Polymer	Lithium Ion	Coin Cell Battery	AAAA Battery
Form Factor (size)	Medium 30mm x 35mm 500mAH	Medium 25mm x 35mm 400mAh	Great 20mm diameter 250mAh	Bad 40mm x 10mm x 10mm ~450 mAh
Discharge Rate	Great 500mA continuous	Good 80mA continuous 400mA burst	Unusable .2mA continuous	Good Up to 300 mAh, but high current draw reduces capacity
Safety	Medium Dangerous (less risk of leaking electrolytic component)	Most Dangerous	Least Dangerous	Least Dangerous
Rechargeable?	Y	Y	N	N
Price (including charger)	$20	$25	$2	$1
Charge Cycles	Medium 500 (until 60% capacity)	Good 300 (until 80% capacity)	1	1

Battery Choice Plan

- Order 500mAh LiPo (Lithium Polymer) batteries.
- Check the battery life of LiPo. (naive initial estimations ~10 hours)
- If battery life is insufficient, then order a larger battery instead of putting two in parallel (as to avoid designing around a BMS)
- Design around maximizing safety (i.e. introduce easy-detach velcro straps on gloves in case of fire and perhaps an anti-puncture box)

MDR Deliverables

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MDR Deliverables

For MDR our system will:

1. Wirelessly send 1 chosen song from a laptop to the bluetooth module on each glove
2. The bluetooth module will feed the signal to the Arduino for each glove
3. The Arduino will process the signal and power the output pin to the corresponding vibration Motor for a time duration equivalent to the length of the note on each glove
4. There will be a visual display depicting which notes should be played
5. The user input will be recorded for an accuracy report

MDR Demonstration

Our Demonstration will Include:

1. The signal wirelessly transmitting to the bluetooth module on the glove from a computer
   - The gloves must be in sync by receiving the signal at the same time
2. The vibration motors must turn on in the correct sequence and for the correct duration of time that corresponds to the notes on the selected piece of sheet music
3. Observation of a working display depicting which key should be pressed
4. The user input will be recorded for an accuracy report

Our methods of measurement and verification include:

1. Attaching an LED to each vibration motor pin to visually observe the correct sequence of power being delivered to the output pins
2. We will time the observed time duration of the LEDs and vibrations to confirm the output pins are being powered for the correct duration of time
3. We will present our Arduino code that will show the algorithm that takes the bluetooth signal as input and then drives the corresponding output pin for the length of time equal to the length of time of the note
4. We will observe the visual display and accuracy report

	Task Name	Start Date	End Date	Team Members(s)	Week 5 (9/26)					Week 6 (10/3)					Week 7 (10/10)					Week 8 (10/17)					Week 9 (10/24)					Week 10 (10/31)					Week 11 (11/7)					Week 12 (11/14)					Week 13 (11/21)					Week 14 (11/28)				
					M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F
Hardware:																																																				
	Actuators Working with Arduino	9/27	10/15	Megan																																																
	Bluetooth Module Working with Arduino	9/27	10/8	Neil																																															
	Battery Working to Power Arduino	10/10	10/28	Neil																																															
	Glove Enclosure	10/04	10/15	Prepsa																																															
	Attach LEDs	10/24	11/11	Prepsa																																															
	Display to Piano	9/27	10/31	Paulina																																															
	Verification for MDR	11/14	12/3	Everyone																																															
Software:																																																			
	Program piano fingering generation	10/24	11/13	Neil																																															
	Load MIDI signals into computer	9/27	10/22	Paulina																																														
	Program GUI	10/24	11/05	Prepsa																																															
	Wireless Transmission of MIDI file to Arduinos	9/27	10/22	Megan																																															
	Sleep Mode and System on/off selection	10/24	11/05	Paulina																																														
	Create Team Website	9/27	10/22	Megan																																															
	Bluetooth Interfacing between Devices	10/04	10/22	Megan																																															
	Interface LED strip with bluetooth signals	10/31	11/11	Prepsa																																															
	Verification for MDR	11/14	12/03	Everyone																																															

Team Responsibilities

Prepsa • Budget Lead • KiCad Lead • Interface between the subsystems • LED sub-system	Neil • PCB lead • Microcontrollers • Bluetooth Modules • 3D Printing
Paulina • MIDI Files • Display Application • Feedback with user information	Megan • Team Coordinator • Embedded Code for the Microcontrollers • Haptic Actuators

Citations

K. Huang, E. Y. Do and T. Starner, "PianoTouch: A wearable haptic piano instruction system for passive learning of piano skills," *2008 12th IEEE International Symposium on Wearable Computers*, 2008, pp. 41-44, doi: 10.1109/ISWC.2008.4911582.

C. Seim, T. Estes and T. Starner, "Towards Passive Haptic Learning of piano songs," *2015 IEEE World Haptics Conference (WHC)*, 2015, pp. 445-450, doi: 10.1109/WHC.2015.7177752.

Evening, Aleksander. “Piano LED Visualizer.” *YouTube*, YouTube, 9 Apr. 2019, https://www.youtube.com/watch?v=IZgYViHcXdM.

Questions?