Design Document: Dual Glove Air Bass

Ying Chen, Pranathi Gummadi, Niranjan Jayanth

ECE 445

TA: Michael Genovese

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1. Introduction

1.1 Objective

As a musician in the 21st century there are many technological tools available to assist the learning process. However, most of those tools are software based and are unsuitable for training muscle memory. This inability to convey, arguably, one of the most important parts of the musical experience impedes the musician's ability to practice relatably on such devices. Therefore, individuals must rely on the traditional method of carrying fragile, cumbersome instruments to and from various locations. The act of repeatedly transporting a heavy instruments can potentially damage the instrument itself.

Our proposal for remedying this problem is to develop a portable electronic device that replicates the physical characteristics of the instrument without the physical medium. For this solution, the inspiration of was drawn from the concept of "air guitar", a performance art in which an individual pretends to play an imaginary instrument with accuracy. In this specific case, we will be implementing a wearable device capable of generating audio output and replicating the stylistic techniques for playing a bass guitar.

1.2 Background

Success in any musical endeavor is a mental mastery over an instrument or voice. The first mental challenge many musicians face is the playing of music without notes. The evolution of that mastery is the mental mastery of an instrument without the physical instrument itself. In one study meant to observe the effects of both mental and physical practice with regards to pianists, many advantages of mental practice were posited and agreed upon. Firstly, it is equivocally agreed upon that mental practice offers a method to improved highly skilled performance. Further, the switching between mental and physical practice as a general practice strategy is suggested to be more effective than simple physical practice [2]. Since this product is a merging of mental practice (psychomotor understanding of the dimensions of a given instrument) and physical practice (auditory feedback upon practice), it offers a harmonious blend of the two practice disciplines. The market for such a virtual instrument thus far has existed solely in the VR realm, with products such as GloveOne. However, these products require an existing VR device, such as an OculusRift or an HTC Vive, which can set a musician back upwards of 500 USD. The cumbersome and expensive nature of such a solution makes it far less appealing, concerns the air bass seeks to avoid with a portable hardware solution.

The other driving need for the air bass is transportability. Despite recent regulations helping traveling musicians, airlines are not required to store instruments in baggage closets, treating them just as other carry-on luggage, when in fact they are far more fragile than the average carry-on suitcase [3]. Further, it is potentially dangerous to store them in the cargo hold of a flight. The extra troubles that traveling musicians who feel a need to practice are thus rather onerous, and can be alleviated from having a portable version of their instruments. This also allows for quite enjoyable musical experiences that require limited effort to set up at any given time; this novelty is what the air bass seeks to achieve. Much of musicians' muscle memory lies in their fingers, so the novelty of having a product that optimizes those abilities would be quite appealing.

High-level requirements list	**High-Level Validation Plan**
The air bass must be able to sustain through 6 hours of battery-operated playing.	Upon completion of initial build, leave the MCU on for 1 hour of use and see if power consumption is less than 6 times of the total power consumption.
The air bass must have at least 90% accuracy of pluck attempts as played notes.	Upon completion of each successive build, individually test right hand accuracy by playing a pre-decided sequence of plucks. Compare each string pluck with 10 sets of preset data of the same motion.
The air bass must have at least 90% pitch accuracy on left-hand finger placement.	Upon completion of each successive build, individually test left hand accuracy by a pre-decided sequence of notes. Compare each note with 10 sets of preset data of the same motion.

2. Design

For our air bass, we will be implementing 20 different hand positions and enforcing single note play. Musically this represents the range of one and a half octaves specifically between E1 and B2. This implementation has four distinctive subunits required for execution. At the core of the hardware is a microcontroller unit which is responsible for data management, distribution, and processing. In terms of outputs, our microcontroller will service the AUX speaker module. However, UI display for calibration will be a two-way relay of data where inputs are taken and processed then displayed. Overall power to all subunits will be delivered by the power module. Note: the phrases “going up” or “going down” will be used frequently in this document. While physically the lower notes on a bass guitar are higher from the ground, these phrases will refer to up and down in a musical context. For example, G2 is a higher pitch than D2, even though G2 is played lower to the ground than D2; still, a transition from D2 to G2 will be referred to as “going up one string”.

2.1 Block Diagram

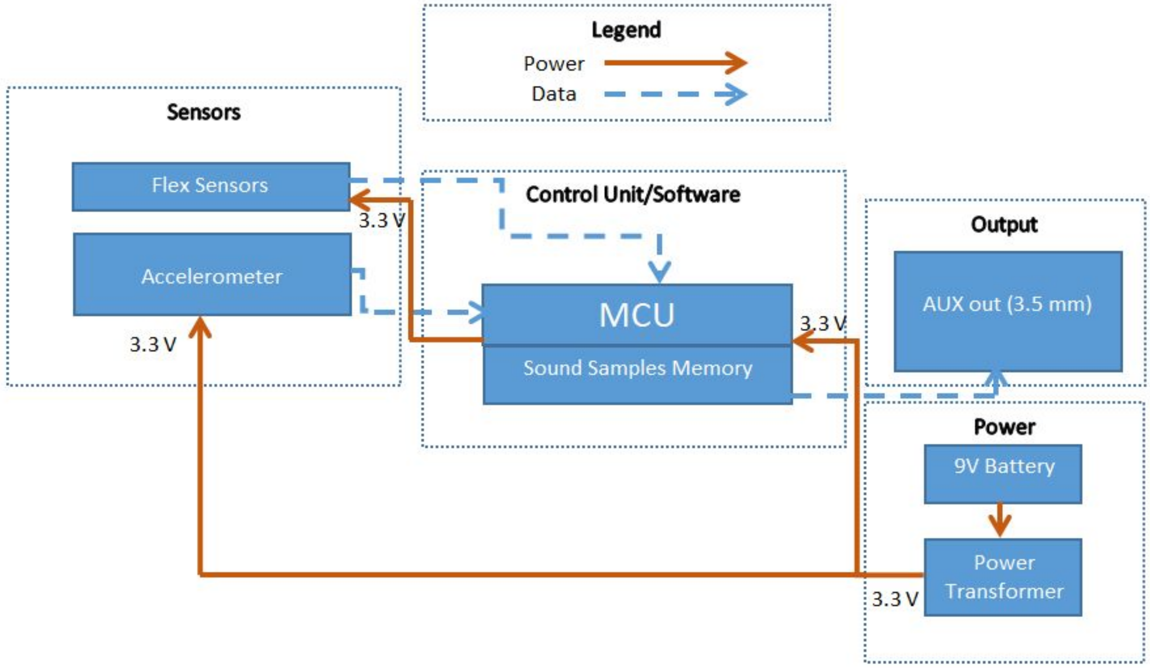


Figure 1: Block Diagram

2.2 Physical Design

Figure 2: Right Glove Sensor Placement

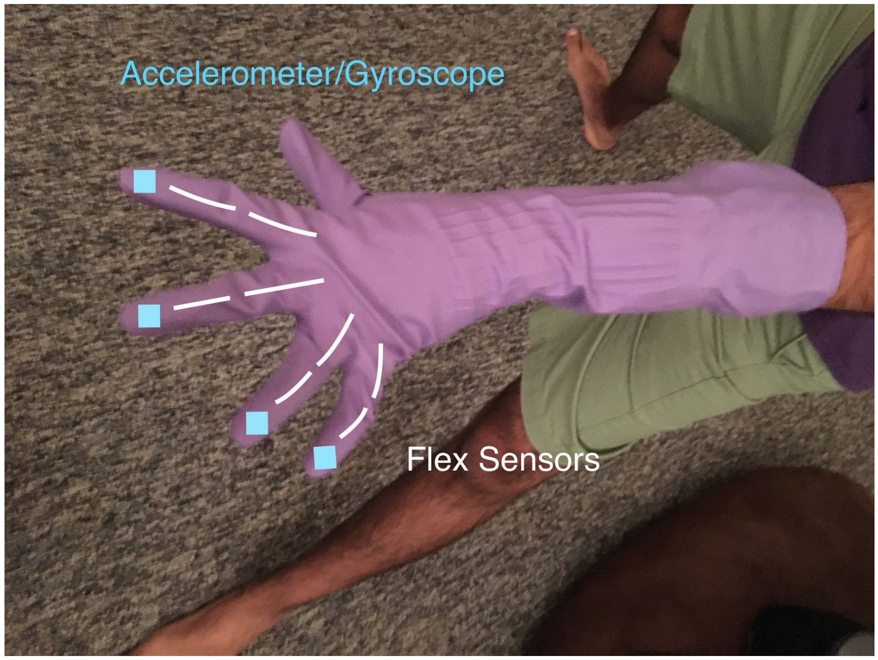


Figure 3: Left Glove Sensor Placement

2.3 Block Design

2.3.1 Flex Sensors
The flex sensors will be used to measure the bend angles in the fingers, indicating the press state of the left hand and the pluck state of the right hand. The sensors are optical, using 2 circuits: an LED circuit and a corresponding photoresistor circuit. They will be powered by the 5V rail getting power from a 9V battery. A voltage divider will be used to measure the value of the photoresistor, which then will be used to train which values are which angles. For the left hand, the first string will see a middle knuckle bend of 90°, the second string will see 120°, the third 150°, and the lowest string 180°. The subsequent voltages will not be hard coded, but used to train the system to recognize different gestures. Further, there will be a second flex sensor on the base knuckle of each finger of the left hand, to tell the difference between a finger on the lowest string and a finger pointing upwards. For the machine learning to be most accurate, we will need the flex sensors to see at least a 0.1 V difference in the target angles.

2.3.2 Accelerometer
The accelerometer will be used to determine relative position and determine pluck state. It will be powered by the 3.3V rail getting power from the 9V battery. The accelerometer will send analog data to the ADC of the MCU to be integrated to find relative position. The MCU will then interpret this and use these inputs as inputs to a state machine to find the next state. The accelerometer and gyroscope will also be used to sense the plucking of the string, based on the rotational acceleration and linear acceleration of the finger, detecting whether the user had the intent of plucking. This will handle the case of a bent finger that is stationary, and thus not plucking the string.

2.3.3 9V Battery

The battery will be used to power the system. Since our project is designed to be mobile, we cannot use a stationary power supply; further, since the components being powered are relatively low-power, we can use a 9V battery.

2.3.4 Power Transformer

The power transformer must be able to supply a 3.3V from the 9V battery. The resulting rails must have a steady voltage with little overshoot for sake of not sending more power than allowed to the flex sensors and accelerometers/gyroscopes. The LD1117 voltage regulator is commonly used to to obtain a clean 3.3v rail from a 5v source, however the upper limit for the source input is 15v. Our intended source is 9v therefore it is in the range of 4.3v-15v to obtain a clean 3.3v rail.

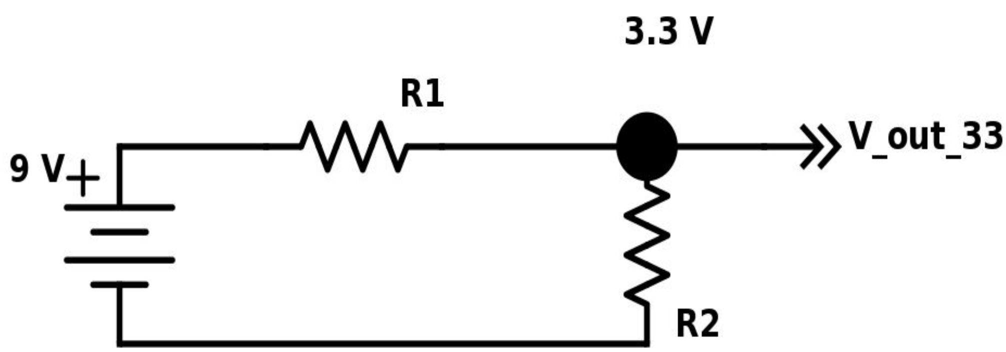


Figure 4: Step-Down Circuit

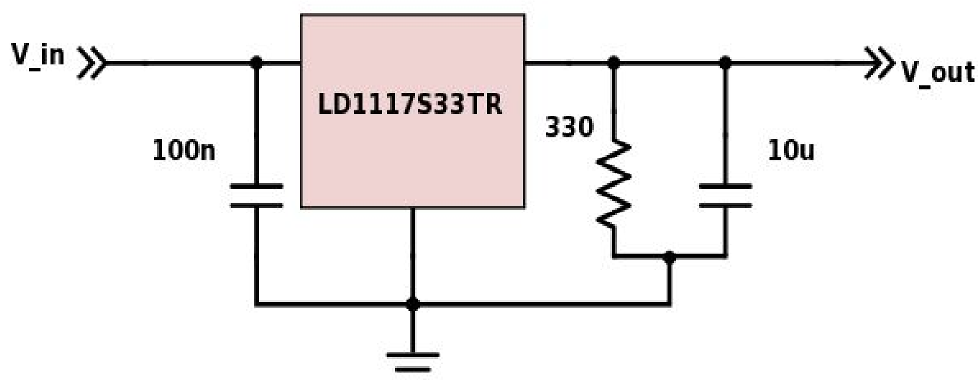


Figure 5: Voltage Regulator Circuit

2.3.5 MCU

We are using the MSP432 microcontroller from Texas Instruments. The MSP432 series is known for its low power requirements and high performance. Texas Instruments provides a large library of technical support documents for UART, SPI, IrDA, and I^2C interface protocols. The microcontroller also features a 14-bit ADC resolution and 24 channels for analog inputs. Our project falls under the category of wearable, portable, consumer electronics which is a common application for the MSP432. On the MCU there is a total of 256kB of flash memory, 64kB of SRAM, and 32kB of ROM available. There is a 6mA current sink/source for digital inputs. The microcontroller must include an option of an SD card support, needed to store sound samples and calibration data from the PC. Our MCU has a ADC sampling rate of 1-Msps (megasamples per second) which is more than sufficient for our data transfers.

$$L = 2^M$$
$$R = |V_{max} - V_{min}|$$
$$V_{res} = \frac{R}{L}$$

Equation Set 1: Voltage Resolution conversion

16-bit resolution gives us 65,536 levels of quantizable levels and the usual full range of the digital voltage is from [-5V, 5V]. This gives us a voltage resolution of .1mV which is theoretically sufficient for our usage.

The integration of the MCU with the flex sensor data (VP) and the accelerometer (LIS3DH) can be seen below.

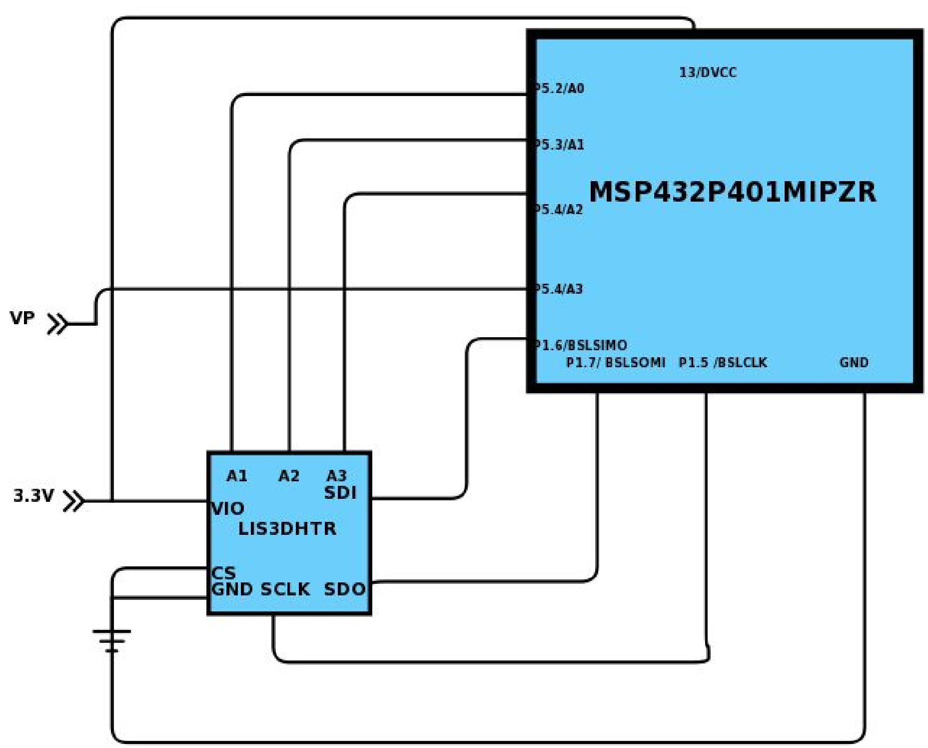


Figure 6: MCU Interface with Analog Data Components

2.3.6 AUX output

The output of our system will be the note played by the user. We will be storing sound samples on an SD card and playing them back out to an auxiliary output. This can be plugged into any given speaker.

$$Nq \geq 2 * F_{max}$$

Equation Set 2: Nyquist-Shannon sampling rate

The range of human hearing is from 20Hz to 20kHz therefore we need to sample at least a 40kHz sampling rate.

2.4 Tolerance Analysis

In order to determine the position of the hands at any given point in time, the performance of the flex sensors module is most key. The sensors must both be able to discern which position is a given output value from the photoresistors, distinguish between various states, and recognize when the hand is in motion vs. when it is still. These factors will determine if the finger is down on a certain string, if it is transitioning to another note, and how long it is down on a given string.

This is the basis for the requirement to see a 0.1 V differentiation between 90° (G string), 120° (D string), 150° (A string), and 180° (E string). These are approximate values, since different people have different hand lengths. However, as seen in Table 2, these closely estimate the average bend angle of the middle knuckle at each string. Further, those who would play the air bass would tend to overexaggerate their left finger movements without the crutch of an instrument. However, in real implementation, the classification will be provided from a machine learning model receiving the angle as an input.

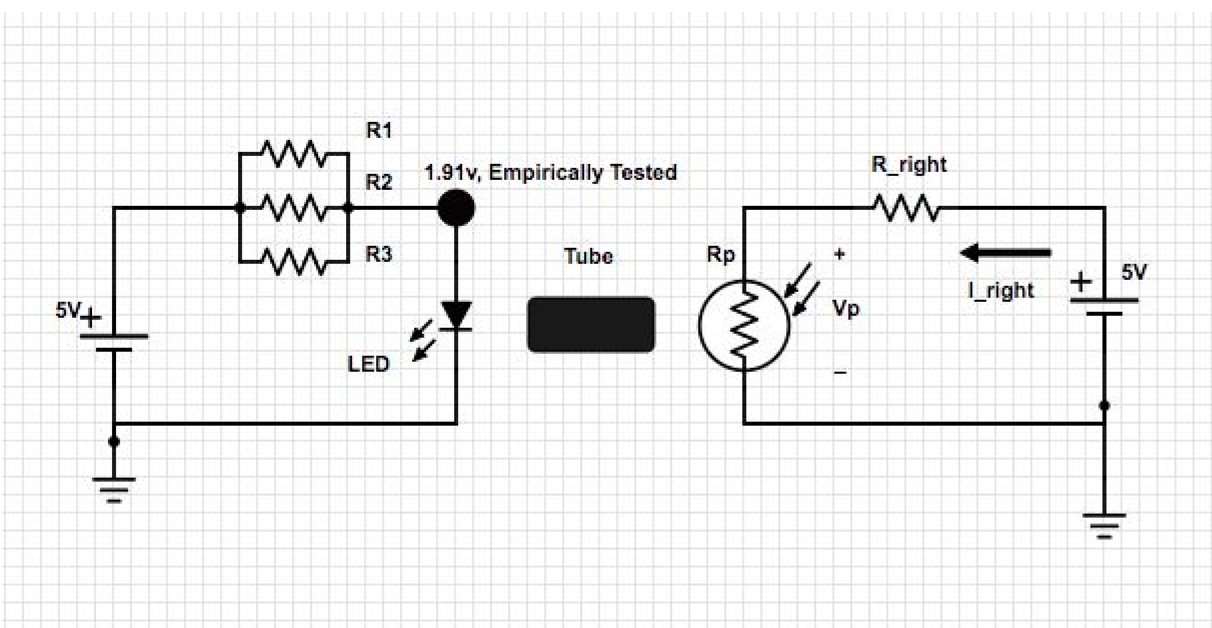


Figure 7: Schematic of flex sensor test circuit

$$R1 = R2 = R3 = 3k\Omega$$

$$R = IV$$
$$R_{total} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$
$$R_{total} = 1k\Omega$$

Equations Set 3: Left Circuit: LED

$$I_{right} = \frac{V - V_p}{R}$$
$$R_p = \frac{V_p}{I_{right}}$$
$$R_p = V_p * \frac{R}{V - V_p}$$

Equations Set 4: Right Circuit: Photoresistor

The flex sensors are developed optically, with an LED sending light through a dark tube and a photoresistor having a variable resistance. The photoresistor is then used in a test circuit (Figure 4) to test the varying resistances and voltages across the LDR. Before testing, the choice of R_right was used from the following table obtained from the GM 5539 Datasheet [8] (Table 8).

Light Impedance	Dark Impedance
50-100kΩ	5MΩ

Thus, a resistor is picked such that there is a significant difference of more than 0.2 V between full light (180°) and first bend (150°). This would imply a 0.8 V difference between full light and nearly no light (90°).

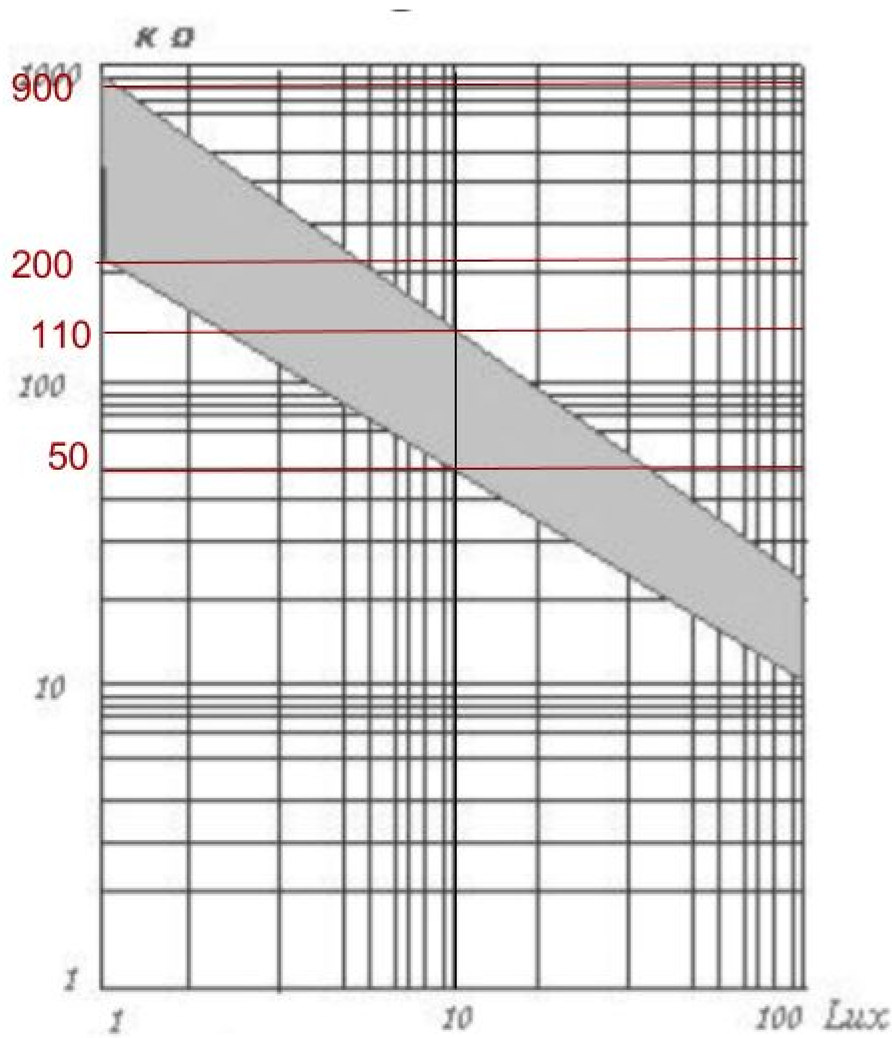


Figure 8: Light-Resistance plot for GM5539

By taking the worst case scenario of a 90 kΩ change and average case of 470 kΩ in photoresistance, we can use Equations Set 4 to determine the ideal series resistor to use in the voltage divider in Figure 4. The result can be seen in Equation Set 5.

$$\Delta R_p = \Delta V_p * \frac{R}{V - \Delta V_p}$$

$$\Delta R_p = \Delta V_p * \frac{R}{V - \Delta V_p}$$

$$R = 472.5\ k\Omega\ (worst\ case)$$

$$R = 2.47\ M\Omega\ (average\ case)$$

Equations Set 5: Average Case & Worst case calculations

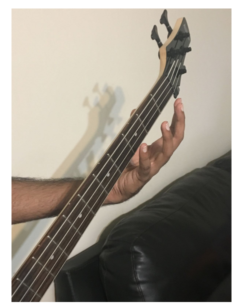
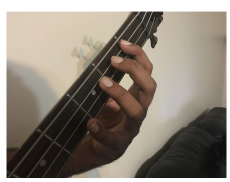
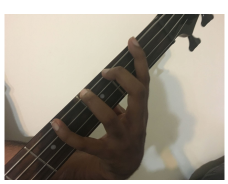
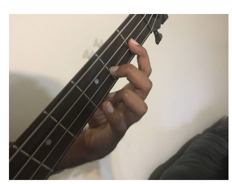
The bending of light around a tube is difficult to predict; it will largely dependent on how reflective the interior is.

Further, because of the bending of light in a light tube, it was seen that the LED must draw at least 3 mA of current, driving a choice of 1kΩ for the pull-up resistor from a 5 V test source. The ideal LED to choose is green, since the LDR has a spectral peak at 540 nm (green).

If voltage across the photoresistor can be obtained, using the equations in Equations Set 4, the resistances for given bend angles can be obtained. The resistances for the photoresistor at each bend angle and their corresponding voltage can be seen in Figures 5 and 6, respectively.

2.5 Design Algorithm

2.5.1 Physical Hand Positions & Permutations

	Strings			
	E	A	D	G
Open	 **E1**	 **A1**	 **D2**	 **G2**
1 Fret	 **F1**	 **A#1**	 **D#2**	 **G#2**
2 Fret	 **F#1**	 **B1**	 **E2**	 **A2**

3 Fret	 **G1**	 **C2**	 **F2**	 **A#2**
4 Fret	 **G#1**	 **C#1**	 **F#2**	 **B2**

Table 2: Left Hand Positions

Strings			
E	**A**	**D**	**G**
			

Table 3: Right Hand Positions

2.5.2 Right Hand FSM

The accelerometer will be used for the right-hand logic. The logic to determine the current state of the right hand is represented through 2 state machines, one to determine whether which string the finger is on and one to transition between a non-string state and on-string state. Integration of the accelerometer over time (twice) is used to determine relative position, and the data is used in the supervised machine learning model. However, in addition to using the model to determine the initial state in figure 8, the state machine in figure 8 will be used to speeden the determination of string.

The use of digital logic to determine the state is to decrease unnecessary runtime for the algorithms; since the ML model will itself be an extensive process initially, further sequential logic to yield output would only slow upon larger sample size. Thus, digital logic will be used to greatly increase the computational speed of the design.

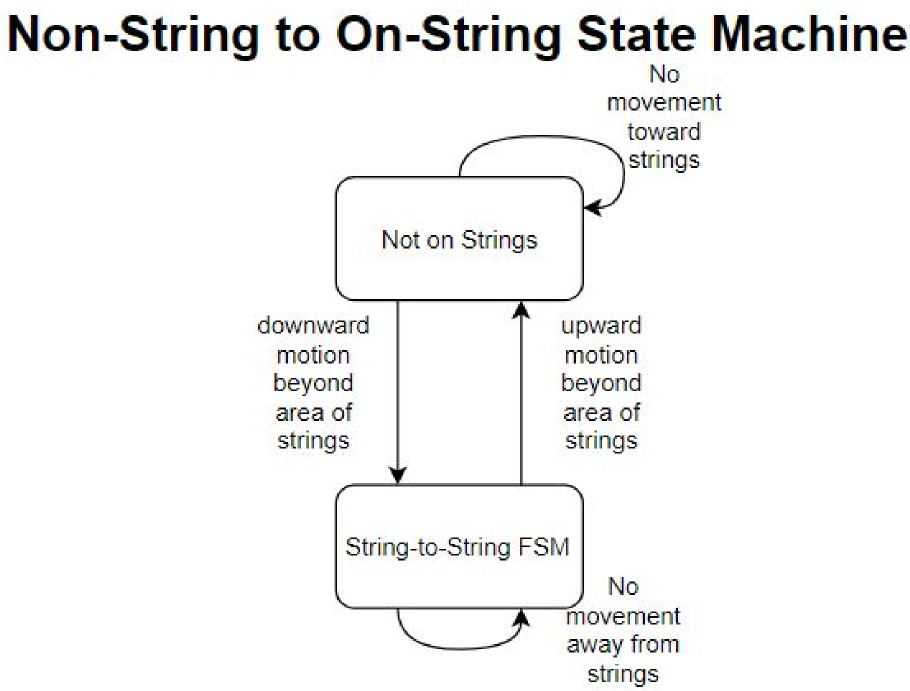


Figure 9: Non-string to On-string FSM

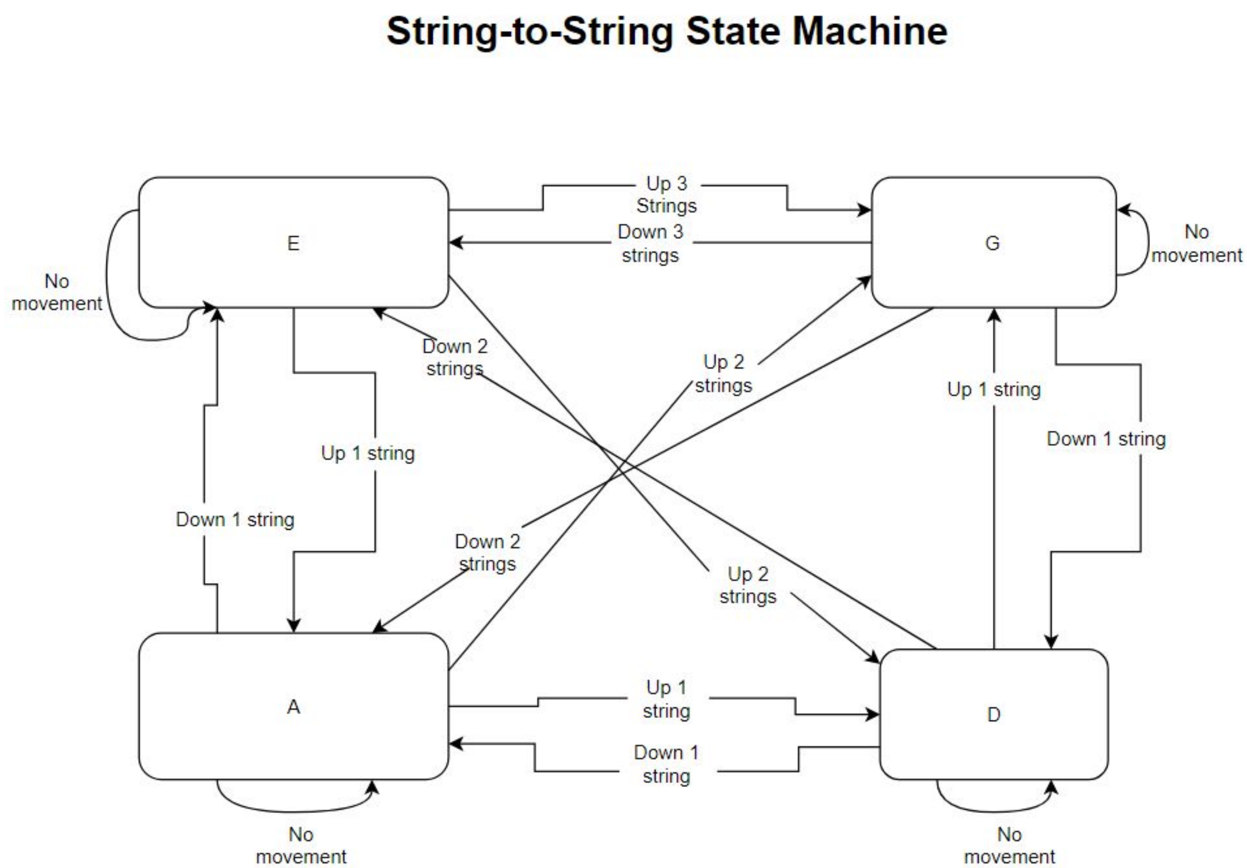


Figure 10: String-to-string FSM

2.5.3 Truth Tables

Legend: Right Hand					
String	NONE	E	A	D	G
Binary (3b) ($S_2S_1S_0$)	1xx	000	001	010	011

Table 4: Right Hand Truth Table for Strings

States S_1S_0 are taken as the states and outputs from the state machine in Figure 10. State S_2 is only in consideration when the right hand is not playing a string, so it is not necessary to determine the notes.

Legend: Left Hand					
String	*off string*	E	A	D	G
Hex (5b) (I, M, R, P)	10000	00001	00010	00100	01000

Table 5: Left Hand Truth Table Flex angles

Similarly, the MSB of each finger is not used; it is used separately to determine silence vs. sound. In the following table, only the relevant slice of finger placement ($I_nM_nR_nP_n$) is used to determine the note.

Flex Sensor States					
	Middle Knuckle (1b)				Pluck (2b)
Note	Index	Middle	Ring	Pinky	String State
E1	0	0	0	0	00
F1	1	0	0	0	00
F#1	x	1	0	0	00
G1	x	x	1	0	00
G#1	x	x	x	1	00
A1	0	0	0	0	01
A#1	1	0	0	0	01
B1	x	1	0	0	01
C2	x	x	1	0	01
C#2	x	x	x	1	01
D2	0	0	0	0	10
D#2	1	0	0	0	10
E2	x	1	0	0	10
F2	x	x	1	0	10
F#2	x	x	x	1	10
G2	0	0	0	0	11
G#2	1	0	0	0	11
A2	x	1	0	0	11
A#2	x	x	1	0	11
B2	x	x	x	1	11

Table 6 : Middle Knuckle Flex Sensor and String States for notes

One-hot coding will be used for the left-hand string states. This is to accommodate the don't cares of the other fingers. Essentially, the pinky is the most powerful, followed by the the ring, middle and index. If the pinky is pressed down, it does not matter the press states of the other fingers on that string as it will play as if the pinky has been pressed. Likewise, if the ring is pressed, while it does not matter if the index or middle are pressed, the pinky being pressed would cause a different note. Thus, a negation is performed on the one-hot state to accommodate all other states.

The memory address of each sound sample is then stored in an array, accessed through a 2D method of rows and columns, as seen in Table 7. The location in the array is given by 4*row+column.

Storage Array for Sound Sample Memory Addresses					
Row	Column				
	0	1	2	3	4
0	E1	F1	F#1	G1	G#1
1	A1	A#1	B2	C2	C#2
2	D2	D#2	E2	F2	F#2
3	G2	G#2	A2	A#2	B2

Table 7: Storage Array for Sound Sample Memory Addresses

To achieve the relevant slice of the finger placement, MUXes were used to select the finger status on the string being plucked, as indicated by S_1S_0 (Figure 11). S_1S_0 was also used to to determine the row, since the row is based on the string being plucked.

2.5.4 K-Maps

Table 6 can be used to create the following k-maps for the column bits.

C2	I_nM_n				
R_nP_n		00	01	11	10
	00	0	1	1	0
	01	0	0	0	0
	11	0	0	0	0
	10	1	1	1	1

Table 8: Column Bit 2 K-Map

C2=P

C1	I_nM_n				
R_nP_n		00	01	11	10
	00	0	1	1	0
	01	0	0	0	0
	11	0	0	0	0
	10	1	1	1	1

Table 9: Column Bit 1 K-Map

C1=RP'+MP' = (R+M)P'

C0	I_nM_n				
R_nP_n		00	01	11	10
	00	0	0	0	1
	01	0	0	0	0
	11	0	0	0	0
	10	1	1	1	1

Table 10: Column Bit 0 K-Map

C0 = RP'+IM'P' = (R+IM')P'

2.5.5 Logic Circuit

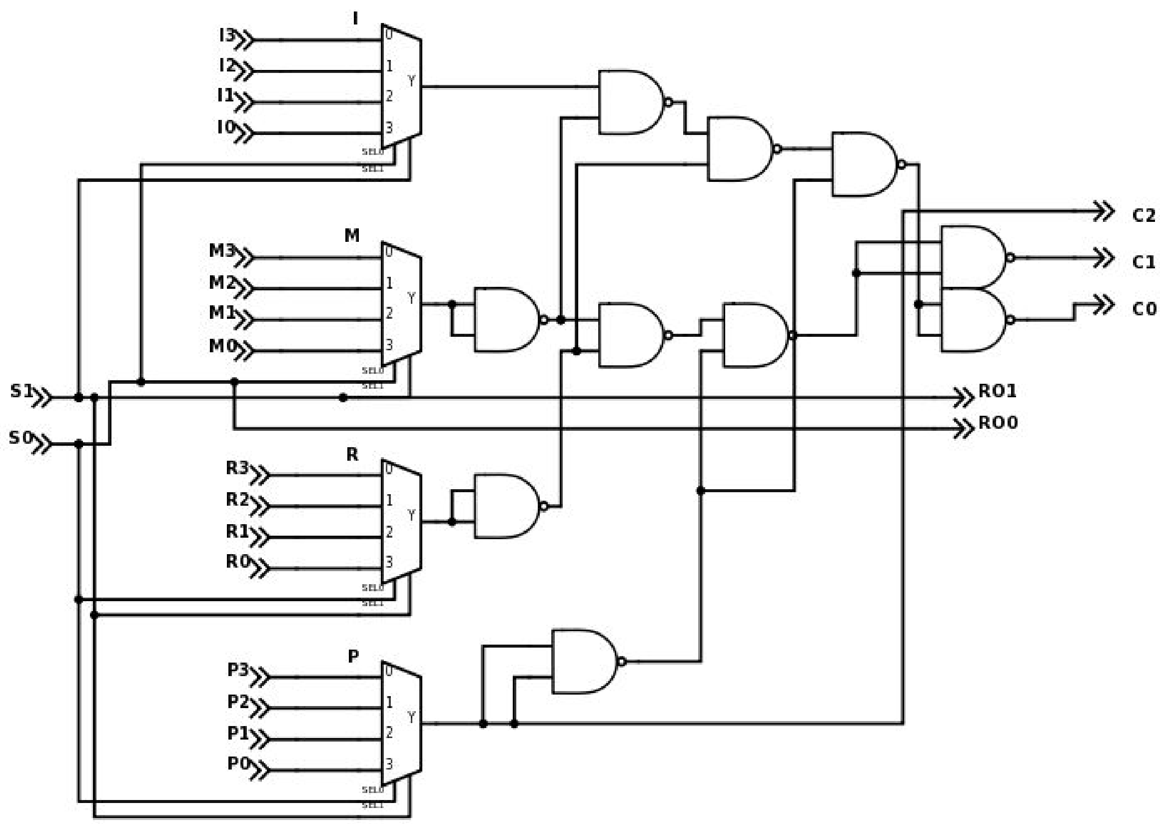


Figure 11: Logic Circuit to Determine Row and Column Bits

3. Requirements and Verification

Flex Sensors	
Requirement	Verification
The flex sensor must produce voltages distinguished by ±0.1 V when bent at 90°, 120°, 150° and 180°.	1. Build a test circuit using three 3kΩ parallel resistors and a 100kΩ resistor 2. Use MCU to supply 5V to a test circuit to measure the voltage through the photoresistor at key angles. 3. Extract data into MATLAB 4. Check for 0.1 V distinguishment on MATLAB generated Voltage graph between key angles.

The flex sensor voltages at a given angle must not differ more than 50 mV.	1. Build a test circuit using three 3kΩ parallel resistors and a 100kΩ resistor 2. Use MCU to supply 5V to a test circuit to measure the voltage through the photoresistor at key angles. 3. Extract data into MATLAB 4. Check for a maximum 50 mV variation within a key angle range on MATLAB generated Voltage graph.
The flex sensor voltages must approach their correct value range for each angle within 12 ms.	1. Build a test circuit using three 3kΩ parallel resistors and a 100kΩ resistor 2. Use MCU to supply 5V to a test circuit to measure the voltage through the photoresistor at key angles. 3. Extract data into MATLAB 4. Check for the time between the key angle steady states on MATLAB graphs.

Accelerometer

Requirement	Verification
The accelerometer must have a minimum range ±2g and the gyroscope must have a minimum range of ±180 dps.	1. Use MCU to supply 3.3 V to accelerometer module. 2. Read accelerometer values for left hand motion and plot using MATLAB. 3. Verify from plot/data that accelerometer can satisfy force range and angular motion range required by fingers.
The module must not exceed dimensions of 50mm x 50mm.	1. Measure size of module to be less than or equal to 50mm x 50mm
The accelerometer must provide real-time data accurate with 12 ms.	1. Use MCU to supply 3.3 V to accelerometer module. 2. Read accelerometer values for plucking motion and plot using MATLAB. 3. Read position values in real-time to see sample-delay and thus time-delay in obtaining relative position.

9V Battery

Requirement	Verification
The battery will be able to provide at least 200 mA at rated voltage for at least 8 hours.	1. Upon completion of initial build, leave the MCU on for 8 hours with intermittent use to see battery life. 2. This will be repeated several times to insure that results are consistent with specified values. 3. We will monitor the voltage drop across via MCU.

Power Transformer	
Requirement	Verification
The step-down power will not exceed ±0.5V below or above intended voltages at 200 mA.	1. A multimeter will be utilized to check if the current output is equal to 200mA and if voltage is within the 0.5 range.

MCU	
Requirement	Verification
The controller must support UART, SPI, and I^2C.	1. Read the Datasheet this is confirmed that the MPS432R supports *UART, SPI, IrDA, and I^2C* [7]
The controller must have at least 10-bit ADC resolution.	1. Read the Datasheet this is confirmed we have a 16-bit ADC resolution [7] 2. Monitor the serial out port of the microcontroller

AUX Output	
Requirement	Verification
The auxiliary output interfaces with the MCU at at least 40 kHz sampling rate.	1. Monitor using oscilloscope between the interface 2. Examine waveform to insure that the signal is at least 40kHz 3. Empirically test audio signal by testing the auxiliary output to confirm humanly audible sound is being produced

4. Schedule

Date	Ying Chen	Niranjan Jayanth	Pranathi Gummadi
October 2nd	Setup MCU for obtaining data. Obtain initial flex sensor data for graphing.	Build flex sensor circuits for initial testing. Assist in MCU setup.	Research and obtain various possibilities for flex sensors, work on 3D printing builds for flex sensors.
October 9th	Begin build of multiple flex sensor model.	Setup accelerometer to interface with MCU. Verify accuracy and precision of accelerometer.	Supervise 3D printing for flat flex sensor build.

October 16th	Begin initial calibration schemes using SVM and data from flex sensors.	Develop accelerometer state machine on build of right hand to detect which note is plucked. Reach 50% accuracy.	Build flex sensor setup on right hand to test pluck detection.
October 23rd	Build flex sensor setup on left hand to test note detection. Verify accuracy of flex sensors at each hand position.	Develop state machines for left hand note detection. Obtain flex sensor data from left hand to send for calibration.	Continue initial calibration schemes using SVM and data from accelerometer.
November 6th	Final PCB designed and ordered	Final PCB designed and ordered	Final PCB designed and ordered
November 15th	Finish software development for calibration.	Setup sound samples to be read from memory.	Setup AUX out to read from sound samples in memory.
November 20th	Integrate PCB in final glove set-up.	Integrate PCB in final glove set-up.	Integrate PCB in final glove set-up.
December 1st	Viable demo of a song involving notes from E1 to B2. Fine tuning until final demo day.	Viable demo of a song involving notes from E1 to B2. Fine tuning until final demo day.	Viable demo of a song involving notes from E1 to B2. Fine tuning until final demo day.
December 6th	Demo Day	Demo Day	Demo Day
December 11th	Final Report	Final Report	Final Report

5. Cost Analysis

Parts					
Item	**Distributor**	**Price**	**Quantity**	**Total (with shipping)**	**Purpose**
Microcontroller MSP432	Texas Instruments	$12.99 Shipping: $15.64	1	$ 28.63	Microcontroller
Micro Tubing	Amazon	$6.12	6	$36.72	Flex Sensor 1
4-in Heat Shrink	Amazon	$9.49	2	$18.98	Flex Sensor 1

Photoresistor	Amazon	$5.65	3	$16.95	Flex Sensor 1
5mm LED	Amazon	$6.32	3	$18.96	Flex Sensor 1
Accelerometer Breakout Board	Amazon	$7.47	2	$14.94	Testing purposes
Accelerometer	Digikey	$1.53 Shipping: $9.00	10	$24.30	Required sensor data
Audio Jack	Amazon	$6.54	2	$13.08	Audio Output
Gloves	Home Depot	$5.47	3	$16.41	Gloves
3-D Printing Filament	Amazon	$22.99	1	$22.99	Flex Sensor 2
Epoxy Glue	Amazon	$8.76	1	$8.76	Flex Sensor 2
Electrical Tape	Amazon	$5.79	2	$11.58	Flex Sensor 2
10 mm Heat Shrink	Amazon	$6.93	2	$13.86	Flex Sensor 2
PET Plastic Sheet	Amazon	$8.40	3	$25.20	Flex Sensor 2
LED Strip	Amazon	$17.49	1	$17.49	Flex Sensor 2
Brewer Science InFlect™ Flex sensor	Brewer Science	$0.00	10	$0.00	Flex Sensor 3
LD1117 Voltage regulator	Adafruit	$1.25	3	$3.75	Voltage regulator
Total	**$ 288.85**				

Labor				
Team Member	**Hourly Rate**	**Total Hours**	**Expense Multiplier**	**Total Cost**
Ying Chen	$33.07	70	2.5	$5,787.25
Niranjan Jayanth	$33.07	70	2.5	$5,787.25
Pranathi Gummadi	$33.07	70	2.5	$5,787.25
			Labor Total	**$17,361.75**

Grand Total	**$17,650.6**

6. Discussion of Ethics and Safety

The most relevant safety concern with wearable devices is the physical contact between electrical equipment and the user's body. Therefore, insolation and build must be of the utmost quality to prevent potential harm. A possible physical safety concern could be the potentially heavy weight of the glove causing repeated stress and strain on fingers and wrists. Continued use could result in medical conditions such as carpal tunnel or wrist tendonitis. We will execute the project while in agreement with IEEE's code of ethics obligation number 9, "to avoid injuring others, their property, reputation, or employment by false or malicious action" [4]. We understand these physical concerns and will take preventative during testing and building.

As the market for wearable technology expands, government regulations are put into consideration for testing product safety. The FCC strictly monitors the industrial and consumer products that make use of RF and electromagnetic waves. Specifically, in the March 2013 vote, the FCC decided to reassess its limits on permissible absorption of radio frequencies [5]. According to Kenneth R. Foster, professor of bioengineering at the University of Pennsylvania, safety concerns due to electromagnetic radiation is negligible due to devices operating at lower power requirements [6]. To support the FCC's reexamination of their policies, Professor Foster also mentions that the FCC's regulations have yet to be updated to reflect current technological advancements [6]. Due to these findings, we can assume that the possibility of repeated exposure to RF/EM due to usage as potential source of harm to be minor.

In addition to miscellaneous electronic components that may require physical contact, we will utilizing a dense battery.

7. Risk Analysis

Potential points of technical failure for the system can be narrowed to two overarching portions: sensors capability and software calibration. Due to the inconsistent play styles between users, inconsistent habits and hand gestures will pose a great threat to the accuracy of our system. While we plan to enforce limitations on the repertoire of recognized motions, these random motions may cause interference. However, our calibration system will attempt to minimize these errors via calculations of repeated data capture. Similarly, the sensors may cause trouble during build, it is common to have inaccuracies due to fickle readings. We plan to integrate over accelerometer data which is known for introducing noise to outputs. The predominant part of our project is position detect and motion recognition. Therefore, if sensors produce a large margin of noise, our classification threshold and error may be significant. In such cases, where the sensors and calibration falter, the overall system may display behaviors of missed detection or false alarm.

The complexity of the gloves pose the critical threat to replication and completion of the instrument. From a management stance, we plan to partition and complete tasks vertically to insure individual feature deliverables ready for independent demos.

In additional to these execution risks, there remains the issue of physical strain on the system due to repetitive testing and usage. Natural movement of the fingers causes wear and tear on the electrical components connected to the glove such as the flex sensors. Considering the prototypical nature of the gloves the priority is to be able to make a functioning glove. The next priority is the durability of the glove given the amount of testing to be done with it. To prevent any malfunctions as a result of physical strain, we will be conscious about the type of materials used and the delicacy with which we set up the electrical components.

8. Citations

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