Maestro Mittens

Design Document Check

Team # 32
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1. Introduction

Learning to play an instrument is hard. It takes time, effort, and a lot of money to get any good. What is even more difficult is learning to play an instrument well as not all people have a knack for picking out harmonic melodies, thus making freestyling even more difficult. Our product, “Maestro Mittens” aims to bridge this knowledge gap by providing an easy way for people to “play” an instrument. In response to your movements, these mittens produce notes in the same key so you are never out of tune; no need to learn scales or music theory! The mittens will have different modes for different types of instruments. For example, in “piano mode” moving your hands to the right/left will produce higher or lower pitches. In “guitar mode”, bending your fingers in different combinations would produce different chords that are also in the same key. The strumming hand would determine the tempo of the sounds produced. WIth Maestro Mittens, consumers can play various instruments easily even with limited musical abilities and skills. More so, our product eliminates the struggle of having to carry around heavy instruments wherever you want to play.

2. High-level Requirements

The flex sensors and accelerator/gyroscope should be calibrated enough to detect finger, wrist and arm movement when they occur with enough precision that a note could be replicated by repeating the same movement. The signals from the sensors should be sent to our computer fast enough so that the audible delay between the hand movement and sound is negligible to the human ear. The computer should appropriately interpret the signals to produce the proper notes such that there are no dissonant notes played or abrupt unintended jumps in pitch.

3. Block Diagram

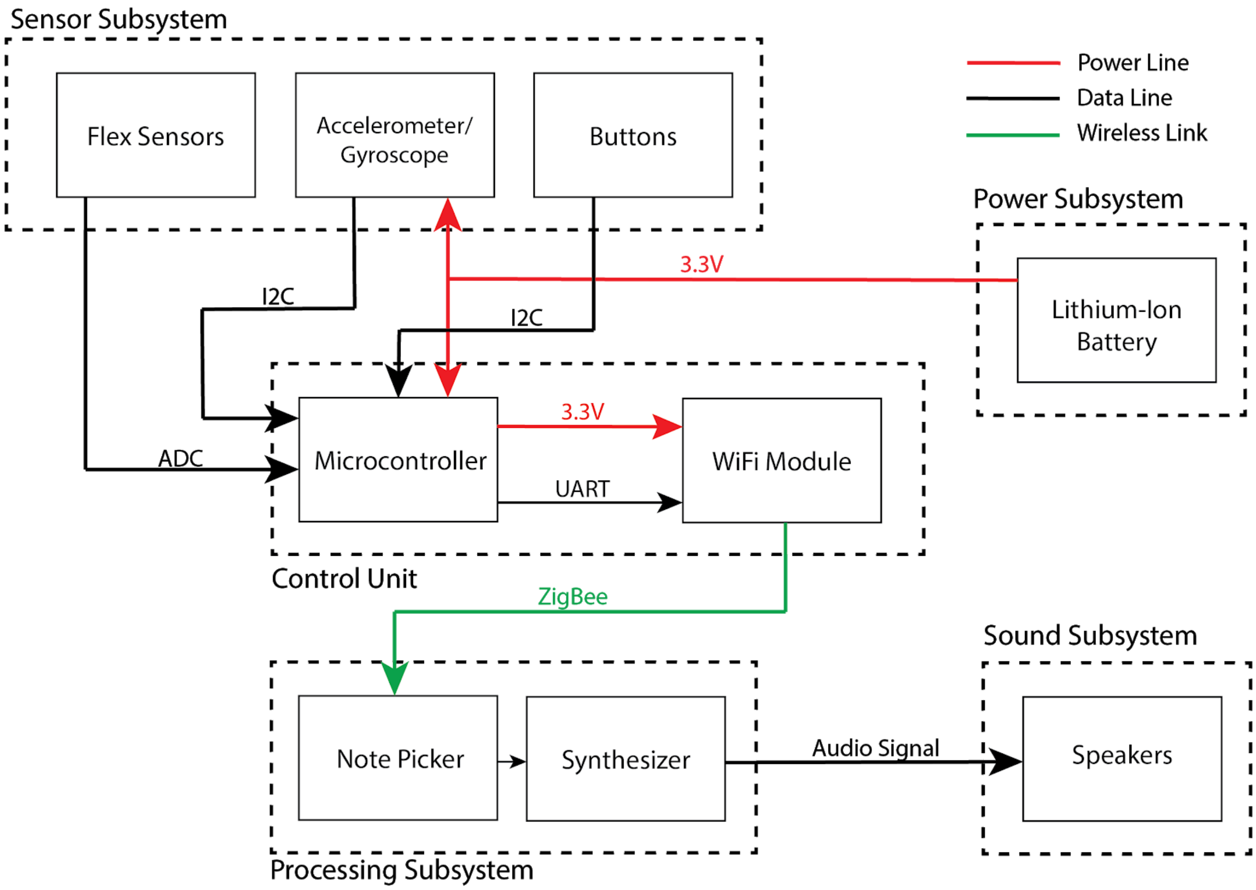

Figure 1: Block Diagram

4. Physical Design (if applicable)

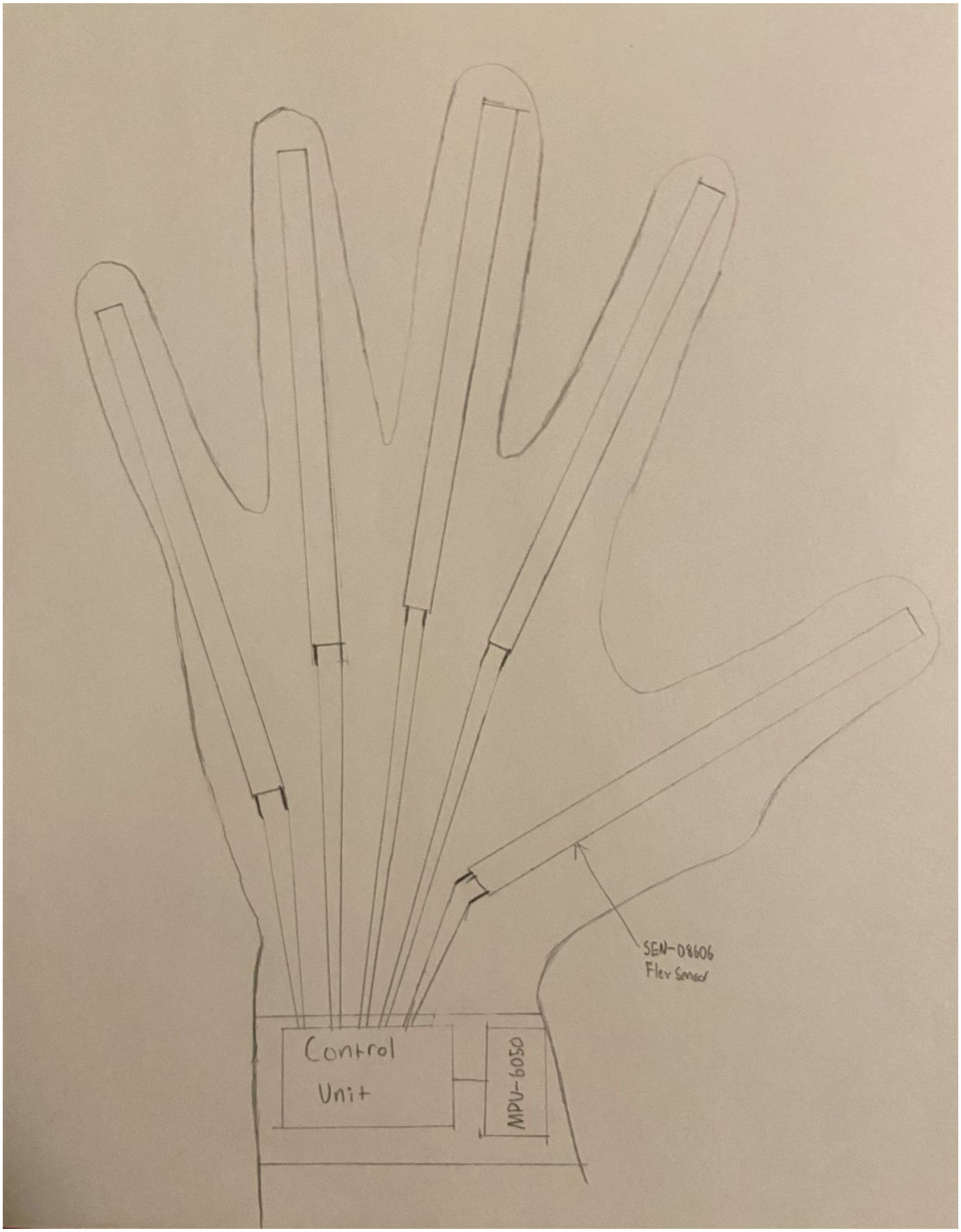

Figure 2: Physical Design
(note: this will be covered by an outer glove)

5. Requirements & Verification Tables

5.1 Sensor Subsystem

5.1.1 Flex Sensor

Requirement	Verification
When bent to about 45^o the flex sensors subcircuit will output a voltage approximately 1V less than when they were unbent.	1. Measure and test the flex sensors average resistance when flat and when bent to about 45^o 2. Use the voltage divider formula: ● $Vo = Vi \bullet (\frac{R2}{R2+R1})$ ● Where Vi = 3.3V, R1 is the flex sensor resistance, and R2 is the second resistor (see fig. 3) 3. Choose a resistance value for resistor R2 that will cause the output voltage to decrease by about 1V when the flex sensor has the resistance of a 45^o bend. It should roughly satisfy the equation: ● $Vo(flat) - Vo(45^o) \approx 1$ ● $(\frac{R2}{R2+R1(flat)}) - (\frac{R2}{R2+R1(45)}) \approx 1/Vi$

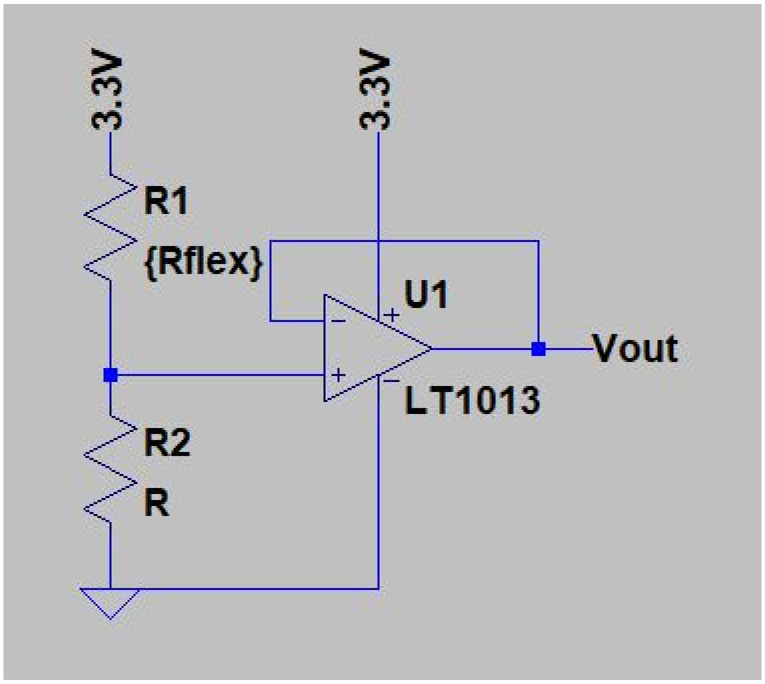

Figure 3: Flex Sensor Schematic
(note: we will be using an LM358 op amp)

5.1.2 Accelerometer/Gyroscope:

Requirement	Verification
The accelerometer/gyroscope should be able to provide the control unit with information on the movement of the user's hands. The data should be accurate enough that the control unit can gauge when the user's hands are separating and moving in together.	1. Test hand movements at various speeds and distances. 2. Use those readings to gauge and set ranges/thresholds for desired movements, and ignore noise from minor hand movements 3. Once the instrument mode is set, place hands in a predetermined start position so we have a starting reference point.

5.2 Control Unit

5.2.1 Microcontroller

Requirement	Verification
Can transmit data over UART at a speed of 115,200 baud Can receive data over I2C at a minimum speed of 115,200 baud	1. Connect microcontroller to a computer via UART USB and ensure that when speed is set to 115200 baud, characters sent can be read. 2. Connect microcontroller to a computer via I2C and ensure that when speed is set to 115200 baud, characters sent can be read.

5.2.2 XBee Module

Requirement	Verification
Can send and receive data between 2 XBees at 115,200 baud	1. Connect two XBees, both to XCTU via a FT231 USB - serial converter, and send data from one to another at 115,200 baud. Confirm data received.

5.2 Power Subsystem

Requirement	Verification
Voltage supply should be within 3.1-3.3 volts Current draw should remain between	1. Connect the battery to a voltmeter and plot the voltage over time 2. Connect battery to an ammeter and the XBee module and plot current draw over time.

6. Note Picker Algorithm:

1. Upon start up, note picker picks a key and filters out notes that are not in that key
2. Note picker takes in values from the control unit
3. Compare values from before to see if pressed fingers have changed, unless the saved value is null, then it will calculate the notes regardless
4. If pressed fingers have changed, calculate right hand notes
    a. If the speed of the right hand is positive, shift right hand window by specified amount
    b. Else if speed of the right hand is negative, shift right hand window by specified amount
    c. For each finger pressed
        i. Pick one note from window and add it to the notes_to_play array
5. If pressed fingers have changed, calculate right hand notes
    a. If the speed of the left hand is positive, shift right hand window by specified amount
    b. Else if speed of the left hand is negative, shift right hand window by specified amount
    c. For each finger pressed
        i. Pick one note from window and add it to the notes_to_play array
6. Send notes to play to the synthesizer

7. Safety & Ethics

We believe our project complies with all of IEEE code of ethics. Specifically, code number 5 states that developed technology should "improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems". Our project aims to improve individuals' understanding of music through the use of this technology. Thus we believe that our project doesn't undermine any of the IEEE Code of Ethics.

There are a few safety concerns in using a lithium-ion battery. If the battery were to fail or overheat, this would result in "thermal runaway which is a reaction within the battery causing internal temperature and pressure to rise at a quicker rate then can be dissipated". Once a battery goes into thermal runway, it can cause enough heat to induce thermal runway in other batteries ultimately resulting in a fire. These fires are more difficult to put out and thus make this uniquely dangerous [6]. Other safety concerns could arise from open or uncovered wires that could potentially cause electric shock to the wearer of the device. Which is why our design will have all wires covered and away from the user's skin; thus adhering to the first rule of the IEEE code of ethics by ensuring the safety of the user [3].

8. Citations

[1] Sparkfun, 'FLEX SENSOR DATASHEET', [Online]. Available: https://cdn.sparkfun.com/datasheets/Sensors/ForceFlex/FLEXSENSORREVA1.pdf. [Accessed: 20- Feb- 2020]

[2] wpengine.netdna-cdn.com, 'MPU-6000-Datasheet1', [Online]. Available: http://43zrtwysvxb2gf29r5o0athu.wpengine.netdna-cdn.com/wp-content/uploads/2015/02/MPU-6000-Datasheet1.pdf. [Accessed: 20- Feb- 2020]

[3] ieee.org, 'IEEE Code of Ethics', 2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 20- Feb- 2020]

[4] "XBee Buying Guide," XBee Buying Guide - SparkFun Electronics. [Online]. Available: https://www.sparkfun.com/pages/xbee_guide. [Accessed: 24-Feb-2020].

[5] "XBee Buying Guide," XBee Buying Guide - SparkFun Electronics. [Online]. Available: https://www.sparkfun.com/pages/xbee_guide. [Accessed: 24-Feb-2020].

[6] "The Hazards of Lithium Batteries", Viceprovost.tufts.edu.(2020). [Online] Available at: https://viceprovost.tufts.edu//ehs/files/The-Hazards-of-Lithium-Batteries.pdf [Accessed: 24-Feb-2020].