Air Guitar Gloves

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1 Introduction

1.1 Objective

People all over the world at some point in their lives have wished they could play guitar and have probably expressed this by playing an ‘air guitar’ along with one of their favorite songs. Despite its popularity, many people still miss out on the experience of playing guitar. Learning how to play guitar primarily involves two resources that govern the majority of people’s lives: time and money. Monitoring finger fret placement, memorizing chord shapes, and keeping track of which strings one’s right hand is playing all take valuable time to build muscle memory for. If the learning curve does not deter an individual, then the prices of a decent guitar and the equipment needed will hold back most others. Additionally, if a person decides that they can spare both of those, the sheer size and unwieldiness of the average guitar can cause even a professional guitarist transportation nightmares.

We propose to create “Air Guitar Gloves” that will allow the user to play guitar through gesture control. The left hand will control what notes and chords are playable by linking a chord to each gesture. The right hand will dictate when and how these chords are played by deciding if the user’s hand is strumming or if they are playing individual strings. The sensor data will be converted into a series of bits that will be sent to the microcontroller to convert into MIDI data. From there, the MIDI data will be put through an audio codec chip to create audio output that will be sent to a 3.5mm audio jack.

1.2 Background

Similar products all require hardware or software that hooks up to the gloves in order to function. This limits the user’s ability to move around comfortably while playing. Whether it is a method that replaces gesture control with a camera that detects the user’s hand positions or the need for an external sound system, none of these solutions allow the user to move freely about an area with ease.
Our project will differ by providing gloves that do not require the user to hook their gloves up to computers or other bulky hardware aside from earphones. Thus, users will have a portable and affordable alternative for playing guitar.

1.3 High-Level Requirements

1. The gloves should be able to play any combination of strings.
2. The gloves can operate for 2 hours without needing to be recharged.
3. Gloves will include major and minor variations of the C, A, G, E, and D chords.

2 Design

Figure 1.1 Block Diagram
Overview

There will be two gloves that will contain flex sensors which will act as variable resistors in circuits that will be placed on the back of each glove. These circuits will act as analog to digital converters and will output to a microcontroller that will convert this data to its corresponding MIDI output. This output will be sent to an audio decoder which will convert the MIDI data to a guitar sound outputted to a 3.5mm audio jack. The setup which contains the microcontroller, audio codec, and audio jack will be placed in a small box that can clip onto a person's hip, and will be connected to the two circuits on the gloves by wires.

2.1 Power Module

Overview: The power module will contain a Li-ion battery and a voltage regulator that will be found in a box on the hip. The voltage regulator will power the rest of the system through wires.
2.1.1

**Lithium-Ion battery**: The battery should be able to supply power to both signal conversion circuits, audio codec chip, microcontroller, and audio jack for 2 hours.

*Requirement: Based on our estimates, our design will draw about 1.2A. As such, the portable battery pack should be able to supply a minimum of 5000mAh at 1.2A.*

2.1.2

**Voltage Regulator**: The voltage regulator must be able to provide power to both the left and right glove signal conversion circuits, microcontroller, and the audio codec chip.

*Requirements: must provide between 1.8V-3.6V to the microcontroller, 5V +/- 5% to the logic circuit for the gloves, and 2.7V +/- 5% to the audio codec chip. The voltage estimate for the microcontroller is based off average values it takes to power a majority of microcontrollers that would be viable for this project. The voltage estimate for the audio codec chip is based of the VS1103’s data sheet. The logic circuit voltages are based off regular error in TTL based logic chips.*

2.2 Sensor Module

**Overview**: The sensor module will be responsible for translating physical gestures to their corresponding digital values that will then be processed by the data module.
2.2.1

**Left hand signal conversion circuit:** The left hand circuit will contain 5 flex sensors that will each be placed on the outside of the glove behind each finger. These flex sensors will act as variable resistors in a circuit that is powered by the voltage regulator. When the fingers bend the flex sensors, their resistances will increase from roughly 10kΩ to almost 20kΩ. These changes in resistances will be processed by a variable deflection threshold circuit in order to convert the analog signal to digital. The threshold circuit contains a voltage divider that is then connected to an operational amplifier. This will output logical low voltage when the flex sensor is flat and will output logical high voltage when the flex sensor is bending over half way. Once the analog signals have been converted to digital signals we run this through a logic circuit that will output the corresponding gesture’s digital signature that the microcontroller will recognize.

*Requirements:* In order to stay within the range of acceptable current draw to maintain a 2 hour lifespan, the total draw of the sensors on the left hand cannot exceed more than 600mA and must output the gestures corresponding digital value to the microcontroller.

**Right hand signal conversion circuit:** The right hand circuit will contain seven buttons and one accelerometer. The buttons are for choosing to either strum or pluck an individual string. In our design we chose not to measure the position of the fingers instead of using buttons because the current draw from adding five extra flex sensors would not allow us to attain 2 hours of portability. Four buttons will be placed straight on the palm of the right hand horizontally to represent the strings D, G, B, and high E. Three more buttons will be placed on the side of the index finger. Two of the three buttons will represent the strings low E and A. When one of these buttons are pressed it will play the note of that string with the chord picked by the left hand, or multiple notes if the user presses more than one at a time. The last button on the finger closest to the nail will be the button for strumming. When this is pressed the microcontroller will read the data from the accelerometer and determine whether or not a full strumming motion has occurred, and if so then play the corresponding chord.

*Requirements:* Based on our estimates the power from the sensors on the right hand cannot exceed 300mA in order to maintain portability for two hours. These sensors must also be able to indicate a string being plucked or indicate a the range of strumming motion that has occurred.

2.3 Data Module

**Overview:** The data module will contain the microcontroller, audio codec chip, and audio output. These will be connected using wires, and will all be contained in a box that will be clipped onto a person’s waist.
2.3.1

**Microcontroller**: The microcontroller we choose must have the ability to have enough memory capacity to hold a lookup table that can correlate our data from both signal conversion circuits to its raw MIDI output. The microcontroller must be able to run at fairly low power and must be able to convert the digital data to MIDI data at a fast enough rate so there is not noticeable lag between the note/notes being played.

*Requirement: This microcontroller must be able to operate under 5V and 50mA and convert the digital sensor data to corresponding MIDI data in order to keep within power estimates for portability.*

2.3.2

**Audio codec chip**: We have decided to not just output sound directly from the microcontroller to a digital to analog converter for a few reasons. First, MIDI is a powerful music protocol capable to producing sound very close to the actual instrument. Attempting to recreate the specific frequency and amplitude to mimic a guitar for each note and chord would be very complex. Second, a microcontroller's ability to play multiple sounds would not work well, as each note would clip the previous note unless you play the notes at the same time. Lastly, decoding MIDI on an audio code would allow us to emulate different types of guitars as will be seen by the instrument select module below. For the audio codec chip we have decided to use the VS1103 MIDI decoder chip. We chose this chip because it has the ability to decode MIDI data and run on fairly low power, as compared to attempting to load MIDI libraries and decode using a microcontroller. This will allow us to feed the raw MIDI data into the VS1103 chip and output the corresponding guitar sound and volume level associated with that MIDI data. This chip contains a digital to analog converter in it, and we will use this converter to output the analog sound to the audio output. This chip runs at a about 2.7V with a maximum current draw of 100mA.

*Requirements: In order to keep the overall current draw under 1.2A this audio codec chip must run under 5v and 150mA, and have the capability to decode MIDI data into its corresponding guitar sound and output that through its own digital to analog converter.*
2.3.3

**Instrument Select:** The instrument select will be one button on the data module that will allow the user to switch between an electric and acoustic guitar. This button will connect to the VS1103 and will signal the VS1103 to change instruments when the button is pressed.

*Requirement: The button must have the ability to signal the VS1103 to change instruments when pressed.*

2.3.4

**Audio Output:** We have decided to use the standard 3.5mm audio output. This audio jack will be connected to the digital to analog converter (DAC) of the VS1103 chip. We decided to use a standard 3.5mm audio output because it is the most versatile and will draw between 20mA-200mA depending on if we use headphones or a small speaker, both of which are within allowable limits to allow for 2 hour portability.

*Requirements: The audio output must be able to connect to the VS1103s DAC and have a device connected to it that is able to output sound that has a draw of less than 250mA.*

2.4 Risk Analysis

The flex sensor accuracy is a significant risk to the success of this project. The sensors are analog devices that change resistance based on how much they are bent. The sensitivity of these sensors dictates the allowable permutations of inputs and thus determines the number of chords available. Furthermore, higher sensitivity may also cause greater difficulty in reading gestures consistently. If there are any lapses in consistency, then the user will find playing to be frustrating. We want the user to feel like they are playing an instrument still and so the number of chords allowed must be diverse, yet still practical for the flex sensors.

3 Ethics and Safety

The primary safety concern of our project is the lithium-ion battery. At high temperatures, the battery may undergo heat failure and combust. We will use a battery back to monitor and ensure the user’s safety. Another point of safety concern is the user’s perspiration that may accumulate while using the gloves. We do not plan on having any circuitry inside the gloves that could potentially shock the user or be corroded by the user. Moreover, the gloves will not be completely closed off and will allow ambient airflow to ventilate the user’s hands. We will ensure that every design aspect of our project is original or properly cites respective references so as to not infringe upon any copyrighted designs of existing products.
References


