# DRUM SMART

ECE 445 Project Proposal — Spring 2020

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# 1 Introduction

## 1.1 Objective

An issue in today's society deals with the amount of opportunities each community throughout America has to offer. For instance, one area might have thousands of available options and possibilities whereas another town could have only a small fraction of the previous community's opportunities. To reduce this difference in opportunity, the Hip Hop Xpress is a bus that will travel to areas and neighborhoods throughout the US to educate people on both music and technology to demonstrate the resources that are available outside of their area [1]. We want to bring each visited community together in an educational way. By adding an interactive device that people could pick up and use, we would have these people physically working with some of the resources their environment does not currently offer. To meet this objective, we plan to design a drum capable of sounding like several other types of drums. It will look just like a marching band drum except the drum pad would consist of a layer of rubber to absorb most of the noise coming from the physical striking of the pad. We want to minimize the sound coming from the strikes because we want the created desired drum sounds to be outputted through a connected speaker through an AUX cable. Our electronic drum will be similar to an actual snare drum in the aspect of force to sound ratio; the harder the strike, the louder the sound. To select the type of drum the user desires, we will implement a control knob the user can twist to select the sound the drum will make when the pad is struck. We also plan to allow the user to control the pitch of every selected drum sound by twisting a control knob to either raise or lower the pitch to add more variation to their drum sounds. To make our drum portable, all our electrical components will be powered by a rechargeable battery.

## 1.2 Background

For many people in America today, they are immensely impacted by their surrounding environment. For example, some individuals have a lot fewer options than others purely due to their communities. Some areas do not present all the possibilities or opportunities that exist around the world. If we are able to demonstrate something that they find very cool or interesting, we have a chance at changing those individuals' futures, hopefully for the better. One way to reach many people and also get a message across is through music [1]. With the help of the Hip Hop Xpress, our idea is to show some simple yet cultivating aspects of music and technology to people that have never seen or even knew of technology like this existing. Overall, we want to spark interest in musical and technological industries hoping that one day, someone visited by the Hip Hop Xpress finds their true passion from interacting with the resources that were not previously offered to them.

The use of technology in music today is very prevalent. Besides gifting musicians with the ability to record their music, technology is also used to develop many of their skills such as rhythmic accuracy, memorization, and expression [2]. Since technology has become such a large part of music, we knew we had to find a creative way to utilize technology with an instrument to achieve our goal of teaching people about both music and technology. However, Drum Smart is not the first solution for addressing our objective. Some techniques that try to solve our issue involve incorporating engagement, utilizing music the users enjoy, and inspiring creativity [3]. We believe Drum Smart demonstrates all the previous methods in one device. Since the user is

physically playing the drum, we are having the user engage with our device. The user can play any music they desire, so they have the option to play music they enjoy or not, the choice is theirs. Drum Smart inspires creativity because there is no electronic drum that allows the user to switch the sound it emits. The most similar product that resembles Drum Smart would be the Rock Band drum set. However, Drum Smart has only one pad to be struck whereas the Rock Band drum set has four separate pads along with a pedal [4]. Our device is also able to be used without having to play a video game, however, the drum set from Rock Band only functions when the game is running. This limits the user to playing only the songs on the game whereas Drum Smart allows the user to play anything they desire.

Our previous idea, Beat Starter, was a simple DJ drum board capable of being used by children, teens, and adults. The board offered a variety of sounds to select from and combine in a loop to create personal beats. To receive user input, the face of the board would have buttons and control knobs. The buttons were for the different instrument sounds, power, and clear function. The turn knobs would adjust volume and BPM. The user's created beats would run in a loop in memory. Beat Starter would also have a simple LCD display panel to indicate the current settings provided by the microcontroller. These settings include volume level and beats per minute (BPM) count. Now, our new idea, Drum Smart, is not a board at all but a marching band drum. Instead of a variety of different instrument sounds, our drum would provide different types of drums and their sounds. Instead of pressing buttons to create sounds, the user strikes the drum pad to create the sound. The user would also have more control over the pitch of each drum sound because we will be implementing a knob to control the pitch of any selected drum sound whereas Beat Starter only offered three options for pitch. Instead of a knob to control volume, we are now having the volume controlled by the amount of force the user strikes the drum pad. Beat Starter needed a display for the user to see the volume level and BPM. Now, we no longer have a need for a display because we will not be using BPM and will not need to show the volume level of each strike. Beat Starter also kept the created beats repeatedly playing in a loop. Our new device will not play any beats in a loop but rather emit that certain sound once per strike.

### 1.3 High-Level Requirements

- One drum sound is emitted for every strike on the drum pad. We do not want two sounds outputted when the pad is only struck once. We want our electronic drum to be as similar to a real drum as possible. Since a real drum does not make multiple sounds from one strike, our device should not either.
- The user has the choice to pick between four different types of drums. The types of drums we wish to include are snare, tenor, bass, and cymbals. These are the main instruments that makeup a marching band percussion section giving the user a variety of drums to pick from increasing the chances the user finds something they enjoy.
- The battery is able to power all the components of the drum for at least four hours without recharging.

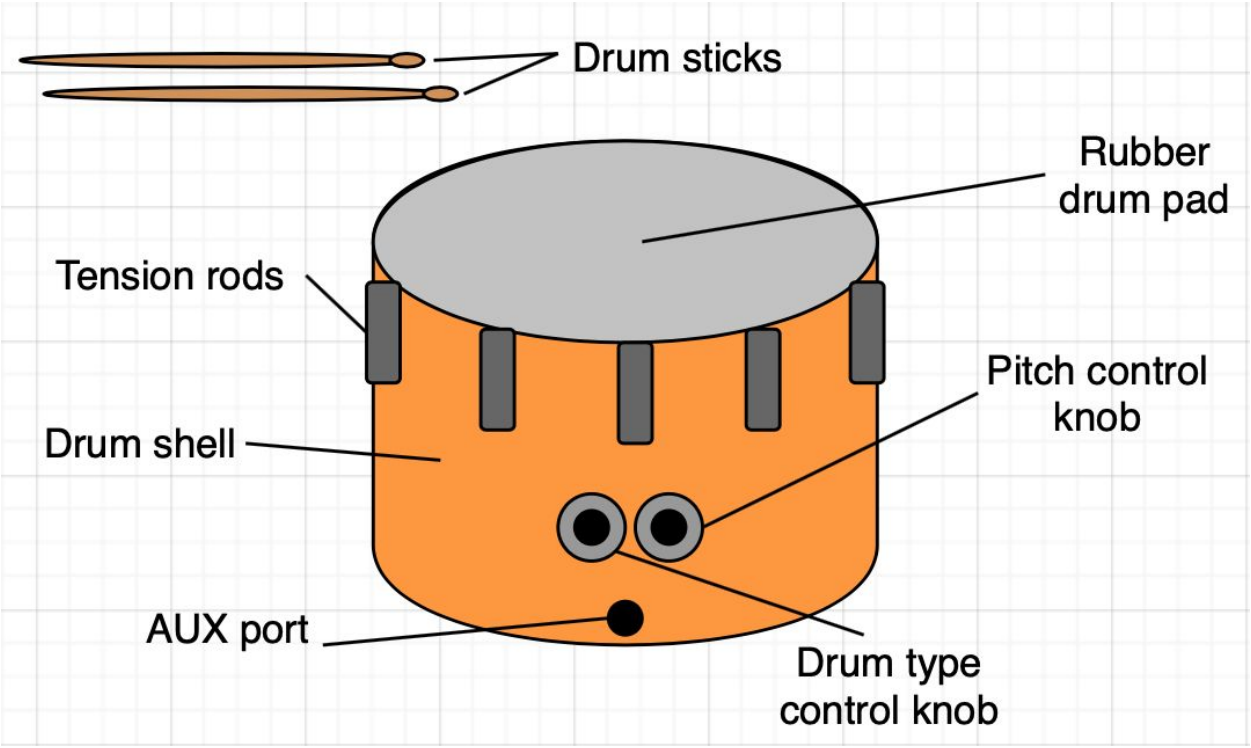


*Figure 1: Physical Design*

*Our drum will look similar to a marching band drum. The user will strike the drum with the drum sticks like a regular drum. There will be a layer of rubber on the drum pad. On the drum shell, there will be control knobs for pitch and drum type selection. Additionally on the shell, there will be an AUX port to connect an AUX cable to play the created sounds through a speaker.*

**2 Design**

Our plan is to design a drum capable of sounding like several other kinds of drums. Our device will look like a marching band drum with a drum pad as a layer of rubber to absorb most of the noise coming from the strikes on the pad. Underneath the rubber, an accelerometer will measure the amount of force used to strike the pad. This data will be sent to our microcontroller. Our microcontroller, a raspberry pi, will use this user input data to access memory to output the desired drum sound. This sound data from memory will be sent to a sound card which will significantly improve the sound quality. These created drum sounds will be output to a connected speaker via AUX. We will implement a control knob the user can twist to select the type of drum sound our drum will emit when the pad is struck. We also plan to allow the user to control the pitch of every selected drum sound by twisting another control knob to either raise or lower the pitch to add more variation to their drum sounds. To make our drum portable, all our electrical components will be powered by a rechargeable battery.

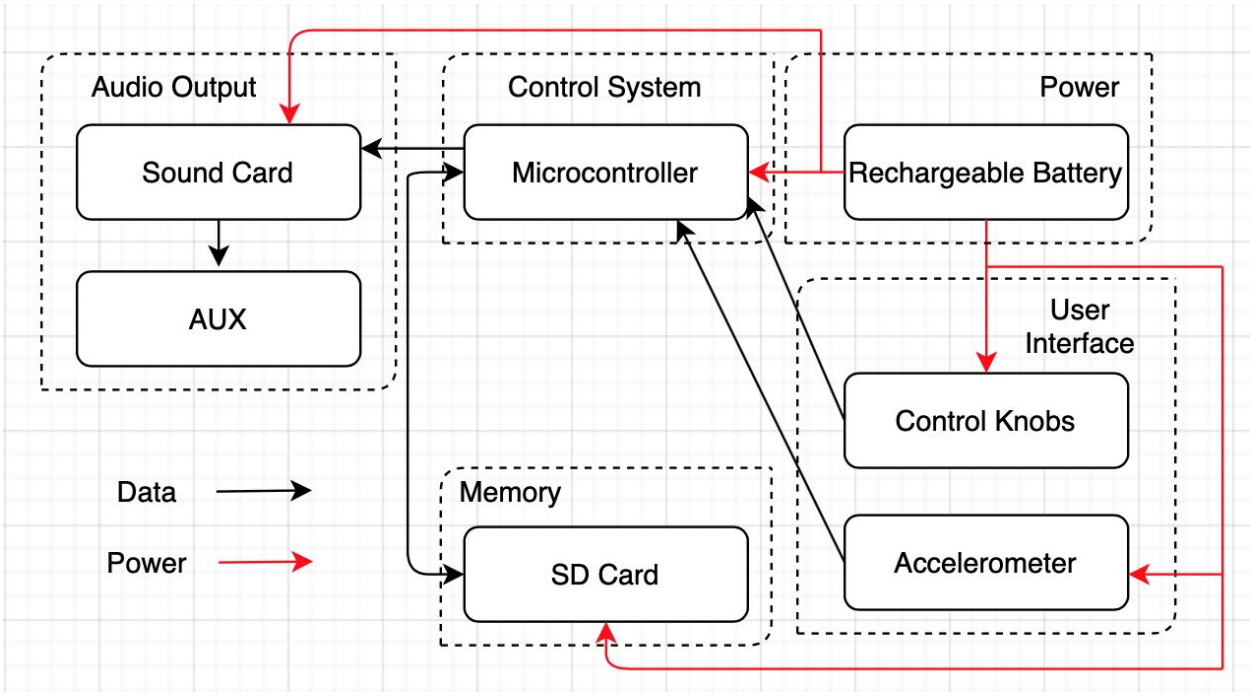


*Figure 2: Block Diagram*

*A rechargeable battery will power our device. The user will be able to control volume by the accelerometer, type of drum by a control knob, and pitch level by another control knob. The data collected by the accelerometer and knobs will be sent to the microcontroller. Our microcontroller will access memory, the SD card, based on the user input data to pull the correct sound from memory. The microcontroller will send this data from memory to the sound card to improve the sound quality. This improved sound is lastly outputted through AUX.*

**2.1 Power**

The power supply will ensure all our components in Drum Smart remain functional. We wanted our device to be portable, so we decided to use rechargeable batteries as our power source instead of using a plug-in which is a big limit where the user can take the device.

**2.1.1 Rechargeable Battery**

Our device utilizes a rechargeable battery that outputs 3.3V and 300 mA [5]. This battery can be recharged using a USB to micro-usb cable. Because the device outputs 3.3V, no voltage regulator is needed. The rechargeable battery allows for portability of the device.

*Requirement: Stored below 60℃. Output 3.3V and 300mA.*

**2.2 Memory**

Drum Smart must store .wav samples that can be played when needed. The memory system must allow for quick access so that the drum hit to sound output delay is not noticeable.

### 2.2.1 SD Card
The .wav files of audio samples are stored onto an SD Card. Using an SD Card, we can store higher quality samples without worrying about limitations of memory. Up to 8 samples can be played at one time. The data from the SD Card is sent to the sound card, then to the output.

*Requirement: Can be read at 250 KB/sec.*

## 2.3 Control System
The control system of the unit must take data inputs from the accelerometer and control knobs and then send the correct wav file to the soundcard for output.

### 2.3.1 Microcontroller
Raspberry pi will be able to take input data from the accelerometer and control knobs. Using this data, the microcontroller decides what audio file from the SD Card to drive to the sound card and at which volume the audio will be outputted.

*Requirement: Function at 3.3V from the battery.*

## 2.4 User Interface
Our desire is to make Drum Smart as similar in use to an average drum, while including parameters that a user can change.

### 2.4.1 Accelerometer
The accelerometer converts the force and acceleration of the drum head into three analog outputs for the X, Y, and Z axis measurements. We chose to use the ADXL337 accelerometer because it has a wide force detection range (±200gs) [6]. This piece reads the amount of force which allows for change of volume of sound output.

*Requirement: Voltage range is 1.8-3.6V. Device typically draws 300 μA.*

### 2.4.2 Control Knobs
Volume Knob: Used to control the overall output volume of Drum Smart. We are using a rotary encoder.
Sample Control Knob: Used to select which sound the drum makes when hit. We are using a snap rotary encoder with 4 sections.

*Requirement: 10 mA at 3.3V is the Power Rating [7].*

## 2.5 Audio Output
After the drum has been activated and a hit has been detected, our device plays the desired sound using the output of a sound card. The audio must be high quality and have negligible delay from hit to sound output.

### 2.5.1 Sound Card
Using a soundcard will significantly increase output sound quality but increase latency. The difference in latency is minimal and the soundcard contains an AUX output. The Sound Card plugs into the USB input of the raspberry pi [8].

## 2.6 Risk Analysis
The control system is a great risk to the success of our project. This is where software meets hardware. Every subsystem of our device is connected to the control system. Significant programming will have to go into our control system to meet our deliverables. Our software will not only use the signal from the accelerometer to determine when a strike has occurred, but also to determine the intensity of the strike. Observing the intensity of the strike is crucial because this will dictate the volume of the outputted audio. Time discrepancy between memory access and outputted audio might be another obstacle we will have to overcome. Lastly, the overall amount of input that can be done at once, along with correct timing of every drum strike, poses perhaps the greatest risk due to the amount of simultaneous data that must be processed.

## 3 Ethics and Safety
Our project, Drum Smart, adheres to the specific ethic and safety guidelines put forth by IEEE and ACM. It is important to practice safety throughout development and use of Drum Smart. We plan on accomplishing this by limiting hazards and electrical hazards. Code 1 of the IEEE Code of Ethics states "to hold paramount the safety, health, and welfare of the public" [9]. The safety of the public is our number one priority. Drum Smart is used recreationally and part of a good experience in ensuring the correct connections of electrical current and creating a reliable device.

An aspect of our device that we were worried could cause hazards is the rechargeable battery. The battery we have selected is an 1800 mAh lithium-ion battery. We will place a warning upon the battery warning the user to not store the device above 60℃, the temperature at which the battery could become hazardous. Adhering to Code 9 of the IEEE Code of Ethics, we will "avoid injuring others" by offering a proper warning of what could cause our system to malfunction, and in turn, harm the user [9].

Drum Smart is a device that can be used by any able-bodied individual that would like to use the product. According to the ACM Code of Ethics, 1.4 emphasizes the value of equality and fairness [10]. Our device encourages use by people of any age or background. Our product specifically targets lower income communities in which Hip-Hop and music has become a focal point of the culture.

According to the CDC, damage to the hearing can be caused by prolonged exposure to sounds over 80dB [11]. Following the advice of the CDC, we want to limit the danger of hearing loss, while allowing for the possibility of loud audio output. In order to be safe and still produce loud audio, we will set very hard drum pad strikes to have a maximum sound output of 80dB.

**References**


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