Music Discovery Band

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1 Introduction

1.1 Objective

Many people do not know how to go about discovering new music because they don't know if they will enjoy listening to it in their current situation. If someone on a treadmill wanted a way to discover new music while they were running, they would most likely have to resort to listening to a specifically-curated, high-energy gym playlist. However, this playlist might not suit the user's tastes after they finish their exercise and might prefer a different type of music to relax to. Currently, Spotify has weekly playlists to discover new music and playlists specifically dedicated to a certain type of mood, but has no functionality to specifically curate a real-time playlist that features unique songs that pertain to a user's physical activity, mood, and surroundings. By considering these factors, the objective of this project is to simplify the seemingly random task of discovering new music for Spotify users.

As mentioned before, there currently exists no technology that can provide song suggestions from the entire Spotify library by keeping track of a person's physical activity levels, environment, and even mood. Our solution is a wearable and interactable wristband that will feature different hardware and software interfaces to accomplish this. By using input buttons to allow the user to signify their mood and using sensors to collect various information including heart rate, acceleration, and background noise, our product will match users to songs that accompany any situation of varying intensity. For example, the wristband would match fast-paced, vibrant songs when the user undergoes strenuous physical activity, or calmer, softer songs to accompany the user doing leisurely activities around the home.

1.2 Background

While there exists no clear-cut method to determine an individual's music preferences, research shows that there are many external influences that may impact one's musical taste. According to a study done at Western Oregon University, one external factor to musical preference is prior exposure due to societal influence [1]. It makes sense that people would prefer music that they are already familiar with, as these are the types of music that society deems popular. However, given the objective of our project, it is impossible to determine whether a user is already familiar with the songs that the product queues up. Thus, we must examine other common factors influencing music preferences. Psychologists recommend activity level, mood, and environmental surrounding context [2] to be powerful indicators of the types of music an individual might prefer. People will want to hear different types of music depending on what situation they are in, which is why our wristband will use the sensors and buttons mentioned above to collect as much information as possible about a person's current surroundings and activity level. Using this information, the product will be able to make an educated guess about the type of genre that one would likely want to listen to in their current situation.

1.3 Visual Aid

1.4 High Level Requirements

- A wristband with accelerometer, heart-beat sensor, sound sensor, and button inputs that can accurately track information as it pertains to the user's activity level, surrounding environment, and mood.
- The wristband can transmit the information it collects from its sensors and buttons to the smartphone app through a Bluetooth transmitter.
- The smartphone app's algorithm must take the transmitted information to automatically queue up and play an "appropriate" song from Spotify's library that matches the user's activity level.

2 Design

2.1 Block Diagram

The five main subsystems presented in Figure 1 each execute individual tasks but feed into the operation of one another to link the system holistically. The power subsystem contains a lithium-ion battery and a voltage regulator which will feed a steady voltage output to the other subsystems to assure they stay on when needed. The sensing subsystem activates the sensors that output readings that can determine the current environment and state of the user. This sensing information is then sent to the control subsystem where a microcontroller with Bluetooth transmitting capabilities processes the information. The data from the microcontroller will be sent to the remaining two subsystems, a hardware user interface and a software user interface. The hardware user interface consists of button inputs for mood, on/off, pause/play, skip song, and turn off device. Status LEDs will show the user that their inputs are accepted and are changing the information processed by the microcontroller. The software user interface is a smartphone application that serves as a basic Spotify music player. It will also display the information coming from the Bluetooth transmitter through the sensors' outputs such as heart rate, current acceleration, and levels of ambiance noise. The user can thus see the information that the backend algorithm is processing to find suitable music.

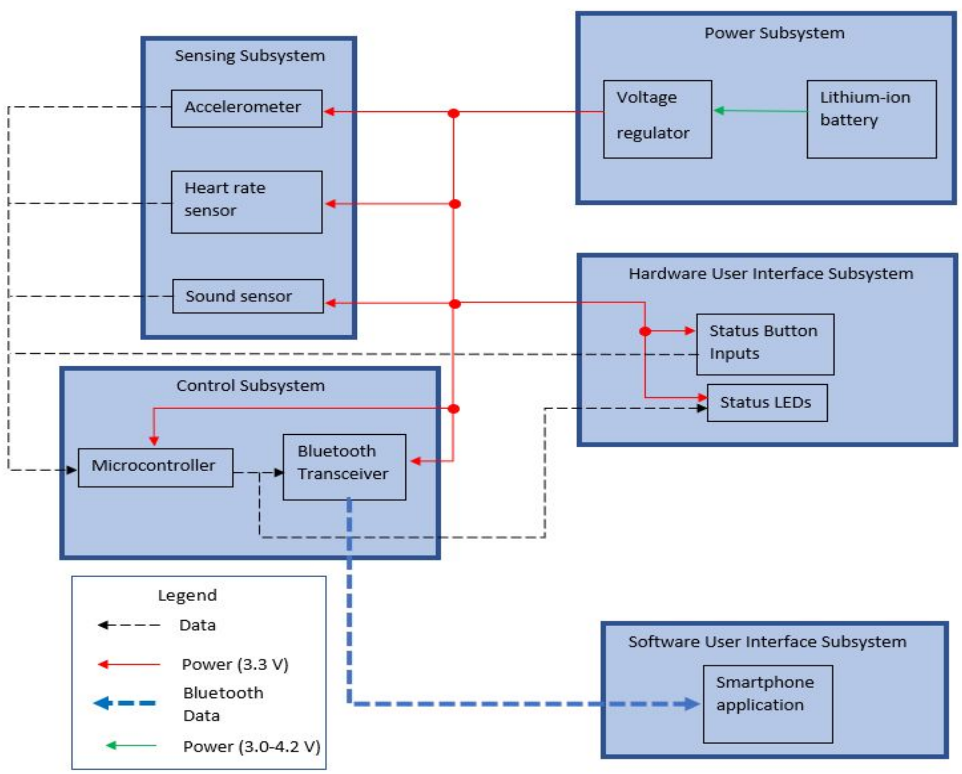

Figure 1. Block Diagram

2.2 Physical Design

The physical implementation of a wristband presented in Figure 2 serves two purposes. The first is that the device is compact and convenient for the user to wear in any environment and the second is that the wristband allows for Bluetooth connectivity with the user's phone since the phone will often be close to the user. Important layout aspects of the various hardware components within the device include the PCB/microcontroller and heart rate sensor on the bottom of the wristband, the sound sensor on the top of the wristband, and the placement of the buttons. The placement of the PCB and microcontroller are important because they will stick out slightly in the wristband and create a flat surface that the user can use to properly orient the wristband. The location of the heart rate sensor allows easy access to the pulse on the bottom of the wrist. The placement of the sound sensor on the top of the wristband is critical as we want to avoid unwanted disruptions such as the sensor bumping or rubbing against objects. Finally, the placement of the input buttons on the outside of the top of the device is also important as they need to be easily accessible to the user and avoid physical interaction, like the ambient noise sensor. These buttons could then also be easily paired with LEDs placed nearby to indicate the change in the user's inputs.

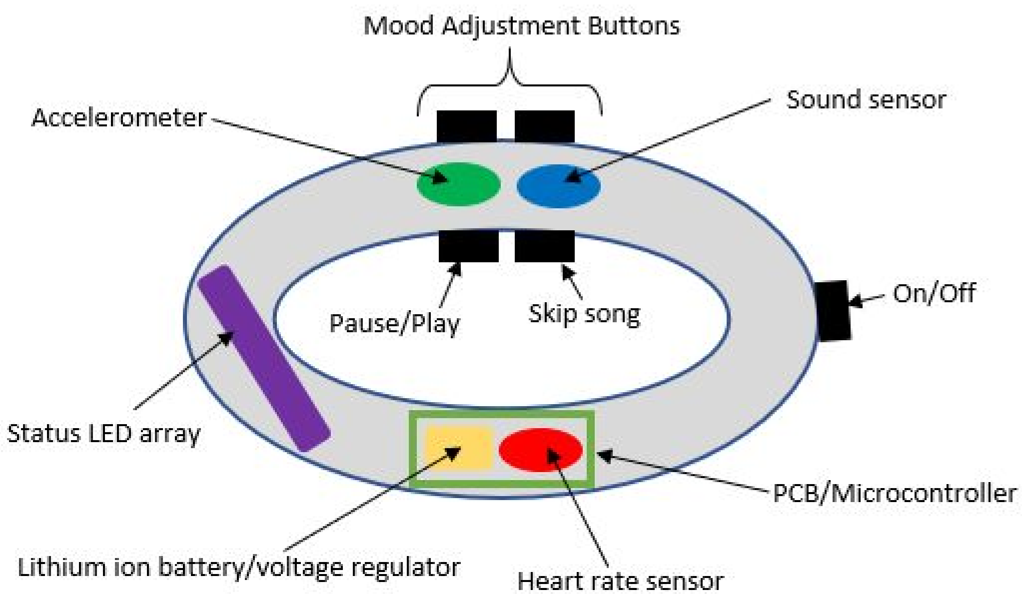

Figure 2. Physical Design

2.3 Power Subsystem

A source of power is necessary to supply the sensing, control, and hardware user interface subsystems. To accomplish this, our design will implement a lithium-ion battery. The voltage provided from the battery must be regulated to 3.3V in order to power the rest of the subsystems of the design.

2.3.1 Lithium-ion battery

The lithium-ion battery will be used as this source of power, providing the wristband with continuous power to allow for uninterrupted use. The power from the lithium-ion battery must power the circuit for an extended period of time. After the battery has run out of power, it should be easy to take out and replace for a new one by the user.

Requirement	Verification
Must supply continuous power to design components for 4-6 hours on full charge.	1. Drain battery charge 2. Provide constant 4.2V to fully charge battery 3. During a 4-6 hours time frame, probe voltmeter to ensure there is above 3.0V being outputted
Must supply between 3.0-4.2 V to the circuit.	1. Measure output at various points in the battery's life using a voltmeter to ensure that the reading is within the required threshold

2.3.2 Voltage regulator

The voltage regulator will be connected to the battery to maintain and provide a constant 3.3V which can be used to power the required subsystems.

Requirement	Verification
Keeps the voltage from the battery into the rest of the subsystems near the target 3.3V (±5%)	1. Measure voltage output using a voltmeter to ensure that the reading is within the required threshold.

Supplies ample current for the design components, and operates between 0-300 mA.	1. Use multimeter on output of voltage regulator to check that output is between 0-300 mA.

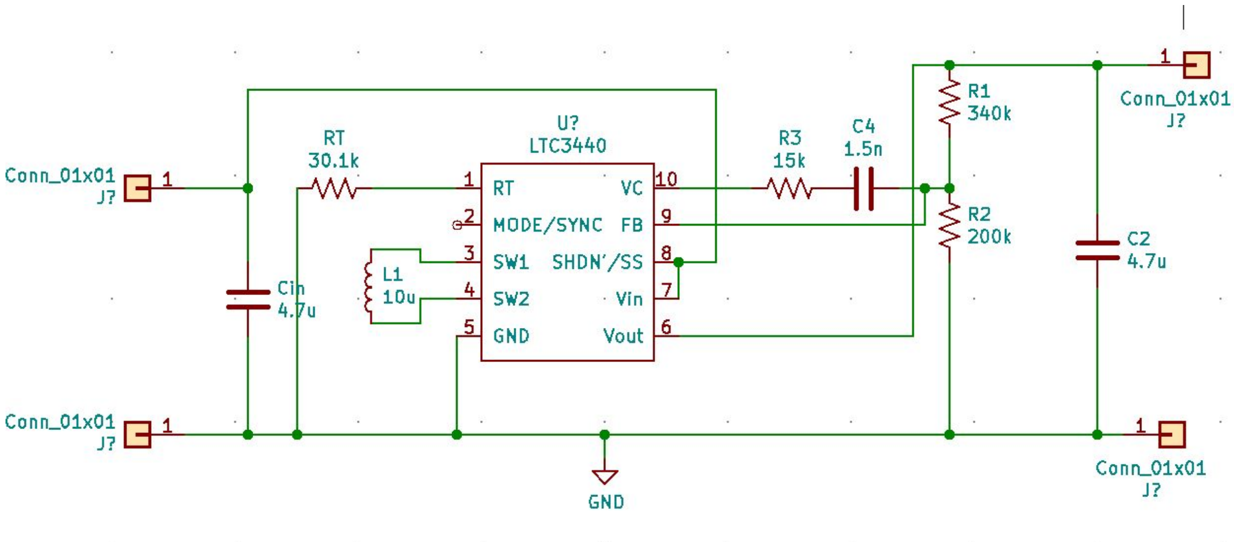

Figure 3. Circuit Schematic of Voltage Regulator

This voltage regulating circuit serves as a buck-boost converter to accomodate for the battery fluctuating from 3.0 to 4.2V. The circuit essentially takes in the input voltage from the battery on the left two pins and sends it through the IC buck-boost to output 3.3V on the right two pins. Important takeaways from the design are the choice of the inductor between SW1 and SW2 which was selected via recommendation from the device datasheet. The input and output capacitors help to maintain a relatively clean DC input and output and serve to stabilize the circuit as much as possible.

2.4 Control Subsystem

The control unit will include a microcontroller and Bluetooth transceiver that will receive data from the sensors and button inputs. This information will then be sent to the status LED lights and the smartphone application.

2.4.1 Microcontroller

The microcontroller will be programmable with software that will allow it to allocate memory for data from each sensor. The microcontroller will process this information and be able to light up the appropriate status LEDs, along with having Bluetooth capability to send the sensor data to the smartphone application.

Requirement	Verification
Must be programmable to control status LEDs, handle button inputs, transfer Bluetooth data, and store data from sensors.	

2.4.2 Bluetooth transceiver

The Bluetooth transceiver on the microcontroller will be used to handle the connection between the wristband and the user’s smartphone.

Requirement	Verification
Must transmit data within a short range, ideally 5 meters.	

2.5 Sensing Subsystem

The sensing subsystem will utilize an accelerometer, sound sensor, and heart rate sensor to capture information on the user’s activity level and environment.

2.5.1 Accelerometer

The accelerometer will be used to accurately detect the current acceleration of the user and any changes in acceleration that can be used to determine how active the user is.

Requirement	Verification
Must accurately gather information of the user’s acceleration to determine amount of physical activity and send the data to microcontroller.	

2.5.2 Sound sensor

The sound sensor will have the capability to detect ambient noise in the user's surroundings by measuring the sound intensity of their environment as another way to fully analyze their situation.

Requirement	Verification
Must be resistant to noise disturbance caused by shifting of the wristband.	
Must accurately collect sound information from sources outside of the wristband and send this information to the microcontroller.	

2.5.3 Heart rate sensor

The heart rate sensor will monitor the user's heart rate to keep track of the intensity of the activity the user is doing. This will then be factored into determining the user's overall situation and what song to select.

Requirement	Verification
Placement of the sensor on PCB should be in the interior of the bottom side of the wrist.	
Must accurately monitor the user's heart rate and send this information to the microcontroller.	

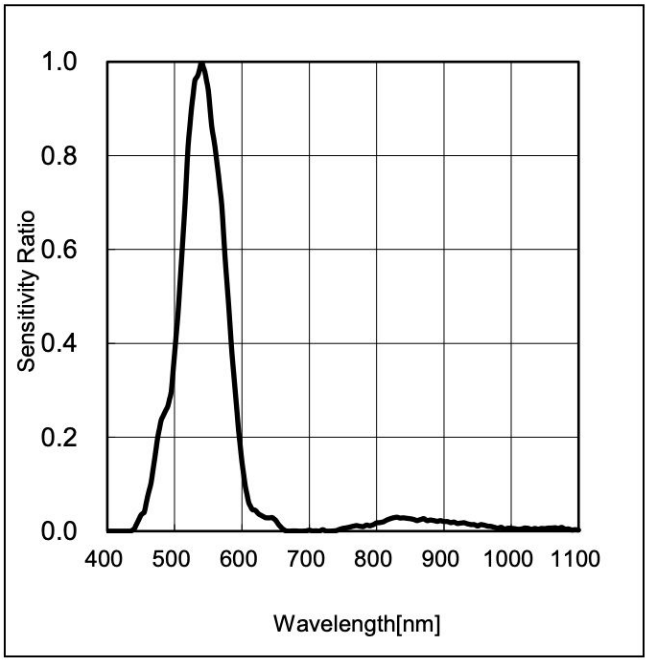

Figure 3. Sensitivity Ratio vs Wavelength for Heart Rate Sensor [5]

2.6 Hardware User Interface Subsystem

The hardware user interface subsystem will contain various button inputs and status LEDs that allow for the user to control music playback and indicate their mood. They can then monitor the status of these button inputs on the status LED array.

2.6.1 Status button inputs

The wristband will include buttons to pause/play a song, skip a song, and indicate mood level. The mood adjustment buttons allow the user to define a numeric value to their mood by giving a range from sad to excited.

Requirement	Verification
Must be easily accessible and clickable by the user.	
Placement must ensure accidental button activation is minimal.	

2.6.2 Status LEDs

Based on the user's button inputs there will be an array of LEDs that will indicate the status of the user's defined mood, playback state, and whether the device is on or off.

Requirement	Verification
Must be easily visible from the user's perspective.	
Must be durable and resistant to damage via outside contact.	

2.7 Software User Interface Subsystem

The software user interface subsystem encompasses the smartphone application that will receive the data from the wristband to determine a suitable song to be played through the user's Spotify account.

2.7.1 Smartphone application

The smartphone application is what will be used to control what songs are being played to the user. Through the wristband's Bluetooth capability, the application will receive the necessary data from the sensors and mood buttons to filter through the Spotify library and queue songs that match what the user's situation is according to the data from the wristband.

Requirement	Verification
Application must be Bluetooth compatible to receive wristband data.	
User interface must be simple and resemble a standard music player.	

Backend of the application must choose a song that is appropriate according to the transmitted information.	

2.8 Tolerance Analysis

A critical component of this project is to detect a user's surroundings and activity level using various sensors, meaning that the sensor's sensitivities and information response time must be carefully considered. The accelerometer and pulse sensors will mainly be used to determine the user's activity level. Activity can be detected by the accelerometer when samples from the sensor are a certain, user-defined amount above the sensor's reference value for a period of time that is also defined by the user, as seen in equation 1. [4]

$$\text{ABS}(\text{Acceleration} - \text{Reference}) > \text{Threshold} \qquad \text{Eq. 1}$$

Taking this into consideration, we can expect our design to have two main modes as they relate to physical activity: "active" mode when the left hand value is greater than the threshold, and "chill" mode when it is less than the threshold. We can tell when the accelerometer gives active measures.

$$\text{Time} = \text{TIME\_ACT}/\text{ODR} \qquad \text{Eq. 2}$$

This gives us an output of the time that has passed since detection of the first occurence of an activity. We will be able to measure this time as long as there is a sustained activity level.

The block within our design that poses the greatest risk to the failure of this project is the sensing block as each of the sensors must work with reliable and consistent outputs. This can be an issue due to excessive movement from the user while using the device for activities such as running that may create unreliable outputs in the sound sensor device. These unreliable outputs might then interfere with the algorithm's process of correctly identifying suitable music. To combat this issue, we are choosing the placement of the sound sensor on top of the wristband opposite of the PCB and heartbeat sensor. We believe that this placement will help in negating some unwanted noise in the ambient sensor from either bumping into objects or the user and be stable in most environments. Another important aspect of this design is that the algorithm needed to choose the song will have to detect unwanted signals from the sensors and give less weight to the choice of the song depending on the reliability of the signal.

3 Ethics and Safety

There is a potential ethical issue that our wristband might discriminate against users that are not able to fit the product around their wrists. To avoid violating code #8 of the IEEE Code of Ethics, our design will be adjustable to fit any size of wrist in order to “treat fairly all persons and to not engage in acts of discrimination” [3].

Another potential ethical issue is that of the durability of the wristband in situations that involve contact with objects or liquids which may damage or destroy the integrity of the circuit. Code #1 of the IEEE Code of Ethics states that our product should “hold paramount the safety, health, and welfare of the public, ... strive to comply with ethical design and sustainable development practices, … [and] disclose promptly factors that might endanger the public or the environment” [3]. To combat this ethical concern the device will be as water resistant as possible to avoid shocking the user or shorting the circuit. Durability will also be compromised if wires connecting the components in our wristband become exposed. To ensure that this is not an issue, our wristband’s exterior will consist of a durable and shock absorbent material to nullify minor physical collisions that may damage the internal circuit or expose wires within the design.

Our wristband will constantly gather information about the user’s activity level, environment, and mood. This can lead to an ethical concern over how someone’s data is used and where this information goes. According to the IEEE Code of Ethics #5, “to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems” [3], it should be clear how the application handles the user’s data and what it is capable of. We ensure that the application on the user’s smartphone is the sole owner of the user’s data and that we do not send or own this information in any capacity. Data is strictly sent through Bluetooth from the wristband to the phone to be used in an algorithm to pick out a song.

To avoid misleading the user about the product’s ability to connect with music services apart from Spotify, the wristband and phone app must clearly reference connection with a Spotify account and various existing songs within Spotify. This can be clearly labelled on the wristband as well as within the phone app. By code #8 from the IEEE Code of Ethics, communication of this is key to both Spotify as well as the user “to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist” [3].

References

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