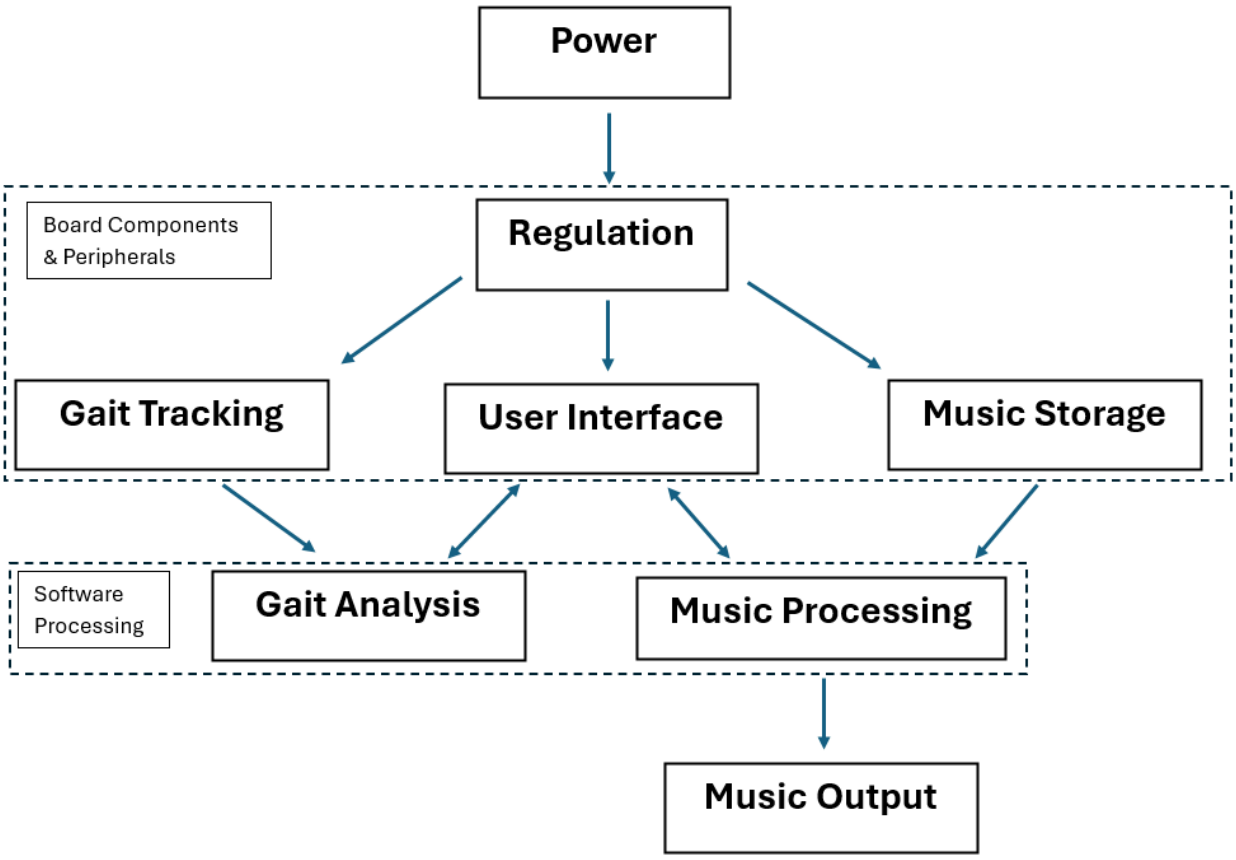
Music Therapy: Design Review 0

Patrick Condon, Ryan Schenck, Laurynas Zavistanavicius, Anna Martelli

1. System Block Diagram

Music Therapy System Diagram



2. Subsystem Requirements

2.1. Subsystem 1: Gait Tracking

2.1.1. Needs to accurately detect motion via our onboard accelerometer. Accelerometer will record when a “movement” has occurred, and (pending further research) our gait analysis will translate these movements into steps. The movements will be quantified, and interfaced to the gait analysis subsystem.

2.1.2. Rugged enough to withstand sudden, quick, and sustained motions up to running speed. Accelerometer should not break down with sudden or accelerated movements. Its physical placement and attachment are factors to consider here.

2.2. Subsystem 2: Gait Analysis

2.2.1. Needs to process the incoming data from the accelerometer into walking steps and specify how much time occurs in between each step. Software uploaded to our microcontroller.

2.2.2. Translate this raw step data into a walking pace, and compare this pace with the user's pre-inputted walking pace.

2.2.2.1. Initial software description: Hold a buffer of "5 steps" worth of data. When a new step is taken, the oldest of the 5 steps in the buffer is replaced with the new step. The average pace is calculated from this 5 step buffer, and when the average pace of the buffer data changes by +/- 10% the music processing software will be told to take action and change the music tempo.

2.2.3. Based on the pace comparison, music tempo recommendations will be sent to the music processing subsystem (whose software is also uploaded to the microcontroller) whenever it is determined that a drastic enough change in pace has occurred that a tempo change is necessary.

2.2.4. The gait analysis should be resilient to any button presses (adjusting volume, for example) while walking

2.3. Subsystem 3: User Interface

2.3.1. Interface focuses on user input, as output is purely audio.

2.3.2. Needs to be simple and intuitive - many of our desired user base are older with limited technology experience. Needs to accurately display music options, and update as selections are made.

2.3.2.1. At this point, pushbuttons seem to be the best option - they can be labeled intuitively and limit the complexity of movements a user can attempt to make when interacting with the interface.

2.4. Subsystem 4: Music Storage

2.4.1. External memory that can store the data needed to present multiple options of music, preferably enough to provide a range of bpm to coincide with desired paces.

2.5. Subsystem 5: Music Processing

2.5.1. Access music and tempo data from the storage location. The music will be stored either in an external flash memory device on the PCB.

2.5.2. Access live gait analysis data (tempo recommendations based on the weighted average of the user's walking pace). The music tempo will be updated to reflect these recommendations when a drastic enough (controllable metric) change in pace has occurred.

2.5.3. Ensure the music is still pleasant to listen to: cannot alter the pitch when altering the tempo. This will require significant real-time signal processing to avoid noticeable pitch changes.

2.6. Subsystem 6: Music Output

2.6.1. Must use a standard jack to connect to headphones or to a loudspeaker

2.6.2. Adjustable volume with push buttons instead of a knob for easier control

2.7. Subsystem 7: Power and Regulation

2.7.1. A rechargeable battery that is not too bulky or heavy to the extent that it makes wearing the device uncomfortable.

2.7.2. Needs to be able to power the whole system for the designated time period. Since this device is not directly connected to the user, worries about power regulation according to other medical devices that interface directly with the body (ex. an electrode) are not relevant.

3. Written Plan for Subsystem Design

3.1. Providing a detailed description of each major subsystem

3.1.1. Power and Regulation

Action Items:

- Identify and purchase rechargeable battery
- Determine which components need regulated and/or unregulated power
- Select appropriate battery power connections and regulators

3.1.2. Gait Tracking

Action Items:

- Identify and purchase accelerometer
- Block out and write the software to identify the movements of the accelerometer that indicates a step has been taken

3.1.3. Gait Analysis

Action Items:

- Plan out needed software function blocks
- Translate information of step recognition to pace and velocity
- Use acquired pace information to guide the music processing
- Look into finding an online example that can be tested

3.1.4. User Interface

Action Items:

- Identify and purchase OLED
- Determine the mechanism (push button, etc) we want for the user
- Determine method of communication between the buttons and OLED

3.1.5. Music Storage

Action Items:

- Identify how much memory we will need to store our music selections, and which flash memory drive will best fit our needs
- Identify necessary connections form datasheet for chosen flash

3.1.6. Music Processing

Action Items:

- Transfer data from the gait analysis subsystem to establish parameters for music tempo alteration
- Plan out software functional blocks, including the connection to gait analysis and mainly focusing on how to alter music tempo in real time
- Investigate DSP for tempo correction in order to maintain pitch and reduce distortion

3.1.7. Music Output

Action Items:

- Identify and purchase output audio jack
- Purchase a speaker to connect to the audio output port
- Investigate any necessary modifications needed to enable headphone use to replace the speaker

3.2. Giving a detailed description of all major components

- According to the action Items listed in 3.1, find the components we intend to incorporate.
- Create a list of each component including its price
  - Ensure that the final output meets our budget constraints
- Based on each components specifications: determine how they will interface
- Describe these components and interfaces with clarity to ensure that the thinking is sound
- Iterate as necessary

3.3. Specify essential connections on all major components

- Create a preliminary KiCad schematic
- Look through component datasheets to identify necessary connections
- Identify and match to available pins on the ESP32 to ensure possible execution
- Identify layout requirements for each components' connections

3.4. Finding and addressing problems we are not clear on

- The tempo digital signal processing appears to be a point of difficulty, so we will further investigate this component
- Further investigate potential issues with respect to programming the accelerator behavior in order to identify that a step has been taken
- Consider how we plan to integrate the gait tracking data and accelerometer into the board and connecting to DSP

4. Written Plan for Subsystem Hardware Demonstration

4.1. Demonstrate that each subsystem is working.

- Ensure the correctly chosen development boards to perform testing
- Write a testing protocol to ensure each subsystem operates as expected before integration

4.2. Provide a preliminary board design that includes all major components, showing appropriate layout and essential connections presented in the previous design review.

- Finalize a schematic and layout in KiCad using iterations from the earlier outlined steps

4.3. Since you will not have created your board yet, it is assumed that the subsystems will be demonstrated using existing kit and development boards and appropriate breakout board.

- First outline our requirements for the development board
- Based on these requirements select the appropriate board (rather than retrofitting our plans to fit with a preselected board)