Smart Exercise Assistant

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1. Introduction

1.1. Objective:

Today, almost everyone is exercising in some way or another but many are uninformed when it comes to the execution of some workout techniques. Every day, there are more than 10,000 people treated in emergency rooms across the country for injuries stemming from sports, recreation, and exercise. Without proper guidance from personal trainers on proper techniques, this puts people at a higher risk of injury while exercising.

We plan to implement a smart wearable tech to improve exercising techniques. The person who is wearing this technology would exercise as usual with data being gathered in the background utilizing Bluetooth sensors attached to the wrists, arm, and shoulder. These sensors will be collecting data from a built in gyroscope and accelerometer which would then be processed using a central hub located on the torso which will be connected via bluetooth to all the Bluetooth sensors. This data would be sent via bluetooth to an app where it would provide feedback to the user on ways to improve form or accuracy of the given exercise. The goal of the app is to select what workout the user wants to do, and our system will gather data on the user performing the exercise and once it is complete, the program will provide tips on how to improve based on the data gathered.

1.2. Background

The problem we are looking to solve is reducing the amount of injuries that occurs to individuals while they are exercising. Some of the many ways to help prevent injuries while exercising would be to stretch and warm up your body beforehand, to have correct form while doing the exercises, or to not lift heavier weights that cause you to break the correct form. We are looking to solve or improve the form that one would use while exercising to help reduce the amount of exercising injuries. **FitBit** has a similar concept as to what we are trying to achieve where they are monitoring a person's physical activity and providing feedback on how one could become healthier as well as tips about eating a more well-rounded diet, and sleeping better. We differ from that in terms that we are looking to improve the quality of the workout that the individual is performing and help prevent injuries by providing feedback to the user. Additionally, our system is supposed to be attached to the body without complex attaching system and without being sewn into workout clothing, unlike many products in the market.

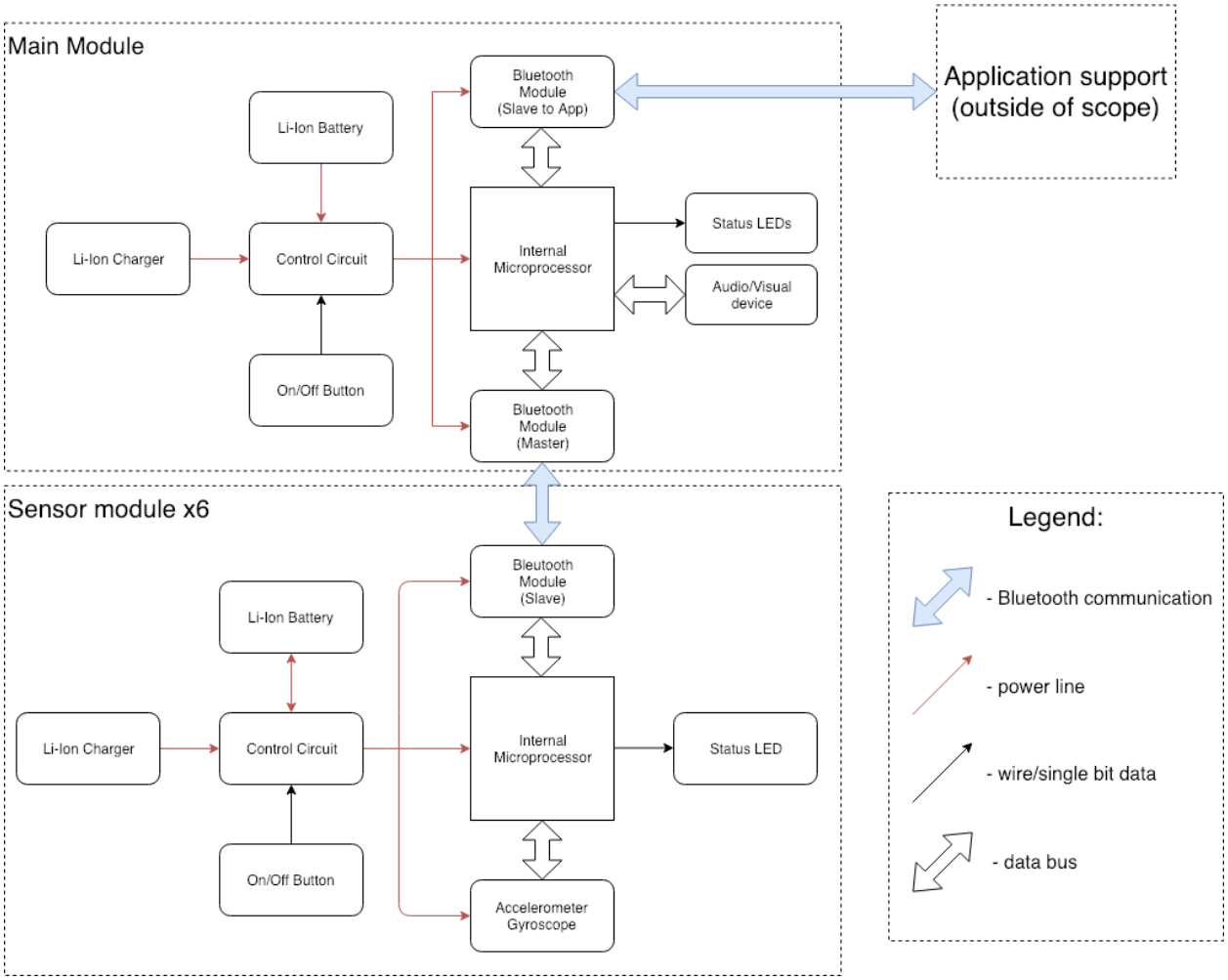
1.3. High Level Requirements

- Our sensors must connect to our central hub to transmit data via Bluetooth.

- Our sensors must be powered by Li-ion rechargeable batteries.
- Our central hub must process incoming data and provide feedback to user.

2. Design

2.1. Block Diagram



2.2. Main Module

This main module is responsible for collecting and processing data received via Bluetooth from the six Bluetooth Inertial sensors.

2.2.1. Li-Ion Charger

Lithium-Ion batteries will be rechargeable by this Lithium-Ion charger which we will incorporate into the power implementation of our BLE sensors. Be sure not to overcharge Li-Ion batteries to reduce battery failure.

Requirement: Must properly charge Li-Ion batteries supplying power to all Bluetooth sensors and Main Module. Must not charge above 45°C threshold rating.

2.2.2. Li-Ion Battery

These small batteries must power all of the Bluetooth Inertial sensors as well as our main module receiver.

Requirement: Must supply between 3.3-5V in order to ensure inertial sensors function correctly and stay below a discharge temperature of 60°C

2.2.3. Control Circuit

Control circuit controls the state of the main/sensor modules, “on” or “off”. Also, it allows for Li-Ion charger to charge the Li-Ion battery while the circuit is in “off” mode.

2.2.4. On/Off Button

Button to turn sensor/main modules on and off.

2.2.5. Internal Microprocessor

The microcontroller, chosen ATmega2560, is responsible for receiving data from 6 sensor modules through Bluetooth module, processing of the received sensor data and decision generation based on this data. The result is then used for the preprogrammed output to the Audio/Visual device. Since our project is going to be data-heavy for microcontroller, we chose this device for its sizable memory of 256KB, which would provide about 12 seconds of data recording.

Requirement: The microcontroller must be able to communicate and process data of about 20 kilo-bytes per second.

2.2.6. Bluetooth Module (Master)

Allows communication to be received from the Bluetooth inertial sensors to the Main Module. Data will be collected from all six sensors simultaneously while exercising.

Requirement: Data must successfully be received from the six Bluetooth inertial sensors and processed.

2.2.7. Bluetooth Module (Slave to Application)

This allows our data to be centralized and sent to an outside application for further user interface connections.

2.2.8. Status LED

LED light would provide some information about main module state. It would blink several times when main module is turned on, and then would provide some other visual feedback, for example it would turn solid color when connection is successful between the Main Module and Bluetooth Inertial sensors.

2.2.9. Audio Visual Device

This is the main user interface through which our project communicates to the user. This will provide feedback to the user after the completion or during an exercise.

2.3. Sensor Module

2.3.1. Internal Microprocessor

Internal component of Bluetooth Inertial sensor which helps process and integrate connections between the sensors and Bluetooth device. Already supplied with the sensor module, being integrated with Bluetooth and inertial sensor.

Requirement: Must provide real-time motion posture of module with data output frequencies of at least 100Hz.

2.3.2. Accelerometer Gyroscope

Built in integrated accelerometer and gyroscope used to collect data sent to be processed.

Requirement: Must get attitude measurement precision to within 0.1 degrees for accurate measurements of position. Must be 3 axis 3 axis Digital Accelerometer and 6 axis 6 axis Gyroscope.

2.3.3. Bluetooth Module (Slave)

Bluetooth device that must send data collected from microprocessor to main module through Bluetooth Serial port Connection Wireless.

2.4. Risk Analysis

Some of the factors that could hamper with the successful presentation of our project include:

- The sensor module being oversized to be on a person's body while exercising. This could be caused by the battery being too big.

- Bluetooth connectivity being unstable, that would prevent the main module from receiving data on a frequent basis. This problem could potentially prevent the microprocessor from being able to differentiate among good posture, incorrect posture and injurious posture due to inaccuracies in data.

- Since this is a wearable device, it would mean that the battery life of the sensor modules and main module is long enough to be used over a period of at least one month, for about one hour per day.

3. Ethics and Safety

Some of the safety concerns we had about this project first started with the Lithium-Ion batteries with the potential exploding [1], considering we would have so many placed on the user. To fix this we will be implementing a separate charging feature where the batteries will not be charging while the user is wearing them. This still brings into the question of them overheating while being on a person who is exercising. To improve this we will separate the battery from the user and circuitry. There is also the issue that the person performing exercises with our devices will be sweating. On top of this, the user would be performing physical exercises and may cause damage to themselves or to the circuits while working out. In order to fix this we will encase our sensors to provide protection from potentially circuit damaging moisture and damage. We are responsible for warning the public of our potential dangers following IEEE Code of Ethics #1 - To hold the public safety first and to disclose factors of our project that might endanger the public. This would also be an example of where we tried to align with the IEEE Code of Ethics #9 -To avoid injuring others through malicious intent. In that there may be a risk and to notify the user and provide protective separation of the battery and main circuit.

We plan to have our design work with anyone to can place the sensors on their arms. This is one implementation of the IEEE Code of Ethics #8 -To treat everyone fairly and not to discriminate. In allowing our device to be used almost universally we see this as something that would help people in their pursuit to exercise. We will also be processing data based on the provided data gathered from the BLE sensors, and in doing so aligning with the IEEE Code of Ethics #3 - To be honest and using the data to provide claims. We will strictly be gathering data from the user, and not generate answers based on false reasoning.

References

[1] Consumer Reports, ‘Why Lithium-Ion Batteries Still Explode, and What’s Being Done to Fix the Problem ‘ 2016. [Online]. Available: ‘https://www.consumerreports.org/safety-recalls/why-lithium-ion-batteries-still-explode-and-whats-being-done-to-fix-the-problem/ [Accessed: 7-Feb-2019].