Project Proposal

Team Omicron

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# Project Description

## Intro

Team Omicron has decided to formally pursue a project involving the creation of a personal fitness data collection device which is to be housed in the sole of a shoe. Yet to be determined is the whether all the data collection and transmission will be placed in the sole of the shoe, or if the data transmission hardware will be housed outside the sole. This device will be supplied with power through passive power supply originating from piezo-electronic materials. Data will then be transmitted over Bluetooth from the data collection device to a smart phone running a service to further transmit the data to a remote server. This server will serve a web page for users to view their data. Team Omicron aims to track foot pressure, steps, and weight through the use of this device. Other possible data attributes may include stride length, distance, and cadence.

Initial market research has indicated that the fitness wearables industry is experiencing strong growth, with a forecast for this to continue. While the smartwatch segment has seen lots of competition the past few years, fitness tracking devices which are embedded into the shoe have just begun to show up. Due to the massive size of this market, its predicted growth, and the relatively untapped “smartshoe” market segment, the wearables (for personal fitness) use case has been chosen for this project. The proceeding document will provide greater insight into the project proposal.

## Customer/User

Team Omicron originally identified several possible customers and/or users that could use a fitness tracking device embedded into the sole of a shoe. Some of the possibilities consisted of:

* Runners
* Pedometer users
* Health Insurance
* Companies (for liability protection)
* Medical Professionals (for back/joint diagnosis)
* Personal Health

After performing research into each market, the team found that several of the categories could be collapsed into a single category. That is, runners, pedometer users, and personal health users could all be collapsed into a single category named “Personal Fitness”.

This left narrowed the decision to a factor of 3, all of which showed strong potential. All 3 industries had hundreds of millions of users globally, with total revenues in the billions of dollars. Due to the ease of entry into the personal fitness market, this was the user the team decided the product would best serve.

### Market Size

As mentioned earlier, the wearables industry for personal fitness tracking is an enormous industry. Several sources indicate that hundreds of millions of users purchase personal fitness wearables annually, which translates to revenues in the billions of dollars. In summary, market research found:

* 125.5 million wearable devices were sold in 2017 (Lamkin, 2017)
* Smart clothing shipments (including “smartshoes”) are forecasted to increase by a total of 3.3 million (21.6%) by the year 2021 (Lamkin, 2017)
* The expected annual growth rate is 4.2% (Statista, 2018)
* The average revenue per use in the US is $77.62 and is expected to rise (Statista, 2018)
* 1/3 of the global population used a mobile app or fitness tracking device to track health in 2016 (Statista, 2016)

The fitness tracking wearables market continues to grow and serves as a great entry point into the market. Furthermore, unlike the smartwatch segment, the “smartshoe” segment is relatively unsaturated and presents and even better opportunity for market entry.

### Similar Products

Based on customer discovery and market research, the team found that in the wearable fitness tracking market, there are several large competitors that dominate. While this is true, it mostly applies to categories outside of the “smartshoe” segment. The major companies (such as Apple, Fitbit, Garmin, Nike) have instead exceled in segments such as smartwatches, smartphones, mobile apps, etc. This further highlights the possibility of tapping into a market segment that has not been fully tapped by the major competitors.

While the largest fitness companies have yet to fully enter the “smartshoe” market segment, smaller companies and startups have begun experimenting with this technology. Some of the existing early products/prototypes that are similar to team Omicron’s proposed project are listed below.

#### Sensoria Fitness Shoe

* The Sensoria Fitness Shoe is “Embedded textile pressure sensors at the plantar area of your foot and [a] detachable electronic device”
* Connected to a mobile app
* Tracks pace, speed, ascent/descent, cadence, contact time, foot-landing technique, and impact
* Not available publicly yet

Source: <https://preorder.sensoriafitness.com/>

#### Adidas miCoach Speed Cell

* A detachable shoe sensor that attaches to heel
* Tracks top speed, burst speed, distance, and game time
* Onboard memory for 7-8 hours
* Syncs to mobile devices over Bluetooth
* Tracks soccer, basketball, tennis, rugby, handball, and football

Source: <https://www.soccerone.com/micoach_speed_cell_bluetooth_smart_compatible_p_2082.html>

#### Digitsole

* Startup aimed at providing smart soles
* Controllable through smartphone app
* One concept was a sole that could dynamically heat feet
* Tracks steps, distance, calories
* Other varieties tracked 3D position of feet and stride

Source: [https://gadgetsandwearables.com/2018/07/13/trackers-feet/#Digitsole](https://gadgetsandwearables.com/2018/07/13/trackers-feet/)

#### Altra IQ Sports Shoes

* Syncs shoe to smartphone
* Analyzes impact of foot with ground
* Measures stride, speed, distance, ground contact time, and cadence
* Real time suggestions

Source: [https://gadgetsandwearables.com/2018/07/13/trackers-feet/#Digitsole](https://gadgetsandwearables.com/2018/07/13/trackers-feet/)

#### Lethal Smart Insoles

* Pairs with phone GPS to provide vibration and patterns indicating direction to travel
* Tracks steps, calories, distance, etc.
* Syncs with phone app
* Battery life lasts 15 days

Source: <https://www.amazon.com/Lechal-Navigation-Fitness-Tracking-Insoles/dp/B01GFWQRY4?tag=healthand0fb0-20>

## Problem Solved

This project aims to solve several problems that exist in both smartwatch and phone technology, but also problems that exist the in the currently existing options for smart insoles and shoes.

### Problems

1. Inaccurate data collection (particularly step count)

Many current pedometers are inaccurate in their tracking of steps. A study found that on average, even for major competitors such as Fitbit, step counts for a distance of 400 meters were off by 40 steps. (Husted & Llewellyn, 2017) In addition, a paper published in the *Journal of Personalized Medicine*found that while major smartwatch manufacturers were bad at measuring calories burned during activities. (Dusheck, 2017)

1. Injury due to poor posture

While smartwatches are capable of measuring GPS data, steps, heart rate, and more, they typically are not able to accurately measure posture other than differentiating standing, sitting, and lying down. By levering the piezo-electric materials in the proposed project’s insoles, a pressure map could be collected and used to identify incorrect posture, poor form, and more.

1. Power Supply

Current smart equipment available on the market, whether that be smartwatches or shoes, typically use rechargeable batteries as a power source. This not only is inconvenient, but it adds significant weight to the product which is important for many users. The proposed project aims to use passive power supply from the piezo-electric material.

1. User Experience

Current wearable technologies typically are bulky, heavy, and obstruct a user’s normal range of motion. The proposed project would dramatically reduce this, as the device would be embedded into the sole of a shoe.

1. Weight Tracking

Current wearable technology typically cannot track weight. By utilizing the piezo-electric properties, the proposed project will attempt to accurately measure weight.

# Project Technologies

The technology required for this project will require both hardware and software heavily. In addition to these broader categories, the project will need a few other miscellaneous materials to complete prototyping and design. While it’s impossible to forecast every required material at this time, the following list of materials has been assembled to help guide planning.

## Hardware

### Technology Required

* Pressure sensors

These will be used in the shoe to do a majority of the sensing. At this time, the team is leaning towards using piezoelectric materials due to their ability to generate electrical signals and power when a force is applied to them.

* Microcontroller

A microcontroller will be required for collecting data from the sensors, temporarily storing it, and transmitting it to a paired device using a Bluetooth connection. This microcontroller will, at the least, require ultra-low power consumption, Bluetooth transmitters, AD converters, and be a small size.

* Mobile phone

This will be required to receive data from the shoe’s embedded microcontroller to a remote server capable of large capacity storage.

* Web server

This is required to receive data from mobile phones and store it permanently. Additionally, this sever is necessary for processing the data for analytical insights presented to users through a web application.

* Miscellaneous components

This project will require small, basic electrical components such as wires, capacitors, resistors, etc.

### Familiarity

* Zach Oberbroeckling:
  + Familiar with microcontroller hardware (Embedded Systems courses)
  + Familiar with electrical components
  + Not familiar with mobile phone or web server hardware, but willing to learn.
* Brandon Reed:
  + Experienced with development on microcontrollers and embedded design.
  + Familiar with basic electrical components and circuit design. Unfamiliar with pressure sensor technology.
  + Unfamiliar with web server and mobile phone development.
* James Windorff
  + Experienced with embedded systems through classwork.
  + Familiar with circuits and circuit design.
  + Have a basic understanding of web design and html.
* Mitchell Larson:
  + Experienced with development on embedded systems
  + Familiar with interfacing electrical components with microcontrollers
  + Unfamiliar with mobile phone deployment
  + Unfamiliar with piezoelectric sensors
* Gunther Huebler
  + Electrical Physics/Mathematics (Atomic level to Transient level)
  + Circuit Design/Analysis (Spice Programming, Electrical Debugging)
  + Embedded Systems (Architecture to component design)

### Assistance Needed

To complete this work, team Omicron will likely need access to MSOE’s hardware laboratories for performing both prototype and design work for circuitry.

## Software

### Technology Required

* Web framework

This will be required to receive data from services running on mobile phones, process the data for analytical purposes, and serve a web page to clients. Initial ideas are the Angular 4 framework.

* Embedded software development tools

This is needed to not only write the software for the chosen microcontroller, but also download the program to the embedded systems program memory.

* Android development environment

This will be required to write the service responsible for transmitting data from the microcontroller to the web server.

* Bluetooth Protocol
* Project Management Software

### Familiarity

* Zach Oberbroeckling:
  + Familiar with embedded software development.
  + Not very familiar with web framework, Android development, or Bluetooth Protocol, but willing to learn.
  + Not familiar with project management software but could research and learn.
* Brandon Reed:
  + Experienced with embedded software development.
  + Unfamiliar with web design, android development, Bluetooth, and project management software.
* James Windorff
  + Understanding of the android development environment.
  + Unfamiliar with Bluetooth.
* Mitchell Larson
  + Familiar with web development using the Angular framework and other tools (knockoutJS, LESS, Jade, etc.).
  + Familiar with development in languages meant for embedded systems (C, C++, ARM assembly).
  + Familiar with using project management software though internships.
  + Familiar with several application level protocols, but unfamiliar with Bluetooth.
  + Unfamiliar with mobile application development.
* Gunther Huebler
  + Embedded Systems (Assembly, C, VHDL)
  + Experience with various communication protocols (I2C, USART, component specific), no bluetooth knowledge however
  + General Programming (C++, Java, Fortran, bash, python, Matlab)

### Assistance Needed

As of right now, team Omicron does not foresee needed assistance for software.

## Other

### Technology Required

* Shoes

Shoes will be needed for housing the electrical components and/or smart sole.

* e-textile materials

This will be required for assembling the smart soles which will be placed in the shoe. The e-textile material has not yet been decided.

### Familiarity

* Zach Oberbroeckling:
  + Not familiar with shoe or e-textile technology, but willing to learn.
* Brandon Reed:
  + Have cursory knowledge of e-textiles, and ready to learn more.
* James Windorff
  + Would like to learn more about E-textiles and how they work.
* Mitchell Larson:
  + Not familiar with shoe or e-textile technology, but willing to learn.
* Gunther Huebler
  + Has shoes, no further shoe or e-textile knowledge

## Roles

Based on project needs and team member familiarity, the following roles will be assigned. Note that just because someone has a project role, it does not limit a team members scope to only that role. Roles are just a team members primary focus.

* Zach Oberbroeckling – Embedded system development and interfacing
* Brandon Reed – Embedded system development and interfacing
* James – Android development and Bluetooth interfacing
* Mitchell Larson – Web application development
* Gunther Huebler – Sensors, power, and etextiles.

### Assistance Needed

Team Omicron may require the rapid prototyping lab for assembling and constructing our e-textile materials and fabricating them into the shoe.

# Project Management

Project management will be done using a cloud instance of JIRA, managed and paid for by Team Omicron. Jira will be used to assign tasks, track progress, track time, and aid in minor organizational tasks. Project documentation will be placed in a publicly visible Github repository under the SeniorDesignTeamOmicron GitHub organization. Additional repositories will be created under this organization for version control of software related any web development and embedded controls.

# Glossary of Technical Terms

**Piezoelectric** – electricity or electric polarity due to pressure especially in a crystalline substance.

**Bluetooth** – a standard for the short-range wireless interconnection of mobile phones, computers, and other electronic devices.

**Server** – a computer or computer program that manages access to a centralized resource or service in a network.

**Cadence** – the total number of steps you take per minute.

**Wearables** – an item that can be worn.

**AD converter** – A circuit that translates an analog signal into a digital binary format.

**Microcontroller** – A small computer or integrated circuit that contains memory and input/output peripherals.

**Web application** – an application that is stored on a remote server and served to a user over the internet in a web browser.

**Embedded Systems** – A combination of hardware and software designed for a specific application, often small in size.

**e-textiles** – fabrics that enable digital components and electronics to be embedded in them.

**Spice** – software for simulation of electronic circuits.

**Android** – An open-source operating system for mobile devices.

**knockoutJS** – A JavaScript library to help create responsive user interfaces with underlying data models.

**LESS** – Extension of cascading style sheets.

**Jade** – Template engine for generating powerful HTML user interfaces.

**C** – General purpose programming language ideal for development on embedded systems.

**C++** – High level object-oriented programming language that extends C.

**ARM assembly** – low level language used for writing software on ARM architectures.

**VHDL** – Hardware descriptive language.

**I2C** – synchronous, multi-master, multi-slave serial computer bus protocol.

**USART** – Universal Synchronous/Asynchronous Receiver/Transmitter

**Java** – High level, object-oriented programming language with high portability using the Java Virtual Machine

**Fortran** – high level programming language used for scientific computation.

**Bash** – Unix shell and command language.

**Python** – high level general purpose programming language.

**Matlab** – programming language used for complex numerical analysis.

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