Ankle Injury Prevention

ECE 445 Design Document

Group 14
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1 Introduction

1.1 Problem and Solution Overview

In basketball, the most common injury that occurs is the ankle sprain or ankle roll. This injury occurs when the ankle inverts or everts more than its normal range of motion, thereby tearing ligaments and causing swelling. A tally of all injuries has shown that 13% of injuries at the NBA level [1] and 40% of injuries at the high school level [2] are ankle injuries, making it the most common injury at both levels of play.

Our team's goal is to help basketball players of all levels prevent ankle injuries by monitoring ankle stress throughout a basketball game. After collecting ankle stress data, we plan to analyze the data and show players time instances where they put their ankle under extraneous stress, how stable their ankle behaves on landings (bad landings is the number one cause of ankle sprain) and whether their ankle stress patterns are similar to the patterns of a low injury-risk player or to the patterns of a high injury-risk player. We will measure ankle stress through the design of a shoe outfitted with the appropriate sensors. By measuring ankle stress, we can even design a metric ankle stability that informs professional players of the reliability of their ankles given their movement mechanics. This measure will provide valuable information for coaches to decide players' game time to maximize their output and minimize their injury-risk.

Today, basketball players have access to athletic shoes and ankle braces that may help to support ankle joints, however these do not provide any sort of feedback to the player. Our device goes a few steps further by collecting the ankle range of motion data, comparing that data to the player's normal range of motion, and then providing feedback as to how the player's ankle behaved during a game. Additionally, our solution will be easy to use and will not interfere with a player's performance. In the end, we expect this device to help prevent ankle injuries among basketball players by giving both the player and the coach a better understanding of possible ankle injury.

1.2 Visual Aid

First, there is a need to establish some anatomical terminology for us to quantify ankle motion. An ankle's range of motion happens in three planes: frontal plane, sagittal plane and transverse plane.

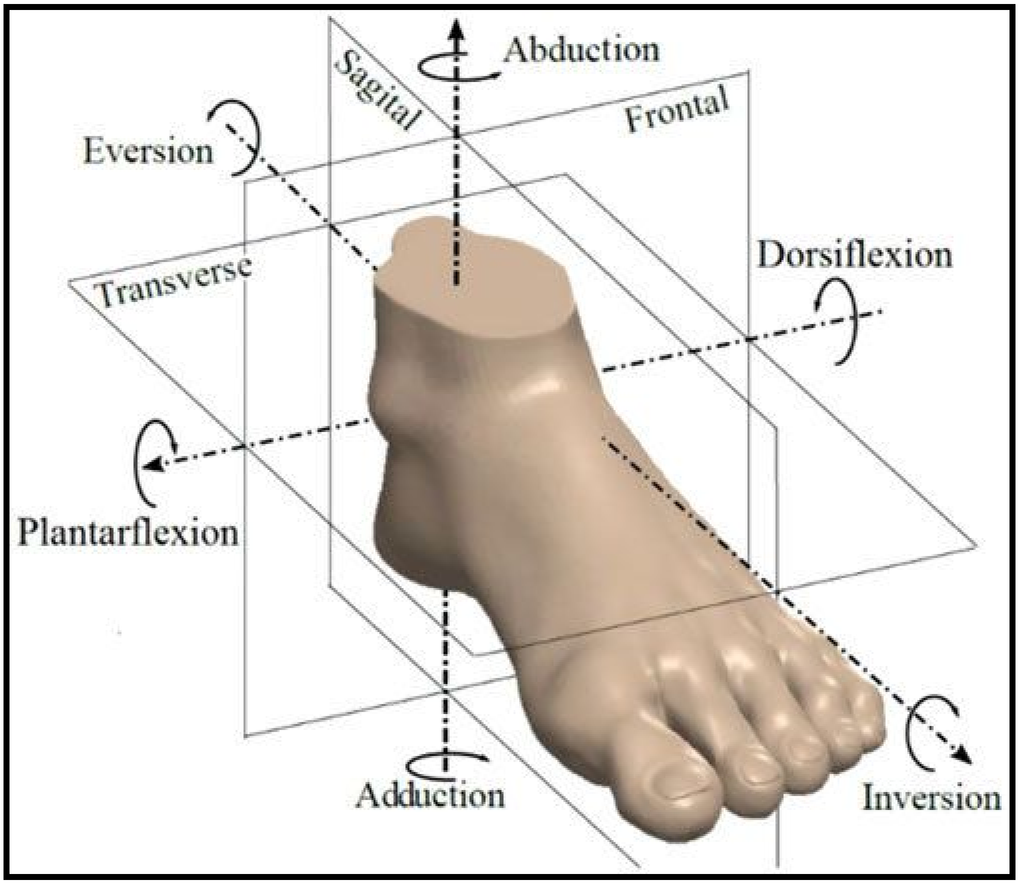

Figure 1: Visual Representation of Ankle Planes [10]

The frontal plane describes the motion of pushing your toes downwards or upwards. The sagittal plane describes the motion of pointing the left or right edges of your foot towards the ground. For this project, we omit examining the transverse plane as few injuries are the result of hyper-extending the ankle in this plane. According to the article, "Biomechanics of the Ankle", these are the normal ranges of motion for the frontal and sagittal planes [3]:

Normal ROM		
Frontal Plane	**Inversion**	23°
	Eversion	12°
Sagittal Plane	**Dorsiflexion**	10°-20°
	Plantar Flexion	40°-55°

Table 1: Normal Ranges of Motion for Frontal and Sagittal Plane

1.3 High-Level Requirements List

- The device must be able to collect and stream data without data drop for a 30 minute period.
- The sensor module is able to detect a player's range of motion (ROM) in each plane and the signal processing module is able to compare that data to the player's normal range of motion for each respective plane. Frontal plane ROM: 23 degrees inversion through 12 degrees eversion; sagittal plane ROM: 10 to 20 degrees of dorsiflexion through 40 to 55 degrees plantar flexion [3].
- The user interface should display informative metrics that tell players how much stress their ankles are experiencing during games and whether the stress they experience could pose any injury risk.

2 Design

2.1 Block Diagram

The power unit will be able to supply power to the signal collection unit for at least 30 minutes to function for the entirety of a basketball game. The physical components, the power unit and the signal collection unit will be designed to inhibit the movement of the player as much as possible. The signal collection, processing and user interface units will all be able to work together to interpret the data and provide relevant feedback to the user. Finally, the pressure and flex sensors of the signal collection unit will be designed to detect the physical angle of the user's ankle and the signal processing unit will be designed to interpret this data and compare it to data of the normal range of motion of the ankle.

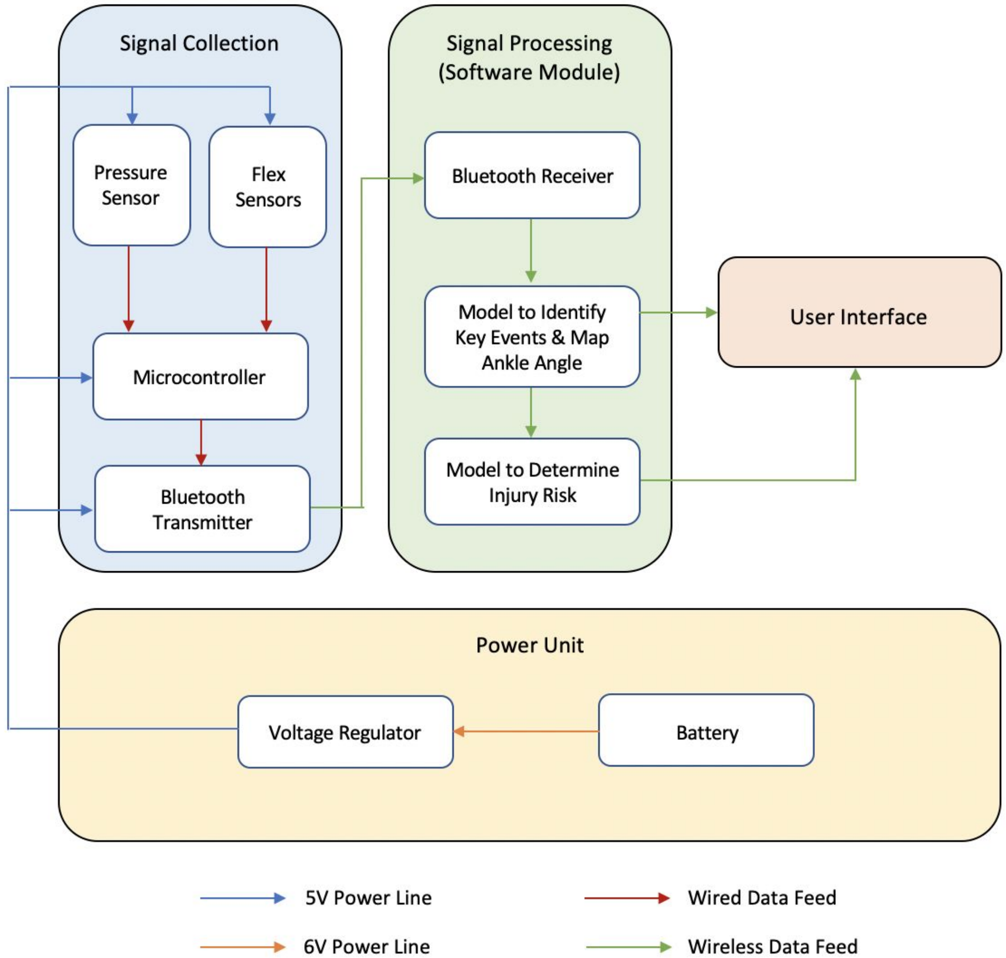

Figure 2: Functional Block Diagram of Ankle Injury Prevention Device

2.2 Physical Design

The system will fit onto a basketball shoe. A pressure sensor will be fitted onto the bottom surface of the shoe, which will help detect when a player jumps and lands. The microcontroller, battery, and Bluetooth components will be packaged and mounted onto the top of the shoe. We thought about placing this package into the sole of the shoe to abstract away the complexities of the design from the user, but we recognized the importance of the sole of the shoe for performance in basketball. Therefore, to preserve the integrity of the shoe, we decided to mount this package on top of the shoe. Flex sensors that help us collect ankle rotation data will be adhered to a soft sleeve that extends upwards from the heel of the shoe. This soft sleeve will adhere closely to the user's ankle, allowing the flex sensors to flex appropriately as the user rotates the ankle.

Figure 3: Physical Design of Ankle Injury Prevention Device

2.3 Power Unit

The power unit is responsible for providing power to the flex and pressure sensors, the microcontroller, and the Bluetooth transmitter. The 6V battery pack will be connected to a 5V voltage regulator to maintain a steady voltage for all of the components.

2.3.1 Battery

We will use rechargeable batteries which will be responsible for powering the microcontroller, Bluetooth transmitter, flex sensors, and pressure sensor. The battery pack will be connected to a voltage regulator, and the voltage will be properly regulated. The 6V battery pack will be charged using an A/C adapter plugged into an outlet.

Requirements:	Verification:
1. Stores and reliably provides 6V for at least a 30 minute period.	1. Discharge to make sure that the battery lasts for at least 30 minutes after a full charge.

2.3.2 Voltage Regulator

The voltage regulator circuit supplies steady DC voltage to other units. The 5V voltage regulator will feed the microcontroller, flex sensors, pressure sensor, and Bluetooth transmitter. The voltage regulator needs to work efficiently and reliably since we have a sensor module. This setup allows us to have a localized power unit, which we can regulate before powering the various blocks.

Requirements:	Verification:
1. Voltage regulator provides 5V (± 5%) from a 6V source. 2. Must maintain the temperature of the chip below 125℃.	1. A) Connect the output of the voltage regulator to an oscilloscope. B) Measure the voltage to ensure that it remains stable at 5V (± 5%). 2. A) While doing the measurement of 1, use an infrared thermometer to measure the IC temperature. Ensure that it will not be hotter than 125℃.

2.4 Signal Collection

This system collects data from the user and transmits it to the signal processing module. It consists of a microcontroller which receives data from the flex sensors and pressure sensor, and passes this data off using the Bluetooth transmitter.

2.4.1 Microcontroller

The microcontroller that will be used for this project is the ATMega328P which is the same chip from the Arduino Uno. The microcontroller will be connected to the power unit as well as the rest of the signal collection unit. It will take in the raw data from the flex and pressure sensors and then utilize the Bluetooth module to transmit the data to the mobile app platform.

Requirements:	Verification:
1. Must be able to communicate with the Bluetooth module. 2. The microcontroller's ADC will be required to read voltage values from the sensors ranging from 0.877 V to 3.061 V.	1. Connect the Bluetooth transmitter to the microcontroller chip and make sure the transmitter and receiver are connected using the Arduino serial monitor. 2. A) Connect the oscilloscope to the analog pins and send varying voltages to them using a flex sensor. B) Compare the oscilloscope values to the values read by the microcontroller.

2.4.2 Bluetooth Transmitter

The Bluetooth transmitter will communicate with the microcontroller using a UART connection. It will send data collected from the sensors through the microcontroller at a fixed frequency to the Bluetooth receiver.

Requirements:	Verification:
1. The transmitter must be able to send the voltage value passed to the microcontroller at a rate of 5 samples/second.	1. A) Connect the Bluetooth module to the microcontroller. B) Send 5 voltage values per second to the Bluetooth receiver for 60 seconds to make sure the values are able to be read by the signal processing module.

2.4.3 Flex Sensors

The four flex sensors will be used to collect data on the angle of the user's ankle. The sensors will use the resistance of the sensor in order to attain a value for normal angle position as well as values for abnormal positions. This data will then be passed to the microcontroller. Two sensors will be used to measure the frontal plane and two will be used to measure the sagittal plane.

Requirements:	Verification:
1. The flex sensors must be able to read the resistances of 10,000 Ω while flat and between 60,000 Ω and 110,000 Ω while bent, with an tolerance of 30%.	1. A) Connect an oscilloscope to a test circuit containing a voltage source and a flex sensor and another resistor of varying value. B) Measure the voltage across the flex sensor at flat, and at angles varying from 0-90° in increments of 10°. C) Use the values measured on the oscilloscope to and compare to the value calculated for that degree measurement.

2.4.4 Pressure Sensor

The pressure sensor will be used to collect data on when varying levels of pressure are applied by the user. It will also be used to determine when the user is jumping and landing. The sensor will be able to attain the value for the normal amount of pressure placed on the foot by the user and compare that to any abnormal amount of pressure signaling a key event. The data will then be passed to the microcontroller.

Requirements:	Verification:
1. The pressure sensor must be able to read values in the range of 0-100 lbs in order to help identify key events such as jumps, lands and push offs.	1. A) Connect an oscilloscope to a test circuit containing a voltage source and a pressure sensor and another constant resistor. B) Measure the voltage pressure sensor with weights ranging from 0-100 lbs, in increments of 10 lbs. C) Use the values measured on the oscilloscope to calculate the resistance of the pressure sensor and compare them to the calculated values.

2.5 Signal Processing

The signal processing unit is responsible for receiving the sensor data from the microcontroller, processing that data to derive physical measurements such as angles and pressure to understand the user's ankle motion and finally using those measurements to determine the user's risk of injury. We plan to implement all of this system through software on the user's personal device. For our demo, we plan to demonstrate the implementation of this system on a computer considering our proficiencies programming on computers. However, this system can easily be ported over to mobile devices with the help of mobile development programmers in the future.

2.5.1 Bluetooth Receiver

The Bluetooth receiver is a software module that utilizes our user device's Bluetooth capabilities to receive the stream of flex sensors and pressure sensors data from the microcontroller.

Requirements:	Verification:
1. Software module receives data without loss through Bluetooth.	1. A) Verify that values are sent to the software module accurately: Set-up independent flex sensor and pressure sensor. B) Activate sensors to their minimum and maximum values and observe values received via Bluetooth. C) Confirm if values received align with our understanding of the sensors. D) Verify that no data is lost: Activate a sensor for 10 seconds. E) Calculate expected number of samples using sampling frequency. F) Check if the Bluetooth system received that many samples during the duration.

2.5.2 Model to Map Ankle Angle & Identify Key Events

This is the software module where we establish basic digital understanding of how the ankle is being used in the real-world. We implement identifying key events in basketball (jump, land, push-off) through analyzing the pressure sensor raw data. We also need to understand the ankle by mapping its real-world position into angle measures through interpreting the flex sensors raw data.

The main purpose of the flex sensors is to model the position of the ankle at any given moment during the game. As we have also derived in our tolerance analysis, the relationship between resistance and flex sensor angle as well as the detected voltage level and resistance are:

$$R_x = \frac{R_{max} - R_{min}}{90°} * \theta + R_{min}$$

$$V_o = V_{cc}\left(\frac{R_x}{R_1 + R_x}\right)$$

Hence, there exists a mapping from voltage output by ADC to flex sensor angle as below:

$$\theta° = \frac{\frac{V_o R_1}{V_{cc} - V_o} - R_{min}}{R_{max} - R_{min}} * 90°$$

This module will read the voltage output values. We can map these voltage output values to the specific angles the flex sensors are at using the equation above.

To account for device error of the flex sensors, we read the values of two sensors for each plane of rotation. When two sensors don't agree in value at a time instance, we can assume one of the flex sensors is experiencing device error and throw away that data point. If two sensors agree in value at a time instance, we can take the average of their values to be the angle of the ankle for that plane of rotation. The readings can be smoothed using neighboring values.

The main purpose of the pressure sensors is to detect when the user is undergoing high-risk events - jumping and landing. When the user jumps or lands, there will be a spike in the pressure sensor indicating the user's feet experiencing high pressure during those time instances. To detect these spikes, we can use filters that are of spike shapes. Whenever convolving a filter produces a large value, we know a jump or landing is occurring. We know that if there is a jump, there must be a landing. So we can accurately label jumps and landings.

Requirements:	Verification:
1. Model maps out ankle angle on both the frontal and sagittal plane accurately. 2. Model determines when jumps and landings are occurring accurately.	1. A) Have the user move the frontal plane across its full motion - start at 23° inversion and step to 12° eversion with 1° increments. B) Confirm if flex angles calculated align with physical measurements of ankle angles. C) Have the user move the sagittal plane across its full motion - start at 15° dorsiflexion and step to 40° plantar flexion with 1° increments. D) Confirm if flex angles calculated align with physical measurements of ankle angles. 2. A) Have the user jump in a variety of different ways. B) Confirm if jumps are detected by model with at least a 90% accuracy. C) Confirm if landings are detected by model with at least a 90% accuracy.

2.5.3 Model to Determine Injury Risk

The previous module "Model to Map Ankle Angle and Identify Key Events" is a module that describes the usage pattern of the user's ankle. The aim of this module is to use this digital description of the user's ankle to determine if the user has an injury risk.

It is highly important to note that this is not a model that informs the user definitively when an injury will occur. That is simply not possible to build in real-life. This model aims to alert the user when their ankle is being overly stressed and to remind them to rest.

After reading medical journals, we understand that significant factors that affect ankle injury risk are: previous ankle injury, height and weight, limb dominance, lack of warming up before activity, muscle & ligament fatigue etc.

Our product can help assess two of these factors:

1) Limb dominance: if an athlete tends to use one foot more predominantly than the other, their risk of injury increases
2) Muscle & Ligament fatigue: like other muscles and ligaments in the body, ankle muscles and ligaments can be fatigued. When they are fatigued, they become less supportive, increasing risk of injury.

We can compute several important metrics that work to inform us of these factors:

<table>
<tr><th>Metric</th><th>Calculation</th><th>Purpose</th></tr>
<tr><td>Total Ankle Stress</td><td>Ankle muscles and ligaments are working hard to stabilize the ankle when the ankle is in a non-neutral position.
To calculate this metric, we find the area between an ankle angle threshold and the ankle angle curve.</td><td>The total amount of ankle stress a player undergoes during one game can be an indicator to their ankle fatigue. This can be informative in the number of minutes they should play in the next game.</td></tr>
<tr><td>Average Ankle Stress per Minute</td><td>Standardize “Total Ankle Stress” by dividing by the minutes the player has played.</td><td>This will make Ankle Stress comparable across players who play a different number of minutes, helping us understand if a player is using their ankle excessively relative to other players.</td></tr>
<tr><td>Jump Ankle Variance</td><td>Calculate the variance in ankle angle for both planes when a player jumps</td><td rowspan="2">Jumps and landings are high-impact events where the player places the most stress on their feet and ankles. The amount of “wobble” of their ankles indicates their muscle strength. If there exists more wobble as time progresses, we can detect the player has ankle muscle fatigue.</td></tr>
<tr><td>Landing Ankle Variance</td><td>Calculate the variance in ankle angle for both planes when a player lands</td></tr>
</table>

Table 2: Ankle Metrics and Calculations

Requirements:	Verification:
1. "Total Ankle Stress" calculation reflects how much a user is utilizing their ankle muscles accurately 2. "Ankle Variance"	1. A) Record or simulate three sessions of data. B) In the first session, have the ankle flex to its maximum range of motion. C) In the second session, have the ankle be in a neutral position. D) In the third session, have the ankle move around and stabilize at its neutral position for intervals. E) Verify if "Total Ankle Stress" for session 1 is the largest, followed by session 3, followed by session 2. 2. A) Record or simulate three sessions of data. B) In the first session, have the ankle wobble largely during a jump/landing. C) In the second sessions, have the ankle be stable during a jump/landing. D) In the third session, have the ankle wobble mildly during a jump/landing. E) Verify if "Ankle Variance" for session 1 is the largest, followed by session 3, followed by session 2.

2.6 User Interface

2.6.1 User Interface

This system receives processed data from the signal processing unit and displays this data to the user.

Requirements:	Verification:
1. The interface must be able to display the processed data to the user within 1/2 second of the data being sent from the signal collection module.	1. A) Start with the completed signal collection circuit and signal processing module. B) Keep the flex sensor at an angle that is within 0 and 50°. C) Make sure the interface displays that the ankle is in safe angle range. D) Bend the angle to 90°. E) Make sure the interface displays that the ankle angle is at an unsafe angle range within 1/2 second of bending the sensor.

2.7 Tolerance Analysis

The most critical feature of our project is being able to accurately measure the angles of the ankle throughout a basketball game. In one of our high-level requirements, we specify that the flex sensors should be able to detect a player's range of motion in each plane and the signal processing module should be able to compare that to the normal range of motion for each respective plane. In order to successfully meet this requirement, we must analyze the range of possible ankle angles, the corresponding flex sensor resistance range, the corresponding voltage divider voltage range, and the granularity of the microcontroller's ADC to convert these voltage values.

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We will look at a single flex sensor and its corresponding voltage divider circuit, as shown in figure 4. V_{cc} is the supply voltage, R_1 is a constant resistance, and V_o is the output voltage fed into an analog pin of the microcontroller. For our analysis, we will represent the resistance of the flex sensor when flat as R_{min} and the resistance of the flex sensor when bent 90 degrees as R_{max}. It is necessary to use variables for these calculations since the flex sensor we plan to use has a resistance tolerance of 30%, meaning that at any given bend angle, the resistance may have up to

30% error [7]. Therefore, we cannot accurately predict the minimum and maximum resistance of the flex sensor until we perform a series of tests.

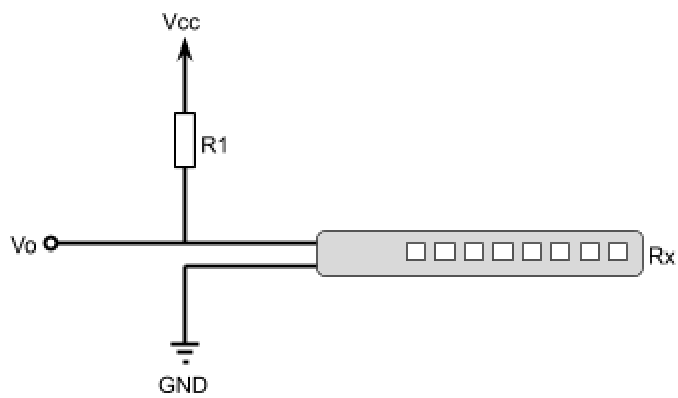

Figure 4: Flex Sensor Voltage Divider Circuit

We can calculate the output voltage, V_o, using the voltage divider rule. From there, we can derive an expression for the flex sensor resistance, R_x, in terms of the constant resistance, R_1, the supply voltage, V_{cc}, and the output voltage, V_o.

$$V_o = V_{cc}\left(\frac{R_x}{R_1 + R_x}\right) \textbf{ [V]}$$

$$R_x = \frac{V_o R_1}{V_{cc} - V_o} \textbf{ [}\Omega\textbf{]}$$

From these equations, we can easily see the relationship between R_x and V_o. As the angle of the flex sensor increases, the resistance of the flex sensor increases, which also increases the output voltage, V_o. Next, we can derive an equation for the bend angle of the flex sensor in terms of the minimum (R_{min}), maximum (R_{max}), and current (R_x) flex sensor resistance, with knowledge that there is a linear relationship between bend angle and resistance.

Angle (θ)	**Resistance (R_x)**
0°	R_{min}
90°	R_{max}

Table 3: Known Angle and Resistance Correlations

$$slope = \frac{R_{max} - R_{min}}{90° - 0°} = \frac{R_{max} - R_{min}}{90°} \textbf{ [}\Omega\textbf{/degrees]}$$

$$R_x = slope * \theta + R_{min} = \frac{R_{max} - R_{min}}{90°} * \theta + R_{min} \textbf{ [}\Omega\textbf{]}$$

$$\theta = (R_x - R_{min})\left(\frac{90°}{R_{max} - R_{min}}\right) \textbf{ [degrees]}$$

Using these equations, we can now calculate the range of voltages that the microcontroller's ADC will be responsible for converting. In order for our design to be successful, we need to confirm that the ADC is capable of reading this entire range of values. We need to be able to collect data over the entire normal range of motion of the ankle plus 5% in all directions, accounting for differences in ROM across players as well as the possibility of hyper-extension. Therefore, table 4 shows the angle range for each plane of the ankle that we should be able to detect with our flex sensors:

		Normal ROM	+5%	Full ROM
Frontal Plane	Inversion	23°	1.15°	24.15°
	Eversion	12°	0.6°	12.6°
Sagittal Plane	Dorsiflexion	10°-20°	1°	21°
	Plantar Flexion	40°-55°	2.75°	57.75°

Table 4: Full Angle Range for Each Plane of Ankle

Since our goal is to confirm that the ADC can read the entire range of voltages corresponding to the bend angle of the flex sensor, we will use the largest full ROM, 57.75°, for our analysis.

$$R_x = \frac{R_{max} - R_{min}}{90°} * \theta + R_{min}$$

$$R_x = \frac{R_{max} - R_{min}}{90°} * 57.75° + R_{min} = 0.642(R_{max} - R_{min}) + R_{min} = 0.642R_{max} + 0.358R_{min}$$

$$V_o = V_{cc}\left(\frac{R_x}{R_1 + R_x}\right)$$

$$V_o = V_{cc}\left(\frac{0.642R_{max} + 0.358R_{min}}{R_1 + 0.642R_{max} + 0.358R_{min}}\right)$$

According to the ATmega328P datasheet, a typical operating voltage for the microcontroller is 5V [8]. Additionally, according to the SEN08606 datasheet, the expected resistance value of the flex sensor while flat is 10,000 Ω, while the expected resistance range is between 60,000 Ω and 110,000 Ω [7]. We will use the maximum resistance, 110,000 Ω, in order to perform our calculations assuming the largest range of values possible. Finally, we will use a 47 kΩ resistor for the constant resistance. Therefore, assuming V_{cc} = 5V, R_{min} = 10,000 Ω, R_{max} = 110,000 Ω, and R_1 = 47,000 Ω, then the maximum voltage value that the analog pin of the microcontroller will need to read is 3.061 V. The minimum value will be when $R_x = R_{min}$ = 10,000 Ω. Therefore, the minimum voltage value that the analog pin of the microcontroller will need to read is 0.877 V.

Since the relationship between angle and resistance for the flex sensor is linear, a change in angle will result in the same change in resistance for any initial angle value. A reasonable granularity for angle measurements is 0.1 degrees. Again, assume V_{cc} = 5V, R_{min} = 10,000 Ω, R_{max} = 110,000 Ω, and R_1 = 47,000 Ω

$$\Delta R_x = \frac{R_{max} - R_{min}}{90°} * \Delta\theta$$

$$\Delta R_x = \frac{110{,}000 - 10{,}000}{90°} * 0.1° = 111.1\ \Omega$$

$$\Delta V_o = V_{cc}\left(\frac{\Delta R_x}{R_1 + \Delta R_x}\right)$$

$$\Delta V_o = 5 * \left(\frac{111.1}{47000 + 111.1}\right) = 0.0118\ V$$

To conclude, the microcontroller's ADC will be required to read voltage values ranging from 0.877 V to 3.061 V to detect ankle ROM up to 57.75°. The ADC will need to have a resolution of 0.0118 V for us to have an angle resolution of 0.1°. This is feasible since the ATmega328P has an ADC resolution of 0.00488 which is more precise than the required resolution.

2.8 Covid-19 Contingency Planning

In the event that all of our group members must be online-only, depending on when this would occur, our overall project should have little to no change. The three of us will continue to meet over Zoom to discuss the project and our individual progress. Erin and Matt will be responsible for all hardware aspects of the design, as they will remain on campus and will have access to all of the parts that have already been assembled. Skyler will be mainly responsible for the software aspects of the design, including all code necessary for interpreting the collected data. If the machine shop is unable to complete the design of the shoe before classes are to go online, a working prototype will still be able to be constructed to perform tests, but it will not be the same quality as the work that can be done by the machine shop. Requirements and verifications will be more difficult to meet without access to lab equipment, however we have planned our schedule such that we should be able to get started on testing as early as mid-October. In the case that we are not able to create a working prototype, we will simulate the signals collected by the device and continue to develop our software module.

3 Cost and Schedule

3.1 Cost Analysis

3.1.1 Cost of Parts

Part Name	Cost Per Part ($)	Number of Parts	Total Cost ($)
ATmega328P Microcontroller	$2.18	1	$2.18
HC-05 Bluetooth	$9.22	1	$9.22
SEN 08606	$15.95	4	$63.80
Pressure Sensor	$19.95	1	$19.95
Battery	$3.75	4	$15.00
Battery Pack	$1.79	1	$1.79
LP38692	$1.93	1	$1.93
Resistor Kit	$7.95	1	$7.95
Basketball Shoe	$70	1	$70.00
Machine Shop Parts	Not yet estimated		
Total			**$191.82**

3.1.2 Cost of Labor

Name	Hourly Rate ($)	x	Hours Per Week	x	Number of Weeks	x	Overhead Factor	=	Cost ($)
Skyler Shi	$40		10		14		2.5		$14,000
Matt Miller	$40		10		14		2.5		$14,000
Erin Sarver	$40		10		14		2.5		$14,000
Total									**$42,000**

3.1.3 Total Costs

Type	Cost ($)
Parts	$191.82
Labor	$42,000
Total	**$42,191.82**

3.2 Schedule

Week	Skyler	Matt	Erin
10/4	Finish buying parts	Work on breadboard prototype	Work on designing PCB with Eagle
10/11	Finalize ankle metrics Design user interface	Finish work on PCB and order PCB	Finish work on PCB and order PCB
10/18	Program ability to simulate flex sensor and pressure sensor data	Work with machine shop on packaging design	Start testing PCB and sensor functionality
10/25	Code Module 2.5.2 Code Module 2.5.3	Verify Bluetooth capability and communication	Continue testing
11/1	Code Module 2.5.2 Code Module 2.5.3 Create User Interface	Conclude testing	Conclude testing
11/8	Start prepping for demo	Start prepping for demo	Start prepping demo
11/15	Final preparation for demo	Final preparation for demo	Final preparation for demo
11/22	Thanksgiving Break - Start prepping for presentation		
11/29	Final preparation for presentation	Final preparation for presentation	Final preparation for presentation
12/06	Work on final paper	Work on final paper	Work on final paper

4 Discussion of Ethics and Safety

It is important that we assess the possible ethical and safety issues relevant to our project. First, we will consider the possible safety hazards involved. This is consistent with satisfying the ACM General Ethical Principle 1.2 “Avoid Harm” [4]. Since this device will be used in close contact with a person’s ankle, the possibility of device failure is a potential hazard. In the case of a short circuit, our rechargeable batteries would explode, releasing shrapnel and acid. Additionally, a short circuit could be accidentally created if our waterproofing solution were to fail, allowing too much moisture into the circuit. Therefore, it is of extreme importance that we are sure to properly waterproof the design. The group must also ensure that the device does not exceed 110 degrees celsius in order to prevent a burn to the user’s skin [9]. It is also extremely important that, when testing the final product, that the person wearing the device does not injure themselves in an attempt to demonstrate that the device works as intended. The group must ensure that the testing done on the device ensures the person wearing it is safely. In order to ensure that the safety concerns are mitigated for this project, lab safety documents for the batteries will be included and thorough testing will be done to ensure that the device is water resistant.

Next, we will consider the possible ethical issues involved. Our project collects and processes potential Protected Health Information (PHI), which means that we must ensure the confidentiality, integrity, and availability of electronic PHI per The Health Insurance Portability and Accountability Act (HIPAA) [5]. Additionally, according to the IEEE Code of Ethics, we must be honest and realistic in stating claims based on available data [6]. Therefore, it is important that we do not make any false claims, but rather provide reliable feedback and recommend speaking with a doctor for any medical diagnosis.

Citations

[1] Drakos, M., MD, “Injury in the National Basketball Association”, *National Center for Biotechnology Information*, 2010. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3445097/. [Accessed: 01- Sep- 2020].

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