Smart Brace for Continuous Monitoring of the Knee Joint

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Abstract

Over 100 million people suffer from chronic knee pain and about 1 million are admitted to the ER for serious knee injuries. Since it is the most common injury in America, knee injuries are the most prominent cause of missing workdays and have led to some professional athletes losing their careers. To solve this problem, a smart brace was designed to continuously monitor the health of the knee joint by measuring the acoustics produced by the bones, muscles, and tendons of the user. These measurements are then stored in an app accessible to the user via their phone or computer. The recorded measurements can also be shared with the user's physician to reduce the number of doctor visits.

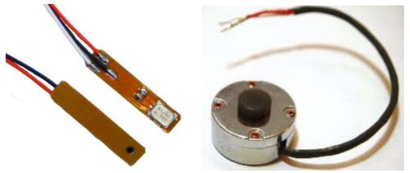
Introduction

The human knee consists of four main components that are vital to determine knee health: Articular Cartilage, Meniscus, Femur, and Tibia. The Articular Cartilage allows the bones of the knee to rub smoothly while in motion and the Meniscus acts as a "shock absorber" for forces exerted on the knee. As the bones in the knee joint rub against each other, they produce sounds that relate to the health of the joint. When the knee joint starts to deteriorate, the sound waves produced by the knee become irregular. Having a device that can monitor the progression of knee joint deterioration, would help reduce the number of knee injuries in America.

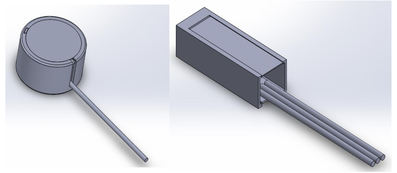
Methods and Materials

Knee Brace and Sensor Placement:

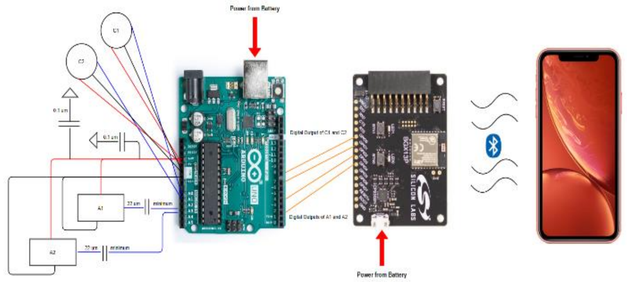
Airborne and Contact Sensors:



Sensor Packages with PDMS:

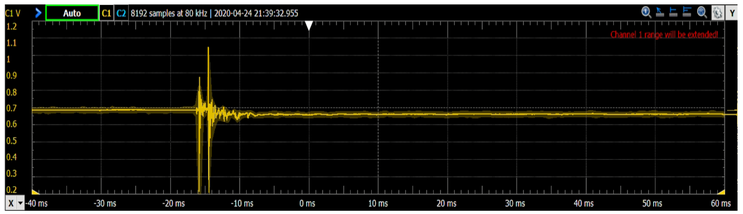


Bluetooth Module and ADC:



Results

Proof of Sensor Functionality for Airborne MEMS Sensor:



Discussion

Using a Digilent Analog Discovery 2, we were able to capture how the airborne sensors function when measuring sound waves. We used clapping as our test noise because of the immobility of the circuit.

Conclusion

A smart knee brace was designed to continuously monitor the progression of knee joint health. The knee brace design consists of a compression sleeve with design modifications to protect the electrical components from potential environmental or situational hazards and secure the components to ensure the user's safety while the brace is in use. The device includes contact and airborne sensors that measure the acoustics produced by the knee joint that can be analyzed to determine knee joint health. An ADC and Bluetooth Module are also implemented in the design to allow the user to access their data from their phone or computer through Bluetooth technology.

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