ShockTop

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Abstract

ShockTop is protective headgear designed to monitor impact for contact intensive activities. A standard football helmet is outfitted with existing XOnano impact sensing smart foam that produces a triboelectric response to deformation in order to determine possible concussion risk factors based on designated safety thresholds (45-90 G: lower possible risk, 90-110 G: higher possible risk, 110 G+ immediate attention recommended). The real-time impact data derived from force and impact energy data outputted by the foam is obtained and transmitted to the user's mobile device via class one Bluetooth (~100m). The data will then be available to coaches and trainers and possibly made available to medical professionals for review based on severity of impact assessed on sight. As opposed to current devices on the global market, ShockTop estimates metrics of impact severity such as impact force, impact energy and impact acceleration through the smart foam and relays impact data to the user. This device is a fast and efficient way to monitor dangerous impacts to the head and can be used as a preventative measure for concussions and possible neurodegenerative diseases such as CTE.

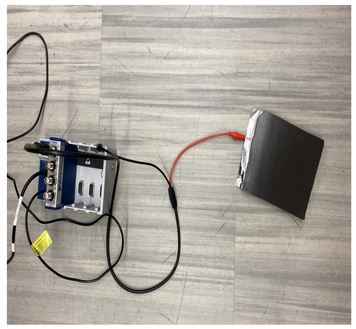
Introduction

Repetitive brain trauma often associated with contact sports can lead to progressive neurological deterioration known as chronic traumatic encephalopathy (CTE). This disease has distinct characteristics of hyperphosphorylated tau (p-tau) aggregates and intercellular lesions of neurofibrillary tangles which are a primary marker of diseases such as Alzheimer's (Mckee et al., 2015). Because the disease is the result of repetitive head trauma, it is characterized by cognitive dysfunction, changes in behavioral traits, possible loss of motor function which may vary based on the severity of the disease in the individual, and the development of Parkinson-like manifestations(Tharmaratnam et al., 2018) in later stages of the disease.

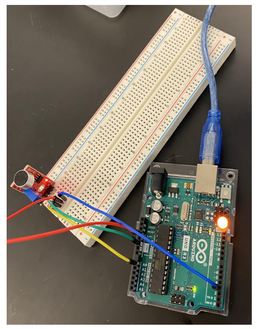
Design Inputs

Requirement 1	Requirement 2	Requirement 3	Requirement 4	Requirement 5
Device must detect clinically dangerous impacts.	Device must be able to measure the force between the helmet and head at multiple locations.	Device must provide same protections to the user as a retail helmet.	Device must be able to record impact without impeding athletic performance.	Device must wirelessly transmit data.

Design Solution

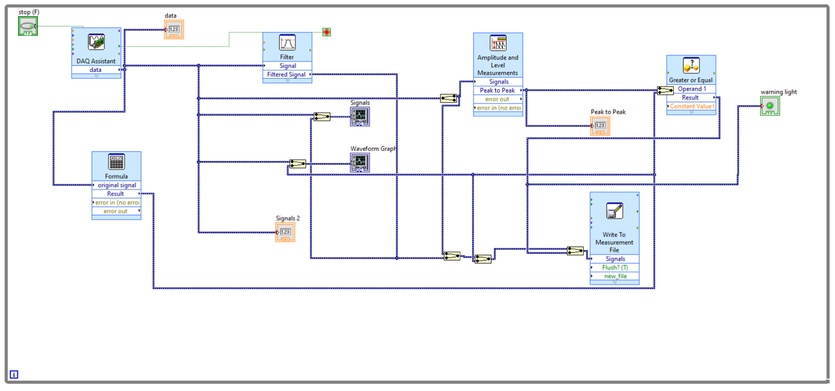


The alligator clips connected to the foam reads the compression produced by items dropped on it, more specifically the football helmet. The waveform graphs are seen in LabVIEW. The values were were also sent to excel issuing the Write to measurement block where the voltage spikes can be seen. This testing simulates the converted voltage to g-force players experience during the game.

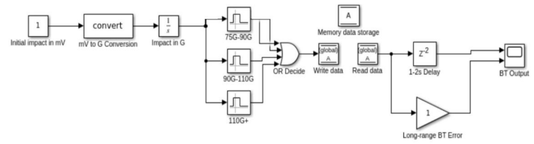


The Arduino program dictates the sensor to send the analog reading of voltage to the Arduino and as the sound waves get stronger, the voltage will change. The sensor acts as a switch for the LED which will switch on depending on the strength of the sound wav since the sensor is polarized and can only have 2 stages (on or off).

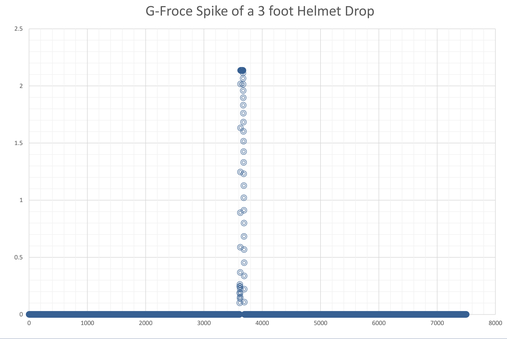
Testing



Once the foam is impacted, the system's Simulink displays how the initial impact is outputted in mV, and converted to G force using a conversion factor. The give G force is intended to fall within a range of 75-90, 90-110, or 110+ G and the OR command then chooses where that G force integer lies out of the three options, takes that data, stores it in memory, and then outputs it, with a delay to make up for time taken to transmit the data. This information is then sent to the proposed Bluetooth component, with an error component as well to account for the fact the device may not be within a 90-100m range of the Bluetooth component. The data then outputs via Bluetooth to our wireless device (whether it be a laptop or phone or tablet with a software or some kind of app installed).



The LabVIEW block diagram displays the output voltage as seen the Excel data sheet. The DAQ is connected to the Voltage card which is connected to the foam with 2 alligator clips. The voltage and g-force is shown on the LabVIEW blocks by using the graph indicator. All tests were sent to excel using the write to measurement file



Conclusions

ShockTop is an experimental device that aims to act as a preventative measure and assessment tool to aid the concussion crisis linked to the development of severe neurodegenerative diseases plaguing the contact sports world by placing a focus on the advancement of technology for protective football equipment.
We tested our requirements and assumptions of the design using Endevco 7264B-2000 accelerometer sensors connected to a NI DAQ system, and compared these outputs collected to the outputs given by the smart foam using an algorithm that converted the voltage from the XOnano foam to G force which was then considered readable data that could be transmitted to the user to determine severity of impact.

References

1. Tharmaratnam, Tharmegan et al. "Chronic Traumatic Encephalopathy in Professional American Football Players: Where Are We Now?." Frontiers in neurology vol. 9 445. 19 Jun. 2018, doi:10.3389/fneur.2018.00445
2. McKee AC, Cantu RC, Nowinski CJ, et al. Chronic traumatic encephalopathy in athletesprogressive tauopathy after repetitive head injury. J Neuropathol Exp Neurol. 2009;68(7):709-735. doi:10.1097/NEN.0b013e3181a9d503

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