

Motion Sensing Technology

Introduction

Motion sensing monitors the kinematics of objects built around or within embedded systems. Devices that are sensitive to motion, or are designed to detect a change in movement, can be found within a number of realms in STEM. A practical application of this technology can be seen in American Football. This document reviews the current, state of the art sensors and systems, including those that detect concussions and other physical trauma.

Commercial Products

Riddell InSite

As time has progressed, football programs nationwide have started to emphasize the importance of player safety and injury reduction. To capitalize on this, the sports equipment manufacturer Riddell deployed their injury monitoring system, the Riddell Insite Impact Response System. The system is composed of sensors positioned inside player helmets to constantly monitor impacts received, while computing the metrics associated with said impact (e.g. location, linear and rotational acceleration). If a high magnitude impact is detected, the off-field player monitor is sent an alert for coaches to consult, detailing the impact and the information of said player. [2] The Insite system sells for \$1000, and includes software to track each player registered in its database. [3]

Shockbox

Shockbox Helmet Sensors offer a portable sensor that can be placed on athletic helmets, as opposed to sensors that are embedded in the internal padding of a helmet. Each sensor interfaces with a mobile phone application through Bluetooth communication, sending alerts when a sensor detects an impact over its set threshold (20g).

Underlying Technology

Force switches

To accurately report force, early generation Shockbox helmets employed force switches to measure linear and rotational acceleration. The use of force switches allows the collection of impact in the X and Y planes. During impact, the force switches produce voltages to be combined with the recorded location of impact to calculate acceleration [4].

Accelerometer & Gyroscope

Another configuration combines the readings of accelerometers and gyroscopes, as seen in the DVT3 mouth guard. A compatible microcontroller can be utilized to poll each component at a given frequency. Accelerometer components will read linear acceleration relative to the players center of gravity, while the gyroscope measures both angular acceleration and orientation of the player at a given time. Vectors derived from these readings allow the final calculation of acceleration experienced at the location of the sensors.

Future

References

[1] Robert C. Cantu, M.D., *CHRONIC TRAUMATIC ENCEPHALOPATHY IN THE NATIONAL FOOTBALL LEAGUE*, Neurosurgery, Volume 61, Issue 2, 1 August 2007, Pages 223–225, <https://doi.org/10.1227/01.NEU.0000255514.73967.90>

[2] Riddell, *Riddell Insite Impact Response System*, [Online]

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[3] Conidi, FRANCIS X. "Helmets, sensors, and more: a review." *Pract Neurol* 15.2 (2015): 32-36.

[4] Foreman, Scott & Crossman, Danny. (2014). Comparative Analysis for the Measurement of Head Accelerations in Ice Hockey Helmets Using Non-Accelerometer Based Systems. The Mechanism of Concussion in Sports. 3-12