HEAD IMPACT TELEMETRY SYSTEM (HITS™) FOR MEASUREMENT OF HEAD ACCELERATION IN THE FIELD

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INTRODUCTION
Correlations between head acceleration measurements and concussions in sports have not been established. Current systems for measuring head accelerations are costly or not applicable for widespread use in sports. A telemetry based measurement and data analysis system incorporating a novel computational algorithm (Crisco et al., 2002) has been developed. Head Impact Telemetry System (HITS™) integrates this algorithm with a wireless sensor system and a large-scale database to provide simultaneous real-time continuous monitoring of head acceleration data from all players on the field. This paper describes the technical validation of the telemetry system in a football helmet.

METHODS
The HITS system provides data measurements for estimating linear acceleration magnitude and direction of the head. It has been initially applied inside of a football helmet (Figure 1). System components include: Sensor Package with single axis MEMS accelerometers, Player Unit with encoder hardware, analog front end and transceiver, Sideline Controller with decoder hardware, transceiver and Software Interface with PC interconnect, user interface, and access to impact database (Figure 2). Other sensors, including thermocouples and position transducers, can be added to the package.

Wireless Sensor System Specifications
- Frequency Agile Radio (ISM Band 902-928 MHz)
- Small Size - 2.75" x 1.20" x 0.75"
- 10-bit Data Acquisition on 8 channels
- 100 Meter Range
- Up to 64 players / Sideline Controller
- All Channel Trigger Monitoring with user selectable threshold
- Up to 38.4Kbaud Data Throughput

Field and laboratory testing was performed to validate the robustness of HITS for field applications in outdoor environments. Measures included: environmental signal strength of sideline controller across the ISM frequency band, communication range...
between Player Unit and Sideline Controller at the Dartmouth College football field, and durability of Player Unit in a football helmet under high g impact loading.

RESULTS AND DISCUSSION

Field tests of the HITS telemetry hardware showed that environmental RF energy varied across the ISM band in an outdoor environment (Figure 3). Increases in environmental signal strength lowers the signal-to-noise ratio of HITS, leading to greater transmission errors and increased download times. HITS automatically switches to the frequency with minimal RF energy within the ISM band.

Communication between Player Unit and Sideline Controller remained acceptable at distances up to 80 m, as measured by number of packet errors and communication retries. Download times per impact (500 bytes) averaged 500 msec, ensuring that if all 22 football players got hit simultaneously, data would all be downloaded before the next play.

Multiple impact testing of HITS hardware mounted in a commercially available football helmet demonstrated accurate transmission of accelerometer data at peak accelerations up to 140 g’s within the defined specification requirements of 10% accuracy. No hardware damage was noted.

To date, there are no commercially available telemetry systems that meet our specifications for widespread use in sports applications. Specifically, we use automatic continuous frequency hopping, a marked improvement over fixed frequency devices, and a single Sideline Controller for up to 64 Player Units. Helmet-radio systems currently used for NFL quarterbacks use a fixed frequency, which if corrupted by other RF devices, prevents communication.

Currently, the Sideline Controller must be near the sideline at the 50-yard line to allow full coverage of the football field. Improved antenna construction will allow increases in transmission range and accuracy.

HITS was initially designed to be mounted inside a football or other sport helmet and can withstand high impact accelerations that might occur on the field during play. The system can also be used in non-helmeted applications, such as studies of head acceleration during the heading of soccer balls.

SUMMARY

A novel RF-telemetry system for measuring head acceleration in the field was developed and tested. This system provides a cost-effective method for studying head impacts and concussions that was heretofore not possible.

REFERENCES


ACKNOWLEDGEMENTS

This work was supported in part by NIH 2R44HD40473