Preliminary Design Review

Team RCA
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RCA (Real-Time Concussion Analyzer)

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Concussion Detection in High School Football

- Current concussion detection
  - Train coaches to recognize symptoms

- Players may hide or not experience symptoms right away
How significant is the problem?

- 1.6 – 3.8 million sports-related concussions in the United States every year
  - Have reached “epidemic level”

- Not only professionals
  - Young people ages 15 – 24 years
    - Second leading cause of TBI (Traumatic Brain Injury)
Context: Effect on Individuals

- **Post Concussion Syndrome**
  - Problems concentrating, irritability, sensitivity to light...

- **If gone undiagnosed**
  - One hit away from traumatic brain injury
  - Multiple impacts add up
Context: Effect on Groups

- Affects team sports and the way they’re played
- “Tough guy attitude”
  - Creates a culture
- Subjective decision making
Requirements Analysis: Specifications

- Real-Time continuous impact measurements
- Player specific adaptability
- Equipment weight increase less than 5%
- Effective range 150 m
- Responds in under two seconds
- Robust
  - Interference
  - Durable
Requirements Analysis: Inputs and Outputs

- **Input**
  - Impact data

- **Output**
  - Likelihood of concussion
  - Access to archived impact data
Design Alternatives

- **HITS – Head Impact Telemetry System †**
  - Six accelerometers
  - Frequency, location, and magnitude
  - Sideline response system
  - Linear acceleration

†Measuring Head Kinematics in Football: Correlation Between the Head Impact Telemetry System and Hybrid III Headform. Beckwith, Jonathan, Jeffrey Chu, and Richard Greenwald. October 13th 2011
Design Alternatives

- **ShockBox**
  - *Impakt Protective*
  - Commercial use for football/hockey
  - Secured with high adhesive bonding tape
  - Wireless transmission
  - Threshold of 50 g set by app

- **HEADS**
  - *BAE Systems*
  - Military use
  - Suspended beneath the crown of the helmet
  - Wireless/USB transmission
  - Processing done by computer at base
From Impact to Probability

- "Rotational Head Kinematics in Football Impacts: An Injury Risk Function for Concussion”

- Rotational acceleration is important

\[
\text{risk} = \frac{1}{1 + e^{-(c_1 + c_2)}}
\]
Risk Function

\[ C_1 = -12.531 \]
\[ C_2 = 0.0020 \]
Risk Function

\[
\text{risk} = \frac{1}{1 + e^{-\left(c_1 + c_2 a\right)}}
\]

where

\[
c_1 = -12.531 \quad \quad c_2 = 0.0020
\]

and

\[
I = m \sqrt{ax^2 + ay^2}
\]
Our Solution: RCA

- **Array of sensors in helmet padding**
  - Continuous measurements
  - Variable impact thresholds
  - Wireless transmit on threshold trigger

- **Base station**
  - Database: Impact data & medical history
  - Concussion algorithm
  - Wireless transmit to UI & triggered helmet

- **UI**
  - Android device
  - Easy to interpret results within two seconds of impact
Our Solution: RCA

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Our Solution: Block Diagram

Impact Data Collection
- Power Supply
- Processing
- Sensors
- TX/RX

Data Analysis
- Data Processing
- Impact Data TX/RX
- DB
- UI TX/RX
- Power Supply

User Interface
- Settings
- TX/RX
- DB Interface
- History
- GUI
Sensor Network

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- History
- GUI
Sensors

- Requirements
  - Accurate
  - Response time under 100 ms
  - Low power
  - Lightweight and secured safely
    - Players should not notice sensors

- Implementation
  - Accelerometers, Gyroscope
  - Successful Senior Design Projects
    - Motion Analyzer for Physical Therapy (2010) for Accelerometers
    - Personal Head-Up Display (2009) for Gyroscope
Power

- **Requirements**
  - 3.5 – 6 V in helmet
  - Safe, reliable and lightweight
  - Up to five hour run time

- **Experience**
  - Power supplies
    - Design experience in previous coursework
    - Theater design project
User Interface and Communication

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- TX/RX

Data Analysis
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- Impact Data
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- DB
- Power Supply

User Interface
- Settings
- TX/RX
- DB Interface
- History
- GUI
UI

- Requirements
  - Easy to use
  - Deliver meaningful results
    - Medical staff
    - Coaching staff

- Implementation
  - Android Development
Tx/Rx for UI

- Requirements
  - Reliable
  - Response time under 500 ms
  - Easy to implement

- Implementation
  - Android WiFi/ Bluetooth Integration
  - Successful Senior Design Projects
    - BlueTag (2010) for Bluetooth
    - UMass Campus View (2010) for WiFi
Data Processing and Storage

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- Power Supply
- Processing
- Sensors
- TX/RX

Data Analysis
- Data Processing
- Impact Data TX/RX
- DB
- Power Supply
- UI TX/RX

User Interface
- Settings
- TX/RX
- DB Interface
- History
- GUI
Data Processing and Storage

- **Requirements**
  - Calculates rotational acceleration
  - Determines probability of concussion
  - Output within 500 ms
  - Store all impact data efficiently

- **Experience**
  - Software development for Bose
  - Data organization and analysis algorithm development for ECM
Impact Processing

- Requirements
  - Low power and lightweight
  - Inputs for at least 7 sensors
  - Tx/Rx Capable
  - Flash memory

- Experience
  - ATmega Microcontroller
    - Used in ECE 353
    - LED Cube
Impact Data Tx/Rx

- **Requirements**
  - Low power and lightweight
  - Effective range up to 150 m
  - Efficient data transfer rates
  - Secure

- **Implementation**
  - XBee
  - Successful Senior Design Projects
    - SAFE-T (2012) for XBee
Proposed MDR Deliverables

- Demonstration of Impact Data Collection
  - Accelerometer interfaced with processor
  - Helmet processor transmission

- Demonstration of Base Station/UI Interaction
  - Using test data
    - Receive from helmet
    - Run algorithm
  - UI able to receive and display test results
Thank You

Questions
Thank You

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Preliminary Weight Analysis

- NFL Helmet Approximately 6lbs. or 2.722kg
- ATMega328P = 2g
- MEMS each approximately 1g
- Gyroscope approximately 2g
- Power approximately 23g
- Estimated total system weight (not including packaging) = 35g-40g

- 5% of helmet is approximately 136g