

ConcussionMonitor

Real-Time Impact Tracking and Safety Analytics

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March 2026

1. Executive Summary

The ConcussionMonitor project was developed to address a critical gap in sports safety: the lack of immediate, data-driven insights into head impacts during athletic activities. While professional leagues have access to expensive medical staff and advanced sensors, amateur and youth sports often rely on subjective observation. This project provides a scalable, software-based solution to monitor, record, and analyze head impact data, allowing for proactive safety interventions and long-term health tracking for athletes.

2. Project Goal and Purpose

The primary goal of ConcussionMonitor is to democratize access to brain health data. By integrating hardware sensors with a robust software backend, the system aims to identify high-risk impact events that might otherwise go unnoticed.

Core Objectives:

- **Immediate Detection:** Provide real-time alerts when an athlete sustains an impact exceeding a specific G-force threshold.
- **Longitudinal Tracking:** Maintain a historical record of impacts to help medical professionals identify the cumulative effects of sub-concussive hits.
- **Data Accessibility:** Create an interface where coaches, parents, and trainers can view simplified safety metrics without needing a background in data science.
- **Preventative Care:** Use trend analysis to suggest when an athlete should be removed from play for further evaluation.

3. Libraries and Technologies Used

The project leverages a modern stack designed for high-frequency data processing and cross-platform accessibility.

Core Technologies:

- **Python:** The primary language used for data processing and backend logic due to its extensive support for mathematical modeling and sensor integration.
- **NumPy and Pandas:** These libraries serve as the backbone for data manipulation. They allow the system to handle large arrays of sensor readings and perform time-series analysis efficiently.
- **Matplotlib / Seaborn:** Used for generating the visual analytics within the dashboard, converting raw impact numbers into readable heatmaps and trend lines.

- **Flask / FastAPI:** Depending on the implementation, these frameworks provide the web-based API that allows the hardware to communicate with the user dashboard.
- **SQLite / PostgreSQL:** A structured database used to store athlete profiles and their historical impact data securely.

4. Methodology and Implementation

The development process followed a modular architecture to ensure that the data collection layer remained independent of the user interface.

Data Acquisition

The system begins by polling data from accelerometers and gyroscopes. These sensors capture motion across three axes. The software filters this raw data to remove "noise" (standard athletic movements like running or jumping) to focus exclusively on high-impact deceleration events.

Signal Processing

Once an impact is detected, the system calculates the Peak Linear Acceleration (PLA) and Change in Velocity. This is achieved through a custom processing script that applies a low-pass filter to the sensor data. If the resulting value exceeds a pre-defined safety threshold, a high-priority event is triggered.

User Interface and Reporting

The data is then pushed to a central dashboard. Instead of showing complex physics data, the UI uses a color-coded system (Green, Yellow, Red) to indicate the severity of the impact. This ensures that non-technical users can make quick, informed decisions during a game.

5. Future Improvements

While the current version of ConcussionMonitor provides a solid foundation for impact tracking, several areas have been identified for future expansion:

- **Machine Learning Integration:** Moving from static threshold alerts to a predictive model. By training a neural network on thousands of impact profiles, the system could eventually distinguish between a "hard hit" and a "concussive hit" with higher accuracy.
- **IoT and Cloud Scaling:** Transitioning the local database to a cloud-based infrastructure would allow multiple teams and leagues to sync data to a centralized medical registry.

- **Integration with Wearables:** Developing a dedicated mobile application for iOS and Android would allow parents to receive push notifications directly to their phones during away games.
- **Biometric Correlation:** Integrating heart rate and sleep data from other wearable devices to see how head impacts correlate with physical recovery markers.

6. Conclusion

ConcussionMonitor represents a significant step forward in making sports technology accessible to the general public. By combining affordable hardware with sophisticated Python-based analysis, the project shifts the focus from reactive treatment to proactive monitoring. This approach not only protects athletes in the short term but provides the data necessary to understand the long-term health implications of contact sports.