Snowboard Wearable

WIT COMP4960 Group 06 SRS
Version 1.4

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1 Introduction

1.1 Purpose

A wearable Internet-of-Things (IoT) device for snowboarders that attaches to the board and connects to a phone via Bluetooth. It collects data from sensors like a gyroscope, accelerometer, GPS, and altimeter, providing post-ride analysis such as speed, airtime, technique analysis, and trick recognition. It can analyze snowboard-specific dynamics like carving angles, board flex, and snow conditions. Ride visualization, performance grading, and tips to help riders improve and tailor their experience to different terrains, making it an essential tool for snowboarders of all levels.

1.2 Scope

The Snowboarding Wearable is a smart IoT device that attaches to a snowboard and communicates wirelessly through Bluetooth, with a mobile application. The key features of the system include:

1.2.1 Data collection from IMU, and GPS.

1.2.2 Performance grading, providing feedback on carving angles, and snow conditions.

1.2.3 Ride visualization for post-ride analysis.

1.2.4 Recommendations based on user riding style and skill level.

Note: As of this submission, the following features have not yet been implemented but are still planned for future development: *performance grading*, *ride visualization*, *mobile app*, and *recommendations*. These features will be developed after the deadline.

1.3 Definitions

1.3.1 IoT: Internet of Things.

1.3.2 GPS: Global Positioning System

1.3.3 ESP32: Espressif Systems 32 Microcontroller SoC

1.3.4 BNO086: 9-axis IMU

1.3.5 API: Application Programming Interface

1.3.6 BLE: Bluetooth Low Energy

1.4 Pertinent Resources

1.4.1 IEEE 830-1998: Recommended Practice for Software Requirements Specifications

1.4.2

[1] B. H. Groh, M. Fleckenstein, and B. M. Eskofier, “Wearable trick classification in freestyle snowboarding,” in *Proc. IEEE Conf.*, 2016.

1.4.3 "Carv" - A similar product for skiing

2 Overall Description

2.1 Product Perspective

The Snowboarding Wearable is a standalone hardware device with embedded sensors that include a gyroscope, accelerometer, and magnetometer, which transmit data wirelessly to a mobile application. The mobile application provides the user interface for data visualization, performance insights, and suggestions. The system is designed to operate in cold conditions with minimal power consumption.

2.2 Product Functions

2.2.1 Data Capture: Continuous monitoring of motion and environmental variables.

2.2.2 Sensor Fusion Processing: Combining data from gyroscope, accelerometer, magnetomeer, and GPS, for accurate motion tracking.

2.2.3 Trick Recognition: Classifies tricks based on motion signatures.

2.2.4 User Performance Grading: Scores rides based on various parameters such as airtime, and carving efficiency.

2.2.5 Historical Data Analytics: Stores ride history and tracks long-term improvement trends.

2.3 User Characteristics

2.3.1 Beginner Snowboarders: Need guidance and feedback to improve basic riding techniques.

2.3.2 Intermediate Riders: Seek analytics on tricks and advanced performance improvement.

2.3.3 Professional Athletes: Require precision metrics and detailed analysis of tricks and competition preparation.

2.4 Constraints

2.4.1 Environmental Conditions: The wearable must function in extreme cold (as low as -20°C) and withstand exposure to snow and moisture.

2.4.2 Power Efficiency: The device must operate for a minimum of 5 hours on a single charge despite the high-energy demands of sensors and wireless communication.

2.4.3 Bluetooth Connectivity Range: The wearable must maintain a stable connection to the mobile app within a 5-meter range, which may be affected by environmental interference.

2.4.4 Data Transmission: The system must process and transmit data, while ensuring minimal delay in user feedback.

2.4.5 Testing Challenges: Due to the requirement for real-world testing on slopes, a simulated physics-based environment in a game engine will be needed for preliminary testing.

2.5 Assumptions and Dependencies

2.5.1 The wearable will be compatible with iOS and Android.

2.5.2 GPS signal must be available in riding areas for accurate location tracking.

3 Specific Requirements

3.1 External Interface Requirements

3.1.1 Mobile App (Client-Side User Interface)

3.1.1.1 **Splash Screen:** A basic screen displaying the logo to welcome the user for 3-5 seconds.

3.1.1.2 **Onboarding Screen:** A step-by-step guide to help the user connect the phone to the wearable.

3.1.1.2.1 Displayed only when the device is not already connected.

3.1.1.2.2 Not manually accessible by the user.

3.1.1.3 **Home Screen:** Displays data from the most recent run.

3.1.1.3.1 Map view of the slope with GPS-based movement tracking.

3.1.1.3.2 Scoring section displaying user performance based on number and quality of runs.

3.1.1.3.3 List of recommended improvements/tips based on collected data.

3.1.1.3.4 Clicking on a suggestion leads to a page with graphical/3D visualization of raw data.

3.1.1.3.5 A navigation bar at the bottom for easy access to other sections.

3.1.1.4 **History Log Page:**

3.1.1.4.1 Displays a list of past runs recorded when the device was active.

3.1.1.4.2 Allows users to select specific runs for detailed analysis.

3.1.1.4.3 Each entry contains metadata such as date, time, location, and total score.

3.1.1.4.4 Includes a navigation bar at the bottom for easy access.

3.1.2 Mobile App (Backend)

3.1.2.1 Establishes and maintains a continuous Bluetooth connection with the wearable.

3.1.2.2 Receives data from the device with a latency of 100ms.

3.1.2.3 Implements algorithms to combine sensor data for analyzing snowboard movement.

3.1.2.4 Processes and displays collected data in the user interface.

3.1.3 Hardware Wearable (IoT Device)

3.1.3.1 **Core Components:**

3.1.3.1.1 ESP32 Dev Board for Bluetooth communication and onboard processing.

3.1.3.1.2 BNO086 9-axis IMU for capturing acceleration, rotational velocity, and orientation data. Selected for its robust sensor fusion capabilities and motion detection accuracy.

3.1.3.1.3 Battery Pack (3.7V, 1000mAh) supporting at least 4 hours of continuous operation at temperatures as low as -20°C.

3.1.3.2 **Durability:**

3.1.3.2.1 IP68-rated waterproof and shockproof casing for protection in extreme snow conditions.

3.1.3.2.2 Clip-on attachment for securing the device to the snowboard boot.

3.1.3.2.3 Physical button on the outer casing for power control.

3.1.3.3 **Charging Mechanism:**

3.1.3.3.1 USB-C breakout board for charging.

3.1.3.3.2 Optional low-dropout voltage regulator to ensure stable power delivery.

3.2 Objects

3.2.1 Sensor Data Collection and Storage

3.2.1.1 Attributes:

3.2.1.1.1 **Gyroscope Data:** Measures rotation and angular velocity.

3.2.1.1.2 **Accelerometer Data:** Tracks acceleration changes across multiple axes.

3.2.1.1.3 **GPS Coordinates:** Determines location and speed, leveraging phone GPS data.

3.2.1.2 Functions:

- 3.2.1.2.1 Capture and store sensor readings.
- 3.2.1.2.2 Apply filtering and normalization to raw data.
- 3.2.1.2.3 Send processed data to the mobile application.

3.2.2 Trick Recognition

3.2.2.1 Attributes:

- 3.2.2.1.1 **Trick Database:** Contains predefined movement signatures for classification.
- 3.2.2.1.2 **Calculation Algorithm:** Implements mathematical analysis of movement patterns.

3.2.2.2 Functions:

- 3.2.2.2.1 Identify trick types based on movement signatures.
- 3.2.2.2.2 Score execution quality and provide user feedback.

3.3 Performance Requirements

- 3.3.1 Data transmission latency: $\leq$ 50ms.
- 3.3.2 Sensor sampling rate: 200Hz.
- 3.3.3 Battery life: Minimum 5 hours of continuous operation in cold temperatures.
- 3.3.4 Data accuracy: 70%+ classification precision for trick recognition.

3.4 Design Constraints

- 3.4.1 Must be lightweight (<200g) and water-resistant.
- 3.4.2 Must not interfere with snowboard movement or rider flexibility.

3.5 Software System Attributes

3.5.1 Security: Encrypted Bluetooth data transmission.

3.5.2 Maintainability: Modular architecture for easy firmware updates.

3.5.3 Portability: Mobile application must support Android 10+ and iOS 14+.

3.6 Other Requirements

3.6.1 Compliance with CE, FCC, and RoHS regulatory standards.

3.6.2 Multi-user support for team-based analytics and sharing ride data.

4 Feature Summary & Development Status

The table below provides a consolidated overview of the key features defined in this Software Requirements Specification, along with their implementation status as of April 14, 2025. This summary serves to clarify the project's scope and prioritize future development efforts.

Feature	**Description**	**Status (April 2025)**
Sensor Data Collection	Real-time capture of acceleration, gyroscopic data, and GPS from wearable sensors.	Completed
Bluetooth Connectivity	Continuous BLE connection between ESP32-based wearable and mobile application.	Completed
Data Fusion & Processing	Combining multi-sensor data for accurate motion tracking and terrain adaptation.	Completed
Mobile App UI	Interface for ride summaries, GPS mapping, scorecards, and performance feedback.	Completed

Feature	**Description**	**Status (April 2025)**
Ride History Log	Stores and displays past run metadata and analysis.	Planned
Performance Grading	Algorithm to evaluate ride metrics like airtime, carving angle, and trick smoothness.	Planned
Trick Recognition	Machine learning model to detect and classify tricks from motion patterns.	In Progress
3D Ride Visualization	Visual replay of ride data using on-board telemetry.	Planned
User Recommendations	Tailored tips and suggestions based on ride performance and rider profile.	Planned
Battery Optimization	Minimum 5 hours of operation with power-efficient sampling and wireless protocols.	Tested and Functional
Cross-Platform Support	Compatibility with Android 10+ and iOS 14+ via Flutter framework.	In Progress
Regulatory Compliance	Meets CE, FCC, RoHS standards for safety and electronic device regulations.	Planned

This document will serve as the baseline for future iterations, ensuring alignment with user needs and technical feasibility. Planned features are outlined in the project roadmap and will be implemented in subsequent development cycles.