White paper

FoilCoach

A Broad Overview of Foiling Performance Tracking and Coaching

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Abstract

FoilCoach revolutionizes foiling sports by addressing the limitations of generic fitness trackers with tailored solutions for pumpfoiling, windfoiling, and kitefoiling. Utilizing advanced sensors, real-time feedback, and machine learning, it delivers actionable insights and personalized coaching. This paper highlights FoilCoach's innovative approach, lowering the sport's entrance barrier and empowering users to optimize performance.

1 Introduction

This white paper introduces FoilCoach, a system designed to meet the unique demands of foiling sports. It consists of an add-on or integrated device for foiling equipment combined with an app, see Fig. 1. The paper begins by exploring the challenges faced by athletes in pumpfoiling, windfoiling, and kitefoiling. It then details the technological innovations within FoilCoach, including its advanced sensors and real-time feedback capabilities. The scope of the paper extends to the practical applications of this technology, emphasizing its impact on individual athletes, coaches, and the broader foiling community. Finally, the paper outlines FoilCoach's commitment to fostering an open and collaborative environment that supports innovation and accessibility in the sport.

Figure 1: FoilCoach System Overview: Connecting hardware, app, and cloud services.

2 Problem Statement

Existing fitness trackers do not adequately address the nuances of foiling sports:

- **General Foiling:** Conventional wearables (e.g., smartwatches) only track certain motion types (like arm movement) and cannot perceive the complex dynamics inherent in foiling.
- **Pumpfoiling:** Requires high data rates and precise measurement of board and/or body motion during starts, the parts where all beginners fail immediately and could benefit from insights into this data.
- **Windfoiling and Kitefoiling:** Benefit from long-session tracking and targeted performance metrics to increase efficiency to enable longer sessions.
- **User-Specific Insights:** Generic advice fails to account for key differences such as weight, fitness, age, and height—crucial for optimizing technique and performance.
- **Rental and Safety Applications:** No integrated solution currently exists for tracking rental equipment usage, crash impacts, or material wear.
- **Calibration and Learning:** There is a lack of a synchronized video and sensor data gathering and analysis pipeline.

The absence of real-time coaching systems and user-specific feedback limits user improvement and the development of novel and data-driven approaches.

3 Our Solution

FoilCoach integrates advanced technology and community data into a comprehensive system:

- **Adaptive Smart Sensor Suite:** Includes IMUs, GPS modules, and height sensors. State-of-the-art sensors and integrated Machine Learning models adapt to a user's skill level and riding style.
- **Feedback:** On-device or cloud-based processing offers instant coaching feedback after each attempt, guiding technique improvements.
- **Real-Time Feedback Mechanism:** Delivers actionable insights during critical sections, such as starting a pump or maintaining stability, enabling users to adjust their technique on the fly.
- **Community Data Insights:** Aggregates data across willing users to identify best-practice movements and equipment setups.
- **Personalized Recommendations:** Adjusts technique advice based on each user's weight, fitness, age, and height, as well as specific equipment details.
- **Asset Tracking:** Provides live status updates for rental gear, including usage frequency and location.
- **Predictive Maintenance:** Monitors acceleration peaks and vibrations to detect potential material fatigue, improving safety.

- **External Data Integration:** Allows video, weather, and other relevant data feeds to refine coaching algorithms and feedback loops.

4 Technology Overview

FoilCoach leverages state-of-the-art sensors for performance tracking and feedback. A detailed view of the device components is shown in Fig. 2.

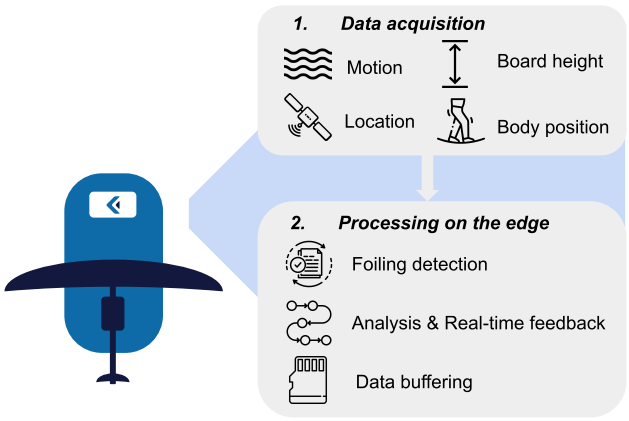

Figure 2: FoilCoach Device Overview: Sensors and data flow.

4.1 Sensors and Data Captured

FoilCoach leverages a variety of sensor technologies:

- **Motion Sensor:** Accelerometers,gyroscopes, and magnetometers measure the motion.
- **Height Sensor:** Tracks the board's height above water, especially critical for pump-foiling.
- **GPS:** Provides location, speed, and distance metrics across all foiling disciplines.
- **Radar Sensor:** Measures water surface conditions and metrics and/or rider body position complementing the motion data using sensor fusion.

4.2 Low-Power Hardware Architecture

A key aspect of FoilCoach's design is specialized low-power hardware to ensure extended battery life alongside real-time processing:

- **Microcontroller with AI Capabilities:** Handles real-time sensor data processing and on-device classification with integrated AI acceleration, enabling immediate feedback even in resource-constrained conditions.
- **Low-Power Network Co-Processor:** A dedicated, energy-efficient radio module manages wireless connectivity for uploading data to the cloud or communicating with a smartphone.

4.3 Data Processing Architecture

FoilCoach employs a modular data processing pipeline, which integrates edge, intermediate, and cloud processing:

- **Edge Processing:** Lightweight ML models classify foiling activity on-device for efficient data storage and for immediate feedback.
- **Intermediate Processing:** Aggregates data from multiple sessions and users to identify patterns and generate personalized recommendations. This step can be performed on the mobile device or in the cloud.
- **Cloud Processing:** Handles historical data analysis, user-to-user comparisons, and advanced model training. This step is crucial for generating community-wide insights and optimizing the coaching algorithms.

The cloud processing step is also responsible for integrating external data sources, such as weather conditions or video feeds, to refine the coaching algorithms and feedback loops. The system captures user's personal data, such as weight, fitness, age, height, and more, to provide personalized feedback and recommendations, and uses equipment details to provide specific recommendations.

4.4 Connectivity

FoilCoach connects the onboard tracker with a cloud-based analysis platform, as shown in Fig. 3. This is done either via a mobile device over Bluetooth or Wi-Fi, or directly over a cellular network.

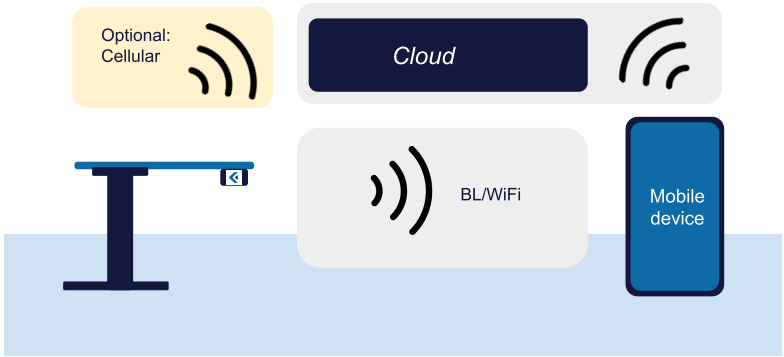

Figure 3: Connectivity Overview

FoilCoach provides detailed insights by capturing and analyzing the following metrics:

- **(Pump) Foiling Starting Metrics:**
  - Length of the push.

- Speed of the board during start.
- Inclination angle of the board during the start.
- Motion stability during the start.
- Effect of the jump (e.g., angle change, height drop).
- Automatically generated performance metrics with user-friendly text prompts created using Machine Learning (ML) and Natural Language Processing (NLP).

4.5 Foiling Metrics

FoilCoach captures a range of metrics to evaluate user performance. These metrics are divided into two categories: simple metrics, which are directly measured by the system, and derived metrics, which combine or process the raw data for more comprehensive insights.

4.5.1 Simple Metrics

- GPS position.
- Height above water.
- Duration.
- Velocity.
- Motion amplitude.
- Energy (derived from acceleration amplitude).
- Pumping frequency.
- Minimum and maximum inclination.

4.5.2 Derived Metrics

- **Relative Performance:** Combines all metrics to evaluate the user's data against their previous performance.
- **Absolute Performance:** Benchmarks the user's data against a standardized dataset of community-wide data.
- **Stability:** Across roll, pitch, and yaw.
- **Variability/Consistency:** Variability of motion, stability, energy, efficiency, etc.
- **Efficiency:** Measures e.g. horizontal acceleration relative to vertical acceleration.

The exact implementation of calculating the performance indexes is still in development, but it will be a composite metric derived from one or more of the parameters above (e.g., user's parameters, equipment, duration, velocity, motion variability, duration, and repeated technique patterns). Not only does it look at the minimum and maximum values, it will focus on how reliably and consistently a user can reproduce movements with minimal deviation, serving as a key indicator of technique mastery and efficiency.

Additionally, the system supports real-time feedback, delivering direct feedback during critical sections of foiling, e.g. when the board is close to hitting the water.

5 Applications and Use Cases

FoilCoach provides tangible benefits across a diverse range of users:

- **Beginning Foilers:** Simplifies learning through real-time coaching and easy-to-understand progress tracking,reducing frustration and early stopping.
- **Seasoned Foilers:** Offers deep insights into performance metrics like stability, efficiency, and pumping frequency, enabling advanced training optimization.
- **Coaches:** Provides synchronized video and sensor data for detailed session reviews and customized lesson plans.
- **Rental Operators:** Tracks gear usage and wear patterns, preventing failures and extending equipment lifespan through predictive maintenance.
- **Safety Monitors:** Detects crashes or high-impact events and sends automated alerts to ensure timely assistance.

6 Conclusion

FoilCoach is a game-changer in foiling sports, delivering precise, data-driven coaching tailored to the sport's unique challenges. Its advanced sensors, real-time feedback, and personalized insights help users improve performance, ensure safety, and maintain equipment.

Importantly, this white paper underscores FoilCoach's commitment to ensuring that foiling tracking remains open and accessible. By avoiding restrictive patents and fostering community collaboration, FoilCoach guarantees that its advancements will serve the sport's enthusiasts without barriers. This approach ensures both satisfaction and ongoing innovation within the foiling community. As foiling continues to grow, solutions like FoilCoach will be vital in shaping the sport's future, offering athletes a blend of enhanced performance and enjoyment.

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Contact

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