

A Smart Wearable System for Resistance Training Performance Evaluation

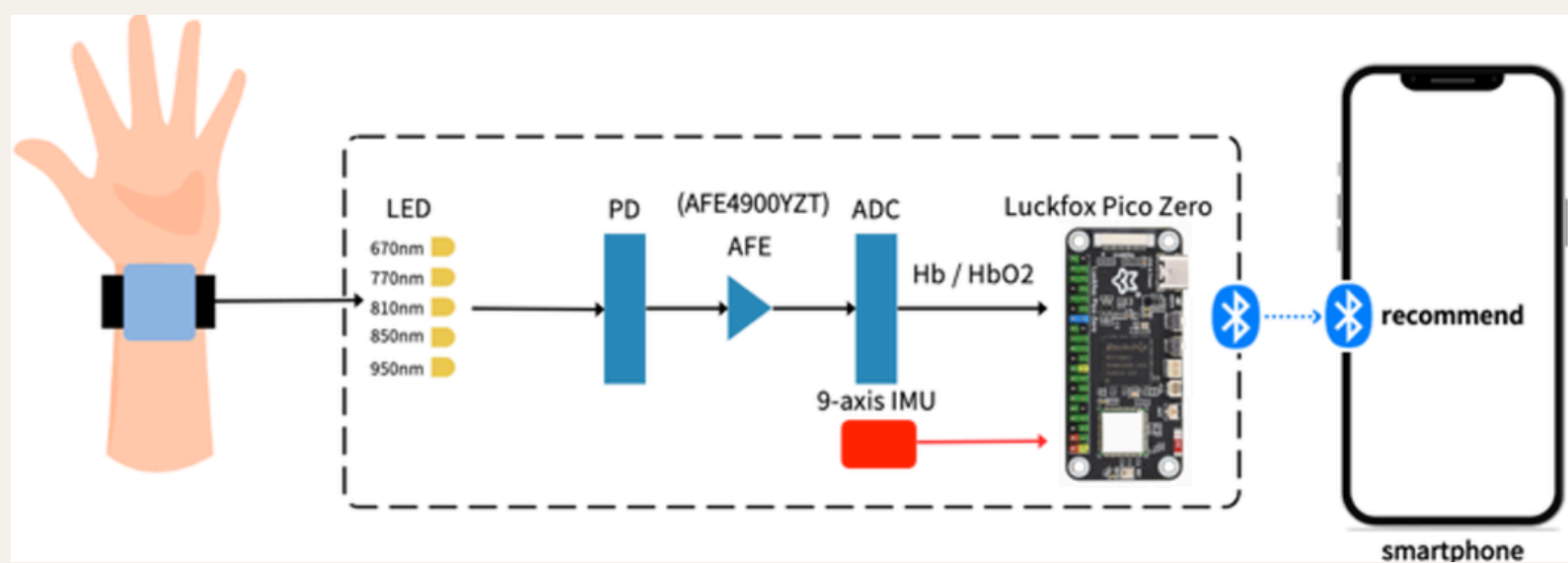
Chi-Hung Yang, Yan-Zong Cui, Jun-Kai Xu, Ji-Ye Li



Abstract

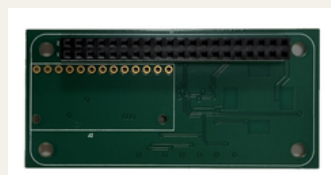
With the growing demand for real-time and personalized fitness feedback, this project presents a smart wearable system for resistance training. By integrating photoplethysmography (PPG) and inertial measurement unit (IMU) signals, the system analyzes exercise type, repetitions, movement tempo, oxygen uptake (VO_2), and perceived exertion (RPE) to evaluate movement quality, fatigue, and physiological load.

System Architecture

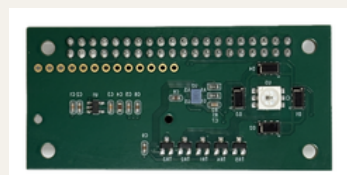


Hardware Architecture

The hardware uses a self-designed PCB integrating multi-channel PPG sensors, a 9-axis IMU, a microcontroller, and Bluetooth transmission. PPG captures wrist physiological signals, while IMU measures motion data. The processed data are sent to the mobile app for model analysis and feedback.



front



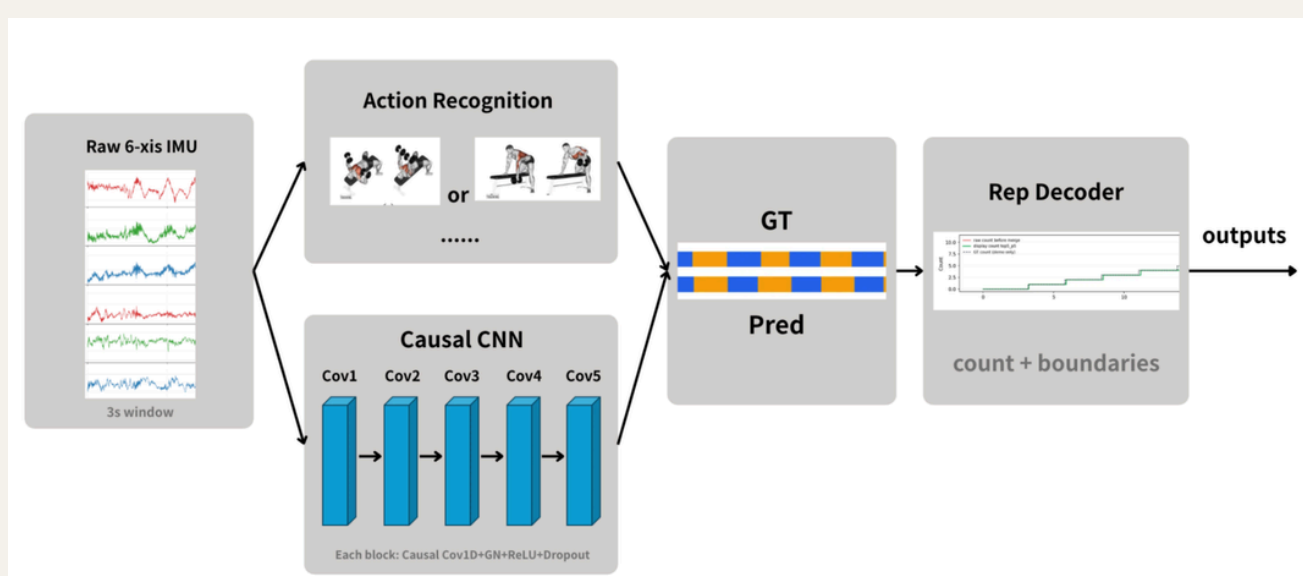
back



wearable device

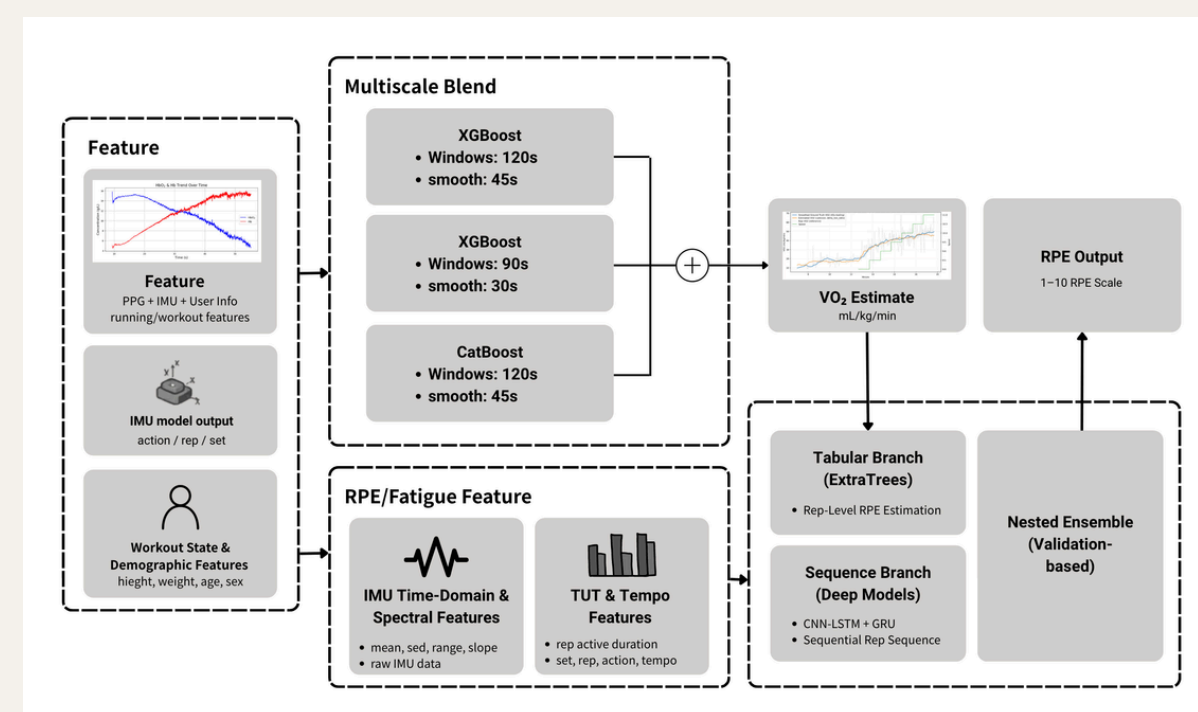
AI Training | IMU Exercise Analysis

This module uses raw 6-axis IMU signals for exercise recognition and repetition analysis. A Causal CNN segments concentric and eccentric phases, allowing the system to extract repetition count, boundaries, time under tension (TUT), and movement tempo for fatigue analysis.



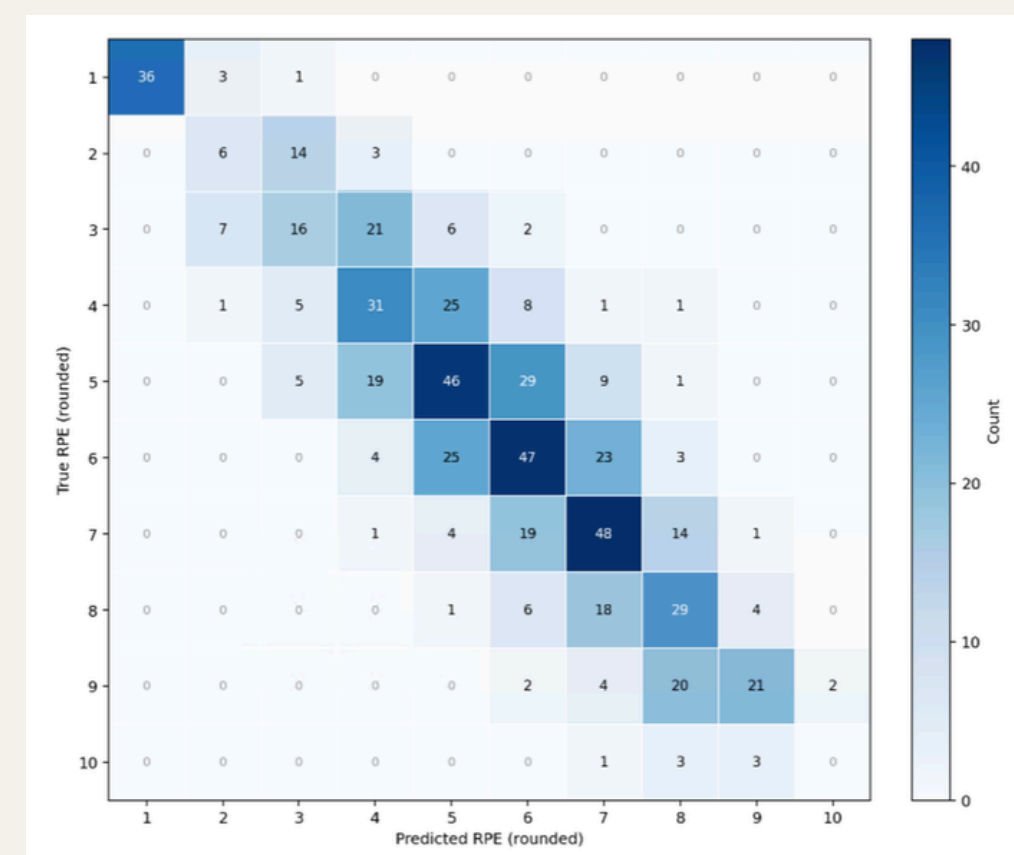
AI Training | VO_2 and RPE Estimation

This module estimates physiological load and perceived fatigue. The VO_2 model combines PPG, IMU, workout state, and user information. The RPE model then uses VO_2 , motion features, TUT, and tempo to predict fatigue on a 1–10 scale.



Results

The RPE confusion matrix shows that most predictions are close to the diagonal, indicating that the model captures fatigue trends. Although exact RPE classification remains challenging, most errors occur between neighboring levels, achieving a within ± 1 accuracy of 88.6%.



Conclusion

Criteria	Back <i>et al.</i> (2025)	Thomas and Wahlström (2025)	King <i>et al.</i> (2025)	Smiley <i>et al.</i> (2023)	Ours
Exercise Types	Bench press	Bicep curl	Preacher curl	Cycling	8 exercises
Exercise Classification	No	No	No	No	8-class
Fatigue Classification	Continuous RPE	Multi-level RPE	Binary RIR ≤ 2	High / low exertion	Continuous RPE
Real-Time Capability	Partial	No	Yes	Partial	Yes
Performance	± 1 RPE > 93%	± 1 Acc = 85.9%	Acc = 92.7%	Acc = 78.3%	± 1 Acc = 88.6%
Edge Computing	No	Yes	No	No	Yes
Feedback	No	No	Yes	No	Yes

This project improves traditional fitness tracking by analyzing movement quality, physiological load, and fatigue status, instead of only recording weight and repetitions. By integrating PPG, IMU, VO_2 estimation, and RPE prediction, the system helps users understand fatigue changes and provides personalized training feedback.