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Real-Time Feedback and Stress Monitoring in Guided Breathing Exercises

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Introduction

Stress is a widespread health challenge affecting both physical and mental well-being. While guided breathing is an effective stress regulation intervention, adherence to the breathing pattern is often difficult to track without objective feedback. This project introduces a real-time system that combines physiological monitoring with interactive feedback to support effective stress management through guided breathing exercises.

Methods

Using a Polar H10 BLE chest strap, we recorded ECG and 3-axis accelerometer (ACC) data. We developed a system architecture in Python/Streamlit consisting of data acquisition, real-time signal processing, and a visualization interface. Two respiration phase estimation methods were implemented: a signal-based approach using ACC data with probabilistic phase tracking and a model-based approach using a U-Time convolutional neural network for ECG-derived respiration. Additionally, stress levels were quantified through variations in the heart rate variability parameters, such as the root mean square of successive differences of 20s intervals (RMSSD).

Results

Pilot tests verified the system's functionality. The signal-based ACC classification correctly identified inhalation and exhalation phases approximately 70% of the time. Offline analysis of the fused ACC and ECG signals showed an RMSE of 0.591 compared to the target breathing pattern. Quantitative stress assessment revealed a progressive increase in RMSSD from 40 ms to 130 ms over the course of a 4-7-8 breathing exercise, indicating a measurable shift toward a relaxed state.

Conclusion

The system demonstrates that consumer-grade wearables can provide effective real-time feedback for breathing exercises and objective metrics for stress reduction, potentially improving user adherence to such practices.

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