Agentic ECG-Based Fatigue and Stress Detection

Agentic AI Course - Final Presentation

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Agentic AI Course

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Outline

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Problem Statement

- Data Complexity: ECG signals contain physiological info related to fatigue/stress, but raw data is hard to interpret directly.
- Need for Automation: Manual analysis is slow; an automated and interpretable decision mechanism is required.
- Gap: Current systems lack ”Agentic” capabilities to provide actionable feedback.

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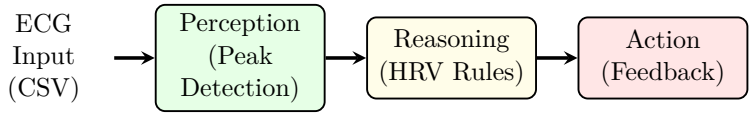
Motivation

Why choose this approach?

- Time-Domain HRV: Features like RMSSD are computationally simple yet clinically explainable.
- Efficiency: CSV-based ECG data allows for rapid processing pipelines.
- Agentic AI: Moves beyond simple detection to enable decision-making and actionable feedback (e.g., ”Take a break”).

System Architecture: The Agentic Workflow

The system follows a Perception → Reasoning → Action loop:



- Perception: Signal loading, cleaning, and R-Peak detection.
- Reasoning: Calculating BPM/RMSSD and evaluating physiological state.
- Action: Generating human-readable recommendations (e.g., Warning).

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Methodology: Time-Domain Metrics

We utilize Time-Domain features for robust detection:

Metric	Description
BPM	Mean heart rate derived from RR intervals.
SDNN	Overall heart rate variability (Standard Deviation).
RMSSD	Root Mean Square of Successive Differences (Short-term).

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Advanced Methodology: Frequency-Domain

In addition to Time-Domain, we analyze spectral density for deeper insights:

Feature	Frequency (Hz)	Physiological Meaning
LF	0.04 – 0.15	Sympathetic / Stress
HF	0.15 – 0.40	Parasympathetic / Relax
LF/HF	-	Autonomic Balance

Note: A high LF/HF ratio typically indicates sympathetic dominance (Stress).

Agent Decision Logic

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The Reasoning Agent applies the following threshold rules:

High Stress

BPM > 100
AND
RMSSD > 100

Fatigue

RMSSD < 30
(Low Variability)

Normal State

Otherwise
(Baseline)

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Challenges

- Signal Quality: Simplified R-peak detection is sensitive to noise; lacks clinical annotations for verification.
- Data Assumptions: Currently assumes a fixed sampling rate, which varies in real-world devices.
- Generalization: Threshold-based rules (e.g., RMSSD < 30) lack personalization for different users (athletes vs. non-athletes).

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Lessons Learned

- Simplicity Wins: Simple HRV metrics (Time-Domain) often provide more interpretable insights than complex models for real-time agents.
- Modularity: Separating ”Perception” from ”Reasoning” clarifies system responsibilities.
- Prototyping: Rule-based agents are excellent for rapid prototyping before moving to Machine Learning models.

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Conclusion

Summary:

- Successfully implemented an ECG-based agentic monitoring prototype.
- Integrated signal processing (Perception) with decision logic (Reasoning).
- System provides interpretable feedback on Fatigue and Stress.

Thank You!

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