Detecting Pre-Migraine Night Patterns with Wearable Biosensors and Machine Learning

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Introduction

Migraine is a prevalent neurological disorder characterized by moderate to severe headaches, often accompanied by disturbances of the autonomic nervous system. These disturbances may manifest in changes in cardiovascular, respiratory, and electrodermal activity. Early detection of these physiological changes could be important in preventing or mitigating migraine episodes.

Aims and Goals

The aim of this study was to investigate biomedical signal patterns that may indicate physiological changes preceding migraines, using the Empatica Embrace Plus wristband and machine learning.

Main Objectives:

- Analyze wearable data with machine learning to predict migraines from nocturnal physiological signals.
- Determine optimal analysis frames to maximize prediction accuracy.
- Identify the most significant physiological features for the detection of migraines.
- Address the existing research gap by making a valuable contribution to the scientific community and expanding knowledge on migraine patterns.

Migraine Pattern Detection Workflow

Data Collection and Labeling

Preprocessing and Feature Extraction

Machine Learning Models

Performance Evaluation

Results

Shorter analysis frames of 5 and 10 minutes yielded higher accuracy and recall, effectively capturing physiological changes that occur before migraines. The most predictive features included mean, median, standard deviation, max, min, clearance factor, crest factor, impulse factor, peak value, RMS, and shape factor. ANOVA tests confirmed the significance of these features, revealing distinct physiological differences between pre-migraine and migraine-free nights. Importantly, importance scores highlighted the relative contribution of each signal: skin temperature (0.8) and pulse rate (0.7) were the most influential, followed by electrodermal activity (0.5), accelerometer data (0.3), and metabolic equivalent of task (0.4). In particular, the most significant features varied across different signals. Individualized models, especially XGBoost and Random Forest, outperformed generalized models, with the best generalized XGBoost model demonstrating stable performance: accuracy of approximately 81%, recall of 59%, precision of 64%, and an F1-score of 60%.

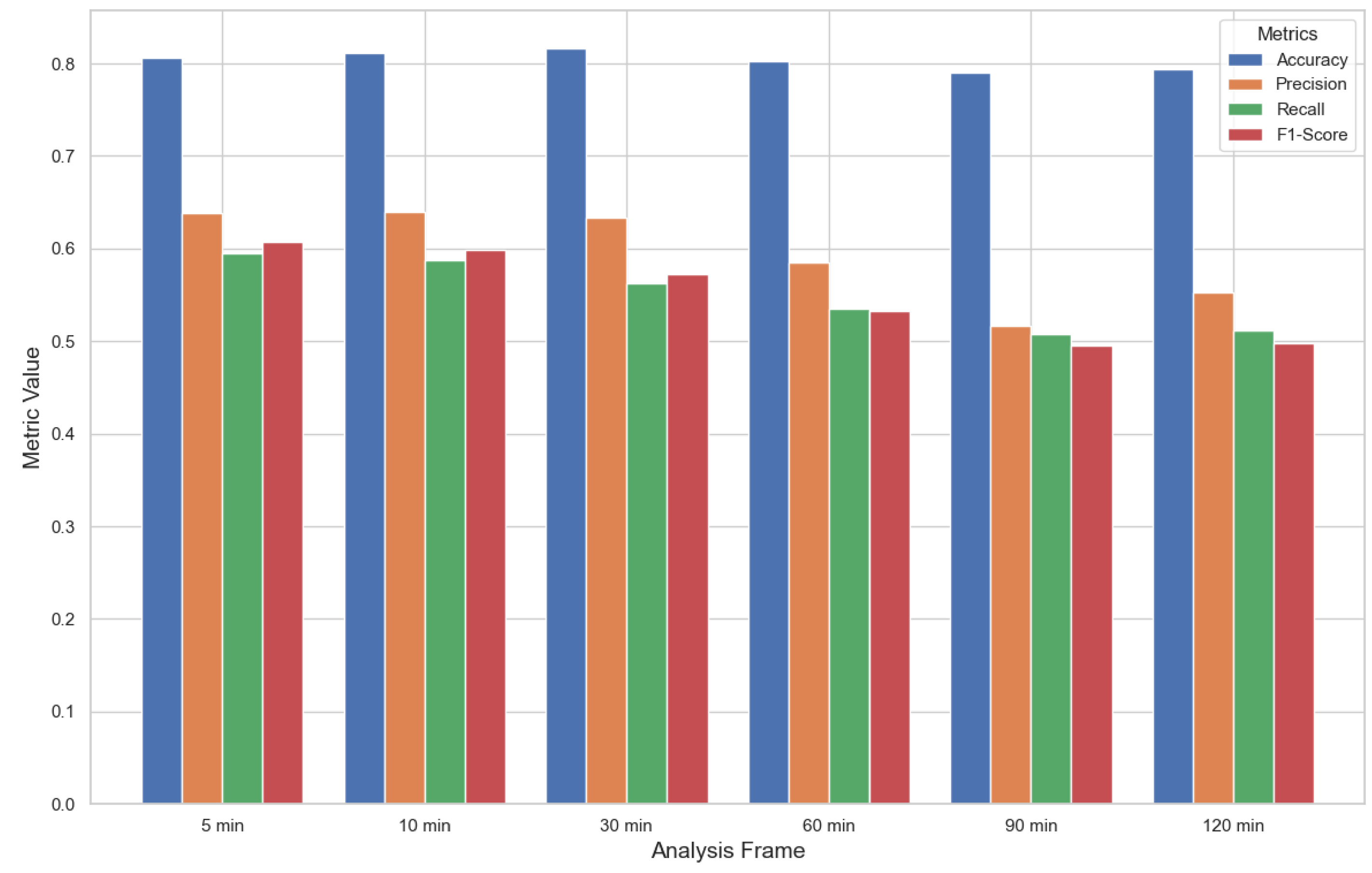

Figure 1: Performance metrics across analysis frames of 5, 10, 30, 60, 90, 120 minutes

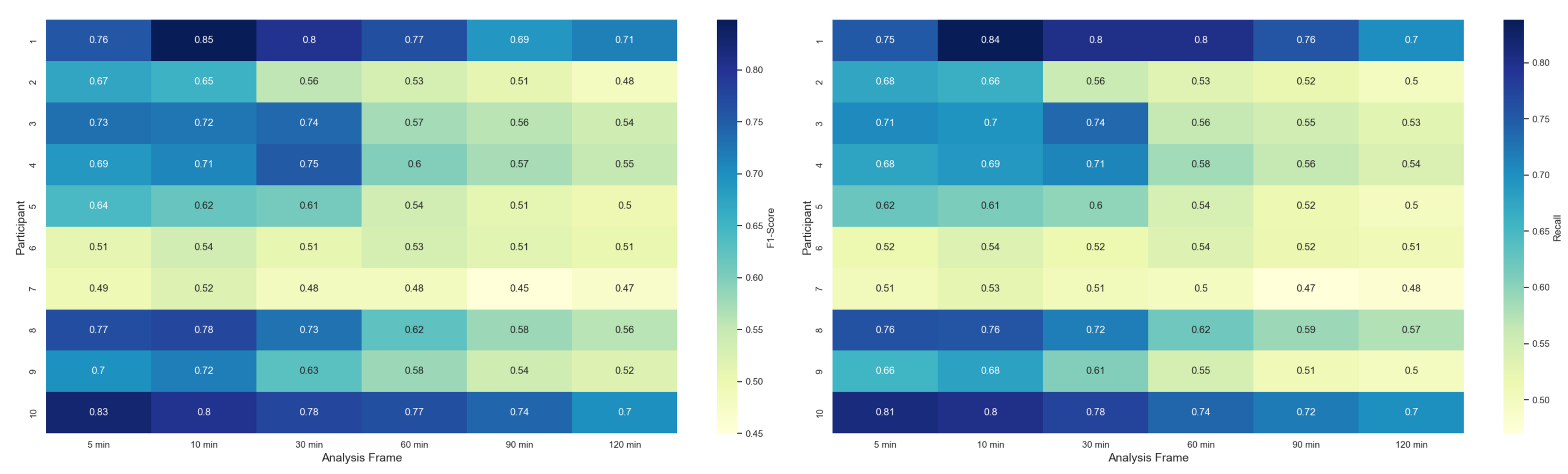

Figure 2: Comparison of classifier F1-Scores by analysis frame and participant (left). Corresponding Recall values (right)

Conclusions

This study supports the potential of wearable technology and ML models in the prediction of migraines. Shorter analysis frames of 5 and 10 minutes provide more predictive information, suggesting the importance of finer temporal analysis. Key predictive signals included skin temperature, pulse rate, electrodermal activity, and accelerometer data with the most valuable features of each detected signal. Future work should focus on larger participant samples and explore additional factors such as daily and environmental influences to improve predictive accuracy and clinical applicability.

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