Predicting Sleep-Wake Times from Wearable Sensor Data using Change Point Detection

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Abstract

In the era of ubiquitous wearable technology, predicting sleep and wake times based on activity and biometric data has emerged as an important area of research. Previous studies have predominantly relied on supervised learning algorithms, trained using polysomnography (PSG) data. However, the collection and labeling of PSG data are prohibitively expensive and logistically challenging. Moreover, the alternative use of self-recorded sleep reports as labels for PSG data is fraught with issues of subjectivity and inaccuracy. In response to these challenges, this study introduces an unsupervised algorithm for sleep/wake times prediction using biometric data (e.g., systolic, diastolic blood pressure, and heart rate) obtained from wearable devices. This algorithm is grounded in the change point detection methodology, a technique well-suited for identifying pattern changes in time-series data. We estimate common parameters based on general patient data, which enhances the algorithm's adaptability across diverse patient profiles. These estimated parameters are then utilized to determine the optimal change points for each patient. The algorithm was tested on a cohort of 590 patients. Our results validate the proposed method's effectiveness and open new avenues for leveraging wearable device data in sleep research.

Keywords: Change point detection, Hidden markov model, Sleep time, Gaussian mixtures, Wearable device

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Education History

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Professional Background

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Selected Awards and Honors

1.	2010	M.G. Michael Award, University of Georgia
2.	2006	Wassily Hoeffding Award, UNC-CH

Selected Publications

1. Lee, B.∗, Ahn, J., and Park, C. (2024) Differential privacy in scalable general kernel learning via K-means Nystrom random features, NeurIPS
2. Han, S., Kim, M., Jung, S., and Ahn, J. (2024), Sparse Ordinal Discriminant Analysis, Biometrics
3. Li, B.∗, Yoon, C.∗, and Ahn, J. (2023), Reproducing kernels and new approaches in compositional data analysis, Journal of Machine Learning Research
4. Yoon, C.∗, Jeon, Y., Choi, H., Kwon, S., and Ahn, J. (2023), Interpretable classification for multivariate gait analysis of cerebral palsy, BioMedical Engineering Online
5. Park, J.∗, Ahn, J. and Park, C (2023), Kernel sufficient dimension reduction and variable selection for compositional data, ICML