Leveraging ML on Biometric Sensor Data to Detect and Predict Sleep Activity

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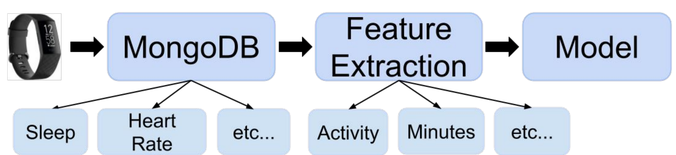
Introduction

Previous research has demonstrated that machine learning has the potential to save lives in the domain of medical technology. Furthermore, metrics such as heart rate, step count, and even time of day can be excellent predictors of biological events. Our research works to take advantage of these metrics, using machine learning, to anticipate sleep activity before it happens.

Materials anMethodsd

- **Process:**
  - Collected continuous, minute-by-minute sensor data
  - Aggregated additional Fitbit data from publicly available sources*
- **Model Selection:**
  - Gradient Boosting Machines produced the most accurate results while minimizing bias.
  - Feature extraction from sensor reported data had an outsized impact on increasing prediction accuracy.
  - Fine-tuning classifier parameters yielded the greatest improvement to the model's precision and recall.
- **Detection vs Prediction:**
  - Initially trained a model to detect sleep by employing Fitbit's own sleep label as our ground truth value
  - Transitioned our model to predict sleep, making use of the features we had developed for detection



Acknowledgements and Datasets

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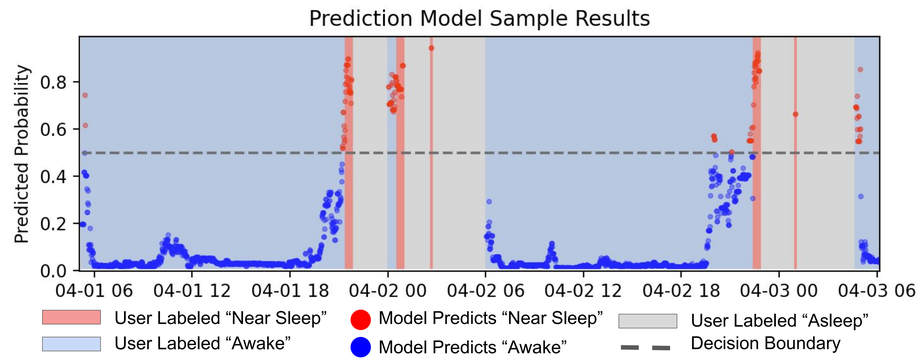
* Furberg, R., Brinton, J., Keating, M., & Ortiz, A. (2016). Crowd-sourced Fitbit datasets 03.12.2016-05.12.2016 [Data set]. Zenodo. http://doi.org/10.5281/zenodo.53894



Model Details

Goal: Train ML models to both detect and predict sleep (see Materials and Methods for distinction).

Input Features

Minute-by-minute biometric data gathered and extracted from Fitbit devices. (See Feature Extraction)

Target Label - Detection

Binary variable gathered from Fitbit devices where
0 - User is awake
1 - User is asleep

Target Label - Prediction

Binary variable inferred from sleep data where
0 - User is awake and greater than 30 mins from being asleep
1 - User is awake and less than 30 mins from being asleep

Model

The prevailing model when considering Accuracy and F1-Score was Gradient Boosting Machines (SKLearn implementation).

Results

Dataset is composed of data extracted from 9 individuals over a 2 month period, data is train-test split with an 70:30 ratio in contiguous time chunks. Precision and Recall metrics are based on 1-class only.

Detection Model

# Samples	Train	Test
0 - Awake	126,331	53,531
1 - Asleep	63,309	27,737

	Accuracy	Precision	Recall
Train	0.950	0.918	0.935
Test	0.949	0.919	0.934

Prediction Model over & under-sampling methods were used to balance training set

# Samples	Train	Test
0 - Awake	60,570	51,881
1 - Near Sleep	30,285	2,075

	Accuracy	Precision	Recall
Train	0.928	0.890	0.901
Test	0.922	0.305	0.794

Feature Extraction

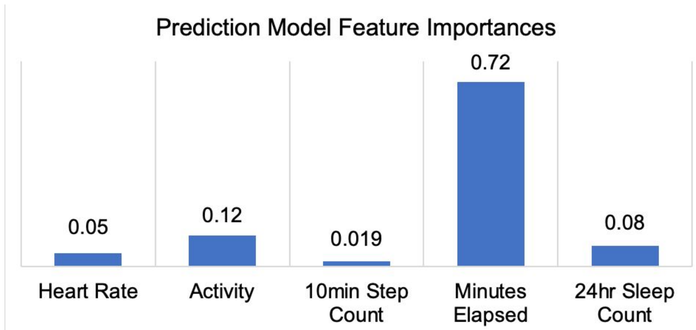
Each data sample represents measurements from a distinct minute of time, information about temporal context is extracted and appended to each sample (e.g. total daily step count).

Raw Data Aggregated from Fitbits

- Sleep
  - binary: 0 - awake, 1 - asleep
  - not used directly as an input to prediction model
- Heart Rate (int)
- Step Count (within minute, int)

Features Extracted from Raw Data

- Activity
  - Sum of current day's steps until the given minute
- 10 Minute Step Count
  - Number of steps taken in the previous 10 minutes
- 24 Hour Sleep Count
  - Total number of minutes the user has been labeled as asleep in the preceding 24 hours
- Minutes Elapsed
  - Time in minutes elapsed from 00:00



Conclusion/Future Work

- A major difficulty in collecting our results is the act of ensuring a high level of prediction accuracy while maintaining a generalizable model with high recall.
- Future research should be based on a diverse dataset that includes non-habitual sleep activity.
- Our final model gives promising results for predicting sleep and provides a basis for future work in generalizing to other biological events.