Gaurav Mishra, Nov 10, 2022 CS7180-Advanced Perception

Sleep Disorder Prediction using day-time ECG

Abstract: The work focuses on simplifying detecting sleep disorders accessible to everyone by incorporating light-weight detection modules. Using ECG signals, the model predicts 7 sleep disorders even when the subject is awake. The work done in this project uses wake ECG data from wearables to predict 7 sleep disorders, with as little as 5 second of data. This might be a good step in the direction of making ubiquitous computing synergetic with predicting sleep disorders with fewer modalities. Sleep related disorders are one of the most commonly avoided problems. It affects people from all background and can be attributed to multiple causes. Sleep related problems often remain sidelined and this can be solved by including such interventions on wearables which are fairly ubiquitous.

Introduction:

Sleep is important and the lack of it leads to a host of problems. Many researchers have tried to incorporate functionalities into wearables to ensure that sleep monitoring is minimally disruptive and accessible. In [3], the authors propose wearable monitoring of sleep disordered breathing by estimating apnea-hypopnea index(AHI) using wrist wearable with PPG(photoplethysmography). In [2], the authors propose unobtrusive, wearable, and wireless system for the prescreening and follow-up in the domestic environment of specific sleep-related breathing disorders. The device integrates PPG, an accelerometer, a microcontroller, and a bluetooth transmission unit. It acquires data during the whole night and transmits to a PC for off-line processing.

In [1], the authors analyse tracheal movement to predict sleep apnea. [4] uses Wavelet-based feature extraction method to convert electroculogram and electromyogram signals and then use Machine Learning to detect sleep disorders. All these works focus on night-time collection of data when the subject is sleeping. The work done in this project uses wake ECG data from a polysomnography(PSG) study to predict 7 sleep disorders, with as little as 5 second of data. This might be a good step in the direction of making ubiquitous computing synergetic with predicting sleep disorders with fewer modalities.

Methods:

The dataset used in the paper is called CAP Sleep Database [5]. It is a polysomnography(PSG) study of 108 subjects, with or without any sleep-related pathology. The data contains PSG recordings of each subject, along with a txt file which contain time annotations per sleep period. The original CAP database has one EDF file per subject containing all PSG recordings. Not all parts of the recordings correspond to wake time. Hence, first the EDF files were converted to CSV(comma separated values) for convenient data wrangling. The original CAP database has one EDF file per subject containing all PSG recordings. Not all parts of the recordings correspond to wake time.

The data was passed through multiple filters like high pass, notch and low pass to get a clean ECG signal in the end. These filters have been shown to reduce artifacts and noise. This cleaned signal was then used to generate 35 time-domain and frequency domain features.

These features were then fed to ML algorithms(Random Forest and SVM in particular)

Results:

The Random Forest algorithm performed best with 100% accuracy on training set(seems like overfitting) and 94% accuracy on validation set. The intermediate results and outputs are shown in the notebooks attached.

Conclusion:

The findings show an interesting direction for the task of sleep disorder detection. Using wearables' data might result in greater awareness about sleep disorders and hence, early diagnoses. Sleep disorders correlate with other serious ailments, and early detection can be helpful in maintaining well being. The integration can be simple and can be done organically into the health apps of devices. What would work best is when these data collections happen on the wearables in order to emulate the actual scenarios. Another limitation of this work is the type of validation that is used. Fields like this choose to use leave-one-subject-out cross-validation to account for the fact that these disorders manifest uniquely in each individual and that one model might not work for every individual.

References:

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[6] Some part of the feature generation was done by the code by Varun Mishra.