An Automatic Sleep Apnea Analysis with Soft Computing Approaches

By

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

Acknowledgment

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List of Abbreviations

Adaptive Boosting (AdaBoost)

Adaptive Resonance Theory (ART)

Apnea-hyponea Index (AHI)

Approximate Entropy (ApEn)

Artificial Neural Networks (ANNs)

Automatic CPAP (A-CPAP)

Autonomic Nervous System (ANS)

Backpropagation (BP)

Body Mass Index (BMI)

Bootstrap Aggregation Learning (Bagging)

Central Sleep Apnea (CSA)

Central tendency measure (CTM)

Chest volumes (CV)

Continuous Positive Airway Pressure (CPAP)

Discrete Wavelet Transform (DWT)

Dissolved oxygen (DO)

Electrocardiogram (ECG)

Electroencephalogram (EEG)

Electromyogram (EMG)

Electrooculogram (EOG)

Fast Fourier Transform (FFT)

Fixed CPAP (F-CPAP)

Flow-based auto-CPAP (f-APAP)

Heart rate variability (HRV)

Heart rates (HR)

Hierarchical Multi Master PSO (HMM-PSO)

Intra Class Correlation (ICC)

K-Nearest-Neighbor (KNN)

LArge Memory STorage and Retrieval (LAMSTAR)

Least Squares Support Vector Machine (LS-SVM)

Mixed Sleep Apnea (MSA)

Nocturnal airway-patency appliance (NAPA)

Non Rapid Eye Movement (NREM)

Obstructive Sleep Apnea (OSA)

Oral Appliances (OAs)

Oxygen Saturation (SO2)

Particle Swarm Optimization (PSO)

Photopletismography (PPG)

Polysomnograms (PSG)

Power spectral density (PSD)

Pressure relief is a continuous positive airway pressure (PR-APAP)

Principal Component Regression (PCR)

Probabilistic ANN (PNN)

Quadratic Discriminate Analysis (QDA)

Rapid Eye Movement (REM)

Reasoning Unit (RU)

Receiver operating characteristic (ROC)

Recursive Feature Elimination (RFE)

Respiratory disturbance index (RDI)

Sleep Apnea (SA)

Support Vector Machine (SVM)

United State Dollar (USD)

Abstract

Sleep Apnea (SA) is a common disorder without "age-specific" that affects approximately 2% of women and 4% of men; sleep apnea is characterized by repetitive cessation of breathing during sleep. The consequences of the sleep apnea include daytime sleepiness, impaired cognitive function, impaired memory, neurocognitive dysfunction, and development of cardiovascular disorders, metabolic dysfunction, and impaired quality of life. This thesis investigates the automated detection and prediction of sleep apnea. Many researchers have concentrated on automated detection of sleep apnea, but not much comprehensive or well-ordered work has been done on signal and feature selection or on predicting of the sleep apnea.

The objective is to find the best set of signals as input and the best set of features from selected signals that can be used by a machine learning approaches to study sleep apnea. The best set here is not only refers to a smallest set of signals with a good performance in sleep apnea analysis but also consideration for a set of signals that can be easily acquired from patients.

During the course of this thesis, several algorithms were developed. These algorithms can be used in sleep apnea studies or in wider machine learning areas. The most important contributions of this thesis can be summarized as below:

-Developing a new signal segmentation algorithm designed specifically for sleep apnea by attention to its properties. This algorithm chose times windows with a greater probability of containing at least one sleep apnea event. After that these segmentations are generated, they should be reviewed by the machine learning approaches to be classified as sleep apnea or normal.

-Developing a novel Support Vector Machine (SVM)-based approach named Self-Advising Support Vector Machine (SA-SVM) that transfers more knowledge from the training phase of SVM to the test phase. This idea helps SVM to learn from misclassified data in training phase and use this gained knowledge, in the testing phase. This approach can be used in any binary classification problems and it shows also high impact in sleep apnea detection.

-Developing a new parallel structure for Particle Swarm Optimisation (PSO). Finding the best set of input signals or the best set of features required a huge amount of computation power which a single PSO – or other optimisation approaches- cannot deal with, so a new hierarchical multi-master structure for parallel PSO was developed in this thesis, which quickly revealed its advantages over previous parallel PSO structures.

In this thesis real data has been used from Concord Repatriation General Hospital in Sydney. Obtained result shows a good performance in detection and classification of sleep apnea. Together with detection and classification, a prediction of sleep apnea was also considered. The prediction stage examines some famous neural networks structures and demonstrated how to improve the final result by taking advantage of multi neural network approach.