Most Discriminative Atom Selection for Apnea-Hypopnea Events Detection

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Motivation

- The Obstructive Sleep Apnea-Hypopnea (OSAH) syndrome is characterized by repetitive episodes of airway narrowing during sleep.
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Medical criteria

- *apnea:* if the amplitude of the airflow signal decreases below 25 % of the “baseline” breathing amplitude and it remains below that level for more than 10 seconds.
- *hypopnea:* if the amplitude of the respiratory signal decreases below 70 % of the “baseline” breathing amplitude, it remains so for more than 10 seconds for more than 2 breathe periods.

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Apnea-Hypopnea Index (AHI) = average number of AH events per hour.

- 5<AHI≤15, mild.
- 15<AHI≤30, moderate.
- AHI>30, severe.

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Polysomnography

Proposed method

SHHS: Sleep Heart Health Study

The SHHS database contains 1000 PSGs of the “Sleep and Epidemiology Research Center (SERC)[1]” at the “Case Western Reserve University”.

- Biomedical signals:
  - Nasal airflow
  - SaO_2
  - OXStat
  - EEG

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Signals of interest

Dictionary

$$\mathbf{s} = \sum_{j=1}^{M} \phi_j a_j = \mathbf{\Phi}\mathbf{a}$$

$$\mathbf{s} \in \mathbb{R}^N$$

$$\mathbf{\Phi} \in \mathbb{R}^{N \times M},\ M \geq N$$

$$\mathbf{a} \in \mathbb{R}^M$$

Sparse representation problem:

- *learning*.
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Learning and inference

- Noise Overcomplete Independent Component Analysis (NOCICA)

$$\mathbf{s} = \sum_{j=1}^{M} \phi_j a_j + \boldsymbol{\varepsilon} = \Phi \mathbf{a} + \boldsymbol{\varepsilon}. \quad (1)$$

Then:

$$\Delta\mathbf{\Phi} = \eta \Lambda_\varepsilon((\mathbf{s} - \mathbf{\Phi}\mathbf{a}_{MAP})\mathbf{a}_{MAP}^T - \mathbf{\Phi} H^{-1}). \quad (2)$$

- Orthogonal Matching Pursuit (OMP)

$$\min ||\mathbf{s} - \mathbf{\Phi}\mathbf{a}||_2 \text{ subject to } ||\mathbf{a}||_0 \leq T, \quad (3)$$

where $|| \cdot ||_0$ denotes the zero-norm.

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Most Discriminative Atom Selection

The idea behind this method is to select the most discriminative atoms of $\mathbf{\Phi}$ in order to improve the classifier's performance.

Main steps:

1. Compute the atom activation frequency n_{ci}^{j} given the class i and the atom j.
2. Select the most discriminative atoms of $\mathbf{\Phi}$ by $D = |n_{c1}^{j} - n_{c2}^{j}|$.

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Substeps:

1. Improve the neural network performance.
2. Obtain the optimal configuration of the classifier.

Database

Training set:

AHI	Total studies
$\text{AHI}\leq 5$	5
$5<\text{AHI}\leq 10$	5
$10<\text{AHI}\leq 15$	5
$\text{AHI}>15$	5

Test set:

AHI	Total studies
$\text{AHI}\leq 5$	21
$5<\text{AHI}\leq 10$	21
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AH events detection

Scatter plots

Tables of results

MDAS method (Multilayer perceptron):

	OAD	CD
Inputs	24	30
Neurons (hidden layer)	14	14

Studies:

	OAD	CD
Total studies	84	84
Sensibility (%)	74.52	68.86
Specificity (%)	76.73	67.69
Correlation (%)	90.04	74.57

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- A novel methodology for detecting AH events by using only the SaO_2 signal was developed.
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¡Thank you!

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