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Identifying sleep apnoea and hypopnoea episodes from respiratory polygraphy signals☆

*Dayana Lizethe Guzmán Sierra, Mariano Carreño León, Luz Helena Camargo Casallas**

Grupo de investigación Ingeniería y Nanotecnología para la vida, Facultad de Ingeniería, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia

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ABSTRACT

Objective: To design a diagnostic support system for sleep apnoea and hypopnoea syndrome (SAHS) using moving average based on knowledge, able to identify SAHS episodes from a respiratory polygraphy (RP) database.

Methods: An analysis was made of data obtained from a public database, that included the RP signals, nasobucal airflow, thoracoabdominal movement, and pulse oximetry of 23 patients between 28 and 68 years with suspected SAHS, and with a body mass index (BMI) from 25.1 to 42.5.

Results: The identification and classification of episodes of apnoea and hypopnoea was obtained.

Conclusions: The algorithm designed identified episodes of SAHS using polygraphy signals, which by implementating in a graphical interface allows visualisation of onset, duration, type, oxygen saturation, and pulse oximetry of each episode, and can be used as a support tool for the diagnosis of sleep disorders.

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Identificación automática de episodios de SAHS utilizando señales de poligrafía respiratoria

Palabras clave:
Polisomnografía
Respiración
Apnea
Sueño

RESUMEN

Objetivo: Diseñar un sistema de apoyo diagnóstico para el síndrome de apneas-hipopneas del sueño (SAHS) utilizando conocimientos basados en media móvil, capaz de identificar episodios de SAHS a partir de una base de datos de poligrafía respiratoria (PR).

Métodos: Se analizaron las señales de poligrafía respiratoria (flujo aéreo nasobucal, movimiento toracoabdominal y pulsioximetría) de 23 pacientes con sospecha de SAHS

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* *Corresponding author.*
E-mail address: lhcamargoc@udistrital.edu.co (L.H. Camargo Casallas).

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(edad, 28-68 años; índice de masa corporal, 25,1-42,5), obtenidas de una base de datos pública.
Resultados: Se identificaron y se clasificaron episodios de apnea y hipopnea.
Conclusiones: Se detectaron los episodios de SAHS utilizando señales de poligrafía respiratoria cuya implementación en una interfaz gráfica permite la visualización del inicio, la duración, el tipo, la saturación de oxígeno y la pulsioximetría de cada episodio, y se puede emplear como herramienta de apoyo al diagnóstico del trastorno del sueño.
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Introduction

Sleep is considered to be one of the necessary phases for the proper functioning of the body, which not only helps to repair the body at the end of the day, but is also associated with the regulation of neuronal processes and other systems, hence why sleep medicine is becoming increasingly important. Sleep disorders in a population are linked to decreased productivity, road traffic accidents,[1] mental health problems and other types of illnesses, such as arterial hypertension, cerebrovascular disease, coronary disease and neurocognitive disease.[2]

Research studies carried out by the American Academy of Sleep Medicine (AASM) indicate that approximately 35% of the US population suffers or has suffered from some form of sleep disorder in their lifetime.[3] The most common nocturnal disorder is sleep apnoea-hypopnoea syndrome (SAHS).[4] Apnoea is the cessation of the oronasal airflow for more than 10 seconds and, in hypopnoea, airflow is reduced by more than 50% of the baseline value, leading to an oxyhaemoglobin desaturation of 2–4%. Each episode of apnoea lasts for 20–30 s, although they can last for 2–3 min.[5,6]

Some studies indicate that SAHS affects 2% of women and 4% of men[7]; however, on considering patients between the ages of 30–60 years at random, up to 9% of women and 24% of men have been found to be affected.[8]

At present, the most commonly used method for diagnosing SAHS is polysomnography (PSG),[6,9] which includes an electroencephalogram, electrocardiogram and submental electromyogram and measures of respiratory changes such as position changes, snoring, thoracoabdominal movement, pulse oximetry, oxygen saturation, oronasal airflow and electrocardiogram. However, this method is costly and very time-consuming, and the detailed analysis that must be performed by the specialist is complex.[10] Various studies have shown that equipment that exclusively records respiratory variables can be used,[11–16] thus reducing costs and waiting times, and facilitating the diagnosis of SAHS at sleep centres.[14]

The objective of this study is to design a diagnostic support system for SAHS using a moving average-based approach that is able to identify episodes from a respiratory polygraphy (RP) database.

Methods

The data were extracted from the Physionet database, which contains overnight polysomnograms (mean, 7 h) of 25 patients with suspected breathing-related sleep disorders.

The subjects from whom the data were obtained were randomly selected over a period of six months from among the patients of the St Vincent's University Hospital Sleep Disorders Clinic, in Dublin, and were aged between 28 and 68 years, with a body mass index (BMI) of 25.1–42.5 and an apnoea–hypopnoea index (AHI) of 1.7–90.9.

Moreover, the patients were deemed not to suffer from heart disease or autonomic dysfunction, and were not on medication capable of interfering with their heart rate.[17] According to the Epworth sleepiness scale,[17] 76% of the individuals presented mild to severe sleepiness.

RP recordings were obtained in the standard European data format (EDF) used for polysomnography (PSG) recordings, which identified each individual and specified the technical characteristics of the recording. The recordings were characterised, annotated by the specialist and in an open code – conditions that allowed them to be used for this project.

For the signal analysis, two recordings did not meet the inclusion criteria set for this study, and so the recordings of 23 subjects were used (19 men and 4 women). To analyse the signals, three main phases were proposed: signal preprocessing, processing and apnoea episode detection.

Fig. 1 shows a diagram of the general proposal for detecting episodes of SAHS, specifying the procedures considered for each stage.

Preprocessing

The American Academy of Sleep Medicine (AASM) classifies RP into four types. Type 1 is conventional PSG, monitored by a sleep laboratory technician (with at least 7 channels); type 2 is PSG performed with a portable device and is not monitored by a technician; type 3 corresponds to what we call RP, where breathing, thoracoabdominal effort and pulse oximetry are recorded (with a total of 4–7 channels); and type 4 corresponds to super-simplified studies with 1- or 2-channel devices (oximetry and/or breathing).[18] For this study, airflow (oronasal airflow), respiratory effort (thoracoabdominal movement) and oxygen saturation (pulse oximetry) data were considered, which are recordings obtained by PSG that correspond to type 3 RP.

To view the RP recordings, non-commercial Polyman software was used, which is compatible with the EDF and facilitates PSG signal viewing.[19] Segments were found that were eliminated based on the following conditions for each signal: Oronasal airflow, amplitude between −20 and 20 l/min, with a dominant frequency of 0.2 Hz, reported for the breathing

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