Analysis and classification of sleep EEG using wavelets and radial-basis functions networks

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Among the great number of biomedical signals considered in the polysomnographic analysis, electroencephalogram signals take a dominating place. Their analysis is essential to carry out a complete and precise classification into sleep stages. However, these signals remain difficult to analyze. First, they are composed of a multitude of rhythms from the cerebral activity itself. Second, they contain various electric disturbances. Third, they vary widely from one person to another.

The aim of this work is to propose an analysing technique of electroencephalogram's signals using wavelet packets transform. It also aims to validate the use of radial-basis functions networks for sleep stages classification.

This work shows how wavelet analysis (in particular the wavelet packets decomposition) are well adapted for the study of these complex signals. The power of this method lies in the concept of multiresolution which provides complete tools as well for rhythms detection at the lowest frequencies as for the events detection which appears such as singularities in the signal. Two fast algorithms were implemented. Many spectral and statistical characteristics were then extracted from the wavelet coefficients on each scale processed on 2.5 seconds windows (with a recovering time of 1.25 seconds). The evolution of the principal characteristics according to the sleep stages was also studied and gives us a rather good idea of the part they play in the classification.

Classification in sleep stages was carried out from the characteristics computed during the electroencephalograms analysis for every epochs with a radial-basis function network. This paradigm contains very interesting properties that could balance the ones of the multi-layer perceptron, commonly used in the polysomnographic analysis. For example, we can note its easy parametrisation or its local approximation property which allows to give a better resolution in the information concentration zone. Therefore, artificial neural networks are appreciated for their robustness or their fault and noise tolerance. Such properties are really interesting when one have to analyse data from different subjects or with slightly different acquisition conditions.

Sleep signals of ten subjects have been used for the training and the testing processes. Quite interesting results have been obtained with 20 second periods by choosing the most encountered stage for all 1.25 seconds epochs in that interval. Indeed, 82.5% of accordance have been reached with hypnograms made by sleep specialists. More exactly, we measured 100% of accordance for the awake stage, 84.1% for the REM stage, 60% for the stage 1, 87.7% for the stage 2, 78.9% for the stage 3 and 83.9% for the stage 4.

Supported by the RW contract 02/1/5341