Discrimination ability of individual measures used in sleep stages classification


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ABSTRACT

Objective:

The paper goes through the basic knowledge about classification of sleep stages from polysomnographic recordings. The next goal was to review and compare a large number of measures to find the suitable candidates for the study of sleep onset and sleep evolution.

Methods and material:

A huge number of characteristics, including relevant simple measures in time domain, characteristics of distribution, linear spectral measures, measures of complexity and interdependency measures were computed for polysomnographic recordings of 20 healthy subjects. Summarily, all-night evolutions of 818 measures (73 characteristics for various channels and channel combinations) were analysed and compared with visual scorings of experts (hypnograms). Our tests involved classification of the data into five classes (waking and four sleep stages) and 10 classification tasks to distinguish between two specific sleep stages. To discover measures of the best decision-making ability, discriminant analysis was done by Fisher quadratic classifier for one-dimensional case.

Results and conclusions:

The most difficult decision problem, between S1 and REM sleep, were best managed by measures computed from electromyogram led by fractal exponent (classification error 23%). In the simplest task, distinction between wake and deep sleep, the power ratio between delta and beta band of electroencephalogram was the most successful measure (classification error 1%). Delta/beta ratio with mean classification error 42.6% was the best single-performing measure also in discrimination between all five stages. However, the error level shows impossibility to satisfactorily separate the five sleep stages by a single measure. Use of a few additional characteristics is necessary. Some novel measures, especially fractal exponent and fractal dimension turned up equally successful or even superior to the conventional scoring methods in discrimination between particular states of sleep. They seem to provide a very promising basis for automatic sleep analysis particularly in conjunction with some of the successful spectral standards.