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Jaspal Singh, R.K. Sharma, A.K. Gupta

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A method of REM-NREM sleep distinction using ECG signal for unobtrusive personal monitoring

Jaspal Singh[a*], R. K. Sharma[b], A. K. Gupta[b]

[a]Principal Engineer, DECD, CDAC, A-34, Indl area, Ph-8, Mohali. India
[b]Professor, Dept. of ECE, National Institute of Technology, Kurukshetra, Haryana, India

[*]Corresponding author. Tel.: +911726619084; fax: +911722237050, jaspal_sng@yahoo.com

Abstract

Computers are used extensively in sleep labs for polysomnography and for assistance in sleep staging. However, the test is highly inconvenient to the patient and requires availability of specially equipped sleep labs. Alternative approaches that enable unobtrusive in-home sleep staging with ECG or other signals are highly desirable. In this paper we describe a method that can be used for distinction of REM and NREM sleep stages using spectral and non-linear features of ECG derived RR interval series. To test the accuracy of the system, we extracted the RR interval series from sleep studies of 20 young healthy individuals. Time domain, spectral and non-linear features were computed and tested for discriminability. Features showing high degree of discrimination were selected. A polynomial support vector machine was trained with selected features - percent power in HF band, LF/HF, Poincare plot parameters, exponents from Detrended fluctuation analysis, and sampEn of the half of the signals. The hyperplane was used to classify the other half of the data. The results show an accuracy of 76.25 percent with Cohen's kappa as 0.52 for a two-class model of five minute signal. The results dropped to 72.8 percent accuracy and $\kappa = 0.48$ for the two class model of one minute signal. The minimal set offers a reasonable trade-off for possible in-home monitoring, at least for some conditions that require only REM-NREM distinction. The method after extensive trials and standardisation, can alleviate the load of special purpose PSG labs and enable the tests to be done on general purpose computers.