METHOD OF AND APPARATUS FOR EVALUATION AND MITIGATION OF MICROSLEEP EVENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is based on provisional application, U.S. Ser. No. 60/041,898, filed on Apr. 11, 1997.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

Not Applicable

REFERENCE TO MICROFICHE APPENDIX

Not Applicable

FIELD OF THE INVENTION

The present invention relates generally to methods and apparatus for the determination, monitoring and prediction of various levels of alertness, and for the design and validation of fatigue countermeasures, and more particularly to methods and apparatus for the automatic characterization, detection and classification of microsleep events through processing physiological, eye tracking, video, performance and other alertness-related data obtained from a person while he or she is performing a primary task.

BACKGROUND OF THE INVENTION

Impaired alertness accompanied by short microsleep events is a frequently reported phenomenon in all areas of modem life. A microsleep event can be defined as a somewhat unexpected short episode of sleep, between 1 and 30 seconds, that occurs in the midst of ongoing wakeful activity. It is suspected that such microsleep events are responsible for many accidents on the road and in the workplace, especially during nighttime. For example, the most notorious industrial accidents of our time, Three Mile Island, Bhopal, Chernobyl, and the Exxon Valdez, all occurred in the middle of the night. Microsleep events can be identified through close inspection of physiological, eye-tracking, video, performance and other alertness-related data. The potentially serious consequences of microsleep events were demonstrated in a study on alertness levels of locomotive operators (see L. Torsvall, T. Akerstedt; "Sleepiness on the job: continuously measured EEG in train drivers"; Electroencephalography and Clinical Neurophysiology 66 (1987), pp.502–511.) During this study, one operator failed twice to respond to a stop signal, because several microsleep events occurred at the time the train passed the signal. The microsleep events were indicated clearly in the electroencephalogram (hereinafter referred to as EEG) and electrooculogram (hereinafter referred to as EOG) recordings.

It is well known in the art that information related to alertness, microsleep events, arousal's, sleep stages and cognition may be discerned from changes in EEG and EOG readings. Unfortunately, not all microsleep events are as easily recognizable as the microsleep events in the aforementioned study of locomotive operators. Often, microsleep events exhibit very complex and diverse characteristics depending on the type of physiological, eye-tracking, video, performance and other alertness-related parameter used for the detection. Furthermore, the characterization of microsleep events is strongly related to the individual person (e.g., EEG type, age, gender, chronotype, etc.) as well as the general alertness level of the person and many other circumstances (e.g., acoustic and optical stimuli, time of day, etc.)

To solve the complex and difficult task of the automatic characterization, detection and classification of microsleep events, a pattern recognition algorithm with several components is needed. These components include for example a data recording system, a feature extraction, normalization and scaling system, an example selection system, an event classification system, an event detection system and a contextual system. A neuro-fuzzy hybrid system (e.g., see C.-T. Lin, C. S. G. Lee; *A neuro-fuzzy synergism to intelligent systems*, Prentice-Hall, Inc. 1996) would incorporate all the components mentioned above. In addition, neuro-fuzzy hybrid systems are numerical, model-free classifiers, which are able to improve their performance through learning from errors and through their capability to generalize even if they are working in uncertain, noisy, and imprecise environments.

In recent years, a broad variety of neural networks were used successfully for the recognition of many different patterns in physiological data. Neural networks seem to be the perfect tool for the automatic recognition, classification and interpretation of various EEG patterns, such as sleep stages (e.g., see A. N. Mamelak, J. J. Quattrochi, J. A. Hobson; Automatic staging of sleep in cats using neural networks; Electroencephalography and clinical Neurophysiology 79 (1991), PP. 52–61, S. Robert, L. Tarassenko; New method of automated sleep quantification; Medical & Biological Engineering & Computing 30 (1992), pp. 509–517, J. Pardey, S. Roberts, L. Tarassenko, J. Stradling; A new approach to the analysis of human sleep/wakefulness continuum; J. Sleep Res. 5 (1996), pp. 201–210, N. Schaltenbrand, R. Lengelle, J.-P. Macer; Neural network model: Application to automatic analysis of human sleep; Computers and Biomedical Research 26 (1993), pp. 157–171, N. Schaltenbrand, R. Lengelle, M. Toussaint, R. Luthringer, G. Carelli, A. Jacqmin, E. Lainey, A. Muzet, J.-P. Macer; Sleep stage storing using neural network model: Comparison between visual and automatic analysis in normal subjects and patients; Sleep 19 (1996), pp. 26–35, and M. Groezinger, J. Roeschke, B. Kloeppel; Automatic recognition of rapid eye movement (REM) sleep by artificial neural networks; J. Sleep Res. 4 (**1995**), pp. 86–91), high voltage EEG spike-and-wave patterns e.g., see G. Jando, R. M. Siegel, Z. Hovath, G. Buzsaki; Pattern recognition of the electroencephalogram by artificial neural networks; Electroencephalography and clinical Neurophysiology 86 (1993), pp. 100–109), seizure-related EEG pattern (e.g., see W. R. S. Weber, R. P. Lesser, R. T. Richardson, K. Wilson; An approach to seizure detection using an artificial neural network; Electroencephalography and clinical Neurophysiology 98 (1996), pp.250–272, W. Weng, K. Khorasani; An adaptive structure neural network with application to EEG automatic seizure detection; Neural Networks 9 (**1996**), pp. 1223–240, and H. Qu, J. Gotman; A patient-specific algorithm for the detection of seizure onset in long-term EEG monitoring: possible use as a warning device; IEEE Transactions on Biomedical Engineering 44 (1997)), microarousal (A. J. Gabor, R. R. Leach, F. U. Dowla, Automatic seizure detection using a self-organizing neural network; Electroencephalography and clinical Neurophysiology 99 (1996), pp. 257–266) and for the prediction of Alzheimer disease (e.g., see W. S. Pritchard, D. W. Duke, K. L. Coburn, N. C. Moore, K. A. Tacker, M. W. Jann, R. M. Hostetler; EEG-based, neural-net predictive classification of Alzheimer's disease versus control subjects is augmented by nonlinear EEG measures; Electroencephalography and clinical Neurophysiology 91 (1994), pp.118–130).

The concept of neural networks is very flexible and broad one. Neural networks have been applied to monitor the