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RESPIRATION UNDER MONOTONUOUS HYPOKINETIC CONDITIONS, ASSOCIATION WITH EEG SIGNAL

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SUMMARY

The following text builds on previously presented work which complements and extends for more information. The general topic of this work is to detect potencial relationship between tiredness and respiratory parameters in view of its possible use for prediction of dangerous situations which may occur in a number of everyday human activities due to tiredness.

The measurements performed and results obtained so far demonstrated that the rate of tiredness can be reliably found in an increased incidence of non-stationarities in an otherwise stable steady breathing of monitored persons. However, this phenomenon has just an indicative character, exhibits also high inter- and intra-individual variability and is detectable in long-term observation only (>1 h).

Currently, the work is focused especially on the research of relationship between the respiratory curves and EEG signal. The work is now going in two directions. The first direction investigates the steady breathing, where the repeated ocurrence of alpha level in EEG recordings during the initial phase of inspiration can be confirmed [3]. This synchronization is then apparently getting lost namely at times of falling asleep. The other direction is focused on investigation of nonstationarities in respiratory curves and their projection into the EEG recordings. In both directions, presence of many artefacts complicate the evaluation and thus the main focus of the work is currently to find a reliable identification method able to differentiate the mentioned artefacts and true respiratory nonstationarities in EEG signal.

KEYWORDS

respiration, tiredness, hypokinetic load, EEG, tracking task

INTRODUCTION

A lot of business and leisure activities are associated with monotonous operations, often with limited possibilities to move. To ensure a reliable performance, it is important to monitor and minimize tiredness and phenomena associated with it. In extreme cases, uncontrolled tiredness may have to tragic consequences, e. g. in municipal or long-distance transport [4]. Currently, there are many parameters defined, which either alone or in combination predict or indicate different stages of tiredness represented usually by an increase of errors in performing a monitored activity. Some control systems that measure certain selected parameters and then evaluate how tired the monitored person is are being increasingly used [1]. As a typical example, safety systems based on monitoring the car driver tiredness can be mentioned.

This work should contribute to solving of the described problem by finding whether and in an affirmative case what changes in breathing pattern during monotonous hypokinetic activities can be exploited.

In the first phase of the work, the respiratory curve was assessed as a whole and it was concluded that changes in breathing during these activities do occur and are reflected mainly in by increasing number of non-stationary segments. Dependence of this increase on the type of performed activity was an important conclusion of the first phase. During activities requiring operators attention, the increase in incidence of non-stationarities became apparent, intervals between them got shorter. Accordingly, total number of nonstationarities seen observation intervals grew over the time of the attention demanding activity. In contrast, during activities that do not require the operators attention, increase in occurrence of non-stationarities was more gradual, breathing pattern exhibited a rather stable characteristics. However, the increased incidence of non-stationarities compared to an error rate in performed activities is just a rough parameter.

Based on those findings, we continued our search for other phenomena and parameters which would exhibit higher sensitivity to upcomming tiredness.

EXPERIMENT SETUP

The experiment was designed and performed according to previously tested and verified scheme:

1. alert proband performing a tracking task (TT); attention required
2. alert proband watching TV; no attention required
3. tired proband performing the TT
4. tired proband watching TV

The tiredness was induced by overnight sleep deprivation prior to the test.

Three healthy males and two healthy females aged 25-35 participated in the pilot experiment. None of them took any medication and all were in good health condition corresponding to their age.

DATA ACQUSITION, PROCESSING & EVALUATION

Experimental data were recorded using technologies which proved reliable in previous experiments and which could easily be mutually synchronized.

From among the technologies used, processing of tracking task is interesting. The task was based on following the motion of a target on a monitor by cursor controlled by proband. The motion of the target was composed from six harmonic functions characterized by amplitude and frequency and to probands, it appeared to be completely random. Evaluation of the recorded data was based on comparison of the amplitude spectrum of the cursor motion generated by proband at specified frequencies. Unfortunately, this approach was complicated by different strategies of used by different probands in controlling the cursor motion. Thus, to evaluate the accuracy of the performed task, some other additional criteria were defined. For this, movements of both the target and the cursor were described by vectors, which were then compared in terms of magnitude, direction and timing.

The so called adaptive segmentation method, able to identify similar segments of the recorded signal, was used in processing of data from breathing and EEG recordings. Important is here the fact that the method works with a variable length of segments, which depends on their current location on the signal curve and on their current value. For the best possible identification of boundaries of each segment, the so called sliding windows were used. The algorithm of adaptive segmentation itself is based on fuzzy c-means approach to enable best possible classification of the identified segments into distinctive classes and to display their incidence rate in time [2]. The aim of this phase of the work was to find the channels (signals) least influenced by artefacts and synchronous with nonstationarities resulting from tiredness. Another issue was existing relationship of synchronous occurrence of the alpha level with the beginnings of inspirations in the awake state, which is evidently changing with upcoming tiredness [3]. This fact has many limitations and it is not easy to find functional regularity, validity of which would hold for different individuals. Therefore, in addition to the approaches mentioned above, conventional clinical evaluation of EEG signal in the selected time periods is performed and is compared with the results of data processing from the task tracking to determine how tired the proband really is.

Because the records of breathing and EEG include a lot of artefacts, it is very difficult to distinguish what is the phenomenon associated with the observed tiredness and what is attributable to other conditions that have their origin not only in physiological processes during the measurement, but also in measurement errors. The initial rough segmentation of the measured data was based on analysis of video recordings, in which the apparent symptoms of tiredness of probands were considered. To mark the detected manifestations of upcoming tiredness, the previously validated method developed at the Czech Technical University was used. It is based on evaluation of the recorded video by 5 persons, who are asked to look for specified signs of upcoming tiredness [1]. The final time of upcoming tiredness for each video is calculated as arithmetical average from values marked by five evaluators.

RESULTS AND DISCUSSION

Although the current phase of the data processing suggests more questions than answers, it confirms results of the previous phase of the work, namely the conclusion that upcoming tiredness is accompanied by an increase in number of non-stationarities in the respiratory curve. At this time, we can add that there is an apparent relationship between the breathing- and EEG signals and that with sufficiently accurate identification, those changes can be used to predict upcoming tiredness, especially states related to micro-sleep.

At present, we are still not able to reliably detect onset of loss of concentration or attention of a person due to similarities of responses to a wide range of different stimuli. Another significant problem in the proposed and currently applied method is detection and filtration of artefacts from the true consequences of tiredness symptoms. So far, it is generally solved by correlating the analyzed signals with synchronous video recording. However, this method appears rather impractical and calls for a really reliable automatic method of identification of artefacts and symptoms of tiredness in measured data. This thus becomes the main aim of our future work, which we intend to solve by a standardization of non-stationarities applicable at least on an individual level.

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REFERENCES

[1] Bittner, R, Smrčka, P., Pavelka, M., Vysoký, P. a kol.: ECG EEG and EOG Based Fatigue indicators, Inteligent Systéme in Patient Care, EUNITE, Austria, 2001

[2] Krajča V., Petránek S., Patáková I., Värri A.: Automatic identificaton of significant graphoelements in multichannel EEG recordings by adaptive segmentation and fuzzy clustering, Int. J. Biomed.Comput., No. 28, 1991

[3] Prokš, J.: Zpracování a analýza EEG. DT CTU, 2002

[4] http://www.mikrospanky.cz/nehody.html, 2013