EVALUATION OF SIGNALS BY DETECTION OF BIOPOTENCIALS

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Abstract

This article deals with the evaluation of electrooculography which deals with the symptoms of incoming cachexia and the use of information systems in eHealth. The current trend in the area of system design, operation and maintenance of control systems with either centralized or distributed structure leads to fully automated control systems.

1 Introduction

Micro-eye movements and macro-eye movements can be studied during the examination of the eye movements. The eye movements or the eye-lid position can be determined using methods based on analysis of the recorded videogram. Development of the eye electrophysiology techniques has brought changes in diagnostic technologies [1].

1.1 Artifacts

Artifacts can be classified into two major groups:

- technical – including electromagnetical interference, base noise-like signal (e.g. network signal noise, harmonic signal noise, white signal noise etc.) and pulse disturbance,
- biological – muscle artifacts, electrocardiographic artifacts, artifacts which occurring due to breathing, artifacts caused by impedance changes during electrode–scalp communication, patient's white-coat hypertension.

2 Selected methods for analysis of eye movements in EOG and Eyetracker

Nowadays, a multitude of different approaches are available to analyze eye movements from electrooculographic records: Analysis in time scale, frequency scale and combination of the two methods - time-frequency analysis.

2.1 Analysis in time scale

Using these methods it is possible to determine the amplitude, steepness, cycle and frequency of eye movements, together with the middle value and other parameters. For evaluation of the eye movement activities, a time meter is indispensable, especially for the actual analysis of the eye movements.

Application correlation methods: Used in the reduction of biological artifacts. In signal processing, correlation analysis is mostly based on a new method the new method, called dynamic time wrapping (DTW).

Artifical neural network: The use of neural networks is convenient in the context of classification of the eye motoric activity. There is no pre-determined scheme available, proving that motoric activity can not be generalized for all humans.

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However, using neural networks, a generalisation may be possible by finding logical connections amongst data from various patients and thus be helpful in solving the mentioned problem.

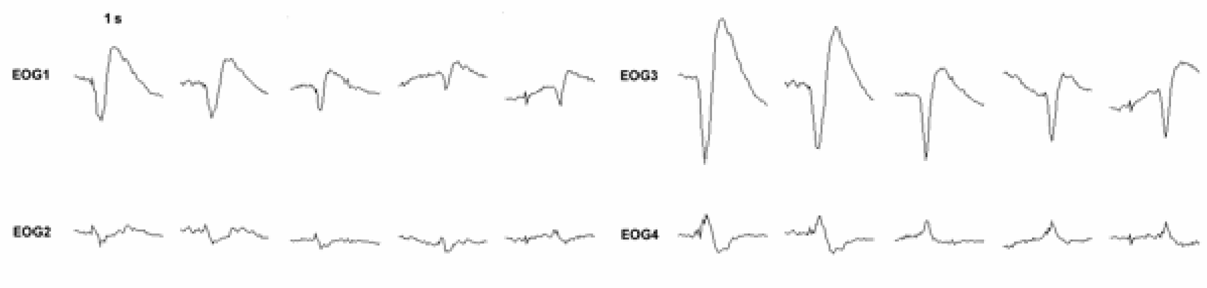

Figure 1: Types of blinking

Kohen's neural network could be helpful in the detection of eye blinking. The training set for self teaching of the Kohen's net is composed of a series of EOG graphoelements of certain length and of certain window overlap (see Figure 1).

2.2 Analysis in frequency scale

The classic Fourier transformation transforms the signal from the time scale to the frequency scale, substituting the original function with the infinite sum of the time-unlimited sinusoidal signals of various frequencies and phase movement amplitudes; but it does not provide information about the frequency signal distribution in specific time intervals [1].

Fourier transformation can be used only for stationary periodical signals. The EOG signal can be considered as stationary only for a short time period. The use of window (weighted) functions represents one of the possibilities to overcome the mentioned problem.

Eye movement analysis in frequency scale has found its use in the particular eye movements monitoring using short-term electrooculagraphic registrations. It is also being used to determine the stage of dementia for senile patients, patients suffering the Alzheimer's disease and Parkinson's disease patients.

Analysis in the frequency scale has shown its usefulness in practice, as it allows for the elimination of disturbing artifacts from the EOG record. Numerical methods of signal filtration are efficient when applied before the analysis of eye movements both in the time and time-frequency scale. Using the Fourier transformation algorithm, it is possible to eliminate undesirable noise artifacts (net artifacts – caused by 50 Hz, muscle and amplitude artifacts), which can otherwise weight the EOG signal with an error (introduce errors into the EOG signal).

2.3 Analysis in the time-frequency scale

The window Fourier transformation presents a certain compromise when processing the signal in time and frequency scales. It provides information on the frequency distribution in different time scales. The precision of this information is however limited by the size of the used window, which is identical during the whole period of the signal recording. If a narrow window is used, the function is better localized in the time scale, at the expense of localization in the frequency scale. This means that while we obtain more precise information about the time, the acquired information on frequency will be less accurate.

3 Evaluation of biosignals associated with the state of vigilance

One of the most useful tools for analysis, detection and prediction of the state of vigilance and human alertness is a dissection of electromagnetic field produced by a whole range of the nervous paths in the brain (mainly by the nervous paths between the cortex and the thalamus).

For similar reasons, there is a whole set of other biological signals, which can be considered at least partially significant, at least partly, as significant. Amongst others, the following are the most significant: frequency of blinking, hand vibrations on the system drivers, resistance and skin temperature, blood pressure and heartbeat frequency, expressions and mimics, response to sound impulses (reflex tympanometry).

In the state of vigilance, the eyes are capable to assimilate information from the environment and to detect the light driven back from the surrounding objects. The information is then processed in the brain. The state of brain relaxation results in the decrease of the EEG alfa and beta brainwaves.

Other significant biosignals enabling the control of the state of vigilance or the degree of tiredness are electrical resistance and the temperature of the skin. Their statistic elaboration is however limited by specificity of each individual (these signals depend on distribution and mass of the body fat found under the skin, or for example the body lotion used by the examined person). The prediction of micro-sleep via analysis of the blood pressure and the heartbeat frequency is not considered optimal (family anamnesis) and using the above mentioned method it is also quite difficult to assess the early stages tiredness/fatigue.

The method which can be used for determination of the mental condition state is based on the system of tools enabling the observation of eye movements and movements of the eye lid, as it was empirically proven, that a tired eye blinks more often and tends to slacken.

Research and statistics indicate that relaxed technology process operators (drivers, engine-drivers, pilots) blink only at intervals and the eye blink has a character of twinkle only [1, 3], however with the growing tiredness, the frequency of eye blinking is growing and the period of closed eye during the eye blink extends.

5.1 Possibilities of the EOG evaluation

During the process of the opening and closing of the eye, the eye ball moves up and down and causes changes in electronic potential. The dipole potential between the cornea and the retina, depends on the position of the eye axis. Eye-blinks can be described as the movement of the eye lid completely covering the eye ball.

Electrooculogram is able to distinguish the tension values in the order of mV (Ag-AgCl electrodes). Individual examined person adaptation to the basic light is a very important aspect in this case rapid transition would cause the under-oscillation of electric potential with the stabilizing period of 25 min.)

The program for the eye-blink assessment is programmed in Matlab. Eye-blink movements can be monitored mostly on electrodes B, C and D (Fig. 2).

There is a clearly negative potential on the electrodes B and C and positive potential on the electrode D, measurable during the eye-blink. These moments can be considered as minimums and maximums of the detected values in the channels.

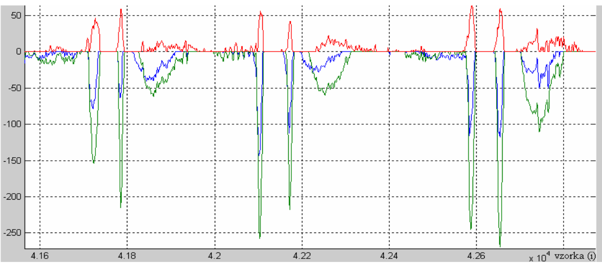

Fig. 2. EOG – canel: B-blue, C-green, D-red

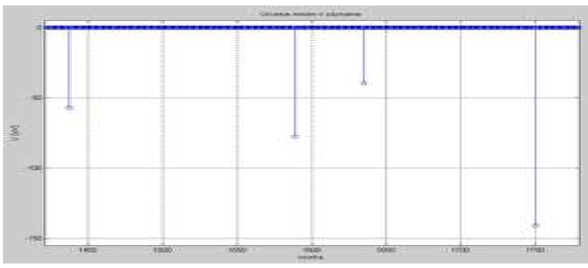

Fig. 3. Evaluation of minimum values in the recording

In every moment of the eye-blink, positions of the minimums and maximums are identical, considering the deviation. Amplitudes of eye-blink are higher on the vertical electrode C, in comparison to the vertical electrode B.

From the registered values, only channels of interest were selected. Each channel has its own specific feature set and so it is processed in a particular way. In the channel, in which minimums are evaluated, the positive values are discarded, and in the channel, in which we want to observe the maximum values, the negative parts of the record arediscarded. It is necessary to also discard a part of the registration which contains the stabilization signal.

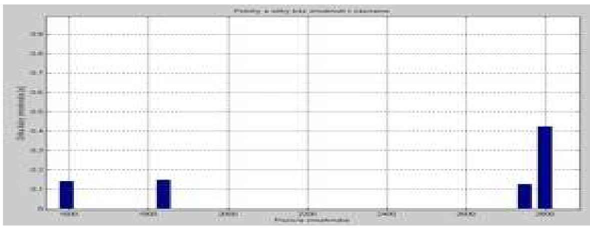

Fig. 4. Positions and widths of the eyeblink bases

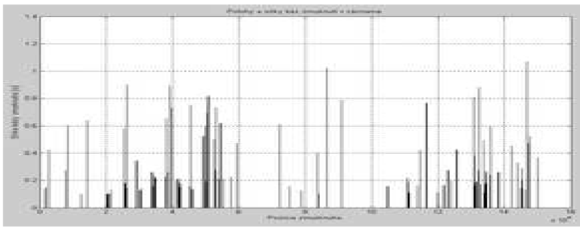

Fig. 5. Occurrence of the eye-blink in the registered record

The acquired matrixes allow us to determine the minimums and maximums, and also to assess the position, size and the width of the eye-blink base. Based on the gathered information, we will be able to compare the positions of minimums of the first and third channel with the maximums of the fourth channel. Only the positions which are in accordance with the tolerable deviation are to be considered. The eye-blink is identifiable with its position, size and width of the eye-blink base in the record (Fig. 3,-5). These parameters allow us to determine the eye-blink length. We have demonstrated that the size of the amplitude towards the eye blink base is not important in the assessment of the eye-blink length.

The proposed algorithm provides a graph with the values of detected eye-blinks together with the exact values of the eye-blink position and eye-blink length. Following the input of the medical criteria of the pathological eye-blink length, the program is able to assess recorded eye-blink as a sign of ongoing/onset tiredness.

6 Conclusion

Many studies have been made in last decade in order to avoid disturbing states caused by failures at work due to the overwork or apathy caused by monotonous work. The number of work areas, where control of vigilance is necessary, is growing and brings the necessity of utilization of electrophysiology and evaluating the biosignals produced by the body.

The human brain is responsible for assimilation of the information from the environment. EEG techniques enable to examine the brain's activity. Eyes are also the source of the electrical potential. During the process of eye opening and closing, a change of electrical potential is generated, which can be detected as EOG. For eye position assessment or eye-lid position detection, methods based on analysis of registered video records - videooculography, infrared camera or Eyetracker can be used.

For the evaluation of the level of the attention of an employee, who is for example constrained to permanently follow indication components (monitor), it is possible to register the EOG-record, which would be assessed and processed in real time.

Further precautions can be taken after real-time evaluation of the biosignal records. If the computer supported system determines based on the biosignals analysis that, for example, the operator of technological process is starting to exhibit tiredness, it will sound an acoustical signal or vibrate the seat.

Gathering the information systems in health service along with the long term recording and detection of biosignals will allow the creation of a database with preventive precautions necessary for the early detection of illnesses caused by work.

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