HARMONIC ANALYSIS USING IN HUMAN VISUAL SYSTEM DIAGNOSTICS BY MEANS OF ELEKTRORETINOGRAMS IDENTIFICATION.

Prof., Dr. Sc. (Math.) Boris G. Marchenko
Ass.prof., Dr. Roman A. Tkachuk
Michail I. Palamar
Ternopil Equipmentmaking Institut
Russkaja 56, Ternopil, 282000, Ukraine.
Phone: 0352 -253-697, 0352- 280-013
Fax: 0352- 251-135, E-mail: PVY@sci.politech.ternopil.ua

ABSTRACT: This paper contain information of theoretical and practical aspects of biosignal measurement in diagnostic equipment for visual system investigation. We shall consider some properties of signals being recorded, give the block diagram of a recording and electroretinograms preprocessing system and analyze some obtained results.

The visual system secures obtaining a considerable amount of information by the man, and so the problem of the medical diagnosis of its state is extraordinarily important.

Among the most effective methods of diagnosis are electrophysiological ones, which are based on the recording and analysis of electric signals of various visual system elements: electroretinography, electrooculography, visual evoked potentials, rheography of the eye [1].

The electroretinogram (ERG) is the graphic representation of the time variation of electric potentials on certain areas of the eye's surface, the said potentials being caused by the reaction of photoreceptors and of other elements of the eye's retina to the light pulse. The value of the electric potentials registered is rather small - a few microvolts to 0.5 millivolt, with the signals recording process accompanied by considerable stochastic interference both of the internal and external origin. Besides, the ERG-signals recording time is limited by the period of the loss of the light adaption as well as by the appearance of destabilizing factors in consequence of some discomfort for the patient. All this imposes heavy demands on the methods of measurement, data processing and analysis.

As is generally known, these methods are based on the mathematical model of the object of measurements. The former investigations of ERG realizations give a possibility to assume that the ERG signal $y(t)$ comprises a "usable" determinate component $x(t)$ and a random component $\xi(t)$:

$$y(t) = x(t) + \xi(t), \tag{1}$$

where t is the time corresponding to the observation interval $[t_0, t_1]$, and as regards summands, we have every reason to hold that the process $x(t)$ has the energy spectrum falling on the 0 to 100 Hz, and the energy spectrum of the $\xi(t)$ process occupies a more wide frequency range.

As a model of the random component a stationary linear stochastic process of the following form is proposed [3]:

$$\xi(t) = \int_{-\infty}^{\infty} \varphi(t-\tau)\, d\eta(\tau), \quad t \in [t_0, t_1], \tag{2}$$

where $\varphi(s)$, $s \in R$ is a real nonrandom function square integrable with respect to s;

$\{\eta(\tau), \eta(0) = 0, \tau \in R\}$ is a homogeneous stochastically continuous random process with independed increments.

The model (2) makes it possible to take into account stochastic properties of the interference that acts as measurements are being taken and is handy when used owing to the fact that there exists, for linear stochastic processes, a common representation of their characteristic functions. The one-dimensional characteristic function of the process $\xi(t)$ (case of Levy representation) is of the following form [2]:

$$f(u) = \exp\left\{ iu\mu \int_{-\infty}^{\infty} \varphi(s)\, ds - \frac{\sigma^2 u^2}{2} \int_{-\infty}^{\infty} \varphi^2(s)\, ds + \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \left[e^{iux\varphi(s)} - 1 - \frac{iux\varphi(s)}{1+x^2} \right] dL(x)\, ds \right\}, \tag{3}$$

where μ and $\sigma > 0$ are real constants; $L(x)$, $x \in R$ is a Poisson jumps measure of the process $\eta(\tau)$.

Conclusion

Possibilities of the linear filtering methods applying for image reconstruction are quite limited. Neural networks method for image restoring may be applied in the cases of both linear and non-linear distortions [4]. In our work we have considered three different factors of detector arrays deffects and their influence on the image distortion. The influence of non linear signal conversion at high signal level is accounted in the same way as linear that is very convinient for computer image processing.

The images constructed using computer simulation method are intended to be patterns for the training set of neural network.

References

1. Applied Optics and Optical Engineering. Edited by Robert R.Shannon and James C.Wyant. Vol.7. Academic Press. New York. London. Toronto. Sydney. 1980.

2. Василенко Г.И., Тараторин А.М. Восстановление изображений.- М.: Радио и связь, 1986. - 304 с.

3. Haykin S. Neural Networks expands SP's Horizons *IEEE Signal Processing Magazine,* 1996, 3, 24-49.

4. Marroguin J.L. Measure Fields for Function Approximation, *IEEE Transactions on Neural Networks,* Vol.6, No.5, 1995..1081-1090.