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COMPONENT METHOD FOR PROCESSING ELECTROGASTRO SIGNAL

The theory of stochastic signal energy based on component method used for statistical processing elektrohastrosignal that will help empower elektrohastrosystem

Key words: elektrohastrosignal, gastrointestinal tract, component method.

Problem statement

According to Health Ministry of Ukraine statistics, there is a tendency to increase the number of people with diseases of the gastrointestinal tract (GIT), which is associated with food poisoning and acute intestinal infections. Particularly at the end of 2013, found 430 cases per 10,000 people, including 297 - is adults and 153 - children under 18 years. Predicted [1] that by 2020, the outbreaks diseases number such double. So Early diagnostics of gastrointestinal tract (GIT) is a challenging problem in modern medicine.

Pathological gastrointestinal tract conditions apparent change in the organs functioning, in particular changes in gastrointestinal motility. These changes are well manifested in electrogastro signals(EGS) - signals that reflect the electrical gastrointestinal tract activity (change in electrical potential arising from smooth muscle specific gastrointestinal). Proper processing of such signals would allow digestive tract diseases diagnosis advance and will help detect functional changes in the early stages of their development and conduct preventive measures, and in case of disease pathology to prevent appropriate treatment.

So, given the above statistics gastrointestinal disease, current scientific and technical challenge is to improve the known or the development of new, more efficient methods of processing EGS to improve the automated diagnostic systems results reliability.

Recent research analysis

At present, common in medical practice diagnosing gastrointestinal tract diseases is automated electrogastro system as an example of the "Гастроскан-ГЭМ" (Russia), "Digitapper EGG" (Sweden, USA), which actually carried out the selection and EGS processing. The software operation in these systems is based on two approaches to the EGS representation, namely deterministic (EGS considered as a mixture of periodic functions) and probabilistic (EGS considered as a stationary process). This used methods of harmonic and spectral correlation analysis EGS. However, these models do not take into account the stochastic nature electrogastro signal (EGS), as a reflection of the gastrointestinal tract functional state. However, these methods have several disadvantages, including the inability evaluation time-phase structure to identify the time points changes the work appearance of the gastrointestinal tract and forecasting trends of the disease if it is available. Also, most methods either do not have the incorporation means of the EGS stochastic component (deterministic approach) or have no means of describing oscillating processes (probabilistic approach), which is the EGS.

The processing signals mathematical apparatus of this type gives stochastic signals energy theory, which use to describe EGS, including its presentation in the form of periodically correlated random process, grounded in the work [2]. In this work, to consider the application to EGS processing techniques such as phase and component. In the work [3] is applied to study EGS-phase method and interpretation are the results. However, the same hardware and software implementation of the method is rather complicated. Easier in this regard is the component method.

Component analysis method the gastrointestinal tract motility

A periodically correlated random processes characteristic feature is the frequency of its mathematical expectation $m_\xi(t)$ and correlation function $b_\xi(t,u)$. Component method based on the fact that these statistical characteristics EGS are periodic functions of time, and therefore can be represented by the type of scheduling:

$$\hat{m}_\xi(t) = \sum_{k\in Z} \hat{m}_k \exp\left(ik\frac{2\pi}{T}t\right), \tag{1}$$

$$\hat{b}_\xi(t,u) = \sum_{k\in Z} \hat{B}_k(u) \exp\left(ik\frac{2\pi}{T}t\right), \tag{2}$$

where, $\hat{m}_k$ та $\hat{B}_k(u)$ – expansion coefficients, with $\hat{m}_k$ random values, and $\hat{B}_k(u)$ - random functions

Expansion coefficients (1) and (2) are also called components and features found on expressions:

$$\hat{m}_k = \frac{1}{T}\int_0^T \hat{m}_\xi(t)\exp\left(ik\frac{2\pi}{T}t\right)dt, \tag{3}$$

$$\hat{B}_k(u) = \frac{1}{T}\int_0^T \hat{b}_\xi(t,u)\exp\left(ik\frac{2\pi}{T}t\right)dt. \tag{4}$$

To find the correlation component, except for Statistics (4) used the expression:

$$\hat{B}_k(u)=\frac{1}{T}\int_0^T\left[\xi(t)\xi(t+u)-m_\xi(t)m_\xi(t+u)\right]\exp\left(-ik\frac{2\pi}{T}t\right)dt. \qquad (5)$$

When known mathematical expectation EGS evaluation correlation component is not shifted. So not shifted is identified and based on these estimates of the correlation function.

Component method for processing EGS as a discrete sequence

To date, all known methods of processing EGS in automated diagnostic systems are implemented as software that operates directly discrete EGS because component method is used to process a sequence of EGS as periodically correlated random sequence of discrete time.

Component method of statistical estimation sequence characteristics EGS discrete time statistics are minor stationary random processes modifications. Therefore, justification of the method of statistical estimation performance is based on the notion $\hbar$-ergodicity, which is expressed as a property of stochastic processes with discrete time [4]

For discrete time process ergodicity as a whole relative to the average necessary and sufficient to vector process with discrete time was ergodic relative to the average:

$$\overset{o}{\xi}(n\Delta t)=\xi(n\Delta t)-\hat{m}_\xi^T(n\Delta t), \qquad n=\overline{0,N-1} \qquad (6)$$

where $\xi(n\Delta t)$ - EGS sequence of discrete time;

Δt - discretization step ($\Delta t \geq \frac{1}{2\Delta f}$, де Δf – sampling EGS rate conditions Kotelnikov theorem;

n - number of reference; N - EGS length sequence $\xi(n\Delta t)$;

$\hat{m}_\xi^T(n\Delta t)$ - periodic continuation expectation EGS as a sequence $\xi(n\Delta t)$ discrete time with:

$$\hat{m}_\xi^T(n\Delta t)=\sum_{k=\overline{1,N}}\chi_{D_k}(n\Delta t)\hat{m}_\xi(n\Delta t+k\Delta t N_T), \qquad n\in\overline{0,N-1} \qquad (7)$$

where k - period number;

N_T – number of points that lie within a EGS period T, $N_T=\frac{T}{\Delta t}$;

$\chi_{D_k}(n\Delta t)=\begin{cases}1, \text{if } n\Delta t\in D_k\\ 0, \text{if } n\Delta t\notin D_k\end{cases}$ - indicator function;

$D_k = [k\Delta t N_T, (k+1)\Delta t N_T)$ - ime range length k-th EGS response;

$\hat{m}_\xi(n\Delta t)$ - EGS rating expectation.

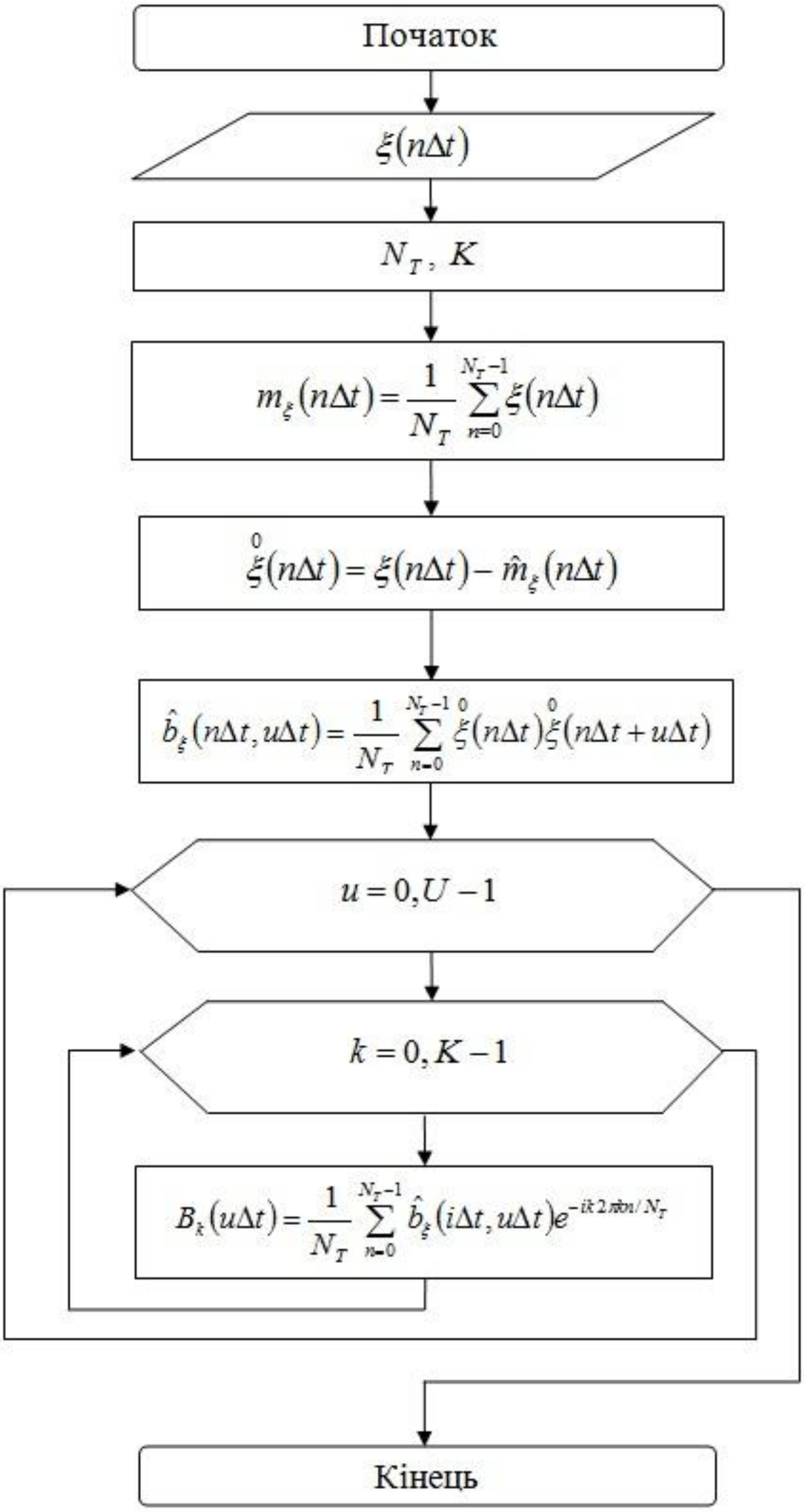


Figure 1. Block diagram EGS component method processing

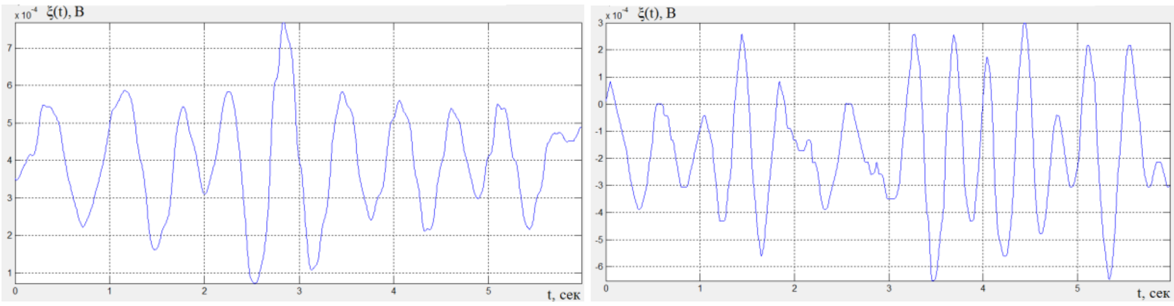
Component method computer implementation

Processing EGS block diagram as a discrete sequence using the above expressions is shown in Fig. 1

Flow diagram of computer processing EGS (Fig. 1) makes it possible to evaluate its characteristics to identify new diagnostics in the gastrointestinal tract informative features based on the mathematical model of a periodically correlated random sequence of discrete time.

The results of computer processing component analysis method the gastrointestinal tract motility

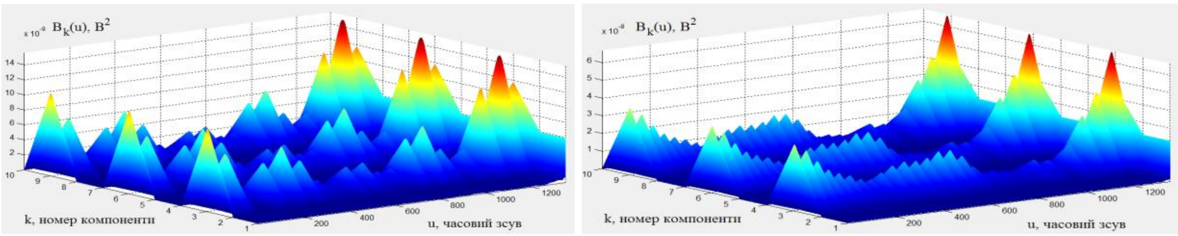
Based on the described algorithm (Fig. 1) in the environment of Matlab program was developed with the graphic interface for automatic processing of individual samples from reyestrohram EGS. In Fig. 2 shows a sample of reyestrohram EGS taken from patients in a state health standards (a) and pathology (b) (actual signals taken from the online medical signals database).



a b

Figure. 2 samples from the EGS realization: a - A patient (normal), b - B patient (pathology)

In Fig. 3 shows the calculated correlation component appearance estimates for patients with normal and pathological.



a b

Figure. 3 Ratings correlation component calculated for the state standards (a) and pathology (b)

To assess the overall functional status (normal/pathology) carried averaging correlation compon (Fig. 3) according to the expression (8).

$$M_u\left\{\hat{B}_k(u)\right\} = \frac{1}{N_k}\sum_{k=1}^{N_k} B_k(u), \quad k = \overline{1, N_k}, \tag{8}$$

where k - correlation components number, N_k - correlation component amount.

The averaging correlation component results shown in Fig. 4.

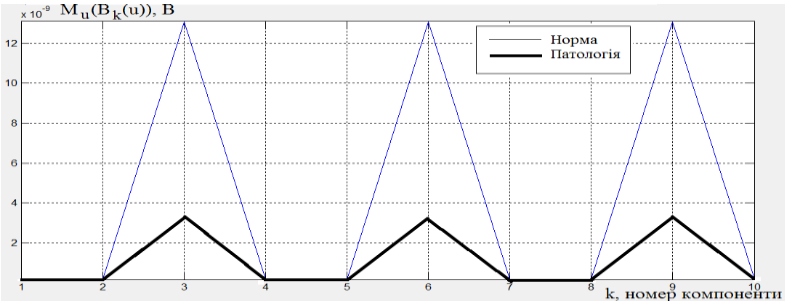


Figure. 4 Realization the average EGS correlation component (health and disease)

In Fig. 4 shows that the peak value of the correlation estimates averaged spectral components in patients with normal and pathology focused on the same components (identical in structure), but despite the fact that the patient is healthy and clinical and B - patients, there is a slight change in the amplitude values maximum of 3, 6, and 9-th component, indicating a clear change in the functioning of the gastrointestinal tract. Therefore, the calculation of the average value of the EGS correlation component are informative signs, and can be used as indicators of the gastrointestinal tract diseases, and their practical application will help extend the automated diagnostic systems.

Conclusions

As a result, EGS processing component by a number of new in the diagnosis the gastrointestinal tract informative signs - correlation components that actually correspond to the functional state of the gastrointestinal tract (normal/pathology). The research results make it possible to apply the method to the component tasks of medical diagnostics of the gastrointestinal tract in the early emergence stages and disease development.

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