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MATHEMATICAL MODELS AND INFORMATION TECHNOLOGY OF INFORMATION TRANSFORMATION IN RADIO-ENGINEERING AND RADIO-COMPUTER SYSTEMS

Abstract – The mathematical foundation of filtration technology of useful information from noises in the radiotechnical and radio-computer systems on the basis of the stochastic modification of Gilbert-Huang transformation has been developed in the article. It is proposed the procedure for processing (filtering) of noisenes useful information. The author developed new adaptive mathematical models and information technology for solving the problem of filtration of useful information from the noise in radio engineering and radio-computer systems. The essence of filtering is based on a modification of the mathematical models of information technology of Hilbert-Huang transformation. The models of the probability theory and the theory of random processes should be used in basis of mathematical models and information technology. Then the noisenes useful information is considered as a random sequence (a sequence of random variables).

Keywords: mathematical model, information technology, Gilbert-Huang transformation.

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МАТЕМАТИЧНІ МОДЕЛІ ТА ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ ПЕРЕТВОРЕННЯ ІНФОРМАЦІЇ В РАДІОТЕХНІЧНИХ ТА РАДІО-КОМП'ЮТЕРНИХ СИСТЕМАХ

У статті розроблено формально-математичні основи інформаційної технології фільтрації корисної інформації від шумів у радіотехнічних та радіо-комп'ютерних системах на основі стохастичної модифікації перетворення Гільберта-Хуанга.

Ключові слова: математична модель, інформаційна технологія, інформація.

Modern computer systems perform different types of data conversion depending on the needs of the particular subject area. It applies to single class of computer systems – radio-computer and radio-technical systems. Computer systems of such class often perform a transformation of information, connected with the filtering of useful information from the noise. Now there are a lot of mathematical models and information technologies for the successful solution of problems of filtration. The main part of them is based on the theory of integral transformations, such as Fourier transform, the Hilbert transform, etc.

But all these mathematical models and information technologies of noise filtering are not sufficiently flexible and adaptive in relation to the form of useful information. Therefore, today the task of mathematical models` developing and information technologies for filtration of useful information from noises still remains actual, in order to take into account the form of useful information. Such decision of filtering task of useful information from the noise is possible, if we use the Hilbert-Huang transformation for development of mathematical models and information technology.

Modern transformations of Hilbert-Huang are presented in many scientific works. Because of all of them are impossible to list, then you can consider only some of them, which, are the most informative in the author's opinion [1–4].

The purpose of the article is to solve the problem of filtration of useful information from the noise in radio engineering and radio-computer systems based on the use of Hilbert-Huang transformations.

The problem is to develop new adaptive mathematical models and information technology for solving the problem of filtration of useful information from the noise in radio engineering and radio-computer systems.

The main part

In recent years to filter the useful information from the noise transformation of Hilbert-Huang and its various modifications were widely used by scientists. It was widely used due to the properties of adaptability. While information processing, which is based on Hilbert-Huang transformation, the algorithms of radio engineering and radio-computer systems are adapted to the structure of useful information. This factor is particularly important because it forms the improvement of filtering results.

Although the use of Hilbert-Huang transformation and its modifications was presented in [1–4 and others], however, as practice shows, this is not enough to provide high performance in the decision of problems of filtration. Therefore, the development of new approaches concerning the application of Hilbert-Huang transformation and its modifications for filtering is an important problem. This means the development of new mathematical models and information technologies, based on the Hilbert-Huang transformation.

In most cases, the relationship of useful information and noise is additive. Transformation of Hilbert-Huang was used to each individual implementation of additive mixture of useful information and noise. Evaluation of statistical analyses was performed from the sample, which is formed from the results of processing. However, this approach gives the accumulation of errors.

Therefore, this article offers an approach regarding the processing of noiseness information in radio engineering and radio-computer systems based on the Hilbert-Huang transformation. Therefore the main idea is to use Hilbert-Huang transformation over a random order (random process) in radio engineering and radio-computer systems.

Thus, the essence of filtering is based on a modification of the mathematical models of information technology of Hilbert-Huang transformation. The models of the probability theory and the theory of random

processes should be used in basis of mathematical models and information technology. Then the noisenes useful information is considered as a random sequence (a sequence of random variables).

Thus, the procedure for processing (filtering) of noisenes useful information will be the following:

1. The local average extremes, that is the average highs and lows are identified by the coordinates and the average value of a sequence of random variables. After that the sequence of random variables decomposes into two subsequence of random variables. One of them is a sequence of random variables which is obtained from the average highs, that is $\xi_{max}(k)$, and the second – medium minimum, that is $\xi_{min}(k)$.

2. The stochastic interpolation of separate each of the sequences $\xi_{max}(k)$ and $\xi_{min}(k)$ is made by algebraic or trigonometric splines and random functions $\xi_{max}(t)$ and $\xi_{min}(t)$ were get consequently, where t is a continuous argument. Then a random function $m_1(t)$ is calculated, which is the average of random functions $\xi_{max}(t)$ and $\xi_{min}(t)$, that is

$$m_1(t)=\frac{1}{2}(\xi_{max}(t)+\xi_{min}(t)).$$

Then a first approximation to the first random mode is calculated

$$\eta(t)=\xi(t)-m_1(t).$$

3. Steps 1 and 2 are repeated. But instead of a sequence of random variables $\xi(k)$ we take a sequence of random variables $\eta(k)$ and find a second approximation to the first random mode $\eta_1(k)$:

$$\eta_1(k)=\eta(k)-m_2(k).$$

The following approximations to the first random mode can be found similarly.

With the increase of the number of iterations average sequences of random variables $m_i(k)$ and $\eta_i(k)$ tends to zero by a probability measure. Stop criterion of such iterations is apriori border set in the form of distance in Euclidean space, that is

$$dist=\sum_k|\eta_i(k)-\eta_{i-1}(k)|^2\Big/\sum_k\eta_{i-1}^2(k)$$

The latest iteration $\eta_i(k)$ is taken as the high frequency random mode $\zeta_1(k)=\eta_i(k)$ of collection of random modes, which directly is a part of the structure of noiseness useful information $\xi(k)$. This allows you to deduct $\zeta_1(k)$ from patterns of noiseness useful information and to leave by this way more low-frequency components:

$$r_1(k)=\xi(k)-\zeta_1(k)$$

The sequence of random variables $r_1(k)$ is treated as a new noiseness useful information by the analogy with the finding of the second random mode $\zeta_2(k)$. The process continues after this: $r_2(k)=r_1(k)-\zeta_2(k)$ and so on.

Thus the decomposition of noiseness useful information in n random-mode empirical approximation in the amount with $r_n(k)$ remnant:

$$\xi(k)=\sum_j^n\zeta_j(k)+r_n(k).$$

Interruption of computational procedure is made, when the average of sequence of random variables is very close to constant.

All these operations together form the basis of the information filtering technology by radio engineering and radio-computer systems of useful information from the noise.

Conclusions

The stochastic modification of Hilbert-Huang transformation (which is presented by new mathematical models) has been proposed in this article and it has allowed to develop a formal mathematical bases of information technologies for filtration of useful information from the noise in radio engineering and radio-computer systems.

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