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The Method of Classification of Signals in Telecommunication Systems

T.I. Lapina, D.V. Lapin and E.A. Titenko
SouthWest State University, 94 St. 50 years of October, 305040 Kursk, Russia

Abstract: In study approach to the solution of problems of identification and classification of these measurements of signals on the basis of the analysis of a form of a signal as the form defines the information maintenance of a signal is considered and it isn't connected directly with power of this signal. In this case problems of recognition of signals come down to a task of the analysis of a form of signals and their characteristics. These measurements are called identification measurements. Receiving quantitative measures, a possibility of algorithmization and automation, decrease in computing complexity of the procedure of identification and classification of signals in telecommunication systems is result.

Key words: Identification, classification, random signals, telecommunication, algorithmization

INTRODUCTION

Increase in requirements to quality, growth of a variety of the transmitted data, in total with the general tendency of integration of different types of messages in telecommunication systems have defined the increased interest in technologies of information transfer, many from directly or indirectly the signals connected with recognition which are the data carrier about a condition of objects or processes. Possibilities of such systems are defined by ability to distinguish, identify and classify the data which are result measurement of parameters of signals.

The need for such systems can be explained with wide circulation of the systems using for performance of identification, recognition and classification as basic data of measurement of signals of various sensors. Access control systems can be examples of such systems, civil identification, criminalistic identification, identifications of technological processes, systems of monitoring of designs of potential and dangerous objects.

In the management theory identification it is accepted to call determination of structure and parameters of mathematical model of the process or the system (Kalikushin, 2009).

For the solution of tasks of identification and classification one of the most widespread approaches is the formalized description of the researched objects and processes by methods and laws of classical mathematics including probability theory and mathematical statistics. Advantage of such approach consists in a possibility of receipt of analytical dependences of functioning of objects.

Other approach connected to development of the computer equipment and the software is use of different non-traditional methods and technologies, in particular tools of the theory of expert systems and the Wavelet-analysis.

One more direction of development of methods of classification is based on use of neural networks and neurotechnology.

Each of the specified directions is specialized, solves a certain circle of problems of classification and recognition of images of the signals arising from the growing requirements of practice. However all listed approaches don't allow to carry out algorithmization and to develop the automation equipment of tasks of classification and recognition of images of signals.

This results from the fact that now classification constructions represent subjective, qualitative descriptions of various properties of signals. For these descriptions the quantitative criteria allowing to divide, signals on classes aren't defined, don't consider interrelation between various properties of signals that, finally, significantly complicates development of objective, automatic systems of recognition.

In this study approach to the analysis, identification and classification of these measurements of signals which allows to create quantitative criteria which can be used in systems of automation is considered.

We will present a signal of f(t) as functions of continuous time of t and his discrete selective realization f(i) consisting of separate counting ($1< I< N$ where N-selection volume). From positions of probability theory and mathematical statistics discrete selective realization of f (i) can be considered how distribution of instant values of a signal and to apply the corresponding statistical characteristics to the description.

Corresponding Author: T.I. Lapina, SouthWest State University, 94 St. 50 years of October, 305040 Kursk, Russia

MATERIALS AND METHODS

Basic data at such approach are the digitized sequences of the discrete non-stationary signals which are read out from the device of measurement.

The analysis of such data has to include the frequency analysis which is necessary for definition of frequency areas in which there are hindrances and a useful signal and allows to carry out cleaning of a signal from hindrances or a filtration. This task can be solved by selection pulse characteristics and the digital filter.

Other approach is use wavelet-filterings. Wavelet- conversion is expansion of a signal in a base of functions. In case of wavelet-conversion expansion of a signal is made on the base or a wavelet formed by shifts and multi-scale copies of function prototype. Principal the advantage of the wavelet-analysis of signals is that by means of wavelet-conversion the signal can be provided in 2 measurements: to time and frequency thanks to scaling of the "initial" wavelet and its offset on time. Time-frequency representation of the studied signal by means of wavelet -transformation allows to reveal his local features. These include the peaks, gap points, threshold points. The choice of the analyzing wavelet as a rule, is defined by what information needs to be taken from a signal.

RESULTS AND DISCUSSION

Everyone wavelet has characteristics in time and in frequency space and allows to mark out characteristic properties of the analyzed signal. Coefficients wavelet transformations of smooth function are small and sharply increase at emergence of feature, noting its localization by lines of local extrema. The nature of feature in a point is defined from asymptotic behavior of coefficients wavelet transformations at aspiration of scale to zero (compression of a wavelet). Accurate definition of signs of a signal which accompany emergence of peaks gives the chance of creation of simpler own algorithm of localization of the analyzed features of a signal. In wavelet-transformations of an initial signal Haar's function can be used (Fig. 1).

Each function of Haar {har (r, m, t) }, except for the first, represents the square bipolar pulse of different amplitude holding strictly certain position on a semi-open interval [0, 1). The first function of Haar har (0, 0, t), unlike all remaining, represents a square pulse of the positive polarity and single amplitude on all interval [0, 1).

Haar's functions har (r, m, t) it is possible to receive from a recurrence relation:

$$\text{har}(0, 0, t) = 1,\ t \in [0, 1) \quad (1)$$

$$\text{har}(r,m,t) = \begin{cases} 2^{r/2}, \text{if } \dfrac{m-1}{2^r} \le t < \dfrac{m-1/2}{2^r} \\ -2^{r/2}, \text{if } \dfrac{m-1/2}{2^r} \le t < \dfrac{m}{2^r} \\ 0, \text{attheothert} \in (0,1) \end{cases} \quad (2)$$

Application of functions of Haar is most effective for the analysis of signals with strongly expressed local features in the form of short-term splashes and fluctuations. This results from the fact that approximation of splashes and fluctuations is performed by limited number of the components of a row located in the corresponding part of an interval (Oh, T).

We will interpret the values received as a result of transformation as a temporary row x_1 (t), x_2 (t),...,x_n (t) Then the problem of identification of a signal can be presented as a task of the analysis of a form of a signal as the form defines the information maintenance of a signal and isn't connected directly with power of this signal.

Therefore problems of recognition of signals come down to a task of the analysis of a form of signals and their characteristics. These measurements are called identification measurements (Klikushin, 2009). The theory of identification measurements is based on the following provisions:

- Form signal doesn't change in case of change of shift and scale on a time axis
- Any analog signal after uniform sampling is partially characterized by the Distribution of the Instantaneous Values (DIV)
- Any analog signal after uniform quantization on level is partially characterized by set of the Time Slot Assignments (TSA)
- Both distributions (DIV and TSA) completely characterize a form of realization of a signal (temporary series of observations)

The specified provisions allow to formulate the conditions necessary for automation of identification measurements of signals.

In mathematical statistics as values of category" a form" for random variables linguistic terms of type are used: "uniform", "normal", "exponential" distributions. Therefore, the task is set as definition of quantitative values of definition" a form"for problems of classification of signals.

Specific features of a form of a signal (DIV) are reflected in frequency structure of functions x_1 (t), x_2 (t),..., x_n (t) and the task of the analysis comes down to extraction of this information.

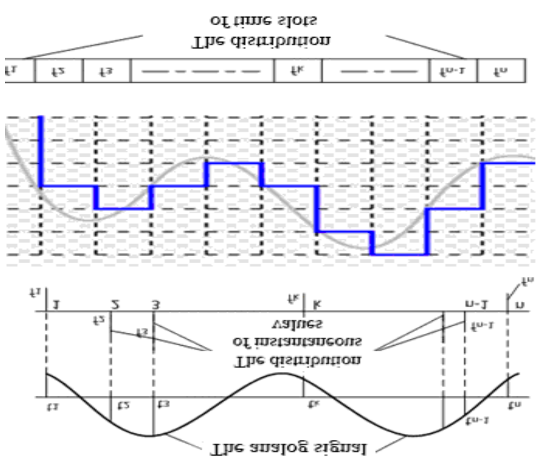

Fig. 1: The formation of a series of measurements of the signal (number of instaneous values and the number of time intervals)

From provisions of the analysis of data on condition of rationing in an interval [0;7] moment characteristics of DIV of a signal can define the DIV form, for example (Lapina, 2008, 2010). The condition of rationing is defined as follows an initial row is given to a piece [0;1]

$$x_i = \frac{(x_i - x_{min})}{x_{max}}, \sum_{i=1}^{n} p_i = 1, p_i \in [0,1] \qquad (1)$$

The choice of a form of model in a method of the given distributions is carried out on value of indicators (for example, the central moments) in space of indicators $s_k = m_r \times^k \sqrt{|\mu_k|}$, k = 2,3,... (Lapina, 2008). The modeling function is selected on the smallest divergence between theoretical and selective distributions that is to distinction of own indicators of models and initial statistical to indicators of selective data in space of the moments (Fig. 2).

On the other hand, TSA it is possible to consider how certain time series of observations and to use such concepts of the theory of measurements as for example, uncertainty for his description. Let in limited space (x^-, x^+) distributions be set:

$$F_{\hat{x}2}(x) \text{and} F\hat{x}_1(x) = \frac{x_r - x^-}{x^+ - x^-} = r_x \qquad ()$$

Where:
$F_{\hat{x}2}(x), x \in [x^-, x^+]$ = Arbitrary distribution
$F_{\hat{x}1}(x), x \in [x^-, x^+]$ = uniform distribution

In work (Lapina, 2014) it is shown that as a measure of distinction of the compared distributions the average amount of information on Kulbaka can be used (Lapina, 2008):

$$I = \int_{x \in X} f_{\hat{x}_2}(x) \cdot \ln\left(\frac{f_{\hat{x}_2}(x)}{f_{\hat{x}_1}(x)}\right) dx \qquad (2)$$

Applying model of representation of distributions (Grigorovich, 2001; Lapina, 2010), the formula can be transformed as follows:

$$I = \int_{x \in X} \frac{f_{\hat{x}_2}(x)}{f_{\hat{x}_1}(x)} \cdot \ln\left(\frac{f_{\hat{x}_2}(x)}{f_{\hat{x}_1}(x)}\right) \cdot f_{\hat{x}_1}(x) dx = \int_0^1 f_{\hat{r}_2}(r) \cdot \ln(f_{\hat{r}_2}(r)) dr r \in [0,1], \qquad (3)$$

$$I = \int_0^1 \frac{f_{\hat{r}_2}(r)}{f_{\hat{r}_1}(r)} \cdot \ln\left(\frac{f_{\hat{r}_2}(r)}{f_{\hat{r}_1}(r)}\right) \cdot f_{\hat{r}_1}(r) dr, r \in [0,1]$$

Where:
$F\hat{r}_1(r) = 1$ uniform distribution in an interval (Kalikushin, 2009).
For $F\hat{r}_1(r) = 1$ equality is fair
then expression

$$I = \int_0^1 f_{\hat{r}_1}(r) \cdot \ln(f_{\hat{r}_1}(r)) dr = -\int_0^1 1 \cdot \ln 1 dr = 0 \text{then expression} \qquad (4)$$

$$I = \int_0^1 f_{\hat{r}_2}(r) \cdot \ln(f_{\hat{r}_2}(r)) dr$$

it is possible to define as a measure a quantitative measure of distinction of selective data TSA (Id) in an interval r∈ [0;1] in relation to $F\hat{r}_1(r) = 1$ or

$$Id_i = \max_{y \in [0,1]} \left| F_{\hat{y}}(y_i) - y_i \right| \qquad (5)$$

Thus, approach to identification and classification of measurements of signals on the basis of calculation of indicators of a form and specification him by means of information criterion allow to develop the block diagram of the procedure of identification and classification of measurements of signals.

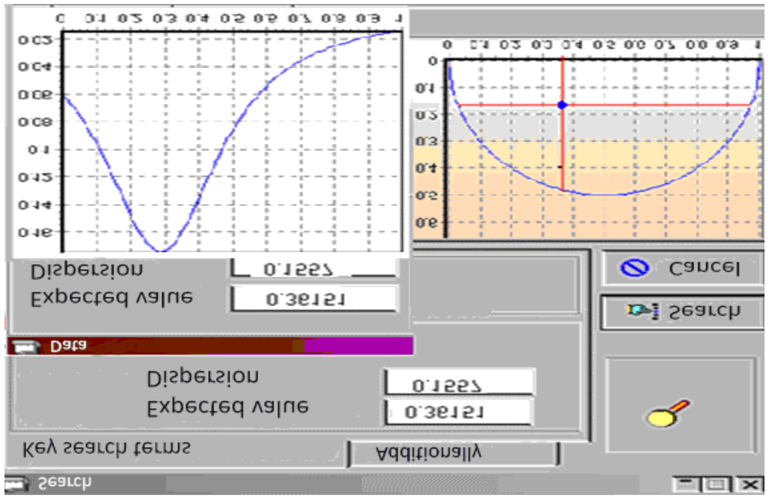

Fig. 2: An example of quantitative assessments of the waveform based on the distribution of instantaneous values

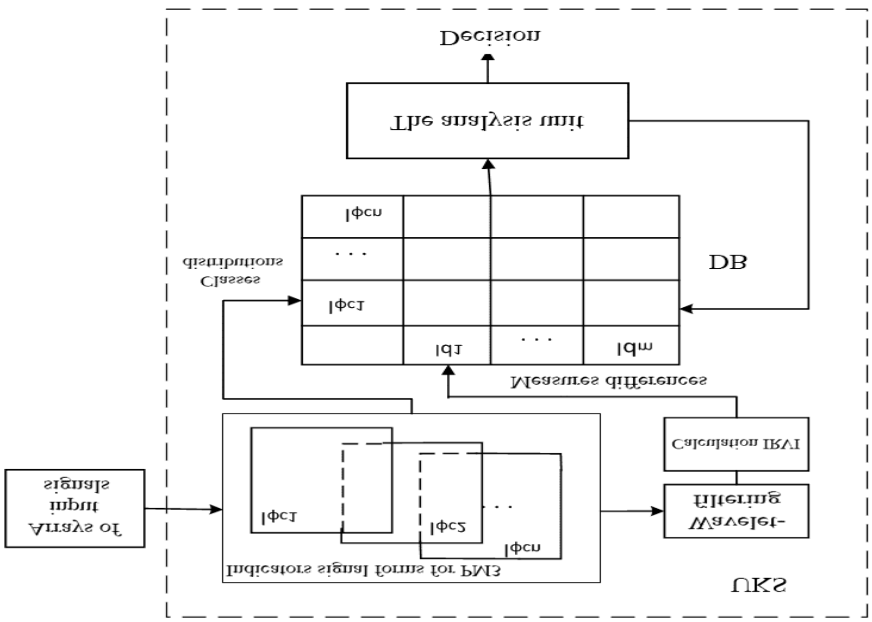

Fig. 3:Structural identification scheme measurments of signals

The structurally functional scheme of identification of measurements of a signal can be submitted as follows (Fig. 3).

CONCLUSION

The results of the analysis research is to obtain quantitative measures, the possibility of algorithms and automation, reducing the computational complexity of identification and classification procedure signals in telecommunication systems.

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