ANNOTATION

dissertation work for the degree of Doctor of Philosophy (PhD) in the specialty 6D071900 - "Radio engineering, electronics and telecommunications"

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«DEVELOPMENT OF IDENTIFICATION METHODS FOR DIGITAL SIGNAL PROCESSING FOR BUILDING MEASURING CHANNELS OF INFOCOMMUNICATION SYSTEMS»

Relevance of work. Today, the main trend in the development of science and technology is the widespread introduction of infocommunication systems in all vital aspects of human life. The main factors in the development of infocommunication systems are the modernization of the base of radio-electronic elements, the scaling of telecommunication systems and the use of high-performance computing technologies. These factors contribute to improving the quality of life of the country's population, eliminating the digital divide and developing technology.

The development of infocommunication systems has a positive effect on the development of such areas as education, medicine, instrument making, mechanical engineering, manufacturing industry, etc., through the introduction and integration of modern telecommunication and computing solutions, the development and implementation of effective methods and algorithms for intelligent processing and analysis of signals. The introduction of infocommunication systems in the above areas will reduce the cost of services produced, increase the efficiency of existing methods while expanding the availability of the population. At the same time, new methods and algorithms for information processing appear in these areas, requiring special hardware support.

The main task of using modern infocommunication systems is the need to increase the automation of technological processes or to analyze various kinds of signals. These signals by means of the measuring channel can carry important information about the state of the investigated object, possible defects and damages, helping the system operator to automatically receive a warning about a malfunction and choose an effective method of restoring the system operability. At the same time, infocommunication systems for automated signal analysis are required to provide support in decision-making to the system operator for efficient, high-quality and fast research in order to obtain analysis results.

As of today, the most effective element for detecting various kinds of defects is an intelligent processing processor, which, using various sensors, captures signals and transmits them through the measuring channel. Thus, the intelligent processing processor provides maximum information about the state of the research object.

Based on the above, the search for solutions in the field of automatic processing and analysis of the measuring signal has been given a lot of attention over the past

decade. It cannot be denied that significant results have been achieved in this direction, but there is still insufficient justification for the use of some stages in an intelligent processing processor. So today, there are practically no methods of automated express diagnostics, questions remain regarding increasing the noise immunity of the measuring signal, etc. The properties of the measuring channel give rise to difficulties in formalizing tasks and high uncertainty, which does not imply an unambiguous and universal approach to the analysis of the measuring signal.

When analyzing the measuring signal, radiotechnical methods of digital signal processing with elements of intellectual analysis are used. This analysis allows you to determine the distortion of the measuring signal at an early stage. As a result, it becomes necessary to use various types of mobile recorders for remote monitoring of infocommunication systems. The development of such registrars requires complex structural and algorithmic solutions. However, the operation of such recorders requires an intuitive functionality of the system without the need for additional training of personnel. Thus, based on the current state of the automation of the measurement channel research, it can be argued that further research work in this direction is associated with the use of modern means of digital signal processing and intelligent analysis.

The aim of the thesis is to improve the quality of functioning of infocommunication systems for research and industrial purposes by building a measuring channel based on radio engineering methods and algorithms for intelligent processing and analysis of the measuring signal and data.

The essence of the proposed methods lies in the development of new approaches to registration and collection of the measuring signal and the formation of new approaches to assess the functional state of objects: forecasting, identification, recognition, etc. The proposed solutions should be able to integrate in infocommunication systems for research and industrial purposes. And also, effectively use their advantages.

After the formation of the research goal, the author formed the following **tasks**:

1) Study of the general structure of the processes of collecting, processing and analyzing IS and data in order to identify existing problems in intellectual data processing.

2) Development and search for effective methods of intelligent processing and analysis of the measuring signal by means of theoretical and experimental studies of primary signal processing and ensuring compatibility with subsequent stages of information processing.

3) Development of recommendations on the use of methods of intellectual analysis and signal processing for the design of a measuring channel of infocommunication systems for research and industrial purposes.

4) Development and experimental research of intelligent algorithms for the analysis and processing of the measuring signal for use in the following industries:

seismology, metallurgy, oil and gas engineering, handwritten character recognition, electrocardiography.

5) Development of a hardware and software model of infocommunication systems for identification measurements.

6) Optimization of the structure of the hardware of the path of infocommunication systems of identification measurements.

7) Synthesis of a hardware-software model of infocommunication systems of identification measurements based on the developed methods and algorithms for intelligent processing and analysis of the measuring signal.

Research methods

To achieve this goal and solve problems, radiotechnical methods of digital signal processing, intelligent methods of pattern recognition and signal identification, tools of mathematical and computer modeling and statistical radio engineering were used.

In the course of the experimental studies, computer modeling tools were actively used, the measuring signal of real objects and processes was used. The circuitry solutions of the hardware part of the model were based on the use of a modern base of radio-electronic components.

The subject of the research is the process of extracting reliable information and data on the state of an object for solving additional functional tasks.

The object of the research is radio engineering methods of intelligent processing and analysis of the measuring signal in infocommunication systems for research and industrial purposes.

The scientific novelty of the dissertation work lies in the following provisions and results:

1) A conceptual approach to the construction of infocommunication systems for research and industrial use with measuring channels based on intelligent processing and analysis of signals and identification measurements has been formed.

2) The introduction of additional functions of the measuring channel into the composition of infocommunication systems intended for the analysis and processing of the measuring signal is scientifically substantiated, which allows obtaining more informative signs about the conditions and operation of objects.

3) A methodology and an algorithm for the functioning of the measuring channel for searching for operational earthquake precursors based on an intelligent analysis of the identification characteristics of seismograms is proposed.

4) A methodology and an algorithm for the functioning of the measuring channel for recognizing handwritten characters, built on the basis of converting the measuring signal into a binary code, with subsequent comparison with reference files, are proposed.

5) A methodology and an algorithm for the functioning of the measuring channel are proposed, which provide the representation of random biomedical signals for the design of databases, representing the measuring signal in the form of clusters.

6) A methodology and an algorithm for the functioning of the measuring channel is proposed, designed to determine the malfunctions of oil and gas equipment, allowing the identification of groups of defects with the same frequency characteristics.

7) A methodology and an algorithm for the functioning of the measuring channel of information processing in infocommunication systems is proposed to determine the effective value characterizing the state of an object or process by the distribution of instantaneous values in the form of instantaneous values of the signal.

8) New constructive and technological solutions for the design of infocommunication systems with integrated measuring channels, built on the basis of identification measurements of information signals and data, have been proposed.

Practical significance

The scientific conclusions obtained as a result of the research carried out by the author were applied in practice to build mobile recorders of a measuring signal as part of infocommunication systems for identification measurements for research and industrial purposes in various industries.

Thanks to the proposed methods, intelligent methods, it becomes possible to simplify the structure and expand the dynamic range and capabilities of the measuring channel and infocommunication systems as a whole.

The proposed approach to the use of algorithms operating in the learning and research modes allows to increase the accuracy and efficiency of the tasks performed, as well as to implement decision support systems for service personnel.

The model of infocommunication systems of identification measurements used in the work can be used in practice in other industries to solve problems in conditions of limited and uncertainty of training data.

Relationship with government programs

Scientific research presented in the dissertation work was carried out within the framework of grant funding from the Ministry of Education and Science of the Republic of Kazakhstan on the topic: "Development of intelligent computer devices and systems for diagnostics and monitoring of oil and gas equipment" (state registration No. 2605 / GF4-15-OD).

The results of the research presented in this work are aimed at solving the problem of developing infocommunication systems, voiced in the program "Informational Kazakhstan-2020". These tasks include eliminating the digital divide between the urban and rural population by providing access to modern infrastructure solutions of infocommunication companies, ensuring greater involvement of the population in the socio-cultural life of the country by providing access to various media services, online platforms.

The intellectual methods and algorithms of analysis proposed in the work, as well as the model of infocommunication systems of identification measurements, are consistent with the concept of development of infocommunication systems in the Republic of Kazakhstan, proposed in the State Program "Digital Kazakhstan" for 2018-2022. In particular, this program proposes in the medium term to create a fundamentally

new trajectory of development, which in the future will become the foundation for creating a new digital economy.

Thesis provisions submitted for defense

1) Compatible methods of conversion, intelligent analysis and processing of the measuring signal, allowing for more efficient assessment and recognition of the state of objects under study.

2) New technical solutions and scientifically grounded technical development of a model of an infocommunication system with measuring channels built on the basis of identification measurements.

3) An approach to the design of measuring channels with additional functions, including forecasting, recognition, identification, estimation of average values, clustering of the measuring signal.

4) Methodological approach to the integration of the measuring channel in infocommunication systems for scientific research or industrial purposes.

5) Hardware and software model of infocommunication systems for processing and analyzing the measuring signal.

Approbation of work

The conclusions made by the author of the thesis were presented and presented for discussion at the following scientific platforms: International Scientific Conference "IEEE International Conference on Power, Control, Signals and Instrumentation Engineering" (ICPCSI, India, 2017); International Scientific and Practical Conference "Science-Intensive Technologies and Intelligent Systems" (Russia, 2019); International Scientific and Practical Conference "Dynamics of Systems, Mechanisms and Machines" (Russia, 2019); International Scientific and Practical Conference "Scientific and Practical Research" (Russia, 2020).

Publications

The main results of the dissertation research were reflected in 15 scientific works, including 4 articles in scientific journals included in the List of scientific publications recommended for publication of the main results of scientific activities, approved by the authorized body; in 3 articles in international scientific journals with a non-zero impact factor according to Journal Citation Reports by Clarivate Analytics and Scopus; in 5 works reflected in the proceedings of international scientific conferences, including 5 foreign ones (2 are indexed in the Scopus database), as well as in 3 patents.

Personal contribution of the author

The main experimental and theoretical results obtained during the dissertation research were obtained by the author independently. In the published scientific works as part of a team of co-authors, the applicant makes the main contribution in obtaining, summarizing and analyzing the results achieved.