Preface

"A considerable amount of time has passed since steam engines, steamers, and railway engines have appeared. God saw that people's life is difficult and boring. Then he decided to help them once more and gave them signals as a present. The devil saw this and created noises, which he mixed up with the signals. People could not use noises and asked scientists to spare them these troubles. People created methods and technologies of filtration and suppression of noises. However, signals were distorted and many valuable and concealed mysteries were lost together with the noise."

This book shows that characteristics of signals and noises at the output of sensors change continuously for both technical and biological objects at the origin of a defect. The known classical conditions are not satisfied. The time for a decision about the problem increases.

For these reasons, in some cases the detection of defects in information systems turns out to be overdue. Sometimes it results in catastrophic consequences.

Taking into account these and other features of the initial stage of the origin of the defect, several technologies are suggested. These technologies allow one to perform the defect monitoring at the beginning of the defect's origin by extracting information from the noise. By duplicating and combining the above technological advantages, a necessary degree of reliability to the results is reached. These technologies are proved theoretically, and the opportunity of their application for solving problems of noise monitoring at the beginning of the defect's origin in oil-gas extraction, in construction, in power engineering, in transport, in seismology, in aviation, in medicine, etc., is shown on numerous examples. In addition, they allow one to improve the results of mathematical modeling, recognition, identification, control, etc., and they can find wide application in solving numerous problems where processing and analysis of signals are required in various fields of science and technology.

The monograph is intended for teachers, post-graduate students, and university students of all professions except the humanities, and also for experts of power engineering, computer science, automation, physics, biology, geophysics, oil-gas extraction, transport, aviation, control, medicine, etc.

At present, the number of failures in power stations, sea objects of oil-gas extraction and communication, main oil-gas pipelines, petrochemical complexes, large-capacity tankers, airlines, etc., remains unjustifiably high because of mistakes in information systems in spite of the repeated increase of reliability of the element base. This often occurs by the fault of traditional information technologies, as they provide defect monitoring after the defect takes its salient character.

Reasons for a defect's origin in various objects such as living organisms and equipment are the subject of research of corresponding science directions. However, considering these problems in view of obtaining information and methods of analysis, monitoring, and diagnostics, one can notice that the problems have much in common with one another [1–14]. In many cases, the signals describing the current state and technical conditions are obtained from the sensors installed on the corresponding objects. The similar or nearly the same information technologies are used in different areas for analyzing these signals as the information carriers [1, 4, 7, 11, 14]. These technologies are realized on the same modern computers. Taking all this into account, the IT specialist does not consider the differences in solving the problem of monitoring the state of these objects despite the wide areas of specific features of each object [1, 4, 11].

However, the process of the origin and evolution of a defect before it takes its salient character has unique features for each object depending on its physical, biological, mechanical, chemical, and other properties [1, 11, 13]. These features also depend on the performed functions, the exploitation modes, etc. Due to these special features, the time period from the origin of the defect of a signal to the time it takes its salient character is unique for each object. It takes a short time for some objects. Others take considerably longer. However, despite all these differences, the information represented as the defect component of a signal has the common property to change continuously for all objects at this period. It becomes stable only after the defect takes its salient character. Thus, the reliability of results for solving the problem of monitoring the early defect's origin depends on used information technologies of analyzing the signal received as the output of the corresponding sensor of objects. As usual, these signals are accompanied by noise. That makes it difficult and sometimes impossible to solve the problem of monitoring the defect at its early origin.

In general, in solving all sorts of questions by signal processing, it is possible to get more or less acceptable results by means of known information technologies only in the case of satisfying classical conditions, i.e., analyzed signals are stationary, they follow the normal distribution law, the correlation between the noise and the legitimate signal is equal to zero, the noise is represented as "white noise," etc. Even in this case, the obtained

results do not always provide enough reliability because noise from real signals differs from "white noise" and its variances and spectral components change in time.

At the same time, in many cases the above-mentioned conditions are not satisfied at all, and it is not always possible to get reliable results and form adequate solutions for the situations that arise in corresponding information systems [15–42]. For this reason, the number of failures of various objects in oil-gas extraction, petroleum chemistry, power engineering, aviation, etc., with catastrophic human, economic, and ecological consequences does not decrease, in spite of the fact that the reliability of both the element base and the equipment in information systems has increased lately. In this connection, filtration methods are often used in traditional technologies for eliminating the noise influence on the results of solved problems.

They provide good results when the filter spectrum and noise spectrum coincide. Simultaneously, for many real processes and particularly in the period of a defect's origin, the noise spectrum and variance widely vary in time. For these reasons, the "filter" spectrum range has to be widened to eliminate the noise influence on the result of signal processing. And this distorts the useful signal much more. In addition, quite often the noise arises as a result of operation of controlled objects. Thus, the noise becomes the data carrier, and this information is erased because of filtration. And in these cases the important and in some cases the only valuable information of the early defect origin is lost [42–54].

Thus, in traditional technologies, the specificity of noise influence of real signals on the desired result is not sufficiently taken into account. These technologies do not have the opportunity to extract information contained in the noise of analyzed signals.

So problems of creating technologies of noise analysis and increasing the reliability of solved problems by signal processing of results are of great importance on the contemporary stage of "signal processing" development [1, 58, 60, 61].

No doubt filtration and traditional information technology allow one to solve numerous necessary problems. However, at the same time, it is necessary and advisable to have alternative technologies possessing the property of extracting the information contained in the noise of noisy signals.

The significance of this work is also connected with the possibility of using the noise as a data carrier for creating technologies of detecting the initial stage of changes to objects. It is now that their time has come. The economy of computer resources was considered as an essential dignity of information technologies in the past for many years. But now, because of their enormous resources, one can create more effective technologies at the expense of the complication of computational process [1].

Unlike traditional technologies, where at the expense of signal noise filtration, the volume of extracted information decreases, in the suggested alternative technology due to analyzing noise as a data carrier, this disadvantage is eliminated. This significant difference opens a wide opportunity for expanding the range of solved problems on the basis of analysis of noisy signals.

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