Computer System for Supporting Periodic Signals Processing, Their Analysis and Visual Control of Results[1]

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Abstract—Some issues of organizing a computer system for the support of processing and analysis of periodic signals are considered. It is assumed that such a support should provide the following facilities: projecting a data processing algorithm with supplying a needed program product; giving the users the access to certain procedures of analysis including the image analysis and the visual control of data before and after processing. To resolve these issues, we propose to turn to a specific window interface. In this paper, some experience gained in a process of projecting and exploitation of such a computer system is considered.

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INTRODUCTION

The computer system in question is oriented to processing and analysis of periodic signals. The prompting motive of our research is the needs in processing noisy data obtained in vibrational seismic investigation and their subsequent analysis. The basis of such data is periodic signals, which are widely used, and an appropriate research could be of interest in other fields of activity. In this paper, we present certain results obtained in the process of projecting, development of procedures of functioning and exploitation of such a sort of computer system.

The first results in this respect are given in [1]. The tasks that were stated in the mentioned paper are the following:

—projecting the weighted order statistics (WOS) filters with supplying a needed program product for processing the periodic signals;

—processing of appropriate data aimed at improving their quality (decreasing a noisy level);

—providing the access to the cluster analysis procedures of both the source data and results of processing for estimating temporal parameters and characteristics of the corresponding signals;

—providing the means of interactive communication for the user.

In this paper, we basically consider the questions of interactive communication with a computer under conditions of window technology and, also, the questions of development of visual (qualitative) control of both the source data and the results obtained. The creation of algorithms and procedures that were used for signals processing and analysis demands a special attention.

At first, let us give some explanations about the choice of the WOS filters as means of data processing and about the choice of cluster analysis for estimating temporal parameters and characteristics of periodic signals.

The essence of the matter is that the WOS filters [2] are nonlinear ones, and the estimation of their behavior is a very complicated process. It depends and on the filter parameters (including the dependence on a sequence of operations) and on properties of a signal and a sort of noise. Therefore, a possibility of projecting such filters and testing theirs influence on a signal is of interest.

Generally, a WOS filter can include a sequence of various operations or steps, where characteristics of each operation at a current step and the corresponding information communications should be explicitly accessible in the course of filter designing. Thus, here, we can pick out two stages of the process: (1) stage of a formal description of the directional structure of a sort of an oriented graph under condition of a single source node and a single end node (i.e., of a graph reflecting an algorithm of processing); (2) stage of supporting the computing process and of controlling both a data flow and the corresponding informational connections.

As for the cluster analysis, it was chosen to meet the demand of estimating temporal parameters and characteristics of periodic signals. As a matter of fact, conventional methods of such signals analysis are being in the field of harmonic analysis, and estimation of temporal parameters and characteristics in these conditions, are associated with the decision of dilemma "frequency—locus in time" (frequency and spectral components of a signal are within the range where the

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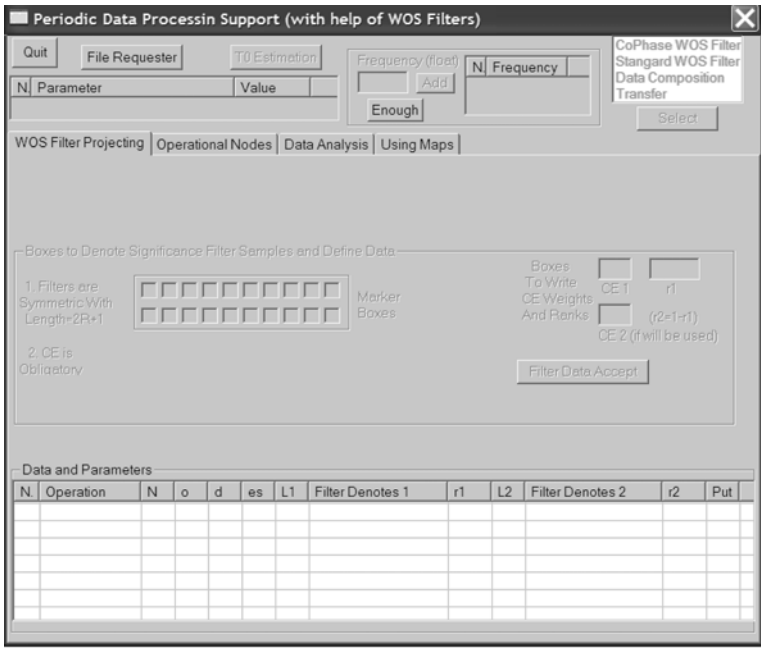

Fig. 1. The right side of the image of the window interface.

scale of time is absent). Here, some compromise is attainable by invoking the wavelet analysis. However, such methods are critical ones with respect to the signal-to-noise ratio. The statement of a task and verifying the algorithm of cluster analysis of periodic signals are accessible in papers [4, 5].

BASIC FEATURES OF THE USER-COMPUTER COMMUNICATION

The window interface was used as means of the communication of the user with a computer. A specialized interface provides, on the one hand, an open access to the basic functional possibilities of the system, and, on the other hand, an access of the user to all the spectrum of services in a clear form (by means of invoking an appropriate elements—gadgets structure). Advantages of such a decision are the following:

—extensive possibilities of using the prompts including images;

—the possibility of visualization of a graph of processing as it is;

—the possibility of managing the access to all the elements of a project depending on both the stage of designing and the condition of automation, which controls the design process;

—the possibility to visualize all interconnections of units of a projecting filter and of its informational flows;

—the possibility to control both the process of the running algorithm and processes of signal analysis;

—the possibility to visualize all the stages of communication with a computer, as well as the results of such a communication, including the possibility to visualize a sequence of steps of processing/analysis and the corresponding results.

The window interface of the computer system in question includes four informational panels of communication, which are separately visualized:

—panel “WOS Filter Projecting”;

—panel “Operational Nodes”;

—panel “Data Analysis”;

—panel “Using Maps”.

The overall image of the window interface is shown in Fig. 1.

THE ALGORITHM OF FORMING A WOS FILTER PROJECT

The basis of the interface of the filter projecting consists of the two informational panels: “WOS Filter Projecting”, and “Operational Nodes”. The first panel is intended for providing the formation of a list of data for each node of the graph, and the other panel is aimed at visualization of the whole structure of the graph (an appropriate chart of informational flows).

The process of designing a WOS filter, naturally, breaks up into a sequence of consecutive steps. At the same time, in the course of carrying out each step, both the list of the parameters of the item of a filter (or,

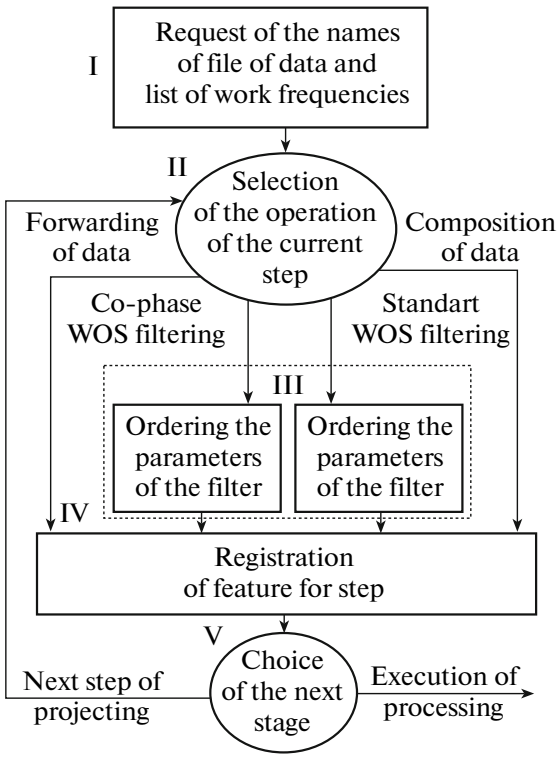

Fig. 2. The iteration scheme of filter projecting.

of a node of a graph) is formed, and the successor of the information (or, the results of the current processing) is named. The iteration scheme of the filter projecting is shown in Fig. 2 [1].

The image in Fig. 1 also depicts all the features of the panel "WOS Filter Projecting". The essence of control buttons and informational frames are explained by appropriate inscriptions.

Figure 3 illustrates the informational frame "Boxes to Denote Significant Filter Sampling and Define Data" of the panel "WOS Filter Projecting". The "coming to the light" picture at the bottom of the frame explains the principle of sampling periodic signal data in the case of its co-phase filtering [3].

CONTROL OF A FILTER FLOW-CHART IN THE COURSE OF ITS PROJECTING

The control of a flow-chart of a project of signal processing is implemented with the help of the panel "Operational Nodes" (see Fig. 4). Here, it is needed to explain that all the files, which can be involved in data processing are numbered from "0" to "101." In this case, the file with the source data is numbered as "0" (the top of the panel), and the file that receives results of data processing is numbered as "101" (the bottom of the panel).

The choice of a graph node demands clicking the computer mouse in an appropriate "Check Gadget" of the informational panel "Grid to Build Operational Taps". Clicking with the mouse the control button "Draw Connections" makes the computer to connect in its memory the corresponding Check Gadgets of the panel and the filter parameters which were ordered at the stage "WOS Filter Projecting". The corresponding information is exported to a special table at the bottom of the panel "WOS Filter Projecting" simultaneously with building a graph of processing. A computer, after preservation of all the information which was ordered at a current step of projecting, initiates the question "Execution of processing/Next step of projecting?". An example of a graph of processing which was used in [3] is shown in the image of the panel "Operational Nodes" (Fig. 4); the corresponding information is presented in Fig. 5.

SIGNAL ANALYSIS

Procedures of signal analysis and control of results are accessible from the panels "Data Analysis" and "Using Maps". Here, calling out such functions as wave arrival time estimation, estimation of a signal existence period, convolution, and some others ones is possible. Specific features of the cluster analysis of time series were considered, for example, in [4, 5]. Therefore, here, we will not dwell on the essence of appropriate operators and will restrict ourselves to some demonstration of corresponding results, only.

Thus, Fig. 6 demonstrates the results of signal processing and the process of cluster analysis for estimating wave arrival times (the arrival time of a signal is

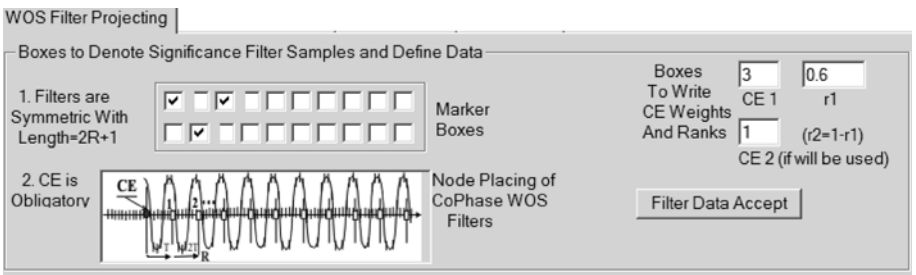

Fig. 3. Informational frame "Boxes to Denote Significant Filter Sampling and Define Data."

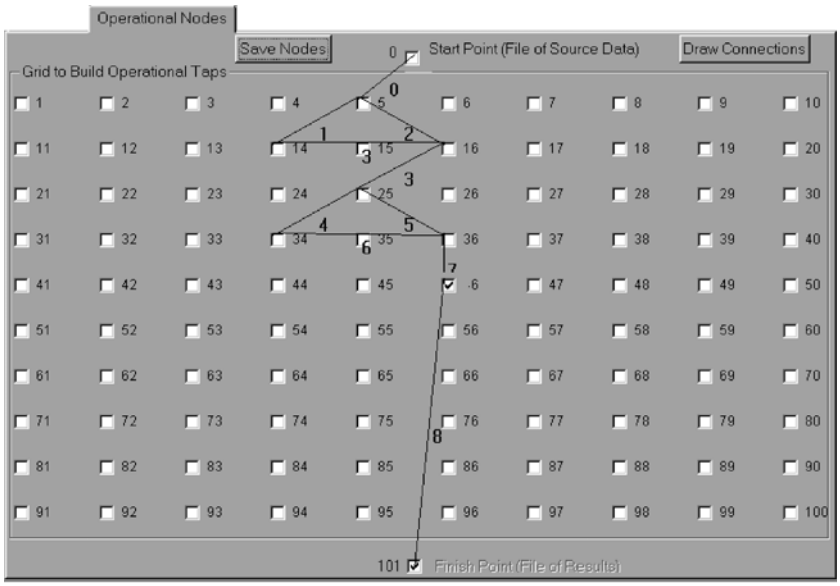

Fig. 4. Panel "Operational Nodes" including an example of a graph of processing.

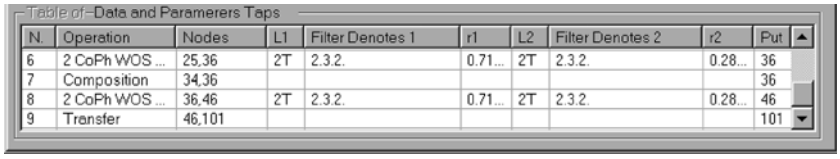

Fig. 5. The informational table including a sequence of steps of processing and the corresponding filter parameters.

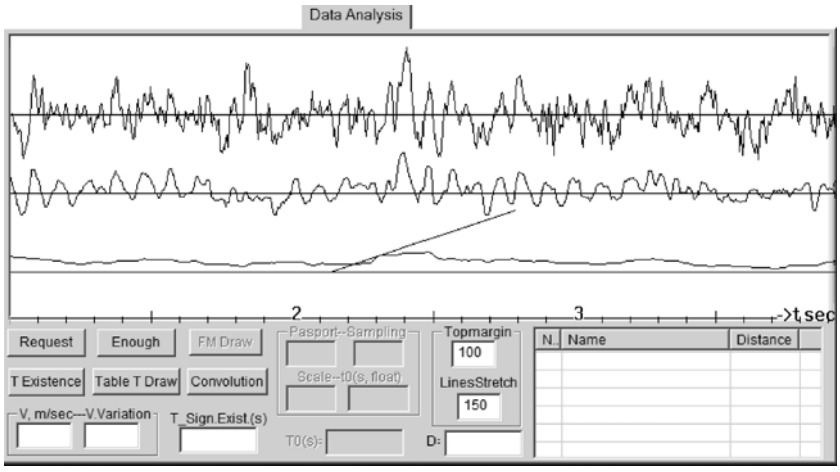

Fig. 6. The "Data Analysis" panel showing, from top to bottom, a source signal, results of processing, and a histogram of clusters distribution with marks of arrival times.

marked as moment of intersection of a straight line with a histogram at the bottom of the visualization frame) [5].

Figure 7 demonstrates the results of estimation of a signal existence period [6], and, finally, Fig. 8 presents the results of convolutions of real data recorded in the course of monitoring (in 2005) of the mud volcano "Shugo" of the Taman Province.

CONCLUSIONS

In this paper, we have considered some questions of organizing a computer system for the support of pro-

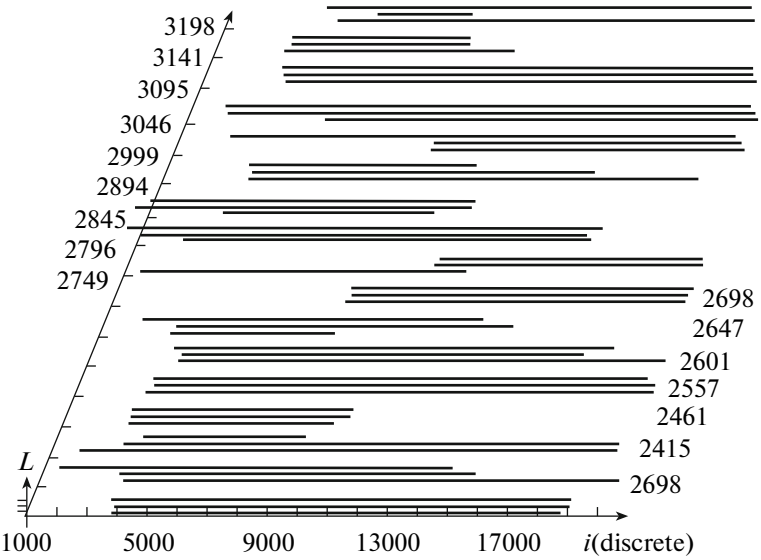

Fig. 7. Estimations of signal locus on the time scale for time for different values of a running basis of dispersion estimation recorded for different distances from a source of vibrations.

cessing and analysis of periodic signals as one-dimensional time series. A special attention was paid to the process of projecting and supporting the WOS filters and, also, the cluster analysis as means of estimation of temporal parameters and characteristics of periodic signals.

The experience gained in exploitation of this system demonstrates its efficiency and convenience for the users who are familiar with computer, but do not know much about programming.

The proposed computer system has been realized in the language PureBasic 4.00 for Windows in the medium of Windows-98.

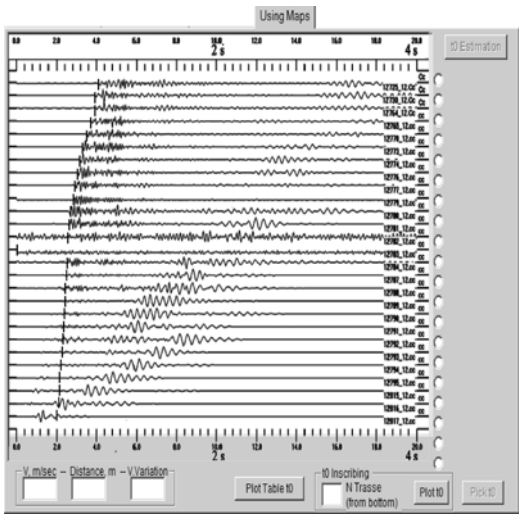

Fig. 8. Results of convolutions of real signals (dashes on scans of convolutions are marks of waves arrival times).

ACKNOWLEDGMENTS

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