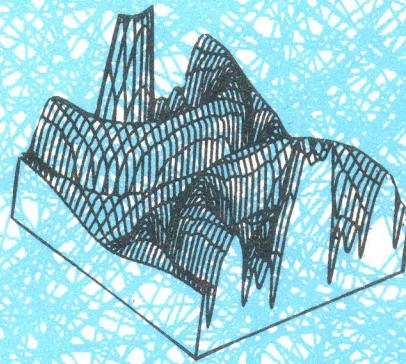


**International Symposium
on Visual Analysis
and Interface**

*August. 1 - 4, 1991
Novosibirsk, USSR*

THESES

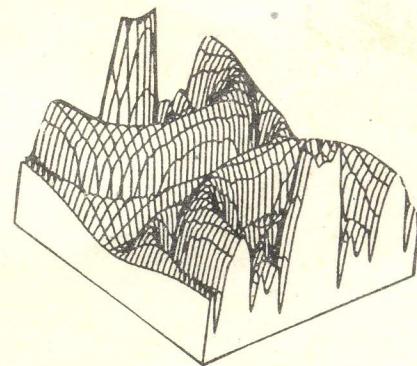


VAI'91
NOVOSIBIRSK

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*Graphic Interface for Interactive
Tsunami Modelling System*

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Novosibirsk

As a result of a feasibility study, a concept of the Interactive Tsunami Modelling System (ITMS) was developed at Novosibirsk Computing Center. This concept is based on the application of the numerical models for prediction of tsunami heights along the coast by implementation of a specially elaborated interactive computer technology that is the near real-time calculation of tsunami generation, propagation and run-up and facilitation of decision-making process through intensive application of formalized expert knowledge in respective fields.

The ITMS is being developed for the user who is not a professional in applied mathematics and computer science. This requirement has predetermined the elaboration of the user's special interface based on pull-down and pop-up menus having on-screen buttons for process management and on-screen windows for input and output of information. A specially elaborated graphic interface provides an ability to manipulate maps, models, data and results of computation in an efficient and convenient manner. The results of computation can be output on the screen as graphics, histograms, isolines and vector fields as well as 3-dimentional figures of the wave field. Special attention is given to the computer mapping of data on real chart basis. Visualization of output information permits the user to make decisions on issuing of tsunami warning much quicker than without graphic performance of it. The usage of graphics helps a researcher to understand some specific features of tsunami generation and propagation that would be impossible with the digital presentation of results.

The present version of ITMS is developed for IBM-compatible personal computer with EGA or VGA graphic cards and uses Turbo Pascal and SMOG graphics.

*Visualization in Analysis and Interpretation
of Data in Environmental Problems*

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Novosibirsk

Solution of environmental problems deals with treatment of large data sets. In this case, as experience shows, visualization may significantly increase the productivity and facilitate the comprehension of the main points of the phenomena.

A workstation realizing the interactive system data processing is used for this purpose at the Computing Center. It is a videoprocessor which is connected by a common memory with the microcomputers performing storage, processing and control functions. Images are displayed on color monitors. The interactive software in use consists of the components responsible for the output to a screen and to a color plotter.

A large volume of computations, needed for integration of contemporary complex models, forces one to resort to the help of large computers. The networks, supported by corresponding software, implement inter-computer communication. Although some techniques of visualization are possible, only one way is used at present: post processing of collected data. This technique is in a common use, because it allows multiple views and applications of different methods to the same data.

The main feature of the problem under discussion is dynamics of processes, therefore animation of images gives an auxiliary advantage to visual perception. The interactive software allows one to choose desired rate and colors. Besides, it is possible to copy to video simultaneously.

As an example, the results of interaction between a visualization system and a 3D computational model of hydrodynamics and contaminant transport of Lake Baikal are considered. The main output variables are: 3 components of the vector velocity, temperature, surface water level and concentrations of contaminants. Some fragments are presented in video to demonstrate the features of the problems.

*Digital and Analog Television
in Synchronous Collaborations*

P.Calingaert
USA

Shared visual workspaces on computer screens provide collaborators with simultaneous access to shared objects, such as documents, images, and programs. To discuss the shared objects, several communication channels are possible. Perhaps more satisfactory than a message area on the screen are voice and video. We would like to determine the situations in which voice and graphics alone are inadequate, as well as those in which even video is inadequate and face-to-face communication is preferred.

We have equipped workstation locations in each of several offices with a color television camera, a microphone, and a television monitor. The equipment is interconnected by the extensive multi-purpose cabling in our building. Split images make four participants visible concurrently.

We have also installed commercial digital television adapters in workstations running our shared workspace system. The images appear in an area of the workstation screen. Use of digital technology obviates the need for separate transmission facilities for the television images. Resolution is lower, however, than that of analog television.

We describe the technical problems solved, our initial experiences in using both approaches, and our tentative conclusions.

*Visualization of Computer Users'
Cognitive Strategies and Behaviors*

P.Calingaert
USA

Our research focuses on supporting scientists and engineers working collaboratively on shared artifacts such as documents, images, and programs. To support them fully, we need to understand their cognitive activities as they interact both with the shared artifact and with each other.

The most common form of data used to study complex cognitive processes, as well as human-computer interaction, has been transcripts, or protocols, made concurrently with the actions. Think-aloud protocols are highly subjective; keystroke records of user sessions lead to massive amounts of data. To perform this work for single users and to extend it to multiple users, we have created four major tools.

One tool automatically records protocols that contain each menu selection, the string typed in response to each interface prompt, the spatial location of each action, and similar data. The system produces records in accord with a simple protocol-language syntax that denotes each such event, its time, and parameters of interest. A second tool replays a session using the recorded protocol as data, providing an over-all sense of a user's strategy over a long session. It can replay a session at various rates of speed.

A third tool is a grammar, written as an expert system, that parses the protocols to produce parse trees that show users' cognitive strategies for particular sessions. The data produced by the grammar are analyzed in various ways, usually by extracting values and distributions and passing them to a statistical package.

The fourth tool is a set of display routines to help us interpret the results. One routine presents a static display of a horizontal slice of a parse tree. If the slice represents the cognitive product level, for example, different cognitive strategies present are readily distinguished visually. Another routine presents an animated display that represents evolution of the artifact over time. ⁴

*CARAVAN: Data Generator for an Expert Vision
Automatic Recognizer System for Ship*

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Novosibirsk

The 'Caravan' system is a generator of data for expert geographic systems. 'Caravan' is expressly designed for debugging expert systems as well as for training personnel how to handle them. It outputs data in the formats similar to those used in real systems.

In addition, 'Caravan' provides a visual model of the outer world. This is needed to perform control over the simulator of sensors and to analyze the results.

'Caravan' was developed specifically to debug a geographic expert system designed for piloting caravans of ships in the ice or along the rivers with highly changeable navigating channels. 'Caravan' uses the models of relief, static geographical objects, dynamic geographical objects, sensors, devices for sensor information processing.

- 'Caravan' comprises two groups of subsystems:
- 1) susbsystems for session preparation (experiment),
 - 2) dynamic modelling subsystems.

The 'Caravan' system is desined for PCs of the IBM PC/386-type with VGA adapter, MS DOS operating system. The subsystem is written in Microsoft Fortran and C, assembler. 28 subprocesses are available, each of which occupies the entire memory. Interaction with the user is performed with 62 menus. The size of original texts is about 2 Mbytes.

*Visualization of the Spatial Distribution
of a Functional Parameter: Application to
Three-Dimentional Medical Images*

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France, Germany

The current three-dimensional (3D) imaging modalities (X-ray computed tomography, Magnetic Resonance Imaging, echography) provide 3D images of the human body. A large variety of 3D visualization techniques has been described in the past to allow interpretation of such data for diagnostic and prognostic purposes. These techniques - known as "volume rendering" techniques - are thus primarily designed to provide a visual access to shape of organs of interest from the original 3D data.

On the other hand, some biomedical studies (radiotherapy studies, biomechanical studies) deliver a functional information about these organs (dosis distribution, mechanical constraints). An efficient exploitation of the results of such studies implies to relate the spatial distribution of the functional information to the anatomic shapes.

In this paper, we describe a technique allowing to provide a visual access to the 3D distribution of a computed functional parameter on the surface of the studied organ. This technique is based on HSL-type transformations, leading to a description of the conventional RGB color space through the notions of hue, saturation and luminance. Coupling such a color space description with the conventional achromatic volume rendering methods allows to map the distribution of any parameter on anatomical surfaces through a color scale while preserving the shape information.

The last part of the paper is devoted to some examples of applications on real medical data: radiotherapy planning from X-ray CT data, ventricular surface curvature analysis from fast X-ray CT data.

Image Fidelity in Tomographic Volume Visualization in Medicine

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Germany

Three-dimensional imaging of tomographic volume data from CT or MR has proven to be useful for diagnosis and operation planning in many areas like craniofacial surgery or traumatology. An important drawback however is the more or less uncontrolled appearance of pseudoforamina, jagged edges, loss of detail, and other artifacts, which might even distort the diagnostic meaning. This problem has been described by many authors, and some common sense rules ("use dense sampling") have been given. In the first part of this paper, a systematic investigation of the effects of data acquisition parameters and early processing steps on the fidelity of the resulting 3D images is presented. Results are derived from signal processing theory, and practically verified with the head of a cadaver. In particular, the following questions are answered:

Given a desired object size, what are the optimal parameters in tomography (slice thickness, slice distance)?

If these conditions cannot be met, what errors will have to be expected qualitatively and quantitatively?

What are the requirements for the subsequent processing steps (interpolation, rotation, ray casting), in order to preserve image quality?

In the second part, it is shown that a consequent application of signal processing theory will result in prohibitively high computational costs for interpolation and rotation algorithms. As a consequence, algorithms with a better trade-off between accuracy and expenses are investigated. Results are compared with the more straightforward algorithms which are mainly used today.

As an outline, some special properties of different acquisition techniques (CT and MR) and their effects on image quality are discussed in the context of the presented work.

*Experiments Towards Intelligent CAD:
From Drafting to Designing*

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Canada

The question of how humans carry out complex design tasks has been examined with the goal to develop better computer-based tools and interfaces. As part of this study, an experiment was conducted in which subjects designed a simple house using a CAD system. Four different subject groups were used: system experts, novices, architects (task experts) and one novice subject repeating the experiment four times. A protocol analysis indicates different approaches to the design process, the level of "chunking" involved in a design task, identification of design strategies, and limitations of the system itself. The results suggest development of new design aids and enable recommendations to be made in the design of an intelligent CAD system currently under development at Simon Fraser University.

Tools for User's Interface Development

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Cheliabinsk

For many users convenient interface is one of the most important (if not the only) criteria of the system applicability. Software convenience is determined by the ability of the designer to predict the user's needs. It is especially difficult to do when you develop multipurpose software.

Thus, an easily adaptable interface becomes desirable both for the programmer and the user. Naturally, interface modification should not introduce any changes into the application program proper.

It is suggested that the interface should be separated from software. The interaction rules should be placed in the definition file, the name of the file being the only thing necessary for interaction.

The application programmer is supplied with the subprogram library providing the interaction with the interface description. Interaction in the form of menu is regarded.

To define any menu it is necessary to define the following:

- application software features pictogrammes layout;
- the method of highlighting the pictogramme being chosen;
- the method of visual identification of the pictogrammes being chosen;
- presence of a sub-menu (or mini-help) in the feature;
- the method of restoring the image destroyed by a sub-menu or mini-help;

- rules for the application program to choose the feature being highlighted.

Graphic representation of the menu as the most general with respect to the text is chosen. The menu of any level is described by the complex of the rectangular part of the screen. The interaction of the applied program with the interface can be limited by three subprograms: menu opening (definition file name is given), function code choice using cursor screen coordinates obtained by any method (the code of the chosen function returns) and the menu closing. If needed the library can include cursor positioning and locating functions.

Thus, such interface allows to change any of menu attributes whenever necessary leaving the menu definition file name and function codes intact.

This method can be used for software input-output, too. The idea was realized using the Microsoft C.

*Medical Expert System: Displaying Probabilities
of Diagnoses in Graphics*

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Novosibirsk

One of the main problems in medical expert systems creating consists in the mode of display of the diagnostic process in an adequate way. Expert system "ALGOS-1", worked out by our group, uses graphics to show the level of probability of the diagnostic hypotheses.

The system carries out differential diagnostics of chronic diseases, accompanied by a cardialogic syndrome. Probability of each diagnosis is evaluated as a summary rating of the diagnostic weights of selected symptoms for a given disease. "ALGOS" gives an opportunity to watch the influence of each symptom on the ratings of diseases, in order to see what kind of changes different combinations of symptoms cause. As a rule, diagnostics includes a lot of symptoms, so the main diagnosis is shown in form of probability of some disease.

It's possible to see the dynamics of rating changes during the consultation. There is a special graph, one axis of which is "the number of questions", and the other - "ratings". Levels of possibility, high probability and a probable disease are also marked in the graph. The reliability of diagnostics is determined by the difference of ratings of different diseases in the graph. Graphic performance of probabilities of the diagnostic hypotheses is a very convenient means for creating the expert systems, too. It gives an expert more opportunities to make a correction of the information gathered in the base of knowledge, which is important for building the solving rules. Graphics makes principles of diagnostic logic visible and explains how diagnostics is carried out.

The Use of Visual Analysis in Studying Space Ordering

V.E.Nekos, V.I.Mamnitsky, A.N.Damasevich
Kharkov

Cosmic survey of the earth surface opened vast opportunities for obtaining the necessary information on the most general properties characteristic of the most numerous geographic objects. Among such main properties the investigation of the space ordering is of a particular interest. As the most important signs of ordering we take mozaic and geographic neighbourhood. Some ideas of these fundamental properties of geosystems and the modes of their studying except the known descriptions are presented in our papers on radiogeography (V.E.Nekos, 1986, etc.). Our experience shows that the man-machine analysis of the picture gives much broader possibilities of getting the necessary primary information on the conformity of space structure to the laws of nature, in particular such signs as sets of its forms, squares (sizes), neighbourhood, etc. studied by us. In our report we consider the experience of using the picture analysis system on IBM PC/AT. Our experimental and visual researches are based on the system including the complex of algorithms and programs designed for improving the decoding properties of the signs under investigation (increasing contrasts, making contours more visible, segmentation, etc.) as well as getting graphic materials from the results of decoding. The work of the system is shown on the decoding of agricultural pictures, in the South Ukraine. The importance of the obtained visual analysis lies in its use for changing speed of space structure as well as for solving numerous applied problems.

*Algorithms and Programs Visual Representation by
π-Schemes and PITHAGORAS Software Complex*

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Sverdlovsk

π-schemes universal algorithmic language is developed for the visual representation of the algorithmic knowledge. Nowadays, there are some widely used graphic (visual) algorithmic languages, the most popular being the "block-schemes" ("flowchart") of algorithms and programs" (ГОСТ 19.003-80 USSR, ISO DIS 5807.2). The organization of block-diagrams is based on the algorithm concept as a sequence of commands, while in the word-languages the concept of structural representation of algorithms is preferred. This promoted the development of the "structural approach-oriented" forms of the algorithms graphic representation. The simplest word-graphic form is writing in a word-algorithmic language, where the structural hierarchy is noted by a number of blanks at the beginning of the line. Among the specially designed graphic structural languages the most widely used languages are those of the "R-technology" (ГОСТ 19.003-86 USSR), the "structurograms" by Nessie-Shneiderman (DIN 65261 HCN 1422). "HIP0-schemes" of IBM corp. are also in use, but the degree of their "graphicity" may be doubted.

The graphic (visual) π-language in its concept is similar to the structurograms language by Nessie-Shneiderman, but seems to be more convenient for paper-records of algorithms, gives a clearer idea of their structure, may be used for functional relational representation and data structures, too.

The π-schemes algorithmic language is oriented exclusively to the structural approach to algorithmization (the non-structural one becoming impossible), and to the "top-down"

technology of algorithms development. The description in the π -language consists of the procedure definition hierarchical structure scheme, algorithmic schemes for procedure definitions, data definition schemes and data structure schemes. The main idea in the procedure definition scheme is considering the algorithm as an algorithmic function with "atomary" operations of data processing as arguments. Thus, we can use the functional approach for visual algorithmic function representation, functional schemes.

Moreover, we can use functional schemes for data structure definitions, too, in case we interpret them as the algorithms of data structure producing. The π -technology concepts are supported by PITHAGORAS software complex developed at the Mathematics and mechanics research institute of the Urals department of the USSR Academy of Sciences (ph. 007-3432-442676, fax 007-3432-442581).

*Algorithm for Interactive Extractions
of Lineaments from Remote Sensing Data*

A.N. Denisov
Leningrad

One of the methods for remote sensing data analysis in geology is an extraction of lineaments from satellite or airborne images. Being photostructures at the same time both lineaments and spatial distribution of their features are correlated with geology structures. There are a number of algorithms for automated lineament extraction. All of them extract something like lineaments, but not the same lineaments usually extracted by a geologist. One more approach to formalize this type of objects is proposed below.

Our algorithm is an interactive one. It contains several parameters controlled by a geologist. We try to reveal fragments of intensity or gradient extrema lying approximately on a straight line. The algorithm consists of two steps.

At the first step we extract local extrema along horizontal, vertical and two diagonal directions. We seek local maximums of the gradient, too. The user chooses the binary field of maximum, minimum, gradient or their sum as a first approximation of a lineament. There are some heuristics to control the width of extrema sets. One heuristic is that for the width K we use $3K$ pixels in extremum testing. Other heuristics are for modelling the local threshold adaptation at the binarization step of conventional algorithms aimed at edge detection.

At the second step we choose the threshold of minimum lineaments length. The algorithm approximates the binary field into the set of straight lines. At this step we have some heuristics as well. They help us to control the line width and

to identify the situation of two lines crossing.

The algorithm is realized on IBM PC/AT with EGA monitor. The program is a part of the interactive system software for remote sensing data processing. The algorithm has been tested by using several scales of satellite and aerial images. The results obtained with this program are reported. We use a modified version of the algorithm for piecewise linear approximation of a curve lines in raster-to-vector transformations of binary schemes.

*The Optimum Search of Targets and the Processing
of Dynamical Images*

S.G.Bratsev, F.A.Murzin, B.K.Nartov
Novosibirsk

A theoretical model of an automatical system for the analysis of dynamical images containing multiple moving objects is investigated. In the main, a set of the point objects is considered. The main functions of the system are:

the transformation of the luminous flux into the two-dimensional matrix of signals intended for the further processing;

the discovering of objects, the estimating of their coordinates, directions and velocities relative to the coordinate system of the gauge;

the tracking of objects in the feedback regime;

the output of data in a convenient form for the user.

The peculiarity of the proposed system is the use of the parallelism at all stages: perceiving, storing, processing the information.

The idea consists in the following. The luminous signal perceived by the photoreceiving matrix is loaded in the parallel access memory analogous to the one described in [1]. After that there appears a possibility of parallel access to an arbitrary square window of a small size in the initial image. In the process of tracking the windows are used and the prognosis is made. Due to the presence of several processors in the system every processor can track its own group of objects. An exchange of information between different processors is also possible. Some optimum search problems which appeared here in the presence of noises were modelled on the personal computer IBM PC.

1. F.A.Murzin, V.A.Sluev A Memory Organization for Parallel Computers//
New Generation Computing Journal, 1988, v.6., N 1., P.3-18.

*Continuous Geophysical Fields Extrapolation
with Nonlinear Filtration of the Earth
Surface Aerospace Images*

I.V.Terent'ev
Leningrad

The cross-correlation between the images and the Earth data is essential for the Earth measuring data (drilling, geophysical data) extrapolation with the images (scheme lineament constructs or smoothed Earth surface aerospace images). However, the images as a rule are noncorrelated with the Earth measuring data because of the higher rock masking influence. A possibility of a nonlinear filtration for the correlation increase is considered.

A method of a nonlinear filter construction for the transformation of some images into one image (a prediction) is presented. The computations have shown the increase of the cross-correlation between the transformed image and the Earth data from 0 to 0.6 (a linear filtration) and to 0.8 (the third degree nonlinear filtration).

This method of extrapolation is a supplement to the [1,2] method, which allows to reduce a mean error variance approximately by $(1-S)\%$ (S is the extrapolated part of the photograph) as compared with the usually employed regression analysis for random values.

1. I.V.Terent'ev "Assessment of parameters of continuous geophysical fields (with reference to aerospace imagery of the earth surface)"//Issled.Zemli iz kosmossa. 1990, N 1, p. 94-102.
2. A.A.Kiryanov, I.V.Terent'ev, I.N.Fadeeva "Geophysical data extrapolation using aerospace information"//Issled.Zemli iz kosmossa 1990, N 3, p.44-49.

*Fast Image Segmentation Algorithms Based
on One-Dimentional Distributions*

V.Kim
Vladivostok

It is evident, that the fastest image segmentation algorithms are pixel by pixel ones, which classify pixels by comparing gray level values with some predetermined thresholds and can be implemented by the look up table. These algorithms are useful, only if one-dimentional gray level distributions corresponding to different type regions (model distributions) are well differentiated. Otherwise these algorithms produce a large amount of classification errors.

This paper is devoted to the algorithms, which allow us to perform segmentation in the cases, when model distributions have substantial overlaps. The developed algorithms are based on comparing the current local distributions with the model ones.

The first of them is the maximum likelihood algorithm. It is shown that this algorithm can be implemented recursively. Further two algorithms using quadratic distance are described. They compute the quadratic distance between the current local histograms and current local cumulative histograms on the one hand and the respective model distributions on the other hand and can be implemented recursively, too. Comparative analysis of these two algorithms from the viewpoint of the "signal/noise" ratio shows the way to design a more optimum algorithm without a loss of computational efficiency. Computational burdens of all the algorithms do not depend on the sliding window size. The model distributions can be estimated interactively by using test images or automatically by using clustering prosedu ^{as}.

*Some Aspects of Constructing "Internal"
Expert Systems for Image Processing*

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Irkutsk

Among expert systems (ES) for recognition and processing complex images it is expedient to separate the following two principal classes: "external" ES and "internal" ES. The first type ES are intended for the more rational compilation of available algorithms and for choosing their working parameters (scheduling the processing). The intention of the second type ES consists in employment of the knowledge about depicted objects and about the properties of their raster representation right in the process of processing images. In the first case, ES "supplements" the input algorithms with the knowledge on their perfect usage. In the second case, ES itself represents a sort of an algorithm, in which the processes of semantic analysis and raster processing are executed simultaneously and in the interdependent form.

The shortcomings of the traditional technique of describing the images in the form of either matrices or vectors are the obstacles on the way of creating the "internal" type systems. These are caused by the pixels which separately do not carry any semantic load and are characterized only by their brightness (colour) and their position on the raster. For this reason, it is expedient to proceed from the "pixel-form" to the "segment-form" description, when a segment turns out to be an elementary unit. The advantages of such an approach are obvious:

- diversity of individual properties of segments, which substantially enriches the system's algorithmic capabilities;

- capability of carrying the individual semantic load, that simplifies constructing the knowledge base and the processes of interaction with it, and furthermore, satisfies the principle of compatibility of the semantic image processing technique and the raster image processing technique;

- possibility (theoretical) of work with "continual" type rasters, when pixel sizes are negligibly small, and their number appears to be unlimited.

One of such approaches is developed at Irkutsk Computing Center.

Improvement of Sequence of Shifted Image

V.R.Krasheninnikov, K.K.Vasiliev
Ulianovsk

Information processing systems containing space apertures of receivers have in recent years become widespread. Radio-location and television complexes of the Earth research are the most important examples of these systems. Visualization in such systems involves at least representation of information by a correlated sequence of images. But interframe shifts and broad band noise make visual analysis difficult or impossible.

Let us consider some possibilities to improve the sequence of images using methods of tensor nonlinear filtering of random fields given on multidimensional lattices worked out by the authors of the paper. For this purpose let's represent the process of forming a sequence of informative images given on the two-dimensional lattice by the tensor stochastic difference equation. Vectors of interframe shifts are considered as stray parameters and constitute the Markov vector sequence described by a similar stochastic equation. Every received image is assumed as an almost arbitrary combination of the information image and noise. Using the tensor version of invariant imbedding it is possible to obtain quasi-optimum recurrent procedure of simultaneous image improvement and stray parameters (i.e. interframe shifts) estimation.

The obtained algorithms generalize some of the well-known operations of vector quasi-optimal estimation and may be used in real-time image processing systems. The essential peculiarity of the suggested algorithms is shift compensation including spatial interpolation based on the estimated parameters. Besides, the methods worked out may be used as an essential part of the procedures for visualization of arising and moving anomalous regions and for fully automatic simultaneous detection and parameters estimation of such regions.