

## *Two Ways of Representation of Scalar Functions of Three Variables*

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Two models - continuous and discrete - are offered for the representation of function  $f : \Omega \rightarrow \mathbb{R}$ ,  $\Omega \subset \mathbb{R}^3$

1. Continuous model. Suppose, domain  $\Omega$  is filled with a substance in which particle radiation and absorption take place, particles moving parallel to the axis OX of some descartes coordinate system. The velocity of particle  $v$  depends on the place of its origin ( $v = \Lambda(f(x,y,z))$ ), the absorption coefficient  $K$  depends on the velocity of the absorbed particle and the place of absorption:  $K = P(v, \Lambda(f(x,y,z)))$ , where  $\Lambda$  and  $P$  are given functions.

Suppose also that the particles leaving the area  $\Omega$  get on the screen of the recording and representing device causing its luminescence. Luminescence colour and brightness depend on the velocity and number of particles per unit of screen area.

2. Discrete model. Function  $f(x,y,z)$  is represented as a set of surfaces of the same level which radiate and absorb particles. The velocity of the particle depends on the surface it originated. Like in the first model the particles which were not absorbed cause the luminescence of the screen of the recording device. The formulas determining the colour and the brightness of the screen luminescence in relation to the functions  $f$ ,  $\Lambda$  and  $P$  are presented.

The models are supposed to be realized in the program of interactive visual analysis of scalar functions of three variables.

*The Building Principles of Automatic Visual Systems*

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The complete or detailed algorithm of the machine vision intelligent systems (MVIS) has been suggested. The apparatus programming complex designed on the basis of the personal computers and coupled devices with optical image transducers based on the charge communication devices (CCD) or photodiode matrices has been considered. It allows to simulate the MVIS operating algorithm, to produce visualization, storing the necessary or needed processing results of the image to be found and also gives a possibility to rationally choose the element base and finally the functional scheme at a rather great number of MVIS various problems in biology, medicine, astronautics, architecture.

For MVIS simulating the automated image processing system (AIPS) has been worked out. AIPS is based on 5 microcomputers forming the local network with a star-like computer topology (one central computer and 4 peripheral ones). Upon the network arrangement the local network of data transfer CMNET is used which operates under the control of RT-11 operational system of the 5th version and relizes the access to the remote disks of the peripheral computers. AIPS also comprises 5 image input-output devices into the microcomputer: a middle format images input device from the stage section (MFIIDSS), a middle format images input device from the optical microscope, a middle format contour images input device, a little format volumetric images input device, a middle format colour images input device. All input devices contain control units for the operational zone

illumination.

Besides, MFIIDSS is equipped with a stage displacement actuator performing the automatic displacement of the operating zone along two reciprocally perpendicular directions. The software of AIPS formed as the subprograms library allows to simulate the following algorithms on processing flat (black-white or colour) or volumetric (black-white) images: filtration, segmentation, recognition of the colour and the form, location estimate and the object geometrical characteristics.

## *Interactive Graphics CAD-System*

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It is known that using the instrumental graphics systems such as AUTOCAD, DRAGON, ANVILL, etc. doesn't influence greatly the effectiveness of the designer's work automation. However, functional capabilities of these systems provide a possibility of creating design systems with a rather high level of effectiveness.

The creation of the suggested CAD-system for making engineering articles is based upon the following principles:

- an article or its elements are represented with three components: draft, parameters, structure;
- an article structure is represented with the parameter conjugation programme;
- an article structure parametrization and forming are made not by ordinary programming but as a result of a graphic dialogue;
- the user's menu represents a design medium, including the commands and procedures of forming the initial structure, determining the parameters and making the workshop drafts.

The suggested system was used for roller storage conveyors design and showed satisfactory results in design time, structural variety, accessibility and effectiveness.

*3-D Conservative Approximation  
by Rational Splines*

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Let the initial data be defined as a set of the points, ordered along the not intersecting, possibly curvilinear cross-sections of a three-dimentional body. In the paper the Gordon type algorithm [1] is proposed for the construction on the basis of data of the approximating surface of the  $C^2$  class with the preservation of geometrical features of the initial data (convexity, monotonicity, etc.) along the finite system of curvilinear coordinate lines, forming a topologically regular mesh on the surface.

For the construction of the curves along the initial cross-sections the algorithm of conservative interpolation by rational splines [2] is used. The storage and the computing of rational splines is realized by means of their representation through the B-splines. To obtain a 2-D spline in the orthogonal direction the system of rational local approximation by cubic splines is constructed. The capacities of the algorithm are illustrated by test 3-D examples.

1. W.J.Gordon, Spline-blended surface interpolation through curve networks, J. of Math. and Mech., 1969, v.18, N 10, pp.931-952.
2. B.I.Kvasov, S.A.Yatsenko, Conservative interpolation by rational splines, Approximation Theory VI: v. II, Chui, SchumakerMard (eds.), Academic Press, Inc., San Diego, 1989, pp.365-368.

*Visualization and Decoding of Soligorsk  
Industrial Region Remote Sensing Data*

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In the course of the complex radiation and ecological investigation of Soligorsk industrial region performed by the Republican scientific-technical center "Ecology" multizone time different air survey by multizone space photocamera-6 was fulfilled to study technological changes of the landscape and the consequences of soil salinization by potassium producing plants.

Digital processing and photodecoding was realized in the Computer Center of the All-Union Scientific Research Center "AIUS-Agroresursy". Input and digitalization of the photoes were conducted using standard equipment in channals 2 (540 nm), 4 (660 nm) and 6 (820 nm) with resolution 10 lines/mm. Digitalized photoes were subjected to primary processing which includes photometry and geometry correction, filtration, quantization, isolation of connected areas, etc.

Further image thematic processing included combining images, computing vegetation indices, application of image recognition methods for the dividing the connected areas into information classes. In the course of processing the areas of the Earth's surface sinking down under mine workings, areas of underflooding, territories occupied by potassium plants, slurry tanks, salt dumps were difined and computed.

*Visualization and Analysis of Data in  
Geoelectrics Using Computer Graphics*

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The software for the visualization and analysis of the results of the array electromagnetic soundings of the Earth is developed. It is based on the program package TRANS, intended for the implementation of more than 70 transforms of the electromagnetic (EM) data, measured at some level in the Earth or in the atmosphere.

Numerical calculation of the EM fields in the typical three-dimensional models of the media has been made. The results are presented in the form of contour maps, "induction vectors", polar diagrams and pseudosections. The visual analysis of these two-dimensional images of the medium allowed to estimate the measure of the information contained and also the resolution power of the EM-field components and their transforms with respect to geometrical and physical characteristics of the objects considered.

The studies resulted in the selection of groups of "focusing" transforms of the EM-field constituting a natural base for the automatized interpretation of the measured data.

*Automatized Mapping in Isolines Using Geodetic  
Splines of the Third and Fourth Order Based on  
Non-Regular Scheme of a Relief Model*

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Integrity of special relief points on the lines of maximum, minimum and zero curvatures of geodetic surface serves as the basis for a non-regular scheme of a digital relief model. Such scheme provides an adequate reflection of any complex site of the relief. It is possible to make this digital relief model automatically using the available maps and aerial photographs.

The main problem of the theory of the digital relief model for the given non-regular scheme is solved, namely, making geodetic lines (contour lines) by specially developed splines of the third and fourth order. The problem setting is given together with its solution, software and IBM PC/AT realization for certain sites of complex mountainous relief of Chimgan region in the Western Tien Shan. Maximum approximation of such geodetical lines to the actual contours of the map is shown comparing with the known interpolation methods of the piecewise linear function and classic cubic spline.

*Interactive Digital Terrain Information  
Systems Design for Data Processing*

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The interactive processing management, which enables to apply the human intellectual abilities and professional practical knowledge more completely, has been required for using the digital information for solving a wide range of problems in different fields of science and engineering.

Composing the complete description of the interactive digital information processing presupposes the performance of the following design procedures:

- the object and task interactive processing definition;
- composing the simplified primary declaration of processing elements;
- interactive processing functional model development;
- selecting the digital terrain information database architecture;
- the processing procedure management substantiation;
- the man-machine interaction scenario development.

The paper deals with the problem of the effect of the digital terrain information characteristics on the interactive processing systems design.

An example of its development is also described.

*Contour-Gray-Scale Approach to the Problem of  
3-Dimensional Scene Interpretation*

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The problem of 3-dimentional scene interpretation based on its gray-scale image arises in different technical applications. High reliability of performance under arbitrary light conditions and sufficiently quick response to change of the scene are usual requirements to the system of interpretation.

At present several approaches to this problem are known, which can be divided into two large groups. In the first group only the contour information extracted from the image is used, and that leads to the decrease of reliability of the object surface shape recognition, but enables to estimate the object edges shape with high precision. In other approaches the gray-scale information is used (shape-from-shading, gradient-based method of scene interpretation, etc.). Such approaches ensure high reliability of the object surface shape recognition, but decrease the precision of the contour shape and complicates the calculations.

In the present work a new approach to this problem is suggested in which both contour and gray-scale information are combined. By means of contour information the image is split into the areas in each of which the gray-scale analysis based on the functional relationship between image brightness and object surface illuminance is performed. During this analysis each detected area of the image is associated, according to one of the theorems of differential geometry, with one of the four types (cylindrical, conic, spherical and flat) of the surface. On this stage the first level description is obtained which becomes the basis of the final scene interpretation.

The application of this approach leads to the new qualitative result: simultaneous increase of the reliability of scene interpretation and decrease of computational burden.

The description of the computer programs realizing this approach is also presented.

*The Human Perception Feature Analysis  
of the Terrain Stereo Image*

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The article deals with the human perception features of the terrain stereo image presented as a half - tone and graphic image. The main common characteristics and differences of the human perception feature are described. The "false" effects which occur during the preception procedure of the terrain spatial models and their measurements are determined. The optimum observing conditions for the terrain models, using both the optical observing systems and the graphic display screen, are also given.

The correlation between the "false" effects occurring in the process of the terrain models perception with the perspective background availability is established. The psychological mechanism of the model preception "false" effects in the operator's brain is given.

The possibilities of using the operator's eyes motions for receiving the metric data on the terrain objects are described. The results of the experimental measurements performed on the mode of the measuring system are presented.

## *Computer Magazines and Toolkits for Their Creation*

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New technical opportunities very often result in the development of new genres of man's creative work. Animated cartoons and computer games are the most striking examples.

We have every reason to believe that a combination of programming, journalism, computer graphics and music will give impetus to the development of a qualitatively new kind of art - computer journalism.

In 1990 the authors started the work in the field of creating a toolkit for computer-aided preparation of magazines and books. Now several numbers of the computer magazine "INPEC" have been published.

At present "INPEC" is, formally speaking, a structure of a "hypertext" type whose terminal units are pages with the text and/or graphics, interactive programs of dynamic and graphic output and audiofragments (musical accompaniment). Program support is realized by providing navigation of the reader through the structure by means of the graphic dialogue and service functions.

In the process of creating the magazine a number of modifications and additions to the VAD system (named after its author V.A.Debelov) have been introduced, new specialized utilities of graphic editing computer artistic representation, programs of computer melody "arrangement" (author - V.M.Golubev) have been made, specialized means of protection from non-sanctioned copying and antivirus control have been provided. The authors see the future of computer journalism in utilizing "back information connections" from readers, in extended application of hypertext and multimedia concepts, in corporative creation of the magazine "as a whole" and generating individual version of the magazine "for a specific client" on the basis of global computer networks.

*Software System of Processing and Visualization  
of Information about Oil Deposits*

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The paper presents the software system "Computer tomograph of bowels" intended for complex processing and visualization of geological, geophysical and working information about oil fields. The information processing is based on mathematical modelling of the structure and processes in oil strata. The results are presented to users as maps, 3D-surfaces, sections and graphs.

All information about the oil deposit is stored in the integrated database. The work with the systems is done in the interactive mode with a wide use of graphic interface. The results of the work with the system are displayed on the terminal, printer and plotter.

The system works on personal computers and is used in some oil extracting enterprises.

## *The System of the Visualization of Measurement*

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The system MAP is intended for the visualization of measurement of some function in arbitrarily distributed points in a plan on IBM PC/XT/AT and compatible machines. The results of the session with the system MAP are 3D-surfaces, isolines or color maps. 3D-surfaces and isolines can be plotted or drawn on the screen. The colour map is drawn on the screen and up to 136 colours are used in the palette.

The isolines or colour maps are built by interpolation ( $C^0$  or  $C^1$ ) over triangulation, based on the Delonay triangulation. To use nonconvex domains two approaches are used. According to the first approach the nonconvex domain is placed into the rectangle in which the Delonay triangulation is built. The function is interpolated inside the triangles and then only a part of the interpolant is used to draw surfaces, isolines or maps.

According to the second approach the points are placed into each vortex of a nonconvex domain. It is possible to generalize the notion of Delonay triangulation for that point configuration so that the new triangulation is placed into the nonconvex domain.

One of the ways of getting function values in the points on the plane is the numerical simulation. For this the second approach is more convenient.

## *Digital Photogrammetric Workstation*

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The development and implementation of digital photogrammetric workstations (DPW) and multifunctional methods of terrain digital data (TDD) processing is one of the main trends of modern photogrammetric production. It is caused by many reasons.

The most important one is the possibility to unite TDD digitizing and mapping devices of high resolution, large main and external memory on the basis of powerful computing kernel.

This possibility enables to increase the reliability and efficiency of photogrammetric works. The main DPW hardware are a stereodisplay, an interactive graphic display, a precision input charge-coupled device (CCD), a TV input unit and a host processor - personal computer IBM PC/T 386 with the system of specialized co-processors. The use of flexible programming technology based on modern PC tools increases the development and accompaniment efficiency of software. DPW gives a possibility to solve three tasks on one system: digital terrain model development, contour line generation, TDD checking and editing. Such DPW has potential possibilities of implementation of digitizing and renewal technology of cartographic materials, analytical phototriangulation, the development of publishing map originals, photoplans and orthoplans development, and the possibility to solve different qualitative and quantitative applied problems based on TDD.

## *Subject Mapping in the Problems of Complex Radiation*

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One of the problems of radiation monitoring of the natural environment is the problem of subject mapping automatic control. Its solution can be subdivided into several stages. These are: preparation of the topographic basis, preprocessing and reorganization of subject data, their reference and mapping of the topographic basis, etc. The importance of the mapping problem resides in the fact that it is to be solved constantly, at every stage of working with the radiation data.

In the present work we consider one of the possible approaches to the solution of the mapping problem and its realization. Topographic and subject information is characterized by a large body of heterogeneous data. We propose methods of radiation data structurization for the purpose of increasing the speed of processing such data. A flexible multilevel data structure has been developed, which involves the nested lists realized with the use of the concept of object-oriented programming. This permits an easy plotting of the desired subject data on the topographic map. The model described is open and allows one to effectively use the created algorithms in the development of different applied packages. The topographic and subject data model as well as the procedure of its application have formed the basis for the graphic map editor EcoMaker for IBM PC XT/AT type. The EcoMaker program allows to realize the input and editing of geoinformation, its viewing, printing and plotting, reading/recording on an external storage medium, scaling on a desired scale, as well as measuring different

topographic characteristics.

A package of EcoMaker programs was successfully used in the processing of real data of remote sensing of the Volozin District (Minsk Region, BSSR) and in the construction of subject maps. Radiation survey was carried out by an aerogramma-spectrometric station "Makfar II" with surface sampling in the test regions. A large scale photography (1:50000) of the whole district and a detailed one (1:10000) of individual farms subjected to the greatest radioactive contamination have been carried out. Using the data of the radiation survey and numerical topographic basis we have constructed subject maps in the isolines of the exposure dose power and of the density of surface contamination by Cs-137 and K-40.

*Video Output Structure in GAMMA-T  
Graphic Station and Generation of TV Effects*

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The possibility of flexible video output control based on the address table (AT) is a distinctive feature of the GAMMA-T graphic station, the length of the AT being equal to the number of the screen rows.

Each element of the AT contains a frame buffer address from which a corresponding screen row starts. One of the 2048 possible scales of row visualization and the indication of the straight/mirror row is the following: for the straight row frame buffer addresses increase from the given in the AT, for the mirror row they decrease. The AT is located in the RAM of the display processor and is accessible for the video processor through the direct address channel.

One of the algorithms of rearranging the current address table is the basis of all real-time TV-effect generators. For instance, rewriting the AT contents in the reverse order looks like an "upside-down" image. Very important is the fact that the whole of the AT or its part for the even/odd half-frame must be rearranged within 20 msec, i.e., within the scan time of one half-frame. In view of this fact all the TV-effect generators in the GAMMA-T station are divided into two groups.

The first group includes the generators working not more than 20 msec. The main unit here is the "transfocator" realizing a smooth change of the image scale. To change the image scale on the y-coordinate it is necessary, according to certain rules, to duplicate the AT elements if the scale increases or to discard them if it decreases. The change of the scale on the

x-coordinate is implemented by the video processor according to the scales given in the AT elements which can be different for different rows.

The generators of the second group realize the AT rearrangement algorithms for more than 20 msec. They consist of two parts: preparatory and playing. The preparatory part prepares a sequence of address tables corresponding to the algorithm and places them into the RAM. The playing part transmits the addresses of the tables to the processor every 20 msec.

*GAMMA-T Software - Hardware Complex  
for TV Applications*

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Studio TV complexes are one of the important applications of the GAMMA-T videocomputer graphic station where it can be used as part of the equipment for the design of TV programs.

The GAMMA-T graphic station contains both the technical elements present in most raster display systems (a 4 Mbyte frame buffer, a 768/206575 pixel colour image monitor working in the first TV standard, a look-up-table, a keyboard, a tablet for entering the co-ordinate information, a 40 Mbyte mass storage on the hard magnetic disk of the Winchester type, a mass storage on floppy disks) and specialized modules (a TV SECAM signal coding/decoding device, a video signal digitizer working in real time, a control interface of the KADR-3P type video taperecorder). The GAMMA-T station software allowing to use it in TV consists of a set of programs realizing the functions of creation, input, transformation, processing, storage and reproduction of the image and its parts, the control over the image output onto the screen as well as generating artistic prints.

Image synthesis programs allow to create both plane and pseudo-3D images. Plane images consist of elementary primitives with different methods of filling (including the imitation of various kinds of painting technique - brushes, pulverizers, water-colours). Pseudo-3D images are obtained from plane objects by means of "extrusion" (the plane object size is given on the z-coordinate).

The programs of forming special effects of real time (as well as the programs of animating images) provide the creation, storage and sequential output of 20 msec intermediate image phases onto the monitor. The member of such phases depends on the size and can reach 300.

## *To the Development of the Visual Debugger*

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The reviews of the visual programming systems make it possible to subdivide the main graphical representation into the following types:

1) natural - the images growing on the physical pictures from the application;

2) quasinatural - the images adapting one conventional graphical metaphors growing on mathematics or technology;

3) artificial - the images adapting new metaphors or arbitrary signs.

The visualization of the traditional style usually uses quasinatural graph representation either for the control flow, or for the data flow of the program. In some systems the control flow animation or algorithm animation are realized. In the algorithm animation systems simple images for simple data structures are constructed.

Some visual debuggers provide an ability of simultaneous simulating in dynamics both the control and data flows. But in general the problem of graphical representation of the program process is hard to solve even in case of simple data structures. The problem is even more difficult when the visualization of the system programs is needed.

As a rough approach to the process of visualization for system programs a combination of visual programming and data visualization methods is suggested.

The system will contain the following possibilities:

1) designing object process and data structures icons or the employment of the icons constructed before;

2) determining for every program unit some rules according to which the data structures icon attributes (a form, a color, etc.) will be changed after unit processing.

The visual debugging investigations are developed within the framework of the scientific visualization system project.

## *The scientific Visualization System Project*

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The computer graphics group at the Institute of Mathematics and Mechanics (Sverdlovsk) develops a scientific visualization system comprising tools for graphic input/output, picture animation and visual programming.

The system project is supposed to separate the computing and visualization processes including the distribution of these processes into large computer and graphic workstations or PC.

The graphic language is realized. The language contains the means for object graphic representation, object motion description and for changing their attributes. The system is supposed to deal with both the applied task model objects and the control and data structures of the program corresponding to the model.

Various graphic interpretations of the same object are possible. Computing and visualization processes interact providing the dynamic changing of the model and program object images. The icon form investigation and the design for the model and program objects are developed.

*Graphics System for Geometric Modelling  
and Visualization of Three-Dimentional Objects*

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Samara

The Samara system consists of 3 main units:

- a language processor for the description of geometric and fotometric object surface parameters and for command input;
- an object mathematical model forming unit;
- a model objects visualization unit.

Object space forms are determined with geometric transformations and primitive set operations. Primitives are space forms bounded with the first- and second-order surfaces.

Geometric transformations used are: scale, shift rotation and geometric interface.

Set operations used are: conjunction, disjunction and subtraction. The set operations are used both for primitive and more complex forms.

The procedural language for geometric design has graphics support. It does not require user's special training, except for the knowledge of geometric design general principles with the help of set operations.

After the compilation the hierachial object model is created. This model is accessible for the application programs. The application program can transform the whole object or its part. There are universal units for user's applications. Object visualization is possible for any stage of geometric design. Three-dimentional, half-toned, colour images with shadow have been developed. Different fill models can be used in visualization subsystem.

The spheres of application are: CAD/CAM, geometric modelling, photometric experiment modelling, etc.

The system batch version works on the IBM 360/370. Non-serial equipment is used for graphic output. The system interactive version will have been ready on IBM PC/T computers by the end of 1991.

## *Formation of Axonometric Assembly Drawings in CAD Systems*

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Integration of various problems within the CAD systems is primarily based on the data describing a geometry of the object designed. Solutions are available for the numerous problems of forming and mapping plane and spatial objects supposed to be used in design systems and preparing the design and drawing specifications. A problem that has not yet been solved for drafting systems is that of generating the images for an assembly drawing.

An assembly drawing of a product is considered to be one of the basic elements in service forms and records governing the product assembly procedure no matter which production activity field may be the case including machine building, radioelectronics, civil engineering, etc.

Among the assembly drawing types employed in various technical documents one should mention an axonometric image of an object the idea of which is that the constituent parts are spaced in the image space so as to make visible their embedding and interaction pattern.

Unfortunately, there is no special term in the literature on descriptive geometry and engineering graphics that could describe axonometric images in an assembly drawing.

The special object model and the projection means are considered to be the reference data for the problem solution.

The projection means in accordance with ESKD (a common system for design documents) can only be orthogonal parallel and prescribed by the projection vector S since the oblique and central projections yield a distorted image and can lead to incorrect conclusions of a designer.

The projection vector can be assigned in any manner but vector S should be selected so as to completely reveal the structure pattern. An object model can be obtained with the aid of the geometrical modelling systems allowing to deal with a constructive solid geometry (CSG) and having some additional