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PLACE AND ROLE OF COMPUTER GRAPHIC ARTS IN RESEARCHES ON APPLIED GEOMETRY, TECHNICAL AESTHETICS AND ERGONOMICS

It is well known that 40 years have passed since the first computer system SKETCHPAD was developed and introduced into design market. These were the years of rapid development of computer technologies in all of production domains, science and technique.

As in the former USSR and in particular in Ukraine today, there is still the lack of professional manuals and educational literature, the author of this paper in co-operation with some colleagues has published the „Reference Book on Machine Graphic Arts in Design" (Kiev, 1984) and a textbook „Geometrical Modeling and Computer Graphics in CAD" (Kiev, 1991). The reference book breaks down into following 12 chapters:

1. Introduction into machine graphic art..
2. Complexes of technical means in computer graphic arts.
3. Elements of computer graphic arts.
4. Three-dimensional computer graphic arts. Perspective, axonometry and other 3D visualization techniques.
5. Interactive graphic methods.
6. Data representation of computer graphic in CAD.
7. Linguistic and program means of computer graphics.
8. Interactive graphics of CAD, CAM and CAE systems.
9. Mathematical modeling of geometrical objects.
10. Geometrical computations.
11. Subsystems of computer graphic in CAD systems of objects of construction.
12. Demands for making documentation literature in CAD.

A reference list of literature follows each chapter. A great number of original material worked up by the authors of the „Reference book..." has been included into the manual.

A textbook contains the following 11 chapters:

1. Basic description and task of geometrical modeling and means of computer graphics in CAD.
2. Technical means of interactive graphic CAD systems.
3. Mathematical representation of picture subsystem forming.
4. Mathematical bases of geometrical modeling.
5. Interactive graphic methods of input data and modeling.
6. Interactive methods of graphic spatial design.
7. Linguistic means of geometrical modeling and computer graphics arts.
8. Fundamental software of interactive graphics systems.
9. Application programs of computer graphic art.
10. Programming of interactive graphic systems.
11. Problem-oriented, interactive graphics systems.

Thus, the necessity for publication of an educational training manual has appeared. The manual ‘Explanation of Terms of Applied Geometry, Engineering and Computer Graphic Arts’ has been written. There were the following reasons for preparing such a manual: 1. The necessity of higher technical education transition to Ukrainian educational system, 2.The need for vocabulary related to geometrical modeling expansion and supply, 3. To bridge the gap in Ukrainian equivalents of computer graphics terms, in particular on computational geometry and computer graphic arts. The manual breaks down into three parts: ‘Applied geometry’, ‘Engineering graphic arts’, ‘Computer graphics’. Each term has been translated into English and Russian. The terms are illustrated by drawings if needed.

An interdepartmental scientific and technical collection „Applied Geometry and Engineering Graphic Arts” has been published in Ukraine since 1964 and 65 issues of this collection have already got into light.

More than 3000 scientific articles from Ukraine, Russia, Uzbekistan, Tadzikistan, France, Poland, Slovakia, Lithuania and other states were published in the collection, the collection which was the only one of that type in the former USSR. Under the Kiev National University of Building and Architecture the council of experts in fields of ‘applied geometry and engineering graphic arts’ as well as of ‘technical aesthetics’ has been functioning. It is a rule today that one part of each of masters or doctorate dissertation is dedicated to computer realization of ideas introduced by the authors.

Let me be allowed to bring in a few examples taken from dissertations of my doctorates. The computer graphic ideas and methods are widely applied in many fields of science and technology. To give an example they are used in research, design and manufacturing of different types of turbo-machines for specific purposes and various constructive performances (Doctorant V.D. Borisenko).

The level of turbo-machine aerodynamics perfection is determined considerably by quality of geometrical simulation of blade apparatus that consists of moving and stationary elements. The main energy transformation takes place in the turbo-machine rotors and this is why a great attention must be paid to their geometrical simulation.

For these types of turbo-machines geometrical simulation of the rotor blades is realized by successive solution of two independent problems. The first problem concentrates on simulation of the hub and shroud profiles of a rotor. The second problem must be solved for the blade profile specifications. This profile is constructed on a reference cylinder with external radius of a rotor.

Taking a traditional approach to the blade shape profiling with computer application as an arrangement that increases the rate of calculations, the designer gets a great volume of numerical information for analysis of the blade apparatus or its separate elements. This information is stored in a computer memory in form of matrices of different dimensions. For this reason it is very difficult to estimate the quality of the blade apparatus which was obtained from the calculations. The designer is obliged to construct by a paper and a hand method the meridian section of a turbo-machine, of blade profiles and of the rotor in the first place. A great stream of numbers does not allow to follow the influence of one or another parameter on the quality of the curve or surface received. It takes a long time and still does not make it possible to analyze the sets of variables to adopt an optimal solution.

These difficulties were overcome due to introduction of computer graphics techniques, which made it possible to reflect the geometrical simulation on the personal computer display. Visual estimation of the obtained geometrical results allows in the first approximation stage to form a conclusion on the rate of aerodynamic perfection of the blade apparatus. The graphs of the first and the second derivatives or radii of curvature distribution of the curves and surfaces

constructed on the display make it possible to estimate values of the effective characteristics of the blade machines with suitable reliability. A specific advantage of computer graphics methods lies in designer's ability to examine a sufficient number of alternative solutions.

Thus, working in an interactive mode it is possible to solve an optimization problem by rendering of the local influence on the blade apparatus geometry and by controlling its output on the display screen by means of its geometrical representation.

The development of computer technologies allows the user to visualize geometrical simulation results on the computer screen and to raise the geometrical solution of problems to a new, qualitative level. By application of the described method we get an opportunity to extend geometrical simulation to the whole blade apparatus instead of profiling separate elements.

Pattern recognition is one of rather new and effective applications of applied geometry. One of the main problems in this area is identification of images in case the analyzed shape belongs to a specific class of geometric forms that are defined by an image-measurement standard by a doctorate V.Kortschinsky. The principle of comparison of the image being analyzed with a standard pattern lies in fundamentals of all existing methods of pattern recognition. Due to huge information contents enclosed in images a direct realization of this principle is impossible. Therefore not images themselves are compared but their descriptions as the sets of information features, which are treated as points (vectors) of some simulating space of large dimensionality. Owing to these reasons the broad draft on funds computer facilities is characteristic of recognition and image analysis.

In majority of practical situations only knowledge on general properties of illumination and geometric, and optical characteristics of the object surface are sufficient to perform analysis of corresponding image shape. The typical example is an image of flat objects (or objects, which can be considered to be flat) and which has been generated in condition of large remoteness of the iconic system from the object. The image itself may be considered to be projective; its geometric shape is determined by both the object itself and the complex of item conditions existing at the moment of image fixation (an aspect angle, mutual arrangement of an object and picture planes in space, type of projection).

The authors have developed an information model of an arbitrary projective image in form of a set of specific order dimensions cumulates of the image brightness function. It has been proved that the map of a set of geometric shapes (arising when the positioning conditions of image fixation change) onto appropriate model becomes homeomorphic when the order of cumulants tends to infinity. The affinities of an image result in moving of a point representing its geometric shape of some surface of the second degree (quadric) in modeling space. The latter may be treated as a hyper-sphere at the pseudo-Euclidean metrization of the modeling space. Identification of an image under analysis is reduced to a positional problem of applied geometry on fitting of a point representing an image shape onto the pseudo-sphere with a radius, which is determined by a shape of a standard image. By the analysis of mutual arrangement of vectors that represent both the image under analysis and the standard image it is possible to compute a full set of positional parameters of projection (angles between an object and a picture plane, distance between them, etc.).

The application of the suggested method is especially effective for the problems of identification and analysis of self-affine fractal images. Geometric structure of such images may be treated as a combination without interceptions of a set of fragments, each of which grows out of some initial image. Realization of the offered approach is impossible without using computer facilities for the following reasons.

Since 1998 a new scientific specialty „05.01.03 - Technical aesthetics" has been approved after the decision of the National Qualifying Committee of Ukraine (NQC), and a

dedicated certifying council of master or doctorate thesis presenting opened. A new program has been adopted in which priority has been assigned to computer aided solving problems in modern design. Main goals of the new specialization are listed below:

I. a passport of the specialty „05.01.03" was set out;
II. a new program for master degree exams was elaborated and approved;
III. new directions for scientific research were detected and listed as follows:

1. An exploration of the common theoretical problems of aesthetic organization of a human environment.
2. An observation of the problems of common links between technical aesthetics and anthropometry, bionics, ecology, qualimetry, etc.
3. Geometric modeling design of the factors in system „Human-Object-Surrounding".
4. Developing and mastering of computer technologies in processes of artistic intermutation.
5. Research on the logic composition and means in architecture, different branches of modern design, decorative and applied fine art.
6. Using computers in principles exploration for formalization of prior 'non-formalized' properties and features of objects, events and processes.
7. Development of theory of visual images recognition. Research on a computer aided graphic information properties.
8. Research and development of scientific-based principles of computer modeling of mark signs and symbols.
9. Developing methods of computer analysis and expertise systems of aesthetic properties of designed objects.

Nowadays two masters (Tsoy M. and O. Zavarzeen) and one doctor dissertations (Yakovlev N.) are considered for presentation at KNUBA within specialty "technical aesthetics".

The theme of Yakovlev's thesis is research on geometrical principles of art intermutation using computer technologies. In the thesis some interesting and important scientific results were employed.

- Basic principles of geometric (graphic) formalization of the objective characteristics of the form.
- The model of mutual subordination between the elements of composition was elaborated and practically tested in a process of artistic intermutation.
- Based on the model of mutual subordination a methodology of automatic definition of the composition center in multi-element planar formations was proposed.
- A methodology and program package for analysis of the composition of masterpieces of art was elaborated.
- Geometric principles of intermutation of sign/mark images were researched and based on these results a LogoMaker program for projecting logotypes was elaborated.

Ornament, as a decorative means of transfer of aesthetic and cultural values of many nations and ethnic groups, is one of art receptors participating in designing of art images in a complex of means forming harmonious subject environment that surrounds the man (architectural structures, interiors, daily necessities, souvenirs, printed production, the fabrics etc. get ornament forms).

The system of computer modeling of ornamental structures within the framework of a discipline «industrial art» and the structure of decision making for tasks on ornamental fields in the graphic system environment includes a number of algorithmically difficult tasks, which

without application of computer facilities on the design stage are not obviously possible to solve (Aspirant M. Tsoy).

The development of special algorithms for machine ornament designing allows to look through ornaments' sets of variables operatively and to generate ornaments of required structure in view of historic, cultural, geometrical, harmonic etc. laws, which are generated in a computer memory as databases.

Using a high level of art preparation, using thus SYSTEMS of the Automated Designing, operator-ornamentalist uses dialogue modes of influence from the COMPUTER, where the COMPUTER incurs the following functions:

- storage of the information about ornaments (elements and factors forming an ornament);
- transformation of images;
- ornament synthesis;
- ornament drawing on a chosen surface in view of minimization of distortions;
- ornament perception by a static and dynamic perception.

The advantage of computer modeling of ornaments lies in its speed and what is even more important in ability to visualize operatively ornamental structures.

Let us now go on to consideration about the fundamental applications of computer graphic arts in ergonomic researches, to perform the following activities:

- encoding and reflection of information;
- designing of control stands;
- testing, control and teaching of operators;
- systems estimation.

We will bring in an example of computer graphic arts application into designing of control stands.

Algorithms of composition base lies in a theory of S-space self-organization, the prognoses of which formally are expressed as invariant of objective models 1- for type, S- for graphs and PC- for diagrams. (Dr. Y. M. Kovalyov)

By packet version *elaboration Aim* COMP (from '97) the demonstration of human-machine systems is possible. Therefore realization of basic suggestions and algorithms are the same, and activities on each of composition stages are done as more 'transparent'.

Elaboration environment and necessary resources we have a packet created in objective-oriented environment of rapid elaboration Delphi 3; Image Editor used in quality of graphic editor. A packet launches as a common program under WASP Windows 95.

A packet interface is typical for any work 'under Windows'; it is intuitively intelligible for each user of this efficient system. Compositions at each of these stages correspond to separate windows, divided into three zones: basic falling menus, functional drawing pins and editing panels.