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METHODOLOGICAL FUNDAMENTALS OF ENVIRONMENTAL IMPACTS DESCRIPTION, SHAPING AND VISUALIZATION IN CAD SYSTEMS

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Abstract

Presented article refers to comprehension of geometrical sciences ` main destinations and issues of accentuate of meaning of geometrical transformation formalism in the field of traditional and possible expansion of CAD system learning and practical usage.

In the article it has been clearly shown that in all three components of study, creation and production activity, namely: joint methodological basis of study of eminent description, formation and visualization instruments on urban developmental objects is formalism of geometrical transformation together with alternative disciplines of this apparatus (analytic geometry, differential geometry, matrix residue).

Gnoseological, pedagogical view of raised problem is very important. Display of intercommunication of pragmatic possibilities of separate ***methodic*** *hence general* ***methodological*** *fundamentals is emphasized in the article, which is considered in the same triad: cognitive, creative and communication aspects.*

Keywords: *geometric transformation, shaping, composition, CAD systems, spatial modification, illumination technology.*

Introduction

In the process of studying the CAD systems, the necessity of considering the intra- and inter-subject relationship is to be underlined for its application and popularization purposes. This point is especially evident in wide aspects of geometric transformation studies and application:

1. Geometric reflection of energetic impact of the environment;
2. Adequate design-engineering response to such impacts via shaping tools;
3. Evident illustration of the results of geometric modeling (screen processes).

The significance of the abovementioned aspects of CAD systems application is a rather convincing argument for recognizing the methodological and creative importance of the geometric transformation.

It is noteworthy that historically such modern, cognitive, productive and creative problems are associated with the Erlangen Program of the prominent mathematician F. Klein's whose common scientific and academic-reformist ideas are not properly analyzed and fully realized in studying the CAD systems and training of their potential applicants.

The main groups of geometric transformation are considered and properly ranged according to the criteria of alteration/maintenance of geometric features of before and after, notably by the invariants' generation degree, which is important with the view of application of their "creative

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power" in the process of shaping as well as in the aspects of nuanced description of the environmental impact (signal of the nature). Such an approach and identified accents make the present work different from other researches where the apparatus of geometric transformation is used as a mean of solving particular problems.

I. Aspects of application of geometric transformation in the CAD systems

A. The first aspect of application of geometric transformation – lies in the geometric interpretation of the results of energetic impact of the environment (track, image). In a very common cases isobar, isopods, isohyps and others (substance or contours relevant to energy concentration zones) are the most evident confirmations of this. However, any object transformation may be associated with power (energetic) influence and, in this view; wide possibilities are identified for application of geometric transformation groups. In this paper, the projection transformation is considered as an example of a nontrivial application. This is particularly noticeable in illumination modeling in the problems of building illumination and shading contours. It is also interesting to utilize circular and topological transformations in the sphere of energetic impact of the environment about which we confine ourselves only to identifying the problems.

In the CAD systems, the study of possibilities of algorithms reflecting the energetic impact of the environment is particularly evident in the problems of modeling of natural illumination due to certain associatively and, sometimes, complete adequacy of commonly physical, and particularly optical and projection problems.

It is known that architectural ecology is one of the priority directions of city planning and spatial planning the important aspect of which is insolation and natural illumination [9].

In new versions of applied packages, so called photometric light sources are used to achieve more precise results, which more accurately reflect the illumination degree, color, light power, according to which real light sources are characterized, that is illumination is expressed in units of received physical_dimension: candela (cd), lumens (lm), and lux (lx). The photometric alternatives of the abovementioned light sources are IES Sun and IES Sky systems (IES - Illuminating Engineering Society).

The photometric theory of a light field is unique for all kinds of natural or manual illumination systems; it is the synthesis of geometrical optics, projective geometry, light transferring mathematical apparatus (differential and integral recording, vector fields and statistical analyses). Optical-geometric approach is a perfect and modern paradigm in representing event of our interest and we believe that its application does not have any alternative in the field of our research [7].

Such approach may be fundamentally generalized for the problems of study, research and management of electromagnetic, hydrodynamic, aerodynamic, acoustic, and atmospheric occurrences, where from the cognitive point of view the object's optical appearance or the result (indication, echoscope, radiography and others) of similar, substance aggregate, symbolic,

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and digital modeling should be finally considered within the context of notions, categories and terms of "illumination and projection".

The paper underlines the necessity of unopposed application of system approaches and modern technical and methodological possibilities of illumination technology in describing, studying, researching, and managing both general and private problems [1,6].

One of the main goals of architecture and construction is to find explanation and adequate response to the environmental energetic impact on objects (buildings, constructions, territories) of urban development in the form of geometric transformation. The model offered by the author is the example – the method of imagining the spherical depiction of celestial dome and the cut of its conical surface built from the observation point which is taken for the sun movement trajectory and, afterwards, measuring its visible part (the track which is equivalent to the duration of insolation) [16].

Promotion of new versions and possibilities of the CAD systems will be positively reflected in the field to be considered. Image 1 depicts the author's version of the sun illumination modeling created in AutoCAD (M. Dinuashvili).

Note: Method of cylindrical and conic section surface is considered in special literature [21]

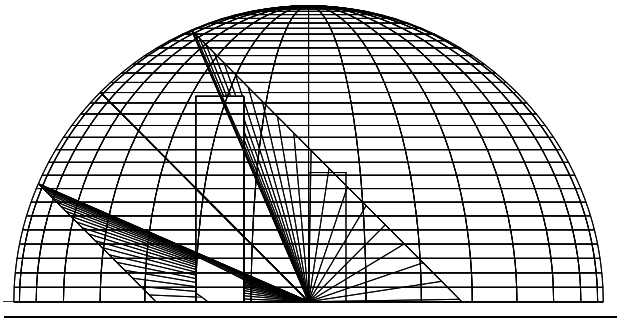

Image 1. Spherical Model of Sun Movement Trajectory

B. The second aspect of application of geometric transformation considered in this paper is the examination of basic capabilities (primitive building and modification) of graphic editors of the CAD systems. These capabilities are mainly based on affine transformations requiring significant attention as a shaping and composition instrument.
The transformation composition issues, particularly commutatively conditions are also discussed here as one of the methods for avoiding unexpected results during editing [15].

Among private transformation forms the interesting ones are the so called conformal transformations such as hyperbolic contraction and hyperbolic turn. The illustration of this particular case (definition of geometrical locus of the angles of rectangles with equal areas) of affine transformation is the method of defining the parameters of construction and planning cells which, apart from the abovementioned principles, contains the features of optimization problem (limitations block, combinations of allowed parameters and the way of analyzing them by various criteria).

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The principle of symmetry can be visible very well especially in geometric transformations. It is known that affine transformation contains several kinds of symmetry.

According to the most common view the symmetry implies the existence of invariance in objects and occurrences with respect to any transformation. In many cases the invariance of geometric figures are meant via turning and reflecting during interchanging of its equal-size parts.

The most interesting for us is its application in geometric shaping, particularly during the modeling of architectural bionic forms [12,13,14].

The principles of symmetry play important role in mathematics and physics, chemistry and biology, technology and architecture, painting and sculptures, poetry and music. Laws of nature are mostly subject to symmetry.

By principles of geometric transformations the interesting results are obtained in architecture and design shaping, especially in modeling of architectural and bionic forms.

It is to be mentioned that by discrete, small-pace application of affine transformation operations (movement, rotation, scaling) it is possible to imitate different transformations (approximation), for example twist or any other nonlinear transformation. Surbosoms (surfaces-bodies of spiral rotation) in nature, technology and architecture serve as an example. Creation of spiral rotation (turbosoms) casing is a specific constructive, typological (as well as topological) method. The principle of spiral rotation (spiral symmetry) is an accepted way of creating modern architectural buildings and decorative forms.

Creation of a bionic form is possible using the fractal algorithm reflecting the recurrent process of self resemblance, dismemberment and transformation of the whole and its element.

C. The model visualization issues (screen processes) are **the third aspects** of application of geometric transformation. The Affine and Projective transformation fully contain the issues of parallel and central planning. Particular attention is paid to the Desargue Theorem and Configurations for interpreting the theory of a perspective image. The importance of application of geometric transformations in these aspects is evident in projection problems [8]:

- Direct projection problem

(Building an object projection when its shape and spatial location are described by any method);

- Reverse projection problem;
- Constructive problem;
- Positional problem;
- Incidental problem;
- Metric problem;

As it is known, the alternative for geometric transformation of figures is the alteration of coordinate system (transformation). This is particularly actual for the so called “Display Processes” when the transformation objects are actually unchanged and the “required” reflection (image) is received by relevant transformation in the coordinate system. In the problems of mechanical graphics (especially in the abovementioned situations) the affine, Descartes rectangular, Descartes skew-angular, polar, cylindrical, spherical and identical coordinate systems are used, which according to the object’s imagination structure, may be used, at the same time, as the world, global, local, instrumental, and other coordinate systems.

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The generalization of the interpretation of geometric transformations is associated with structural elements of an object as well as with the plurality of objects over the principle possibilities of their application. Proceeding from the principle of the systemic approach, the levels of environmental impact (similar object modification) can be formed in the following ways:

- Sub-object level;
- Object level;
- Object plurality level.

At the same time, it is to be underlined that the classical triad – **transferring (move), rotating, and scaling** remains again as the way of effective transformation at the sub-object level.

As opposed to the non-parameter objects discussed above editing (3dsMax base objects, AutoCAD primitives - solids, surfaces and etc.) of the parameter objects is limited at the sub-object level due to minimal segmentation (frequently only edges and facets are editable). Among editing commands which are active at the object level, the universal command can be singled out as a special one and the most active on the primitives of all type (e.g. linear primitives only).

Using several editing operations (transformation, modification) for separate objects is a common modeling (shaping) practice. Methodologically this process is based on the principle of transformation composition. Relevant formalism was discussed in the previous section of the paper [15].

This problem can be clearly discussed using the example of application panel of 3DsMax modifiers (set of modifiers). The modifiers on these panels are placed coherently (according to their application chronology); it is possible to activate/deactivate them, change their sequence depicting corresponding effects. Prediction of the results is somewhat related to the so called problem of commutativity [11].

It is to be mentioned that geometric transformation means are in principle similar at all hierarchical levels. The specificity of structural objects and plurality of objects is defined by their nature (capacity).

Vivid examples are the possibilities of systems (particles) spatial modifiers; which is the imitation of a physical process. In principle, modeling of climate and ecological regime of urban territory is possible with the use of computer technology, on the basis of climatologically and geo-informational data utilizing the spatial modifiers, or so called “Spatial Curvature” operations such as Gravity, Wind, Wave, Rippe, Vortex options.

The reasonability of studying and applying of visualization algorithms (shades) used in the CAD systems for better understanding of energetic impact of the sun on buildings and territory is also worth pointing out, as they have better mathematical support compared to empirical images yet utilized in practice. Notably, modern shades such as Mental Ray and V-Ray are more realistic, nuanced (via full nomenclature of parameters) and, hence, more precise [3].

All render models represent the approximate solution for the equation given below:

$$L_0(x,\vec{w}) = L_e(x,\vec{w}) + \int_{\Omega} f_r(x,\vec{w},\vec{w}) L_i(x,\vec{w})(\vec{w}\cdot\vec{n})d\vec{w}'$$

The informal definition is as follows: the amount of light illumination (Lo) coming out from a certain point and going to a certain direction is a self illumination and reflected illumination. The reflected illumination is a sum of illuminations arriving from all directions (Li) multiplied

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by the reflection coefficient of a given angle. This equation describes the entire flow of light within a certain system combining the arrived and outgoing light into one point [2].
Such an approach may be fundamentally generalized (reasonably) for the problems of electromagnetic, and not only alike, illuminations, as well as for the research and management of the hydrodynamic, aerodynamic, acoustic, and atmospheric occurrences, where from the cognitive point of view the object's optical appearance or associated result of similar, substance aggregate, symbolic, and digital modeling should be finally considered within the context of notions, categories and terms of "illumination and projection" (geometric transformation).
At the present moment the authors work at the project **"Evident Visualization of Environmental Energetic Impact on Objects of Urban Development at the Example of Computer Model of Urban Aeration Regime"**, the main purpose of which is new comprehension and assessment of criteria known in the field of urban environment and making emphasis on the necessity to implement new modern methodological and technical tools.
Project goals: creation of objective grounds for adequate response to the impact of environmental climatic factors (particularly wind aeration effect in the urban-orthographic situation) and explanation of urban development and engineering and designer decisions, encouragement in introduction of numerical methods and computer modeling both in cognitive and creative and project-technical activities; consideration of urban and ecological approaches on a single platform and its visual illustration- testing on various scale models considered in the work. The principle of animation adopted in CAD system and the principle of so called "Space Warp" modifier will be used as a special tool. Visualization parameters will be maximally approximated with adequate mathematical images of physical event without excessive empiricism and rectilinear approximation and taking into account stochastic nature of the factor.
The present project generally belongs to the field of urban development ecology. That is why certain aspects of this discipline can be successfully spread to possible variants of its use as for example: visualization in educational process, establishment of ecological thinking as obligatory component of civil self-consciousness; increase of the sense of professional responsibility, creation of objective grounds for testing and assessment of architectural and urban-development decisions – these are the goals to be achieved in the framework of the present project.

III. Conclusion

In the article it has been clearly shown that in all three components of study, creation and production activity, namely: joint methodological basis of study of eminent description, formation and visualization instruments on urban developmental objects is formalism of geometrical transformation together with alternative disciplines of this apparatus (analytic geometry, differential geometry, matrix residue).
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Proposed model: measurement method of sphere-depicted dome of heaven and representation into sun mechanical trajectory of conic section surface constructed from point of observation and further its visual part – equivalent paths of insolation duration includes methodic innovation and may be used as in real projection as well as project solution appraisal and example of use of visual method in study process of appropriate disciplines. By such approaches usage of exact or heuristic methods will be stimulated in mentioned spheres.

By way of example of specific possibilities of CAD systems, generally modern versions of Autodesk program packages, interpretation offered in the work is focused on comprehension of problems of architectural physics and construction climatology in a new manner and creation of joint systems approach of their modeling for the contingent learning engineering specialties.

Proposed approach is a precondition for drawing methodically correct study programs.

Literature:

1. Obolenski, N.V. Architecture and the Sun. M. Stroyizdat1988.
2. Rendering equation (Kajiya, J.T. The rendering equation. Computer Graphics ,Proceedings of SIGGRAPH, 1986
3. Cook, R.L. Carpenter, L. Catmull, E. Reyes algorithm. The reyes image rendering architecture. Computer Graphics, Proceedings of SIGGRAPH, 1987
4. Hanrahan, P. Krueger, W. Subsurface scattering. Reflection from layered surfaces due to subsurface scattering. Computer Graphics ,Proceedings of SIGGRAPH 1993
5. Jensen, H.J. Christensen, N.J. Photon mapping. Photon maps in bidirectional monte carlo ray tracing of complex objects. Computers & Graphics 1995
6. Bakharev D.V. “Optical Method of Calculating Natural Illumination”, Svetotekhnika, № 7, 1996.
7. Gershun A.A. Theory of light field. Selective Studies on Photometry and Lighting Technology, M.: GIFML, 1958,.
8. Sobolev N.A. Common Imaging Theory , M Architecture C, 2004.
9. Orlova L.N. Radiation Model of Unclouded Atmosphere in the Spectre of Optical Range, Svetotechnika 1993.
10. Kiknadze Z., Beridze L., Dinuashvili M. “Application of Geometrical Transformation in Algorythms Realized in CAD Systems Reflecting the Energetic Impact of the Environment”. Intellectual, , №8, 142-147, 2009.
11. Kiknadze Z., Dinuashvili M. “Algorythms Reflecting Energetic Impact of the Envirionemtn on Objects of Urban Development”. Thesis for Scientific Conference, Technical University, 2010;
12. Gorshkov G.F. Fundamentals of Geometric Modeling M.; “MIREA” 1995,104 c..
13. Z Kiknadze., Lagidze V., Modeling of Architectural and Bionic Forms on Computers, TBILZNIIEP, 1984.
14. Azgaldov G.G., Numeric Measure and Problems of Beauty in the Architecture, M. Stryizdat1978.
15. Foley J.D., Van Dam A., Fundamentals of Interactive Computer Graphics. London, 1982.
16. Dinuashvili M., Modeling of Natural Lighting in CAD Systems. GTU, “Automated Systems of Management” №2 (7), 180-187, .2009.

ISSN 1512-1801
17. Kiknadze Z., “A Paradigm of Form Creations and Compositions in Architecture”. (Historical and logical aspects)”. Supplement to the journal “MOAMBE” of the Academy of Sciences of Georgia. Works 2(17) Tbilisi 2010.
18. Kiknadze Z. “"Some information and reasons on preconditions, the beginnings and development at us of multimedia designing"”. Supplement to the journal “MOAMBE” of the Academy of Sciences of Georgia. „Works“, 2(17). Tbilisi 2010.
19. Кикнадзе З. Применение Arc GIS 9 в целях градостроительной оценки территории ARCREVEW. Москва 2006, №1.
20. Dinuashvili M., “On some Concepts of the Study of Higher Mathematics” Supplement to the journal “MOAMBE” of the Academy of Sciences of Georgia. „Works“, 2(17). Tbilisi 2010
21. A.L. Heifetz. Engineering Computer Graphics. AutoCAD. Instruction experience and latitude of views. M., Dialogue МИФИ. 2002 – 432 p.

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