THE SPECIALIZED SYSTEMS OF SCIENTIFIC OFF-LINE VISUALIZATION.

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Abstract

In this work the description of an attempt of unifying the specialized system of scientific visualization is given.

Keywords: Scientific visualization, 3D graphics, programming

1 Introduction

In mathematics in conjunction with the development of means of visualization gets so-called ”cognitive” computer graphics the special value recently. The concept of cognitive i.e. stimulating thoughts computer graphics in contrast with the illustrative graphics is introduced in [1]. The purpose of cognitive graphics is visualization of scientific abstractions promoting reception of new knowledge of the given subject domain. Singularity of the given kind of graphics is that on a development cycle of model both algorithms and methods of their realization and frequently mathematical models are not even completely clear. Therefore representation of features of investigated models will require new and untraditional in this context methods for displaying, which are not supported by all-purpose visualization system.

The tasks of cognitive visualization require development of specialized systems, which will implement new methods of data representation, modes of interactions. These systems may rely on dedicated, developed for every model (probably heuristic) algorithms of reconstruction of graphical information required for image building. Such algorithms can be based on knowledge of specific singularities of mathematical models and corresponding computing algorithms.

Thus the algorithm of recovery of 3D solid from the initial data becomes the important part of the visualization system. These algorithms can and should be varied for different types of mathematical objects, providing a fulfillment of the missing data for rendition and emphasizing of important properties of these objects.

2 Experience

As a result of work of computer graphics group in Institute of Mathematics and Mechanics (Ural Branch of the Russian Academy of Sciences) a wide experience of creation of specialized visualization systems was accumulated. It is possible to consider that the most successful elaboration was a system of visualization of maximum stable bridges in linear differential games. For problems with the fixed moment of the termination and terminal function of price each set of a level of a function of the price is the maximum stable bridge. Bridges are constructed in 3D space defined by a bidimensional phase variable and time. The received tube (that is maximum stable bridge) corresponds to a defined value of a price of the game. The tube is set by a set of parallel bidimensional polygonal sections, perpendicular time axis. The section is determined by the ordered list of coordinates of its vertex. Tools of visualization of separate bridges or the systems of bridges should give the information on the structure of a function of the price and its features.

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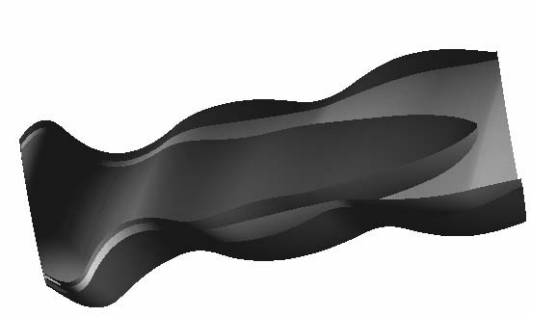

Figure 1: Three stable bridges cut by a plane.

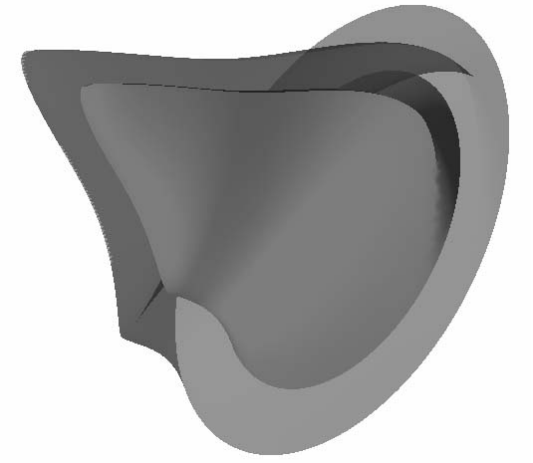

Figure 2: Two stable bridges with transparency.

The system allowing in an interactive mode to examine the set of 3D objects from different points of view was designed. The bridges are rendered in two views. Maiden is a parallel projection of contours of sections to an arbitrary plane. This view of mapping serves for finding such aspect angle, which most fits the user. When the successful aspect angle is retrieved, the second view of rendering will be used - restored with the triangulation on contours of sections surface, which is filled with Guro method. The designed algorithm of triangulation allows emphasizing unevenness of a surface, which one in turn corresponds to features of a function of a price of a game. The surface can be illuminated by several light sources, the position which is set by the user. Such attributes as color and transparency are assigned to the objects. The simultaneous rendition of several objects is possible. The switching of modes of a transparency/opacity and visibility/invisibility is enabled. Thus, the system allows mathematicians to investigate interesting features of bridges, operating in an interactive mode with their 3D model.

3 Plans

Summarizing the experience of creation of an above described system and a number of others; we come to a following conclusion. One way or another, all problems of scientific rendition comprise two phases of their implementation:

- Creation methods for displaying objects and algorithms of recovery of the graphic information.
- Creation of the ”Viewer” program for reconstructed geometrical objects.

Further, as it has appeared, the main time at system development is spent on very laborious and labour-consuming work on creation friendly and enough functional user interface. Also problems arise when it become necessary to combine two or several specialized systems of scientific visualization. As a matter of fact such attempt leads to a remaking of a large part of one of the systems. An attempt to consider and to conceive the obtained experience became the creation of universal development tools of specialized systems of scientific off-line visualization.

The main idea at construction of this system was the separation of a system into two parts - Common and variant. To the common part are related a user’s interface for controlling 3D objects and procedure of reading of sets of 3D objects from the descriptions, described in special meta-language. This part provides interactive control of image output and changes methods displaying of information. The user has a capability to change quickly a position and orientation of object in 3D space, scale of image output, the position of a light source and intersecting planes, to change an aspect angle, to show objects in different modes of transparency, and also to fulfill other auxiliary manipulations with the objects.

To variant part are related all procedures necessary for creation of 3D object: directly calculation of source-information on object, triangulation, decimation, construction of normals, etc. The common part remains invariable for all users. It can be elaborated and be improved independent of the variant part. This is provided with an invariance of the format of the description of 3D objects, since the parts of a system are connected only by this format.

At the disposal of the user there is the following set of base objects, which can be used to create complex 3D scenes:

- The surface - a set of triangles and normals;
- The polyline - ordered set of points;
- Points - set of points in space;
- The compound object - it can consist of an arbitrary set of objects of the first three types.

For each type of the objects there is a structure in the language of the description of objects.

The variant part should be built for each type of mathematical entity, which will be visualized. Separately a set of changeable properties of 3D model for the given mathematical entity also should be indicated. A possible set of properties of object is as follows:

- type of rendering (solid/wireframe/mesh);
- a degree of a transparency;
- color;
- availability of clipping planes;

In the given moment the system is in a development stage. The basis of a module of displaing the 3D graphics is high-level API of the Sun Corporation - Java3D. All data are stored and are transmitted in the subset of XML format, however the architecture of a system allows to create and to use other formats, including binary.

4 Conclusion

The success of our activity is connected with close co-operation with mathematicians, future users of a specialized system, at all stages of system design and development. However close contacts with the specialists do not save the developer of the necessity of deep analysis of all aspects of a studied mathematical problem, including calculation algorithms. It is completely necessary to analyze, how the mathematics ”see” the objects and to look up for ways of showing mental picture of an investigated phenomenon in a set of visual images (according to the classic definition of the concept of visualization presented in explanatory dictionaries of the English language).

5 Acknowledgement

The research and development described in this paper was supported by Russian Foundation for Basic Research, grants 01-07-90210.

References

[1] Averbukh V.L., Zenkov A.I., Ismagilov T.R., Manakov D.W., Pykhteev O.A., Yurtaev D.A. The Development of Specialized Scientific Visualization Systems // Algorithms and Software of Parallel Computing. IMM Ural Branch of RAS, 2000 Issue 4. Pages. 3-23. (In Rissian)

[2] Zenkin A.A. A back task of iconics and some problems of visualization of scientific abstraction // User Interface: research, designing, realization. 1993. N 2. pages 57-63.(In Rissian)