

THE METHOD OF COMPUTER-AIDED BIONIC SURFACE MODELING IN OBJECTS DESIGN

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Abstract. The research data on the shaping principles in the self-developing natural systems are taken as a basis for creation of a computer-aided system of a specific surface type modeling being the natural system with a common classical, measured structure. The aim is to automate the process of obtaining surfaces and use them to create visual comfortable environments and aesthetic design objects. There have been identified the organization principles of self-developing natural structures on the basis of the mathematical functions. The options of integration between the mathematical representation of the system and its design realization by solid modeling are recommended and based thereon the versions of the design objects are designed. There set up the principles of the visual evaluation of the produced objects.

Keywords: visual comfortable environment, natural forming, automation of modeling process, mathematical model of the spiral.

1. Introduction

Currently in the modern post-industrial society there comes up a need to discover the whole value of the digital visual environment. Therefore it is important to develop and apply in the current industrial design the principles of the natural self-developing systems' shaping by automation of the modeling process for further design of the visual aesthetic object based thereon. [1]. This principles are proposed to use for modeling of wide variety of jewelry in the trends of bionic shaping and new visual styles. [2]. If to look at the consistent patterns in shaping of the natural structures and objects, one can note that the growth of plants and animals, the acquisition of the attributes and formation of the organisms' structure are not disordered, though subjected to the strict laws of the symmetry, proportion, rhythm and integrity, and can be described using the universal mathematical tools. [3]. Any natural object is integral and indivisible, that in turn derives one of the principal laws of composition, i.e. the concept of the composition integrity. The same occurs in nature, the organism is an indivisible system that does not require any additions [5]. One of the first principles of shaping in natural self-developing strict law-abiding systems is involution or spiral winding. The spiral of Archimedes is the first spiral that was formula derived based on the observations for the natural shaping. The increase in its pitch is always even and steady. Currently, the spiral of Archimedes is widely used in the engineering [6,7].

It is proposed to use the principle of phyllotaxis to create the visual comfortable environment in the modern design. The current trends in design aimed at creation of the visual comfortable environments, the use of the environmental friendly materials, renewable resources and shaping principles related to the use of the natural patterns, which are comfortable for the human visual perception justify the development viability of this direction [4]. Phyllotaxis or arrangement of leaves on the stem or in the bloom is a natural principle of the visual comfortable system organization being universal in natural occurrence and having been of high interest to the scientists for many centuries [1]. The natural system of the inflorescences organized by this principal is shaped by spiral winding of the bloom structure from the center to the edge. The number of groups in the bloom corresponds to the neighbor numbers of the Fibonacci series, that is the consistent pattern which was specified by the French mathematician Edwards Lucas. The principle of phyllotaxis creates a common classical, measured

structure, that promotes a visual aesthetic environments and an object which shaping involves a similar structure [8]. At the moment, this principle is not universally used in shaping and the application of this principle in modeling and prototyping is not computer-aided. The technologies of computer simulation and prototyping, up-to-date approaches and materials allow development of the complex systems of the previously unavailable design configuration and structure. The application of the self-developing, self-organizing systems through the process automation of their modeling offers the great opportunities to enhance the creation of the new objects with complex shaping structure as well as the development of a new visual style which combines the modern biotic principles in the design objects' shaping, such as jewelry, interior design objects and art-objects and new technologies of rapid prototyping in the process of creation of the visual and comfortable environments and objects.

It is expected to develop the computer-aided design system to solve the tasks of the surfaces design by the principle of phyllotaxis. The solution and corrective actions with the volume restriction are possible by adding the additional layers, repeating the surface at the design stage, that complicates the design process, though allows creation of the more diverse structures keeping to the resultant surfaces and the used principle. Also at the design stage getting additional volume is possible due to use of the common flat structure for the rotational surface.

The object of study produced as a result of the computer-aided design is a surface possessing the specific structure. This surface is to be produced by the algorithm including from the mathematical description of the system to its graphical realization and further modeling. The study stipulates for the use of a wide range of the software products to develop the algorithm of the surfaces production based on the mathematical tools for the further object design and creation of the designer tool for this purpose. The solution of the specified tasks is assumed by means of the use of the application program package and the special programming language MatLab to solve the technical computing, the GrassHopper graphic editor of the algorithms and parametric modeling tools and Houdini software package to operate the 3D graphics.

2. The algorithm of models construction

The software MatLab is assumed to be used as a means of the mathematical tools realization to set the equations of curves forming the basis of the surface model, that follows from the comparative analysis according to which MatLab is the most relevant for realization of the complex mathematical model. For the quick shift to the design phase under the resultant models there is possible integration of the graphical information obtained in MatLab with Autodesk Maya or AutoCad through ScriptEditor. The process of the planes development starting from setting of the mathematical function of the spiral and construction of the experimental model to design on the basis of the resultant planes of the design object, is described by the algorithm (Figure 1).

The surface production by the given shaping principle implies the preliminary construction of the guides to create a similar to natural structure. These guides are the spirals. It is assumed to use two different types of the spirals to implement the proposed modeling method as well as selection of the most relevant mathematical model for the computer-aided modeling. A logarithmic spiral is the first spiral which will be the basis for the surface modeling principle.

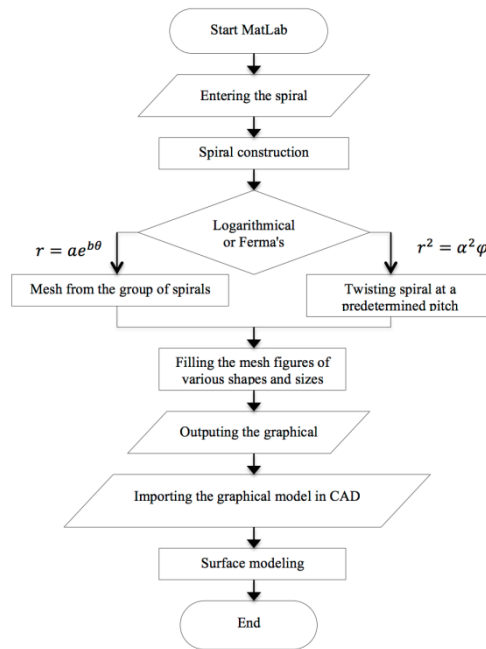


Figure. 1 Algorithm of the surfaces modeling process

The second type of the helix used in the study is the Fermat spiral, which is a modification of Archimedes spiral that forms the structure of the bloom at the angle of divergence equal to 137,5 degrees or the angle resultant by division of the overall circle length through the "golden section" [6,7,9].

Upon construction of the mesh using the one of the proposed methods it is filled with the shapes dependent on the distance between the points and the requirements made for the scope of application of the future planes. In order to follow the principles of the visual comfortable environments creation, it is filled with the circles at the research stage [8]. The variability is achieved by using the circles both of the regular and elliptic shape. Depending on the desired image, the space between the objects may be left void or filled. The model produced by this method is a structure of the spiral-twisted shapes [6]. This model can be easily imported into any modeling system and depending on the target objectives different types of the surfaces are formed on its basis. All computer simulation methods are applicable to this structure and its modifications, and depending on the future object the manipulations are made either on the internal structure or on the external or as a whole. As a result of the study there were produced a few different modifications of the same structure for the further modeling of the surfaces (Fig. 2).

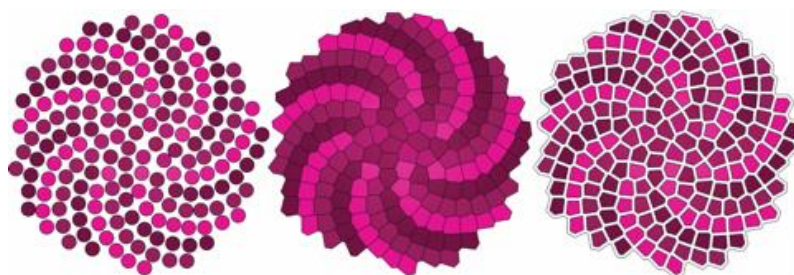


Figure 2. Different variation of a structure for surface modeling

Based on the research findings using the modeling method by means of the surface of rotation and creation of the volumetric surfaces a few variants of the jewelry (Fig. 3) were produced as an option of the practical realization of the presented ideas.

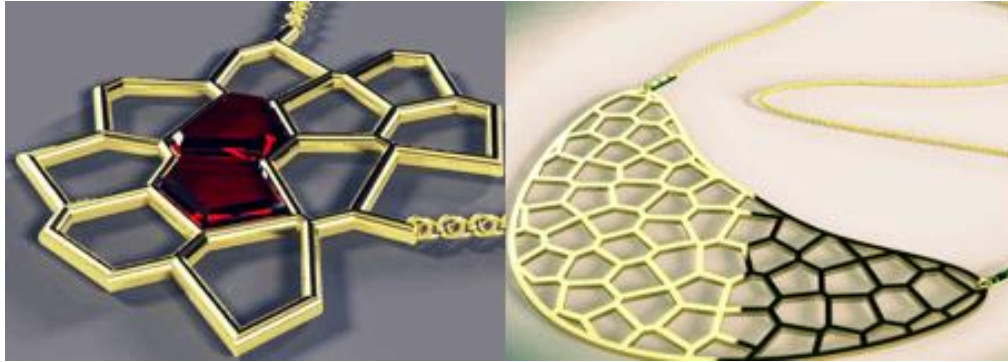


Figure 3. Variants of jewelry made using the method of automatic surface modeling

In the course of the study there were analyzed the self-developing systems and the principle of phyllotaxis was chosen as the principle of the visual comfortable measured structure organization with the possibility of its wide application in the modern design. For the purpose of the universal application of this principle in the design, the development of the computer-aided surfaces design system on the basis of a mathematical model was suggested. The advantages and disadvantages of this computer-aided system application were studied. The current software was analyzed in terms of realization of the proposed mathematical tools, including the capacity to develop the design objects using the new mathematical models. There were studied the application aspects of the proposed software products and their advantages and disadvantages. The algorithm for the surfaces production by the given mathematical model was developed. There were created a few modifications of the surfaces with different volume and structure. And the variants of the jewelry were created as a practical realization of the method and demonstration of the possibilities for its use in the design.

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