THE USE OF SEVERAL TYPES OF GEOMETRIC MODELING TO CREATE THE MODEL OF A HISTORICAL BUILDING

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***Abstract**: A geometric model is a mathematical representation of the geometry of an object or a building as a whole, using geometric shapes, which are described by surfaces, which in turn are described by curves and so on. Data such as the geometry, the topology and other specific data have to be represented by the model.*

Many computer-aided design systems use parametric polynomial representation for free-form curve and surface modeling.

In this article we will present a brief description of the existing types of geometric modeling, as well as a comparison of them.

***Keywords:** Digital Model, Wireframe Modeling, Polygon type Modeling, Solid Modeling, Geometric Model*

1. Introduction

The progress in many areas now depends largely on how well we can create geometric patterns.

The precision of modeling methods is an art and a science (the modeling itself is an art and a science). The creation of geometric models is done with the help of mathematics. "One reason why mathematics enjoys special esteem, above all other sciences, is that its laws are absolutely certain and indisputable " - Albert Einstein, Geometry and experience, Sidelights on Relativity.

Practically, any modeling has the point cloud as a starting point, as raw data (input) from which the model is made using different processing methods. The point cloud represents the totality of 3D points obtained with the help of laser scanners or with the help of photographic images. It is known that the basic representation in Euclidean 3D space is the point. The distance between two points is called the length of the respective segment, and a simple geometric figure, such as a square, consists of four points. Starting from these basic notions, simple and complex geometric figures can be created with the help of which the 3D model of an object is created.

When the model of an object is created, a more accurate representation of that object is made. You can create models for objects that exist physically, for some that do not yet exist physically, for virtual or imaginative objects that may or may not be physically made, or summary representations using basic geometric figures for visualization and interpretation only.

For a better understanding of geometric modeling it is necessary to understand the connection between the object and its geometric model, the correspondence of the elements,

the details, and the resolution of ambiguities in the model. For this, the chosen method is important, the time actually needed, what the model will be used for, etc.

2. Types of Geometric Modeling

If in the past mathematical geometric models were created by engineers with the help of hand-made drawings, nowadays, due to the appearance and fantastic development of computers, the way of making geometric models, visualizing and adding different information about these models has completely changed. Between the 1960s and 1970s, several well-known companies began an important work on creating non-rational free-form curves and molded surfaces using the Hermite cubic interpolation scheme. Several other companies have also made significant developments in the understanding and usefulness of cubic and bicubic Hermitian shapes of curves and surfaces. This emphasized the universality and versatility of the representative shape of the model, leading to a widespread use of NURBS (nonuniform rational B-Spline) shapes. If until then the design and manufacturing processes were based on standard analytical shapes (lines, circles, polyhedra, etc.), NURBS curves and surfaces include both standard shapes and contour-created shapes. After a decade of research, the idea of representing portions of curves and surfaces was born, which then, by joining these segments of curves and portions of surfaces to create more complex geometric shapes. Meanwhile, those working in areas such as computer graphics or computer-aided design (including architecture) have developed two directions of geometric modeling, called wireframe and polygonal schemes.

The 1906 monument in Carol Park, Bucharest, was chosen for the study of modeling methods.

Fig. 1. The picture and the 3D model resulted from several pictures

A pillar at the base of the stairs was isolated, which also includes simple geometric elements and more complex elements in order to be able to observe the difference between the different types of modeling.

Fig. 2. The selected object

In the figure below we can see what the original object looks like and how it was represented, using the point cloud resulting from several images, with the help of wireframe technique.

a) The image of the object b) Wireframe model
Fig. 3. The selected object

A wireframe model is composed of lines and curves that cover an object, defining its edges. However, three-dimensional wireframe models are constantly ambiguous.

In the figure below, you can easily see the large ambiguities, visible at first glance, but also other ambiguities, especially those related to the contour of the object.

Fig. 4. Model using wireframe technique

Polygon modeling schemes were initially developed to create images or for color reproduction (rendering), the structure of these polygonal data being formed by faces, edges and nodes.

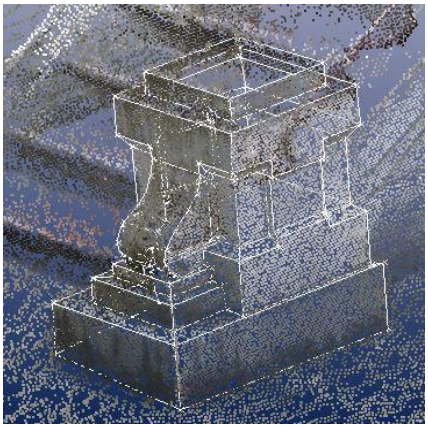

Fig. 5. Polygon type modelling

You can see the difference between the two types of modeling (wireframe and polygon) in the figure below.

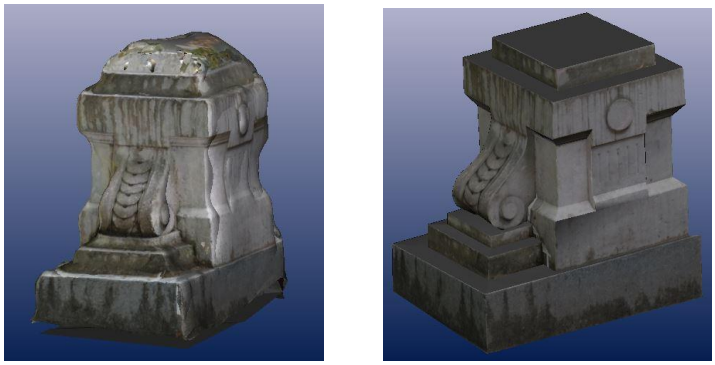

Fig. 6. Wireframe and polygon modelling

The polygonal model is a clear, valid model, two surfaces can easily intersect, but it is more difficult to draw and very difficult to describe complex shapes.

In addition to the representation of objects by reproducing the initial colors, they can also be represented in colors depending on height or orientation or according to whatever criteria we want to choose.

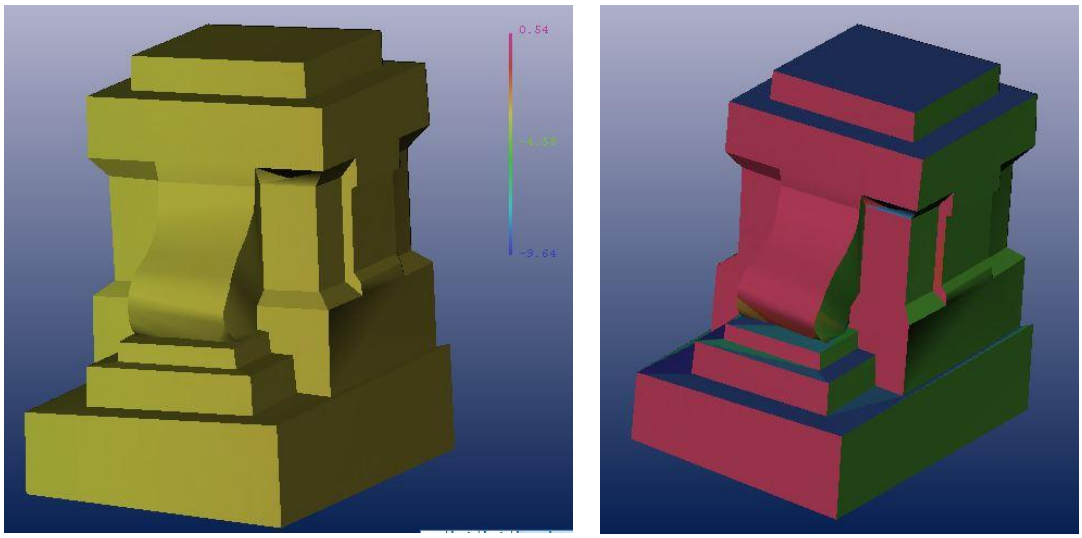

Fig. 7. Use of colors in modelling

Coons, Ferguson and others have developed carved surfaces to replace old techniques with faster, more accurate and versatile ones. Subsequently, Gordon and Riesenfeld introduced and applied B-Spline curves and surfaces, so that later NURBS curves and surfaces (nonuniform rational B-Splines) became widely known and used.

Solid modeling, a relatively new beginning, aims to create complete and unambiguous geometric representations of objects.

Fig. 8. Solid modelling

Solid modeling is a method of creating the geometric model in three dimensions. The solid model of an architectural element is represented much more completely than the wireframe model, because it provides more topological information in addition to the geometric ones that help to represent the model without ambiguities.

In order to highlight the importance of solid modeling, a short comparison will be made between two types of modeling.

Table 1. Comparison between the wireframe model and the solid model

Wireframe model	Solid model
uses 2D objects: points, lines, polygons, circles, etc.	uses 3D objects: blocks, cylinders, cones, spheres, etc.
the contour is constructed of mesh	looks like a real model
it is incomplete and ambiguous	it is complete and clear
it cannot be transformed into a solid model	can be transformed into a wireframe model
it is difficult to generate the model for complicated architectural elements	it is easy to generate the solid model for complicated architectural elements
cannot be used for computer aided design	can integrate and automate design
uses less computer memory for processing and storage	uses more computer memory for processing and storage
does not calculate mass, volume	calculate mass, volume

Fig. 9. Solid model, wireframe and texture

Generally, a wireframe model can be extracted from a surface or a solid model. In the figure 9, the wireframe model was extracted from the solid model.

Next we will create the solid model at a historical building.

Fig. 10. The model of a building (solid model and texture)

For 3D modeling we can list several types of models used:

- wireframe model
- polygonal model
- mesh model (triangle mesh)
- surface model - uses the created contour shapes (free form)
- solid model

Currently there is an independent evolution of these methods, but also are attempts to combine different modeling methods, to hybridize them.

Solid modeling is the most advanced method of geometric modeling that improves the quality of design and object visualization.

3. Conclusions

Each method has advantages and disadvantages. Depending on the requirements of the project, the modeling method to be chosen is analyzed or several methods can be used as modeling steps.

In recent decades, geometric modeling has constantly evolved, although the basic principles of geometric modeling remain unchanged, being closely related to mathematics and computer science, and applications are increasingly diversified in many fields (including architecture), as the models become more robust and realistic.

4. References

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