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METHODS OF CONSTRUCTION OF THREE-DIMENSIONAL MODELS OF DETAILS

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Summary **– this article discusses the main types and programs for 3D modeling. A review and analysis of literature sources related to the subject of three-dimensional modeling, on the basis of which the peculiarities of the formation of the construction of modern 3D forms were revealed. The main software products are presented, with the help of which it is easy to create 3D objects, mainly for technical products and design. The spheres of application of this technology, the basic programs and types of 3D modeling are defined. The following bases of technique of creation of three-dimensional models are allocated in the work: solid-state modeling, polygonal modeling, procedural modeling, digital sculpture (sculpting), modeling by means of splines.**

The basic principles of 3D modeling determine the selection of modeling methods in different design situations. In systems of automated design and preparation of technical documentation solid-state modeling is most used. But the main stages of product creation are the same regardless of the method of modeling. An example of the algorithm of modeling stages for obtaining the finished product is given. Creating solid models is more important than ever today. It is important not only to create an object quickly, but also to edit it just as quickly. Solid state modeling has these qualities, so it is considered the most advanced technology. 3D modeling and design not only create virtual objects and 3D images, but also make them a reality. This leads to the widespread use of computer graphics technology and their application in all areas of human activity. Therefore, providing a detailed description of modeling techniques using various techniques for creating 3D objects is relevant.

Keywords**: 3D modeling, modeling method, SolidWorks, AutoCAD, construction algorithm, model of detail, software, solid modeling.**

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Introduction. Professional 3D modeling software is a tool that creates three-dimensional objects that visually represent real objects (parts, assemblies, mechanisms, the environment - architecture, landscape, etc.). With the development of 3D modeling technologies, new possibilities of shaping have appeared, varying in complexity, which allows to better imagine the future shape of the product [1-4]. The question arises in identifying the most affordable and effective ways to build three-dimensional objects.

Three-dimensional modeling combines knowledge from different fields of science and technology: geometry, drawings, computer technology, basics of color, composition and graphics, design, landscape, and more. Therefore, it was important to explore developments in various scientific fields, which in one way or another affect the issues of 3D modeling.

General issues of 3D graphics and 3D modeling algorithms are covered in the works of Petrov E.G, Bakalova V.M, Banach D., Boardman T. and others.

It should also be noted the work of Yu.S. Rostorgueva, where the general characteristics of the term 3D modeling are given, the main programs of three-dimensional modeling are considered [5]. In studies of A.V. Cherenkova and D.A. Kornienko analyzes various methods of computer modeling and types of architectural objects, which are modeled using the above types of modeling [11].

In the work on geometric modeling of complex three-dimensional surfaces, which are elliptical surfaces of rotation, a matrix method of surface description is proposed, which allows to control the shape of the curve given in parametric form and easily calculate and implement the solution using standard computer programs [6].

The considered materials of Internet resources on 3D modeling reveal the relevance and insufficient scientific validity of this topic.

Formulation of the goals of the article. Identify the features of 3D modeling of objects, make an algorithm for building three-dimensional models of parts.

Main part. 3D modeling programs and technologies are now widely used as modeling of technical products and design. Computer modeling makes it possible to achieve the most realistic design of the project, be it a product of design engineers, specialists in architecture or urban landscape, etc. In each case, the appropriate method of modeling or their synthesis is selected.

In general, the following bases of technique of creating three-dimensional models are distinguished: solid-state modeling, polygonal

modeling, procedural modeling, digital sculpture (sculpting), modeling with the help of splines [8, 10].

Due to the variety of approaches of different 3D modeling programs, it is advisable to consider only the creation of objects using solid and polygonal modeling techniques. Because they are the basis for the formation of the geometric shape of the object.

The most popular and available for widespread use are such programs as SolidWorks, AutoCAD, COMPASS-3D, SketchUp, 3DMAX, Blender 3D, Maya. Such programs as 3DMAX, Sweet Home 3D, Archicad, Planner 5D, etc. are more suitable for creating design projects of premises, landscape [1, 8-11].

In computer graphics, 3D modeling is the process of developing a mathematical representation of any three-dimensional surface of an object using specialized software (SOFTWARE). The simulation product is a 3D model. It can be represented as program code or displayed in a viewport or viewer as a 3D model, as well as using a two-dimensional image created through a rendering process. 3D models can be created manually or automatically. Making models by hand is similar to creating a sculpture in plastic art.

Mathematical approaches are integrated into the software in one form or another, which distinguish according to their capabilities different algorithms for creating the same model, each of which has its own properties.

Algorithms can be divided into four categories:

Spline modeling (the term "spline" means curves that come in different types).

NURBS – surfaces are defined by curves that are affected by "heavy" control points. The curve follows the points (but does not necessarily touch them). Increasing the weight of the point will draw the curve closer to it. NURBS are actually smooth surfaces, not imitations of small flat surfaces, so this method is often used to model organic shapes. Often the term NURBS is used to refer to all methods of spline modeling (Patches and Bézier curves - a primitive type of NURBS; Bi-splines - English special type of splines, which can be quickly calculated as the sum of basic functions; Rational; Non- uniform (non-uniform) - allows the possibility of uneven parameterization along the surface).

Polygonal modeling - points in 3D-space, vertices connected by a line – an edge, form a surface according to the laws of creation of geometric planes. A set of combined planes is called a polygon mesh. Most 3D models today are built as textured polygonal models because they are quite flexible and the computer can render them fairly quickly. However, polygons are flat and can only roughly convey curved surfaces using many polygons.

Subdivision surfaces is one of the modern algorithms that is progressively evolving and increasing competition from the previous two.

Procedural modeling – this modeling allows you to operate large-scale projects, requires most of the pipeline (Pipeline - the development process), so it is used by large studios of computer graphics.

Modern software allows you to use, regardless of the simulation algorithm, a variety of approaches to build a model. The most available - primitives - modeling using simple geometric shapes (balls, cylinders, cones, etc.), which are used as bricks in the construction of more complex objects. The advantage of the method is quick and easy construction, as well as the fact that the models are mathematically defined and accurate. Suitable for technical modeling and less for modeling organics. Some programs can render from primitives directly, others use primitives only for modeling, and later convert for further work or rendering, etc.

The basic principles of 3D modeling determine the selection of modeling methods in different design situations. In systems of automated design and preparation of technical documentation solid-state modeling is most used. But the main stages of product creation are the same regardless of the method of modeling.

Modern software allows you to use, regardless of the simulation algorithm, a variety of approaches to build a model.

Figure 1 shows the stages of modeling to obtain the finished product. The first step is to make an informed choice of object and method of modeling. Depending on the method of modeling and the type of finished product, the software for model development is selected.

If you need a set of documentation for the final product, select the appropriate program, the functionality of which allows you to design a product of any complexity in 3D, and then draw up for this product a set of documentation required for its manufacture in accordance with applicable standards. For example, a set of technical documentation that is easy to get in AutoCAD or КОМПАС.

The use of the proposed modeling algorithm in 3D format has several stages of practical application.

First, there is a visual illustration of each stage of model construction, for each individual part of the assembly unit. If the obtained results are used for a wide range of parts, their number is set for current production, and the volumes are significant, the obtained models reduce the path and time for their production.

The obtained results: algorithm, technique and visual models are widely used in the educational process and in the development of engineering solutions for devices and other equipment.

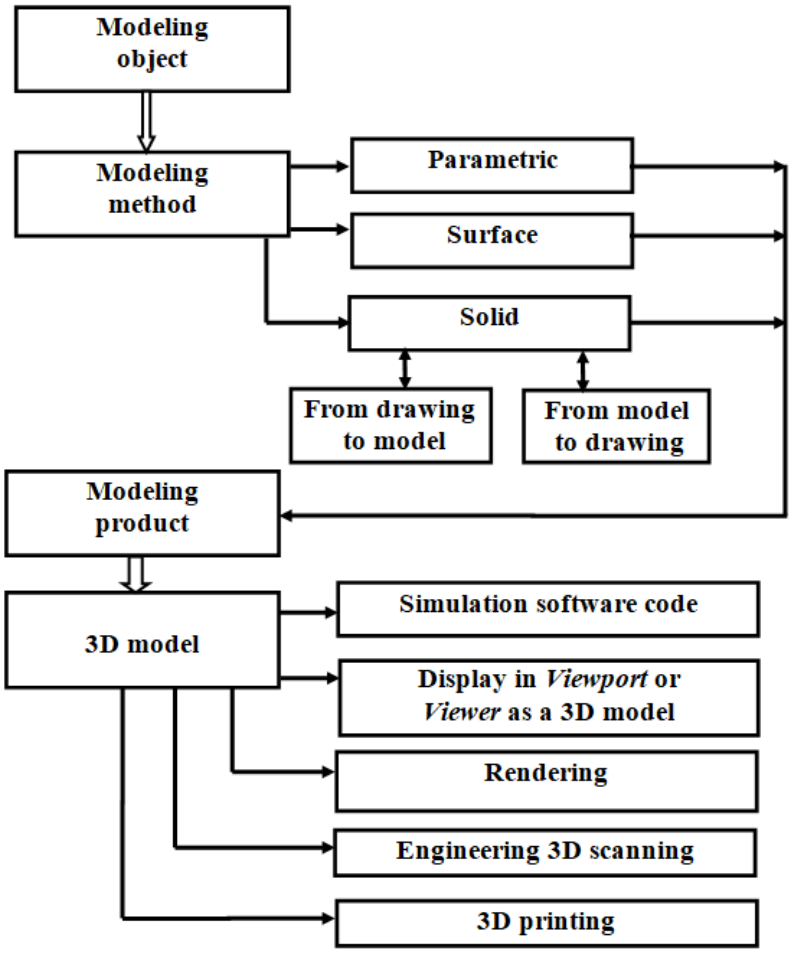

Fig. 1. Stages of modeling to obtain the finished product

Parametric modeling is the design of an object model using the parameters and relationships between the parameters of its elements. With the help of parameterization (parametric modeling) you can in a short time to test different combinations of geometric ratios and changes in the parameters of the model, make the necessary adjustments and avoid further errors.

Parametric three-dimensional or two-dimensional modeling is significantly different from conventional drawing or 3D modeling. In the case of parametric modeling, a mathematical model is created with parameters, the change of which entails a change in the entire configuration of the part, the movement of parts in the assembly and other similar transformations.

Surface modeling is one of the best technologies used to create three-dimensional or 3D objects and shapes.

Surface modeling is used to create complex shapes; used to depict the surfaces of appearance parts - cars, aircraft, household and industrial

appliances. Surface modeling is able to project the surface of the object, inside the product is empty.

Solid state modeling is the design of bodies that have all the features of a physical body. Objects made with this technology are better perceived than objects made in other ways.

Advantages of solid modeling:

- three-dimensional model with the use of modern technologies looks more than realistic;
- one of the main advantages of this technology is the automatic formation of drawings, which is relevant for design engineers. Building a model and forming drawings on it using solid modeling – a matter of a few seconds;
- speed and ease in the process of making changes and adjustments to the model - no need to re-form the drawing, just change the necessary items and update the program;
- association with various additional programs - integration allows to reduce time, using at once the received results at the following stages of work;
- solid-state modeling reduces the design time of the object. The speed of modeling has a positive effect on the rate of return on investment.

The creation of a single body begins with the construction of a single body of simple shape (rectangular prism, spherical body, cylindrical body, conical body, toroidal body) or the construction of a body based on surfaces (extrusion body, rotating body, shear body, sweeping body, body based on flat sections), or building a body based on lines (body in the form of a sheet).

Creating solid models is more important than ever today. It is important not only to create an object quickly, but also to edit it just as quickly. Solid state modeling has these qualities, so it is considered the most advanced technology.

Using 3D modeling, graphic designers create three-dimensional images of parts and objects, which can then be used to create molds and prototypes of the object.

Conclusions. Solid state modeling has these qualities, so it is considered the most advanced technology. Modern software allows you to use, regardless of the simulation algorithm, a variety of approaches to build a model. But the main stages of product creation are the same regardless of the method of modeling.

For further research, it is proposed to expand and consider new, in terms of computer modeling, techniques and methods of three-dimensional formation of objects, to provide a detailed description of modeling techniques using various techniques for creating 3D objects, the use of three-dimensional modeling systems. within STEM education.

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СПОСОБЫ ПОСТРОЕНИЯ ТРЕХМЕРНЫХ МОДЕЛЕЙ ДЕТАЛЕЙ

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***Аннотация* – в данной статье рассмотрены основные виды и программы для 3D моделирования. Проведен обзор и анализ литературных источников, касающихся тематики трехмерного моделирования, на основе которых было обнаружено особенности формообразования построения современных 3D форм.**

Основные принципы 3D моделирование обусловливают подбор способов моделирования в различных проектных ситуациях. В системах автоматизированного проектирования и подготовки технической документации наиболее применяется твердотельное моделирование. Но основные этапы создания продукта одинаковы независимо от способа моделирования. Приведен пример алгоритма этапов моделирования на получение готового продукта. Создание твердотельных моделей как никогда сегодня актуально. Важно не только быстро создавать объект, но и так же быстро редактировать его. Твердотельное моделирование обладает данными качествами, поэтому оно считается самой совершенной технологии. Поэтому

предоставление детального описания методик моделирования с использованием различных техник создания 3D объектов является актуальным.

Ключевые слова: **3D моделирование, способ моделирования, SolidWorks, AutoCAD, алгоритм построения, модель детали, программное обеспечение, твердотельное моделирование.**

СПОСОБИ ПОБУДОВИ ТРИВИМІРНИХ МОДЕЛЕЙ ДЕТАЛЕЙ

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Анотація **– в даній статті розглянуто основні види та програми для 3D моделювання. Проведено огляд та аналіз літературних джерел, що стосуються тематики тривимірного моделювання, на основі яких було виявлено особливості формоутворення побудови сучасних 3D форм. Представлено основні програмні продукти, за допомогою яких легко створити 3D об'єкти, переважно для технічних виробів та дизайнерського проектування. Визначено сфери застосування даної технології, основні програми та види 3D моделювання. В роботі виділено такі основі техніки створення тривимірних моделей: твердотільне моделювання, полігональне моделювання, процедурне моделювання, цифрова скульптура (скульпуринг), моделювання за допомогою сплайнів.**

Основні принципи 3D моделювання обумовлюють підбір способів моделювання в різних проектних ситуаціях. В системах автоматизованого проектування та підготовки технічної документації найбільш застосовується твердотільне моделювання. Але основні етапи створення продукту однакові незалежно від способу моделювання. Наведено приклад алгоритму етапів моделювання щодо отримання готового продукту. Створення твердотільних моделей як ніколи сьогодні актуально. Важливо не тільки швидко створювати об'єкт, але і так само швидко редагувати його. Твердотільне моделювання володіє даними якостями, тому воно вважається найдосконалішою технологією. За допомогою 3D моделювання та проектування не тільки створюють віртуальні об'єкти та 3D зображення, але й втілюють їх у реальність. Це зумовлює велику поширеність комп'ютерних графічних технологій та їх застосування в усіх галузях людської діяльності. Тому надання детального опису методик моделювання із використанням різних технік створення 3D об'єктів є актуальним.

Ключові слова: **3D моделювання, спосіб моделювання, SolidWorks, AutoCAD, алгоритм побудови, модель деталі, програмне забезпечення, твердотільне моделювання.**