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COMPUTER-AID DESIGN TECHNOLOGIES IN HYBRID MODELING BASED ON INFORMATION MODELING IN AUTODESK FUSION

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Currently, much attention is paid to the tasks of increasing the speed and quality of product design in modern CAD. The process of creating objects of complex shape requires solving a variety of tasks. Various modeling methods are used to implement them. The paper proposes using Autodesk Fusion to solve design tasks based on hybrid modeling. To implement these tasks, an information model of hybrid product modeling in Fusion is proposed. Hybrid modeling allows using top-down design technology. This type of design speeds up the development of products, especially with complex shapes. To optimize the shape, it is possible to use cloud technologies and artificial intelligence elements. All stages of the proposed model are sequentially considered. Using the information model of hybrid modeling allows you to analyze the creation of all product elements. Fusion simplifies design using parametric modeling, which provides quick setup, seamless iteration, and automated updates at the design and production stages — all within a single cloud platform. If necessary, we simulate the load on the model elements and optimize the possible choice of materials. To view the finished product, we perform rendering, which allows us to polish visual effects in order to present our design qualitatively or obtain client approval. When working in the cloud environment of the designer in Autodesk Fusion, the following tasks are performed using artificial intelligence: calculation of model elements, load testing, shape optimization, rendering and product viewing, drawing design, preparation of control programs for technological processes of manufacturing parts using various technologies, for example, additive. The paper provides an example of hybrid modeling of a game manipulator when designing in Fusion using the proposed information model. The use of all steps of the information model is shown in detail. The features of surface and solid modeling when creating an object of complex shape are presented. The developed information model can be adapted for various types of modeling when designing in Fusion.
Keywords: information model, hybrid modeling, surface model, solid model, design, Autodesk Fusion.

Introduction. Computer 3D modeling is a rapidly growing field of technology. Various modeling methods are constantly evolving and improving. Computer modeling significantly reduces the time required for the design process, providing incomparably greater opportunities. Hybrid modeling methods provide new opportunities for computer design technologies, and the development of information technologies gives them new meaning.

There are various types of modeling: solid, surface, frame, hybrid, and hybrid modeling. Each operation has its advantages and limitations, so it is wise to choose the best characteristics from each and use all methods simultaneously. This is the main assumption of hybrid modeling. The main obstacle may be a clear boundary between different types of modeling and the use of completely different commands/modules each time. But this is not a problem if we perform a single operation to trim a solid using a surface. True hybrid modeling significantly changes the concept of modeling and the very approach to computer-aided design, as well as increases work efficiency. With hybrid modeling, logical operations work with both types of geometry—solid and surface—which opens up new possibilities and imagination during the design process. For complex processes, it is not easy to change the shape by modifying the surface alone. Furthermore, simple hybrid modeling in most systems works with only one logical operation of the Boolean system, or the design environments are clearly divided into those specializing in solids and those specializing in surfaces. In fully hybrid modeling software, most operations

work for both solids and surfaces—there is no difference, so it is simply the same command. Hybrid modeling technology removes the barriers between modeling methods that limited many advanced features to professional design only. Hybrid modeling allows designers to save time-consuming repair work and focus on more creative tasks.

Hybrid modeling is not just a software feature. It is the core programming technology for all types of CAD. With this technology, designers do not need to consider whether they are working with solid or non-solid bodies, thereby simplifying the entire manufacturing process. Hybrid modeling in Fusion involves combining different modeling methods, primarily parametric solid modeling and direct or freeform surface modeling, to create complex designs more efficiently. This approach leverages the strengths of each method, such as the history and precision of parametric modeling for elements such as ribs and bosses, and the flexibility of free-form tools for organic shapes. The goal is to use the right tool for the right part of the design, integrating solid and surface modeling to maximize workflow and design exploration.

Product designers and engineers use several modeling methods: bottom-up modeling, top-down modeling, horizontal or middle modeling, and hybrid approaches that combine these methods. Several approaches to top-down modeling include multi-part modeling, parameter binding, and skeleton modeling, in which a “skeleton” sketch conveys the design intent, and designers model individual components around this common final assembly—potentially in a single CAD file. The top-down modeling method is particularly well suited for complex products such as automobiles and other vehicles, electronics, appliances, and machinery.

CAD software that supports top-down modeling reduces the risk of errors such as part mismatches, which can result from the traditional bottom-up approach. Autodesk Fusion uses a single design model that easily allows global parameter changes that update the entire project. To optimize the hybrid modeling process, it is necessary to develop an information model of this technology.

Analysis of recent studies and publications. Key aspects of hybrid modeling in Fusion. You can use parametric tools for fundamental parts of the design, such as the main body, and then switch to free-form tools (T-spline) for organic or complex surfaces [1-3].

Integration of solids and surfaces. The basic concept is to integrate both solid and surface modeling methods, for example, creating a complex surface model and then using a solid modeling command such as “shell” to cut it out for rapid prototyping [4].

Hybrid modeling is also crucial for hybrid manufacturing, where designs must consider both additive and subtractive processes. Fusion tools allow engineers to explore materials, dimensions, and design implications for both manufacturing methods in a single environment, as illustrated by examples of hybrid modeling in various fields such as dentistry, aerodynamics, and prosthetics [5,6]. Hybrid modeling allows you to create a more reliable and efficient workflow by switching between different modes as needed. For example, creating a complex, organic handle using free-form tools and then adding standard solid elements. Papers [7-11] explain how different types of modeling can be used when creating mechanical devices.

Paper [12] provides an overview and prospects for the use of hybrid modeling technologies. Works [13-16] explain the use of information models to optimize the design processes of various devices and technologies. Information models are used to structure data and ensure consistency, which improves data quality, facilitates interaction between systems, and simplifies the organization and search for information.

Purpose of the work. Currently, new objects in various fields are created using computer-aided design technologies that utilize cloud technologies. When creating an algorithm for designing new objects using computer technologies, it is important to use an information model. An information model generalizes the approach to design using various technologies.

Let's take a closer look at the information model of hybrid product modeling in Autodesk Fusion CAD (Fig. 1).

When creating and analyzing a product model, several sequential and interrelated steps must be performed. The proposed information model consists of two main components: surface modeling and solid modeling.

Let's consider the components of the proposed information model for hybrid design using Autodesk Fusion. The sequence of stages in the information model of hybrid design in Fusion corresponds to top-down design technology. In top-down modeling, designers and engineers start with a model that conveys the design concept for the entire assembly and defines the general relationships between the elements in the assembly.

The following steps are involved in surface modeling.

1. At the beginning of the work, we have the initial data for the future product model, for example, in the form of a cloud of boundary points of the conceptual model. We upload them to the Autodesk Fusion environment.
2. Formation of sketches of surface model elements. At this stage, 2D and 3D sketches of the boundary elements of the future conceptual model are formed.
3. The next stage is the formation of conceptual model elements using surface modeling, which includes various options for creating surfaces.
   a. Creating model elements using simple surface creation commands.
   b. Creating model elements using spline curves of surface frames.
   c. Creating a model using standard surface models

The type of model element creation is selected depending on the technology of further modeling.

4. Based on the selected modeling technology, a conceptual surface model is created and modified. This can be a modification of individual boundary surfaces or a single surface based on sketches or a standard surface model.

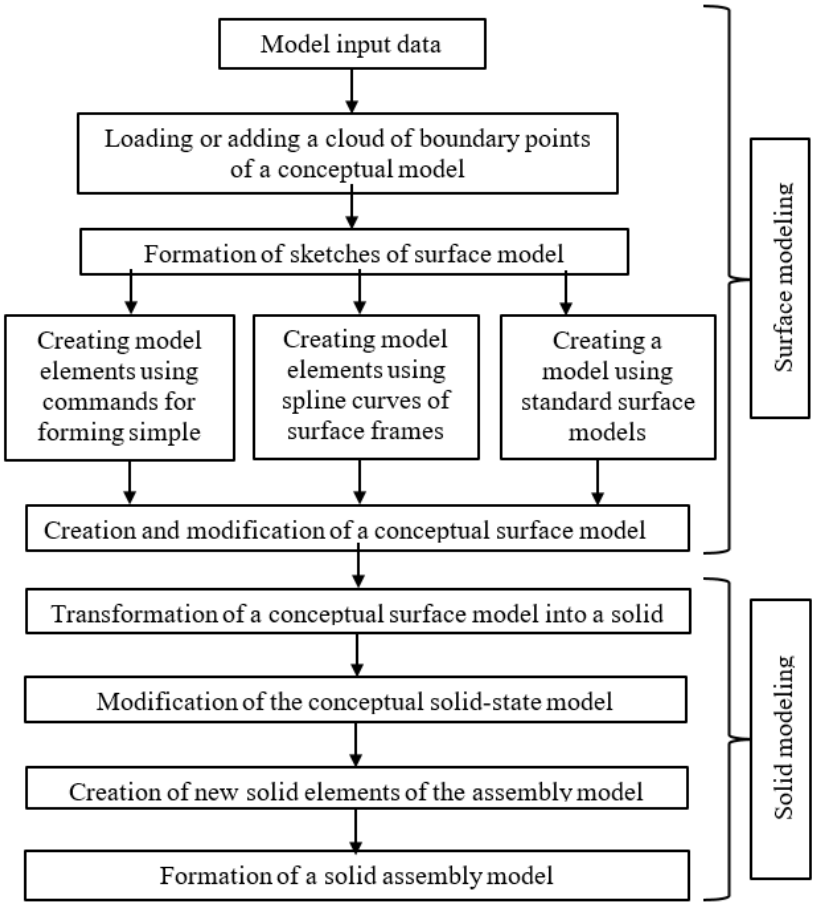

Fig. 1. Information model of hybrid design in Fusion

This completes the surface creation component of the conceptual model. After that, we move on to the solid parametric modeling component of the assembly model of the object.

1. Converting a conceptual surface model into a solid model. A surface model has no thickness. To convert such a model, you need to specify the thickness in the modeling parameters.
2. The next step is to modify the conceptual solid model. This can be done by dividing the model into separate elements or changing its shape. At this stage, we complete the formation of the structural elements of the assembly model of the product.
3. Creating new solid elements of the assembly model. Using solid modeling, we create additional assembly elements.
4. The final stage is the formation of a solid assembly model.

Fusion simplifies the design of an assembly model of an object using parametric modeling, which provides quick configuration, smooth iteration, and automated updates during the design and manufacturing stages—all within a single cloud platform.

Main section. Using the proposed information model, a hybrid model of a game manipulator was created.

At the initial level, we will create a conceptual surface model of the manipulator's body. We load the boundary points of the model. Based on these points, we form 2D and 3D sketches of the boundary elements of the conceptual model (Fig. 2).

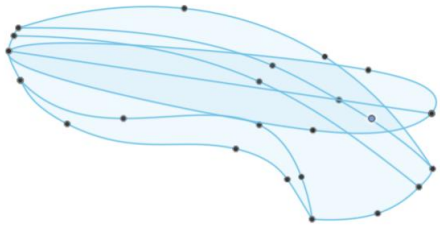

Fig. 2. 2D and 3D sketches of boundary elements of the conceptual model

Using the created sketches, it is possible to form a surface model in three ways.

The first is to create model elements using commands for forming simple surfaces, as shown in Fig. 3. This approach requires complex editing for objects with non-linear shapes.

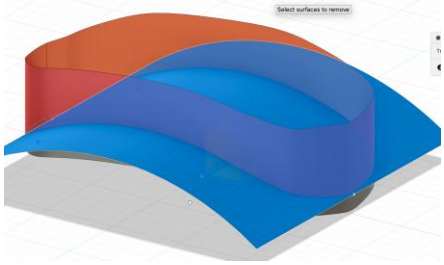

Fig. 3. Creating model elements using commands for forming simple surfaces

The second is to create a model using standard surface models as a base template (Fig. 4). This option can be used for objects with simple shapes.

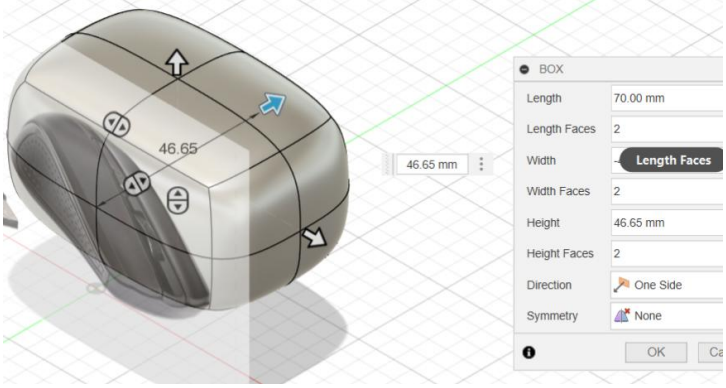

Fig. 4. Creating a model using standard surface models

The third is the creation of model elements using spline curves of surface frames. This technology allows for more optimal formation of complex surface models.
Let's take a closer look at hybrid modeling technology using spline curves.
Select the Sweep command to create a three-dimensional shape based on the sketches you have created. Select the necessary profiles to form the initial part of the manipulator. It is important to check that the profiles are correctly aligned and match the contour of the future model.

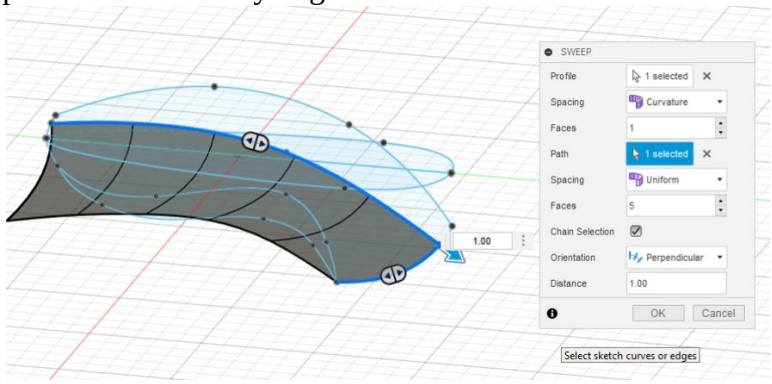

Fig. 5. Creating model elements using spline curves of surface frames

After editing and using the necessary intermediate sketches, we obtain an open conceptual surface (Fig. 6).

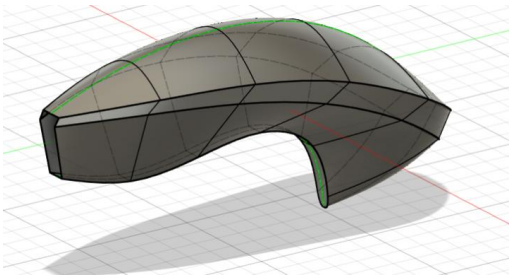

Fig. 6. Open conceptual surface

Adjust the position of the lower part of the surface using the Match command to align it with the specified profile. Combine the holes using the Bridge command to obtain a complete closed conceptual surface of the manipulator (Fig. 7). Use the Shell command to convert the shell into a solid object. Create a new sketch to divide the solid object into two parts. Use the Split Body command to cut the body into two parts (Fig. 8). Solid models of the manipulator body and cover have been created.

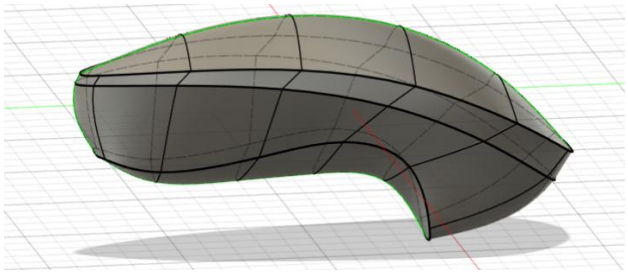

Fig. 7. Closed conceptual surface of the manipulator

Fig. 8. Cross-section of the model into 2 parts

We disable the visibility of the cover, and we will get only the body part on the screen. Fig. 9.

Fig. 9. Solid model of the manipulator body

Create a new solid component – a button. Using the created model of the new element, use the Split Body command to make a hole for the button (Fig. 10). Repeat these steps to create side buttons on the body and a joystick on the manipulator cover. We will get the finished model of the game manipulator (Fig. 11).

Fig. 10. Solid-state component button and button hole

If necessary, we apply materials to individual parts of the manipulator and visualize the created model (Fig. 12).

Fig. 11. Game controller model

Fig. 12. Visualization of the manipulator model

The model of the game manipulator created using computer-aided design technology in hybrid modeling mode was implemented in accordance with the proposed information model.

Conclusions. Designing objects based on hybrid modeling allows the use of top-down technology. This speeds up the design process. An information model has been proposed to optimize hybrid modeling. This model explains the relationship between the stages of surface and solid modeling. Possible options for surface modeling in modern CAD systems are

considered. The paper shows the implementation of hybrid modeling in the development of a game manipulator in Autodesk Fusion using an information model of design. The scientific novelty of the result lies in the fact that for the first time a hybrid modeling technology based on an information model of design is proposed. All stages of manipulator design based on the proposed information model in Fusion were considered. The practical significance of the results obtained lies in the fact that the use of the proposed information model will increase the speed, accuracy, and quality of design based on hybrid modeling. Prospects for further research lie in determining the conditions for interaction with other CAD programs. When designing complex shapes, optimal processes for their creation can be found.

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ТЕХНОЛОГІЇ КОМП'ЮТЕРНОГО ПРОЄКТУВАННЯ В ГІБРИДНОМУ МОДЕЛЮВАННІ НА ОСНОВІ ІНФОРМАЦІЙНОЇ МОДЕЛІ У AUTODESK FUSION

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На даний час велика увага приділяється задачам підвищення швидкості та якості проєктування виробів у сучасних САПР. Процес створення об'єктів складної форми потребує вирішення різноманітних завдань. Для їх реалізації використовуються різноманітні методи моделювання. В роботі пропонується використовувати Autodesk Fusion для вирішення завдань проєктування на основі гібридного моделювання. Для реалізації цих завдань запропоновано інформаційна модель гібридного моделювання виробів у Fusion. Гібридне моделювання дозволяє використовувати технологію проєктування зверху вниз. Такий тип проєктування пришвидшує розробку виробів особливо зі складними формами. Для оптимізації форми можливо використання хмарних технології та елементів штучного інтелекту. Послідовно розглядаються всі етапи запропонованої моделі. Використання інформаційна модель гібридного моделювання дозволяє провести аналіз створення всіх елементів виробу. Fusion спрощує проєктування за допомогою параметричного моделювання, яке забезпечує швидке налаштування, безперебійну ітерацію та автоматизовані оновлення на етапах проєктування та виробництва — і все це в рамках єдиної хмарної платформи. При необхідності проводимо симуляцію навантаження на елементи моделі и виконуємо оптимізацію можливого вибору матеріалів. Для перегляду готового виробу проводимо рендеринг який дозволяє відшліфувати візуальні ефекти, щоб якісно представити свій дизайн або отримати схвалення клієнта. При роботі у хмарному середовище дизайнера в Autodesk Fusion виконуються наступні завдання з використанням штучного інтелекту: розрахунок елементів моделі, тестування навантажень, оптимізацію форми, рендеринг та перегляд виробу, оформлення креслеників, підготовку керуючих програм для технологічних процесів виготовлення деталей за різними технологіями, наприклад адитивні. У роботі наведено приклад гібридного моделювання ігрового маніпулятора при проектуванні у Fusion з використанням запропонованої інформаційної моделі. Деталізовано показано використання всіх кроків інформаційної моделі. Наведено особливості поверхневого та твердотільного моделювання при створенні об'єкту складної форми. Розроблена інформаційна модель може буте адаптована для різноманітних типів моделювання при проєктуванні у Fusion.

Ключові слова: інформаційна модель, гібридне моделювання, поверхнева модель, твердотільна модель, проєктування, Autodesk Fusion.