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Humanoid Robot Gripping Device 3D Model Development Siemens NX Unigraphics

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Abstract:

The article presents the process of humanoid robot gripping device detailed 3D model development using the Siemens NX Unigraphics system. The main attention is paid to detailing the design and carrying out simulations to analyze the deformation forces acting on the device during its operation. As a result of building the model and conducting simulations, it was possible to determine the optimal parameters of the gripping device, which ensure its high functionality and reliability. In addition, the use of Siemens NX Unigraphics made it possible to significantly reduce the development time and reduce the cost of the prototype. The obtained results can be useful for engineers and developers of robotic systems, as well as for further research in the field of robotics.

Key words: Humanoid robot, Gripper design, 3D modeling, Deformation analysis, Simulation, Industrial Innovations. Manufacturing Innovation

Introduction

Humanoid robots are becoming increasingly common in various fields, such as medicine, industry, service, and entertainment [1]-[13]. Gripping devices are key elements of these robots [14]-[20], as they ensure accurate and reliable manipulation of objects. The 3D model is a key tool that ensures the successful development, production and operation of a humanoid robot gripper. The 3D model serves as the basis for creating physical prototypes using 3D printing technologies or other manufacturing methods. This speeds up the development process and allows design changes to be made quickly. Creating a 3D model allows engineers and designers to accurately design a gripping device, taking into account all the necessary parameters, such as size, shape, mechanical properties, etc. In this case, various methods and approaches can be used [21]-[37].

Using Siemens NX Unigraphics to create 3D models allows not only to develop the design of the gripping device in detail, but also to conduct the necessary simulations and analyzes to optimize its operation. This ensures high accuracy and functionality of the model, which is critical for the successful implementation of such devices in practical use. In addition, the use of modern CAD/CAE technologies contributes to shortening the development time and reducing the cost of manufacturing prototypes, which makes this approach extremely effective and promising [38]-[40].

Related works

Developing a gripping device for a humanoid robot is a complex multi-stage task that requires a thorough analysis of the mechanics and kinematics of the human hand. One of the most important stages is the development of a 3D model of such a device. It is natural that many scientists are engaged in solving such problems and writing scientific papers on this topic. Let us look at several recent ones.

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Let us begin with the work [41]. Here the design of a prosthetic hand for wrist amputations is decribed. The mechanism considers the use of three actuators: one each for the movement of the little finger, annular finger, and middle finger.

The authors in [42] propose a Fast Development Cycle to accelerate the design and test process of new industrial grasping devices. The cycle consists of the three main steps: Build, Test, and Learn. The most fundamental aspect of the methodology is to decompose a gripper idea into its essential uncoupled constituents and convert it into a gripper pretotype that is solely oriented to validate its basic principles.

The researchers in [43] note, that an important capability of humans when performing dexterous precision gripping tasks is our ability to feel both the weight and slipperiness of an object in real-time, and adjust our grip force accordingly. In their work [43] they present for the first time a fully-instrumented version of our PapillArray tactile sensor concept, which can sense grip force, object weight, and incipient slip and friction, all in real-time.

The actual grip force provided by a hand prosthesis is an important parameter to evaluate its efficiency [44]. The scientists in [44] made various measurements in order to evaluate the performances of the “Federica” hand, simple low-cost hand prosthesis.

Ramasubramanian, A. K., and co-authors in [45] investigate a method to automatically generate new iterations of the gripper finger design as well as to validate its performance in a simulation environment.

The paper [46] contributes to the development of seamlessly embedding optimized sensing elements in the monolithic topology of a soft robotic system and controlling the robotic system using the feedback data provided by the sensing elements to validate their performance.

The study [46] draws our attention to the fact that handling the low-strength components by using the industrial grippers is the vital challenging routine in production units. Authors try to fabricate the optimal robot hand to perform several operations.

Mbakop, S., & et al. [47] investigate an inverse dynamics model-based shape control of soft continuum robots in the presence and absence of external efforts.

Thus, we see how diverse the tasks of creating gripping devices for humanoid robots are. Further in this article we will look at the development of a 3D model of our gripping device.

Humanoid robot gripping device detailed 3D model development

The choice of Siemens NX Unigraphics CAD/CAE system for humanoid robot gripping device detailed 3D model development is justified by the high accuracy and power of this software. Siemens NX provides tools for complex modeling, analysis and optimization of structures, which allows you to create realistic and functional models. Thanks to integrated modules for simulations and verifications, it is possible to identify potential problems in the early stages of development, reducing risks and costs for further refinements. In addition, support for a large number of file formats and a high level of compatibility with other CAD/CAE systems make Siemens NX the optimal choice for interdisciplinary projects.

In fact, assembly is a kind of hierarchical structure, at different levels of which there are components - selections or parts.

Connections are used to place parts in the assembly. Assembling ties allow you to specify the relative location of assembly components, that is, it fixes the degree of freedom. Having correctly set all the component connections in the assembly, you can analyze the operation of the

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entire mechanism. A component relationship is applied to component geometry (for example, to flat faces, to edges, etc.).

Each component located in space has 6 degrees of freedom (3 translational and 3 rotational). Some degrees of freedom are fixed by superimposing constituent connections. One bond usually constrains several degrees of freedom. In the graphical interface, the removed and preserved degrees of freedom are indicated (white and red arrows). Fig. 1 presents the "Assembly" toolbar.

Figure 1: Siemens NX Unigraphics Compose Toolbar

The design gripping device for a humanoid robot consists of elements such as a body and 5 fingers. This model has 4 fingers with an identical design, the assembly of which is presented in Fig. 2.

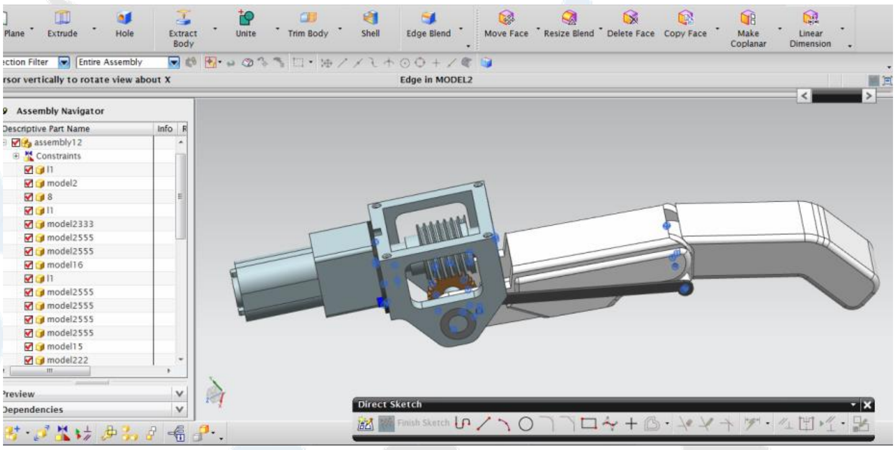

Figure 2: Assembly of a gripper finger for a humanoid robot

The second element of the design of the manipulator is the thumb, which has a different type of assembly. Fig. 3 shows the assembly of the robot's thumb.

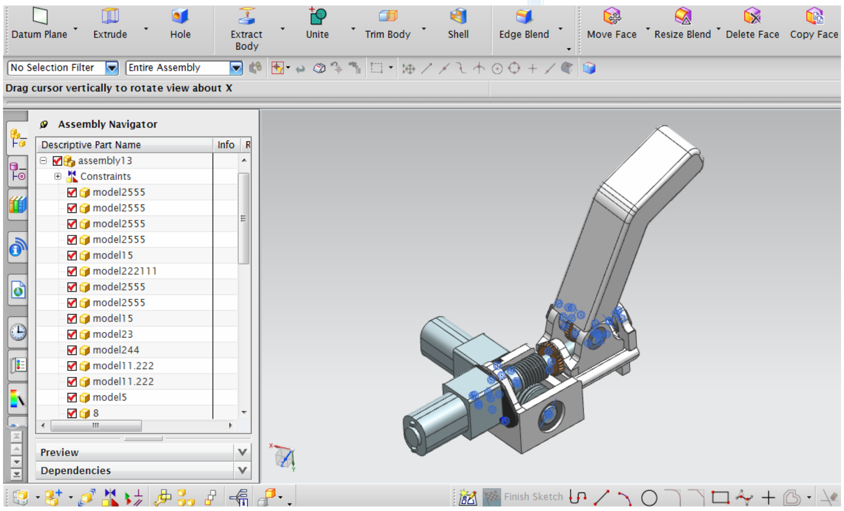

Figure 3: Assembling a gripper thumb for a humanoid robot

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The final work is the assembly of the manipulator wrist, which consists of the body, 4 identical fingers and 1 thumb. Obtained 3D model of a gripping device for a humanoid robot is presented in Fig. 4

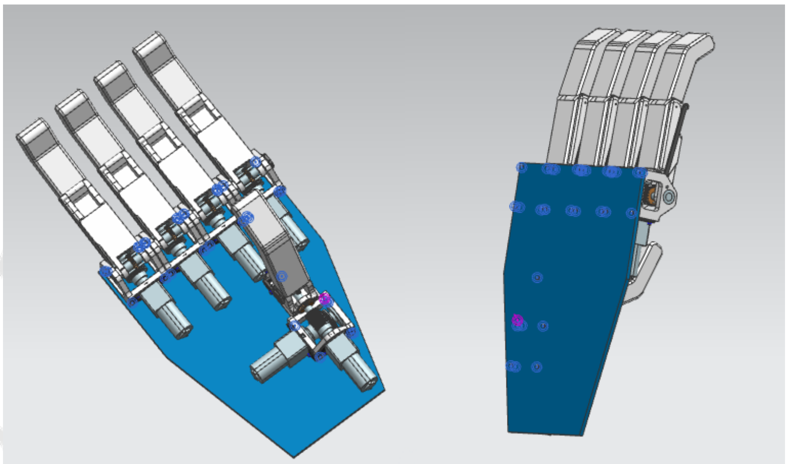

Figure 4: Obtained 3D model of a gripping device for a humanoid robot

Modeling of the force applied to the body of the manipulator

The use of numerical methods in the design of various structures and machines is dictated by the need to constantly improve the reliability and quality of products, as well as the ability to use new modern materials, take into account the complex operating conditions of modern structures, if necessary, to increase their competitiveness and reliability. The maximum effect from the use of numerical engineering analysis technologies is achieved when they are used starting from the early stages of design. At the same time, the cost of the product, the probability of occurrence of risks and the time of release of the product to the market are reduced. "NX Advanced Simulation" systems are a set of basic principles and concepts of numerical engineering analysis with consideration of the finite element method (FEM).

The mathematical and engineering calculation of NX gives us the maximum risk reduction when performing the modification in order to increase the gripping force of the griping device and release the finished product. Fig. 5 presents the simulation of the gripping force.

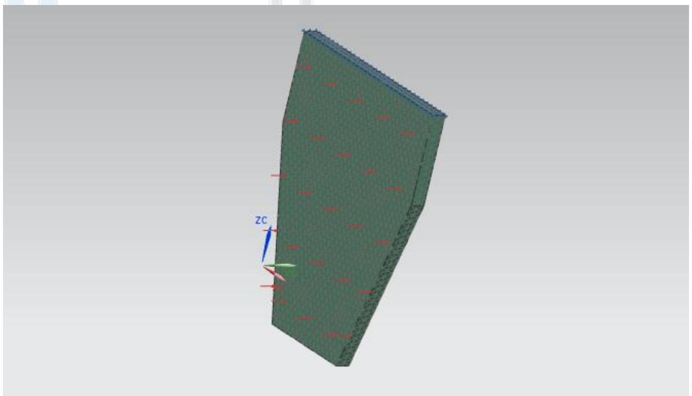

Figure 5: Gripping force simulation

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When modeling the deformation of the manipulator body, it was suggested to choose Titanium-Annealed material. The results of simulation of deformation forces are presented in Fig. 6.

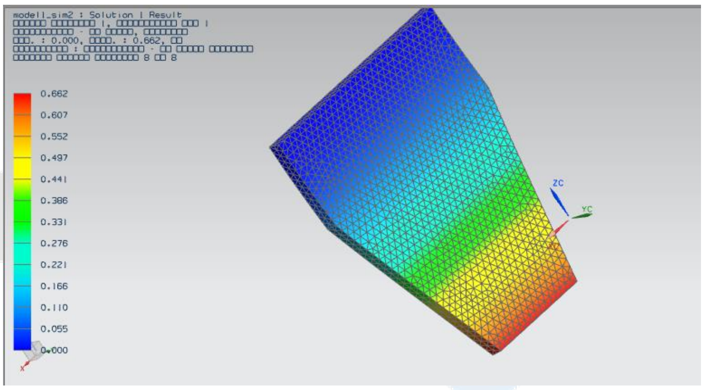

Figure 6; Modeling of the deformations force with the selected material Titanium-Annealed

Conclusion

As a result of the research, a humanoid robot gripping device 3D model was developed using Siemens NX Unigraphics. It was noted that the use of this system allowed creating a highly accurate and functional model of the gripping device. Conducted simulations of the force of deformations confirmed the effectiveness of the selected design, revealing the critical load points and allowing optimization of the model parameters. This ensured high reliability and functionality of the gripping device, which is important for its practical use. The use of Siemens NX Unigraphics significantly reduced development time and reduced prototyping costs, demonstrating the effectiveness of integrated CAD/CAE solutions. The obtained results can be useful for further developments in the field of robotics, providing engineers with tools to create reliable and efficient robotic systems

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