Manufacturing-Oriented Network Collaboration 3D Mechanical Components Rapid Design Technology

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Abstract. Traditional design method of 3 d mechanical parts to complete the design of mechanical parts, but lack of existing design cycle is long, not suitable for mechanical three-dimensional rapid design of the parts and components for manufacturing oriented network collaborative 3 d mechanical parts rapid design technology. Using three-dimensional mechanical parts the construction of the collaborative design platform, and the determination of network collaborative design principle based on the establishment of network collaborative design data transfer mode to complete network collaborative construction of three-dimensional mechanical model of rapid design components; Web-based collaborative design task decomposition, and the conflict of network collaborative design solutions, relying on the online conflict detection, access control, ORG connecting key technology to realize network collaborative 3 d mechanical parts rapid design. Experimental data show that the proposed rapid design technology compared with traditional design, shorten the design cycle by 84.41%, at the same time to ensure accuracy, good design is suitable for mechanical 3 d parts of rapid design.

Keywords: Network collaboration · 3d design · Mechanical parts · Rapid design technology

Traditional three-dimensional mechanical parts design methods can complete the design of mechanical parts, but there are deficiencies in the long design cycle, resulting in low design efficiency, difficult to apply high-efficiency enterprises, not suitable for the rapid design of mechanical three-dimensional parts [1], This proposes a manufacturing-oriented, network-based, collaborative 3D mechanical component rapid design technology. By using logical layer design, engine service layer design, and support layer design, a 3D mechanical parts collaborative design network platform is established to determine the principles of network collaborative design. Relying on the establishment of a network collaborative design data transfer mode, a network collaborative 3D mechanical component rapid design model is completed. Construction; based on the decomposition of network collaborative design tasks, and the solution to network collaborative design conflicts, relying on online conflict detection, access control, ORG connection key technologies, complete the proposed manufacturing-oriented network

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collaboration 3D mechanical parts rapid design technology. In order to ensure the effectiveness of the designed three-dimensional mechanical part design method, the mechanical design test environment was simulated to use two different three-dimensional mechanical parts design methods to carry out the design cycle simulation test. The experimental results show that the three-dimensional mechanical part design method is proposed High effectiveness.

1 System Objectives and Analysis

Manufacturing-oriented network collaboration 3D mechanical components rapid design technology mainly includes:

Using network coordination to replace the traditional design pattern of one person or several people, through the decomposition of the tasks of three-dimensional mechanical parts, relying on the collaborative network platform for design, the original workload of a dozen days was reduced to more than a dozen people a day's workload.

Constructing the principle of network collaborative design is to make designers design within the framework of collaborative design constraints, reduce design conflicts, and resolve the design conflicts through online detection.

Set up a network cooperation design data transmission mechanism to ensure the accuracy of data transmission for the collaborative design of 3D mechanical parts, and use online conflict detection, access control, and ORG connection key technologies to realize the rapid design of network collaborative 3D mechanical parts.

2 Constructing a Network Collaboration 3d Mechanical Component Quick Design Model

2.1 Build a Three-Dimensional Collaborative Design Network Platform for Mechanical Parts

The three-dimensional collaborative design of mechanical components network platform is an operating platform for rapid design models to ensure the smooth flow of collaborative information exchange. The establishment of a network collaborative design platform mainly includes three aspects: logical layer design, engine service layer design, and support layer design.

The logical layer design mainly consists of message system components, agent work components, resource cooperation components, event discussion components, and announcement release components. The use of system bus and engine service layer interconnection [2]. The engine service layer design mainly includes data flow engine, message flow engine, workflow engine, search engine, knowledge reasoning engine, sharing service, integration service, management service, and security service. Using integrated design, relying on the support layer of the operating system, database systems, network services, infrastructure platforms, transmission protocols to ensure the smooth flow of collaborative information exchange, successfully set up a network collaborative design platform.

2.2 Determining Principles of 3D Network Cooperative Design for Mechanical Parts

The three-dimensional network collaborative design of mechanical parts is to divide a whole three-dimensional mechanical parts into several units by means of decomposition. Different designers design the three-dimensional mechanical parts that are decomposed and finally assembled. Due to the fact that there is a large number of decompositions and it is easy to cause confusion in assembly, it is particularly critical to formulate principles for network collaborative design [3].

The principle of 3D network collaborative design of mechanical parts is based on the decomposition of the 3D network collaborative design task, naming the single 3D mechanical part unit that is decomposed, and using the key technology of network collaborative design to make the process principle of the 3D mechanical parts assembled quickly and automatically. The following takes T-shaped three-dimensional mechanical parts as an example to analyze the naming principles of 3D network collaborative design for mechanical parts. The naming principle is as follows:

Firstly, the origin of the three-dimensional coordinates of the T-shaped three-dimensional mechanical parts is constructed, the origin is set to O, and the origin is the graphic center of the designed three-dimensional mechanical parts. Then determine the three-dimensional coordinate orientation of the T-shaped three-dimensional mechanical part, and define the task of the collaborative design as the XY plane, and the positive direction is the Z-axis. Second, determine the unit distance of the three-dimensional coordinates of the T-shaped three-dimensional mechanical part, and finally encode the three-dimensional coordinate sequence according to the (O, X, Y, Z) display of the three-dimensional coordinates. The coding diagram of the T-shaped three-dimensional mechanical component unit is shown in Fig. 1(a). The assembly of the three-dimensional mechanical component unit code is shown in Fig. 1(b).

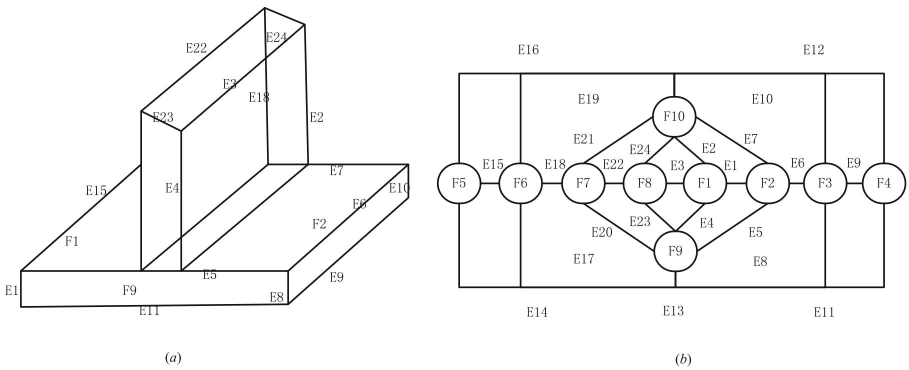

Fig. 1. Schematic diagram of assembly of T-shaped three-dimensional mechanical components

2.3 Establishing a Network Cooperative Design Data Delivery Model

The collaborative design data transfer of 3D mechanical parts is a conversation platform for ensuring technical exchanges between design and technical collaboration. The user side includes the session layer, message layer, and data layer for the extraction, compilation, and transmission of collaborative data. Transfer of data using STEP standards, based on XML converters, relying on TCP/IP protocol for data transfer [3]. Its network collaborative design data transfer mode process is shown in Fig. 2

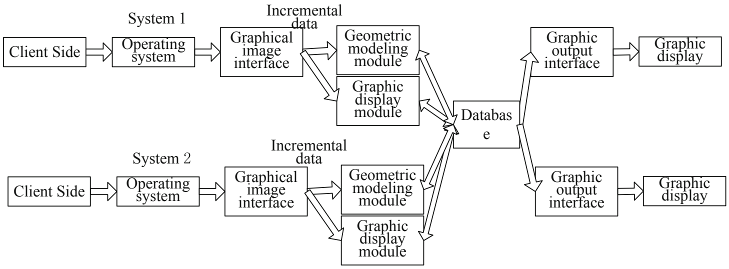

Fig. 2. Network cooperative design data transfer mode process

Relying on the establishment of a three-dimensional collaborative design network platform for mechanical parts, the principle of 3D network collaborative design for mechanical parts was determined, and a network collaborative design data transmission model was established to realize the construction of a network collaborative 3D mechanical parts rapid design model.

3 Realize the Collaborative Design of Networked 3D Mechanical Components

3.1 The Decomposition of Network Collaborative Design Tasks

The decomposition of the network collaborative design task is to ensure that the three-dimensional design of mechanical components is best split, and it is best to assemble, but also to ensure that each designer's workload is balanced [4]. Taking a mechanical part of a gear train as an example, each smallest unit of gear should be used as a split unit, and finally the gear train should be assembled. At the same time, the design of the gear system considers the module of the gear, the depth of the key position of the gear, the involute of the gear, etc. These data must be solved by relying on the network collaborative design data transmission mode and the solution to the network collaborative design conflict. Set a mechanical component as S, which is composed of n units of mechanical minimum units, i.e., do S1, S2, …, Sn, then build the decomposition function of the network collaborative design task as shown in Eq. 1.

$$k = \frac{\sum K_o + (R_k/S_{x,k})}{\sum (K_o + \Delta G_j)} \tag{1}$$

In the formula, K0 represents the design element, Rk represents the number of designers, Sx,k represents the organization capability, ΔGj represents the designed Bridgeman coefficient, its Bridgeman coefficient mainly depends on the design degree of difficulty, and the Bridgeman coefficient can be expressed by formula 2.

$$\Delta G_j = \sigma_o \gamma_i + \frac{\partial^2 q_k dx}{h_i} \tag{2}$$

In the formula, σ0 represents the minimum unit surface area of the three-dimensional mechanical design, qk represents the three-dimensional design degree of difficulty, and hi represents the three-dimensional design dynamic range.

3.2 Network Cooperative Design Conflict Resolution

The disadvantage of network co-design is the use of non-individual design solutions, but the use of multiple people to design solutions. When multiple people design at the same time, there may be a design conflict, resulting in the design of three-dimensional mechanical parts can not be assembled, there are many reasons for the design conflict. In order to solve the conflict of network collaborative design reasonably, the conflicts caused by different aspects are attributed to three types. The first type is the reason for the conflict parameters, the second round is the degree of conflict manifestation, and the third is the scope of conflict. Using three sets of conflict resolution process to resolve conflicts arising from the design parameters of many people [5].

The reasons for the first type of conflict parameters are mainly summarized in the following ten aspects: that is, different design goals, poor information flow, unreasonable resource allocation, and different evaluation criteria, different knowledge representation systems, unreasonable role assignments, different evaluation objectives, and interrelational constraints, as well as unreasonable resource allocation. Based on the above reasons, relying on the principle of collaborative design of three-dimensional networks of mechanical parts, the conflict parameter constraint equations are constructed so that the design objects, designers, and design software are within constraint equations, restricting the authority of the designer [6] and making reasonable design within the authority. Its conflict parameter constraint equation can be expressed by the following formula:

$$\begin{cases} D_a = \dfrac{\partial(q*w)dx + \partial(e)dx}{\|\partial(r+t) + \partial(y)\|dx} + \|\partial(u)dx\| \\ D_b = \dfrac{\partial(o*i)dx + \partial(u*y)dx}{\|\partial(t+r) + \partial(e)\|dx} + \|\partial(w)dx\| \end{cases} \tag{3}$$

In the formula, q represents different design goals, w represents poor information flow, e represents irrational resource allocation, r represents different evaluation criteria, t represents different knowledge representation systems, y represents unreasonable role assignment, u represents different evaluation goals, i represents mutual constraints, and o represents different resource allocations. If the design of three-dimensional mechanical components is E1 ~ F12, then according to the constraint equation D, the E1 ~ F12 constraint set $D = \{D_{E1}, D_{E2} \ldots, D_{F12}\}$ is obtained. Its design objects, designers, and design software run in a constraint set D.

The degree of manifestation of the second type of conflict is mainly divided into the conflict of display and divergence, and is different from that of the first type of conflict, the extent of the appearance of the second type of conflict and the scope of the third type of conflict are technical conflicts. Therefore, technical solutions are adopted. Firstly, online conflict detection technology is used to check the cause of the conflict and adjust the conflict accordingly. Its online conflict detection technology is one of the key technologies for network collaborative design [7]. The degree of manifestation of the second type of conflict and the third type of conflict relied on online conflict detection technology to determine the elements involved in the conflict. Based on the design rules, the conflict was analyzed using the backtracking method, and parallelism and coupling were used to eliminate conflicts.

3.3 Network Cooperative Design Key Technologies

The key technologies of network collaborative design mainly include online conflict detection technology, access control technology, and ORG connection technology. The online conflict detection technology mainly discriminates between the second type and the third type of network collaborative design. Among them, online conflict detection technology mainly includes four kinds of detection technology based on Petri net, true value detection technology, constraint satisfaction-based detection technology, and heuristic-based detection technology. Due to the complexity of the causes of the conflict, four methods of joint detection are used for this purpose. Through the backtracking method to analyze the conflict, using the parallel and coupled way to eliminate the conflict [8].

Access control technology is a control technology that enables design agents, process agents, and management agents to communicate with each other through the Internet under the secure network cooperative operation. In order to ensure the security of the network collaborative design, the design agent, process agent, and management agent are subject to authentication management, certification management components, and authentication application components to complete the composition and supervision of the certification [9]. Password authentication component is used to supervise the design of Agent, process agent and management agent. The authentication management component mainly includes access rights handling for user groups, dynamic protocol processing, interaction description, and authorization processing. For the design of communication between departments, communication between management departments, and communication between process departments to provide network coordination communication security [10].

ORG connection technology is the core technology of network communication technology. Relying on HTTP protocol, ORB protocol performs data communication on web browsers of different objects, and synchronous system design tools for network co-design, asynchronous collaborative design tools, and message managers. ORG connection technology includes PDM database, ERP database, and call message database. Relying on J2EE server to achieve data communication, data communication structure shown in Fig. 3

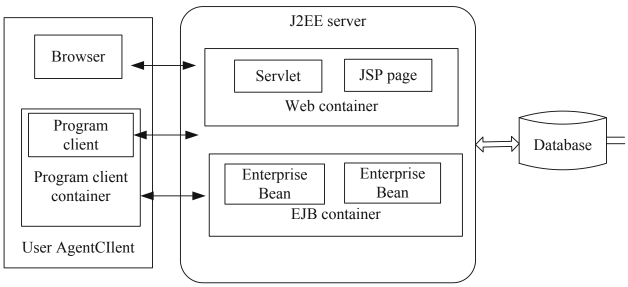

Fig. 3. Data communication structure

Based on the construction of network collaborative 3D mechanical components rapid design model, the use of network collaborative design task decomposition, reliance on network collaborative design conflict resolution methods, online conflict detection, access control, ORG connection key technologies, realize the rapid design of network collaboration 3D mechanical components.

4 Test and Analysis

In order to ensure the effectiveness of the manufacturing-oriented network collaborative 3D mechanical component rapid design technology proposed in this paper, simulation experiments were conducted. During the test process, different design mechanical components were used as test objects to conduct design cycle simulation tests. Different types of structures for designing mechanical components, as well as degree of difficulty, are simulated. In order to ensure the validity of the test, the traditional three-dimensional mechanical part design method was used as a comparison object. The results of the two simulation simulation experiments were compared and the test data was presented in the same data chart.

4.1 Test Preparation

In order to ensure the accuracy of the simulation test process, the test parameters of the test are set. This paper simulates the test process, uses different design mechanical parts as test objects, uses two different three-dimensional mechanical parts design methods, carries out the design cycle simulation test, and analyzes the simulation test results. Because the analysis results obtained in different methods are different from the analysis methods, the test environment parameters must be consistent during the test. The test data set results in this paper are shown in Table 1.

Table 1. Test parameter settings

Simulation test parameters	Execution range/parameter	Note
Three-dimensional mechanical parts design degree of difficulty	SL0.1 ~ SL1.6	SL three-dimensional design degree of difficulty unit, 2.0 maximum
Analog Design Mechanical Components	Mechanical parts consisting of chain, sprockets, racks, gears, shafts, chucks, screws, rods, cams, flywheels, mixing rollers, and keys	Using two different design methods to conduct design analysis one by one
Simulation System	DJX-2016-3.5	Windows platform

4.2 Tests and Results Analysis

During the test process, two different three-dimensional mechanical parts design methods were used to work in a simulated environment and the changes in the design cycle were analyzed. At the same time, due to the use of two different three-dimensional mechanical parts design methods, the analysis results cannot be compared directly. For this purpose, third-party analysis and recording software is used to record and analyze the test process and results, the results are shown in the curve of the comparison results of this experiment. In the simulation test result curve, the third-party analysis and recording software function is used to eliminate the uncertainty caused by the simulation laboratory personnel operation and simulation of computer equipment factors, and only for different design mechanical parts and different three-dimensional mechanical parts design methods. Perform a design cycle simulation test. The comparison curve of the test results is shown in Fig. 4, where a is the traditional 3D mechanical part design method and b is the 3D mechanical part design method. According to the results of the test curve, the third-party analysis and recording software was used to arithmetically weight the design cycle of the proposed three-dimensional mechanical part design

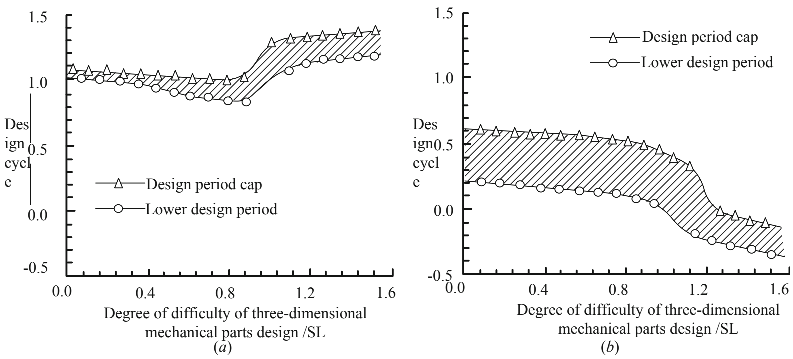

Fig. 4. Comparison of test results

method and the traditional three-dimensional mechanical part design method, and the proposed rapid design technology was compared with the traditional design, the design cycle is shortened by 84.41%. At the same time, it can guarantee a good design accuracy and is suitable for the rapid design of mechanical three-dimensional parts.

5 Conclusion

This paper proposes a manufacturing-oriented network collaboration 3D mechanical parts rapid design technology, based on the construction of a network collaborative 3D mechanical parts rapid design model, as well as the decomposition and conflict handling of network collaborative design tasks, using the key technologies of network collaborative design to achieve the research of this paper. The experimental data shows that the method designed in this paper has extremely high effectiveness. It is hoped that the study of this paper can provide a theoretical basis for the design method of three-dimensional mechanical parts.

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