# Construction of Design Characteristics Model of Manufacturing Structures for Complex Mechanical Parts

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**Abstract.** Traditional mechanical parts manufacturing structure design feature model can more complete mechanical parts structure design feature extracting, but for complex mechanical parts for structural design feature extraction, feature extraction error rates higher deficiencies, this proposed complex mechanical parts manufacturing characteristic model building structure design. Based on the ADO.NET structure, the design platform of complex mechanical parts manufacturing structure is built, the constraint equation of feature model is determined, and the framework of complex mechanical parts manufacturing structure design feature model is constructed. The feature model function of design structure design is designed, and the embedding of complex mechanical structure design software is realized by using XTF embedding technology, and the construction of complex mechanical parts manufacturing structure design feature model is completed. The experimental data show that the proposed complex feature model is 14.24% lower than the traditional model, and is suitable for the application of complex mechanical parts manufacturing structure design characteristics.

**Keywords:** Complex mechanical parts · Manufacturing structure design · Feature model construction · Data parameter import

## 1 Introduction

The traditional structural design feature model of mechanical parts can extract the design features of mechanical parts completely. However, when extracting the structural design features of complex mechanical parts, due to the limitations of the model basic frame, there is a deficiency in the extraction feature error rate [1]. To this end, the construction of a design feature model for the manufacturing of complex mechanical parts is proposed. Relying on the ADO.NET structure, the Data Reader object was introduced to perform read-only operations on the platform data flow, set up a structural design platform for manufacturing complex mechanical parts, calculate the random sample constraint state function, and substitute control model variables to obtain the design features of the complex mechanical part manufacturing structure. The constraint equation of the model completes the construction of a design model


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framework for the manufacturing structure of complex mechanical parts. In order to meet the performance requirements of the structural model design features of complex mechanical parts manufacturing, construct drawing function, data analysis function, intelligent AI mapping function, cloud computing function, use XTF embedded technology, optimize Design source, Mapping unit, and realize complex mechanical structure design software The embedding is completed and the proposed design model of the manufacturing structure of the complex mechanical parts is completed. In order to ensure the effectiveness of the designed mechanical design feature model of the mechanical parts, the test environment of the mechanical parts structure was simulated and designed. Two different mechanical parts were used to manufacture the structural design feature model, and the feature error rate simulation test was conducted. The test results showed that the proposed Mechanical parts manufacturing structure design feature model has extremely high effectiveness.

## 2 System Objectives and Analysis

The construction of complex mechanical parts manufacturing structure design feature model mainly includes:

(1) Solve the problems existing in the structural design feature model of traditional mechanical parts manufacturing, optimize the model building process flow, combine scientific and rational combination of modern computer technologies, and realize the construction of complex mechanical parts manufacturing structure design feature model.
(2) Optimize the structural design platform of traditional mechanical parts manufacturing, analyze the structural design variables of complex mechanical parts manufacturing structure, and determine the constraint equations of the manufacturing structural design feature model of complex mechanical parts.
(3) Manufacturing structural designs for complex mechanical parts, feature models for building drawing functions, data analysis functions, intelligent AI mapping functions, and cloud computing functions. Based on the embedding of complex mechanical structure design software, the construction of a design model for a complex mechanical part manufacturing structure is accomplished.

## 3 Construction of Complex Mechanical Parts Manufacturing Structure Design Feature Model Framework

### 3.1 Set up a Complex Mechanical Parts Manufacturing Structure Design Platform

The complex mechanical parts manufacturing structure design platform is an operating mechanism that carries the structural feature model of the manufacturing of complex mechanical parts. The operation design of the complex mechanical part manufacturing structure design platform directly affects the operation of the complex mechanical part manufacturing structural design feature model. For this reason, ADO.NET's structural platform is used as a structural design platform for manufacturing complex mechanical parts. ADO.NET structure platform mainly includes two core components of Data Set and .NET data provider, namely .NET Data Provider, and four core objects of Connection, Command, Data Reader and Data Adapter [2]. The Connection object mainly represents the connection of a specific complex mechanical data source, determines the correlation and specific relationship of the complex influence coefficient of the mechanical quantitative calculation, and traces back to the structural design database file, at the same time, in order to prevent repeated extraction, the data stream is marked, and the extracted data is marked with a specific character at the end of the string. The Command object is a data service platform, which analyzes the management authority for the mechanical design project. To ensure the security of the system operation, the project management staff assigns the user layer authority to use non-open source distribution, and this data has certain confidentiality. The Command object is to allow permission to extract data without destroying the object and encode the data to form a calculable character string. At this time, the generated data file is a numeric type. Because the data is continuously updated and does not maintain a certain value, the Data Reader object is introduced to perform read-only operations on the platform data stream and provide related technical information such as design project data and mechanical part data for the Command object. Its ADO.NET architecture diagram is shown in Fig. 1 [3].

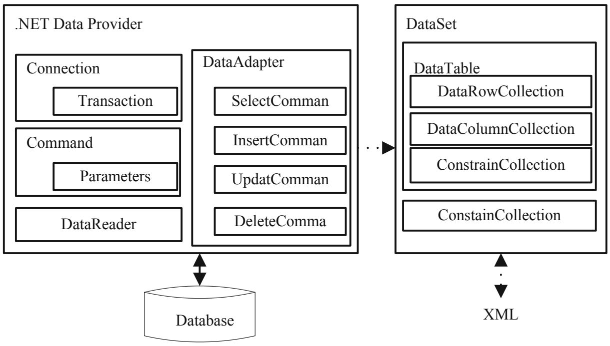


**Fig. 1.** ADO.NET architecture diagram

Where ADO.NET requires the hardware environment to use the TCP/IP network protocol. The CPU of the server is not less than 3.2 GHz, and the memory is not less than 8 GB of hot-swappable SAS hard drives and dual Gigabit Ethernet adapters. The software environment operating system adopts Windows 7 Ultimate Edition, database development tools select Visual Studio 2008 [4].

### 3.2 Determining Constraint Equations for Designing Feature Models of Manufacturing of Complex Mechanical Parts

In order to ensure the reliable operation of the manufacturing structural design platform for complex mechanical parts, the constraint equations for the design feature model of the manufacturing structure of complex mechanical parts are determined. Constrained complex mechanical parts manufacturing structure design feature variables are complex mechanical parts manufacturing structure design feature variables running on a controllable platform. Let's $f(x,\theta)$ be the overall characteristic model variable function, where $\theta \in \Theta$. A parameter vector consisting of one or more unknown parameters of the design variables, $\Theta$ for the parameter space, use $x_1$, $x_2$, ... $x_n$, to represent the characteristic model variables. Then the control model variable sample function $L(\theta; x_1, x_2, \ldots, x_n)$ can be expressed as [5]:

$$L(\theta) = (\theta; x_1, x_2, \ldots, x_n) = f(x_1,\theta)f(x_2,\theta)\ldots f(x_n,\theta) \tag{1}$$

In the formula, $L(\theta)$ represents the characteristic model variable sample function, If a statistic $\hat{\theta} = \hat{\theta}(x_1, x_2, \ldots, x_n)$ satisfies the following conditions $L(\hat{\theta}) = \max_{\theta \in \Theta} L(\theta)$. Then say $\hat{\theta}$ is the condition constraint coefficient of $\theta$, abbreviated as MLE. Let $x_1, x_2, \ldots, x_n$'s conditional coefficient $\theta \sim N(\mu, \sigma^2)$ have n random samples, the constraint state of the random sample can be expressed as:

$$L(\theta) = \prod_{i=1}^{n} f(x_i; \mu, \sigma^2) = (\frac{1}{\sqrt{2\pi\sigma}})^n \exp\left\{ -\frac{\sum_{i=1}^{n} (x_i - \mu)^2}{2\sigma^2} \right\} \tag{2}$$

Take the logarithm of both sides of formula 2 and get $\ln L(\theta) = \frac{n}{2}\ln(2\pi\sigma^2) - \frac{1}{2\sigma^2}\sum_{i=1}^{n}(x_i - \mu)^2$, substituting into formula 1 yields $\frac{\partial \ln L(\theta)}{\partial \sigma^2} = \frac{1}{\sigma^2}\sum_{i=1}^{n}(x_i - \mu)^2$, just do $\frac{\partial \ln L(\theta)}{\partial \sigma^2} = \frac{-n}{2\sigma^2} + \frac{1}{2\sigma^4}\sum_{i=1}^{n}(x_i - \mu)^2 = 0$. Substituting the constraint state of the random sample into the sample function of the control model variable yields the constraint equations for the manufacturing structural design feature model of the complex mechanical part as follows:

$$\begin{cases} \hat{\mu}_{MLE} = \frac{1}{n}\sum_{i=1}^{n} x_i = \overline{X} \\ \hat{\mu}^2_{MLE} = \frac{1}{n}\sum_{i=1}^{n}(x_i - \overline{X}^2) = \frac{n-1}{n}s^2 \end{cases} \tag{3}$$

Based on the complex mechanical parts manufacturing structure design platform, the hardware design of the structural model design framework of the complex mechanical parts manufacturing is realized, and the constraint equations of the structural design feature model are manufactured by using the complex mechanical parts. Completed the software construction of the structural design model framework for the manufacturing of complex mechanical parts, and realized the construction of a design model framework for the manufacturing of complex mechanical parts.

# 4 To Achieve the Construction of Complex Mechanical Parts Manufacturing Structure Design Feature Model

## 4.1 Complex Mechanical Parts Manufacturing Structural Design Feature Model Functional Architecture

The complex mechanical part manufacturing structure design feature model is a feature model used for the structural design of complex mechanical parts manufacturing. In order to meet the design requirements, the drawing function, data analysis function, intelligent AI mapping function, and cloud computing function are constructed.

Among them, the drawing function includes two-dimensional drawing function and three-dimensional drawing function. Including points, lines, surfaces, graphic editing, data conversion, 2D to 3D, 3D to 2D. The data analysis function, in the framework of the design feature model of complex mechanical parts manufacturing structure, based on the constraint equation of the complex mechanical parts manufacturing structure design feature model, using statistical data processing functions, data analysis of the manufacturing structural design features of complex mechanical parts [6]. The statistics of the data analysis results can also be used to predict the results. The intelligent AI mapping function can generate three-dimensional coordinates for simple mechanical part drawing, and data shunting for complex mechanical part drawing to prepare for data processing. The cloud computing function is to improve the computational convenience of the design feature model of the manufacturing structure of complex mechanical parts, and to ensure the accuracy of calculation. The data expansion calculation is based on the cloud computing function. The data extension interface is as follows (Fig. 2) [7].

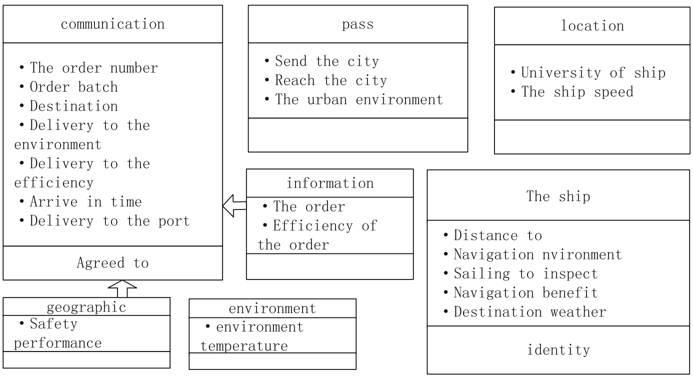


**Fig. 2.** Data extension interface

### 4.2 Complex Mechanical Design Software Embedded

The software embedded technology for the design of complex mechanical structures is the core technology for manufacturing structural design feature models for complex mechanical parts. Traditional mechanical parts manufacturing structure design feature model adopts conventional software embedded technology and is difficult to operate on high-performance platforms. Therefore, when extracting structural design features for complex mechanical parts, there is a disadvantage of high extraction feature error rate. For this reason, this article relies on regular JSF embedding technology to optimize Design source, Mapping unit, and incorporate XTF (Extended Triton Format) embedding technology for encoding processing. Using the strong compatibility of the XTF format [8], JSF files, DSE files, and MUT files are packaged into an XTF file program for modulation adjustment.

XTF embedding mainly includes three phases: data preparation phase, data processing phase, and data display phase. The data preparation phase provides data preparation for software designed for complex mechanical part structures. The data preparation stage works on the data preprocessing layer. The data preprocessing layer includes a file processing unit, a data packet processing unit, and a channel processing unit, and the data preparation of software data is based on Mapping unit processing [9]. The data processing stage is to process the prepared data, prepare to embed complex mechanical structure design software, start the embedded program, and finally use XTF's Embedded technology to realize the embedding of complex mechanical structure design software. The flowchart of the embedded mechanical design software is shown in the following Fig. 3 [10].

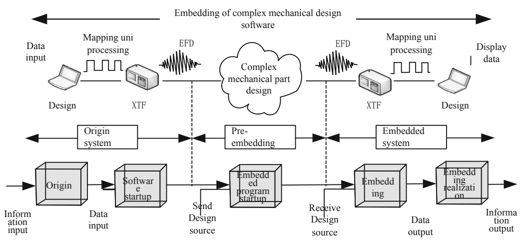


**Fig. 3.** Embedded software for complex mechanical design software

Based on the construction of complex mechanical parts manufacturing structure design feature model frame, the structure feature design model function of complex mechanical parts manufacturing structure is built, and the embedded design of complex mechanical structure design software is implemented using XTF embedded technology to complete the construction of the design feature model of the manufacturing structure of complex mechanical parts.

## 5 Test and Analysis

In order to ensure the validity of the design feature model construction of the manufacturing structure of complex mechanical parts proposed in this paper, the simulation test analysis was carried out. During the test process, different design and manufacture of mechanical part structures were used as test objects, and characteristic error rate simulation tests were conducted. Different types of mechanical structures for designing and manufacturing mechanical part structures, as well as extraction difficulty coefficients, are simulated. In order to ensure the validity of the test, traditional mechanical parts are used to manufacture the structural design feature model as a comparison object. The results of the two simulation simulation tests are compared and the test data are presented in the same data chart.

### 5.1 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 and manufacture of mechanical parts as the test object, uses two different mechanical parts to manufacture the structural design feature model, carries out the characteristic error rate 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 |
|---|---|---|
| Design and manufacture of mechanical parts structure degree of difficulty | SL0.1 ~ SL1.6 | SL three-dimensional design degree of difficulty unit, 2.0 maximum |
| Design and manufacture of mechanical parts | Gear train parts, chain drive train parts, belt drive train parts, worm drive train parts, screw drive train parts, coupling parts, clutch train parts, rolling bearing train parts, and sliding bearing train parts | Using two different design methods to conduct design analysis one by one |
| Simulation System | DJX-2016-3.5 | Windows platform |

### 5.2 Test Results Analysis

During the test, two different mechanical parts were used to fabricate the structural design feature model to work in a simulated environment, and the variation of the feature error rate was analyzed. At the same time, due to the use of two different mechanical parts to manufacture the structural design feature model, the analysis results cannot be compared directly. For this purpose, third-party analysis and recording software is used. The test process and results are recorded and analyzed, and the results are shown in the comparison results curve 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. Only for different design and manufacture of mechanical parts structure, different mechanical parts manufacturing structure design feature model, the characteristic error rate simulation test. The comparison curve of the test results is shown in Fig. 4, where a is a structural design model of a traditional mechanical part, and b is a structural design model of a mechanical part. According to the results of the test curve, the third-party analysis and recording software was used to mathematically weight the feature error rate of the mechanical part manufacturing structure design feature model and the traditional mechanical part manufacturing structure design feature model. The proposed complex feature model is lower than the traditional model, and the extracted feature error rate is reduced by 14.24%, which is suitable for the application of complex mechanical part manufacturing structure design features.

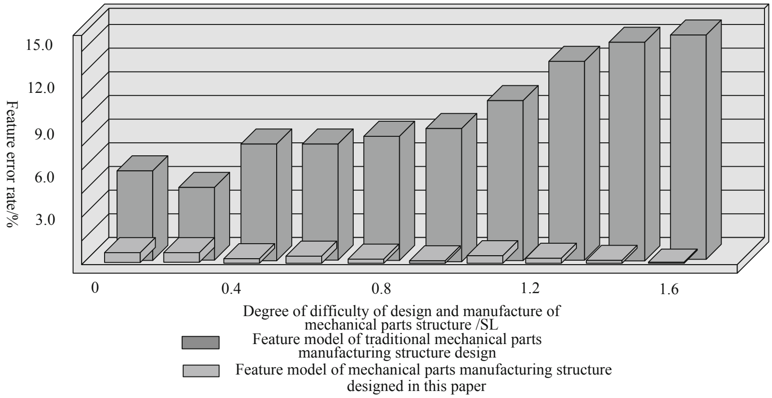


**Fig. 4.** Comparison of test results

## 6 Conclusion

This paper proposes the construction of a design feature model for the manufacturing of complex mechanical parts and the construction of a design feature model framework based on the manufacturing structure of complex mechanical parts. The use of complex mechanical parts manufacturing structure design feature model design, as well as the complex mechanical structure design software embedded technology, to achieve the study of this article. 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 manufacturing of structural design feature models for mechanical parts.

## References

1. Peng, C., Fei, L., Junfeng, N.: Multi-objective monitoring integrated model of machining automatic production line and its application. Comput. Integr. Manuf. Syst. **23**(3), 473–481 (2017)
2. Weihui, W., Dongming, X., Xing, M.: Automatic ultra-light structural design and laser additive manufacturing of metal parts. Infrared Laser Eng. **009**(11), 124–131 (2016)
3. Wang, H., Riliang, L., Zhang, C.: Design and implementation of workshop reconfigurable automatic programming system based on processing features. Comput. Integr. Manuf. Syst. **22**(10), 2396–2407 (2016)
4. Zhou, L., Li, F., Li, J., et al.: Energy consumption correlation modeling of mechanical product manufacturing based on design features. Comput. Integr. Manuf. Syst. **22**(4), 1037–1045 (2016)
5. Huang, B., Zhou, L., An, L., et al.: Variant design method for machining and aero-engine parts driven by process model. J. Aeronaut. **38**(1), 290–304 (2017)
6. Song, S., Jian, B., Keqing, D.: Active remanufacturing design and timing control method of centrifugal compressor impeller. China Mech. Eng. **28**(15), 1862–1869 (2017)
7. Song, S., Wei, W., Keqing, D.: Active remanufacturing design based on structural function derived coefficients. J. Mech. Eng. **53**(11), 175–183 (2017)
8. Shao, L., Zhang, S., Bai, X., et al.: Three-dimensional process model construction method for milling parts. Mach. Sci. Technol. **35**(8), 1297–1301 (2016)
9. Zhang, K., Hang, C., Zhao, X., et al.: A 3D CAD model local structure retrieval method for design reuse. J. Agric. Mach. **48**(7), 405–412 (2017)
10. Wang, K., Zhang, S., He, W., et al.: SPEA2-based selection and assembly method for complex mechanical products. J. Shanghai Jiaotong Univ. **50**(7), 1047–1053 (2016)