CAD Method Supporting Mechanical Innovative Design Based on Artificial Intelligence

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Abstract: With the development of CAD technology, modern CAD design software is not only used to replace manual drawing, but also plays a more and more important role in enterprises. The current focus of CAD is to adapt to the market demand. The purpose of this paper is to study the CAD method of mechanical innovative design based on artificial intelligence. The traditional design method based on finite element is limited by the huge gap between CAD and CAE and the huge time-consuming caused by multiple numerical calculations, so it is difficult for engineers to modify the CAD model and carry out CAE structural analysis quickly and accurately. Combining the innovative research of CAD design with computer, a new CAD design method based on artificial intelligence is developed, which provides a high-performance system for researchers by using the high storage capacity of computer. In this paper, firstly, the mechanical innovative design method is summarized, and then through the study of the relevant design theory of transmission parts, the object-oriented design method is adopted. Aiming at the shortcomings of CAD system, the multi-agent is deeply studied Based on the application of CAD technology, evolutionary technology and collaborative design technology in CAD system, a CAD system supporting innovative conceptual design is established and implemented. Finally, through the system test and result analysis, the static test error is 0, and the two errors of the dynamic test line are fixed. Finally, the system runs well, and the genetic algorithm has good adaptability to the layout design.

1 INTRODUCTION

In order to enhance their competitiveness, shorten the product development cycle and reduce the development cost of products, enterprises constantly explore and practice some advanced integrated manufacturing technology and methods of electronic computer to adapt to the increasingly fierce market competition (Oliveira, Rbd , et al, 2019). At the same time, after the merger and reform of global companies or enterprises, manufacturing industry has developed into a global industry of large-scale, wide-ranging and wide-ranging cooperation (Kuna and Skaan, 2019). Many famous manufacturing companies and enterprises from the world have not only R & D and manufacturing departments, but also relevant parts manufacturing enterprises. Therefore, many complex products need to be co designed and constructed by producers and designers distributed in different locations and locations in design (Tao and Li, et al. 2018). All enterprises are actively using CAD, computer - aided design).

This paper mainly relies on the academic background of the provincial mechanical engineering discipline, and studies the graduate innovation research project (cx2016b079) and the national key basic research technology development plan ("973" plan), The research is carried out under the guidance and support of 2010cb328005, the key project of national natural science fund construction (61232014), and the general project of NSFC construction (11472101). In order to overcome the huge gap between CAD and CAE in mechanical structure design and the huge effort needed in the process of repeated calculation and modification of structure, the geometric model of structural CAD is realized by engineers, which is simple, convenient, quick and accurate (Chen, J. L and C. L. Lee, 2017).

Based on the professional background of the mechanical engineering discipline, this paper conducts relevant research work under the support of the provincial graduate innovation and research project (cx2016b079), the national key basic research and development plan (973 Plan, 2010cb328005), the

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National Natural Science Fund key project (61232014), and the National Natural Science Foundation general project (11472101) (Mandal, D. K and C. S. Syan, 2016). In order to overcome the huge gap between CAD and CAE in mechanical structure design and the huge time required for repeatedly calculating and modifying the structure, the engineer can easily and accurately represent and modify the geometric model of structural CAD, and obtain the dream of the results of CAE analysis of structure quickly and even in real time, so as to accelerate the product development and improve social benefits (Innovative Materials, 2016).

2 CAD METHOD FOR MECHANICAL INNOVATIVE DESIGN

2.1 Agent Technology

Multi agent system is one of artificial intelligence, which has the characteristics of intelligence. In this system, each agent is an independent and intelligent entity, which takes action or solves problems through interaction with external environment and coordination between agents. Multi agent system is usually applied in dynamic, distributed and intelligent environment (Hadhami, et al, 2020).

2.2 The IGA-IFU Method is Used for Accurate Reanalysis of Structural Integration

Based on IgA, the integration of CAD and CAE is constructed, which lays the foundation for the subsequent real-time analysis and optimization. The engineer can eliminate the representation error by accurately representing the geometric model of the structure, and easily modify the CAD geometry model of mechanical structure by changing the control point (Dietterich T G, 2017). The CAE model can be obtained immediately, which avoids the complicated conversion between CAD and CAE in traditional methods, and the errors and time consuming (Raedt and Kersting, et al. 2016). When the structural modification does not affect the overall displacement of the structure, the independent coefficient method has a very high precision; while when the overall displacement of the structure is greatly affected by the structural modification, especially when the structural modification causes the structural deformation mode to change, the accuracy of the independent coefficient method may not be guaranteed (Seyedmahmoudian, et al, 2016).

3 SUPPORT THE DESIGN OF CAD METHOD SYSTEM FOR MECHANICAL INNOVATIVE DESIGN

3.1 Multi Agent System

3.1.1 Question Raising

Technological innovation is the spirit and soul of CAD. The competition of new products based on knowledge is becoming the focus of the competition of Chinese enterprises in the complicated global manufacturing environment in the 21st century (Bryson, and Winfield, 2017). At present, all kinds of manufacturing and processing equipment manufacturing enterprises in China have entered a period of rapid development oriented by market main body. The economic benefits and quality of enterprises depend on the revolutionary innovation of technology and products to a large extent. Whether an enterprise has the ability to research and develop a set of innovative products that meet the needs of the market and the consumption mentality of different types of customers in the coming years will become the final decision on the survival and development of an enterprise (Price, and Flach, 2017).

3.1.2 Multi Agent System Structure

The agent in the design environment is usually called design agent. Design agent is a kind of computer software that helps designers to complete the design task in some way.

A multi agent system is generally composed of the following aspects:

1) Multiple existing agents;

2) There is a joint intention among multiple agents, that is, multiple agents act together to achieve common goals;

3) Common sense: that is, the common knowledge between agents;

4) The environment on which agent depends is the basic guarantee for agent behavior.

Multi Agent System Supporting Innovation Concept Design

In this system, complex design is completed by multiple agents. Each agent has its own independent knowledge and design decision-making scheme, and

can understand the design state representation, so as to assist us human design technology experts to achieve the design objectives to be done. The design strategy of agent mainly depends on some basic algorithms, such as genetic algorithm and classification algorithm. Once a new task is arrived, the task decomposition agent (TDA) is used to decompose the whole design task into many independent sub task sets, and a product design tree is used to represent the decomposition results. TDA knowledge base contains many product design tree templates. TDA selects the appropriate template according to its product category and recommends it to designers. The designers and engineers make preliminary decisions and send the results to the design agent of each component. For example, if a user needs to submit a request for housing design, TDA will extract the information of all components of the house and the information of all finished houses in a corresponding knowledge base, and decompose the functions of these products into several relatively independent functional components, which are transferred to different components and design agents for design. The design agent of each component helps designers and personnel to do their work according to their own tasks. When all the sub tasks are completed, all the design results are submitted to the assembly agent. In the process of assembly, the assembly agent needs to check the assembly limit. For components that do not meet the requirements, the information that must be modified is sent to the required design agent. After the assembly agent completes the assembly of new products, the new products are uploaded to the customer, and the users will evaluate the quality of the products and give the new products a score. If the user is satisfied with the new product, the new product will be output. Otherwise, the components shall be replaced or changed according to the user's requirements. After the component is modified, it is re submitted to the assembly agent for assembly until the user is satisfied.

3.1.3 Specific Implementation of Agents

The implementation of component design agent adopts genetic algorithm, which uses mathematical functions to generate two-dimensional curves and three-dimensional entities to inspire people's thinking, so as to realize innovative design.

3.1.4 Improvement of Genetic Algorithm

This paper first extracts the basic features, expresses it by component tree, then cuts and combines them, uses genetic algorithm based on natural selection and evolution principle, simulates the learning process naturally, adjusts the elements of product composition structure, and makes it have a more efficient and reasonable structure, so as to optimize or increase the function of products and realize the support for innovation.

3.2 Belt Drive Design Calculation Subsystem

Design Calculation of V-Belt

1) Main failure modes and design criteria of V-belt drive

The main failure modes of V-belt drive are slipping, fatigue damage, wear and static breaking of the belt; the design criterion of V-belt drive is to ensure that the belt has sufficient fatigue strength and life without slipping; there are two design constraints of V-belt drive, which are as follows:

$$\mathrm{F} = 1000\frac{P}{v} \leq F_1 \ \left(1 - \frac{1}{e^{f\alpha}}\right) \tag{1}$$

(1) is a condition that the mechanical transmission will not slip, where f is the friction coefficient, α is the angle of the pulley, e is the bottom of the natural logarithm, and V is the linear velocity of the belt. The fatigue strength conditions are shown in (2):

$$\sigma_{max} = \sigma_1 + \sigma_{b1} + \sigma_c \leq [\sigma] \tag{2}$$

Where σ_1 is the tight edge stress, σ_{b1} is the bending stress, σ_c is centrifugal stress.

(2) Parameters and conditions for interactive input or selection in V-belt design

The parameters and conditions that must be input or selected interactively in the design of V-belt pulley mainly include: starting type, load property and working hours per day of belt drive, power generated by belt drive, slip friction ratio, requirements of other conditions, such as bearing size, center distance limit, etc, When designing the pulley structure, it is necessary to know the types of various driving force generators.

3.3 Chain Drive Design Calculation Subsystem

Chain drive is a kind of transmission widely used in mechanical transmission. It transmits motion and force by the meshing between sprocket teeth and chain link. The design content of chain drive design and calculation module includes roller chain and tooth chain. The following is the theoretical basis of

chain drive module design and calculation and the realization of roller chain design and calculation.

Design and Calculation of Roller Chain

3.3.1 Main Failure Modes

The main failure of chain drive is chain failure. The main failure modes are: chain compression failure, chain collision fracture, chain wear, and chain crushing due to overload.

3.3.2 Design of Chain Drive

Because the roller chain itself is a standard part, it only needs to select the corresponding type of roller chain according to the design, so the main content of chain drive design is to calculate the relevant parameters and the design of sprocket.

3.4 Design and Calculation Subsystem of Gear Transmission

Gear is one of the most important transmission parts, which is widely used in mechanical industry, automobile, aircraft, shipbuilding and other industries. In the gear design calculation module, the design of involute spur gear, helical spur gear and straight bevel gear is studied and designed.

3.5 Data Processing

In the design calculation module, because the system involves many kinds of parts, there are many kinds of coefficients and data that need to be queried in the part design. How to query the parameters manually and obtain them efficiently and quickly in the design module through programming is a key problem to be solved in the design process of this system.

Mathematical Model of Data Processing

3.5.1 Least Square Method

For some given data $(x_i,\ y_i)$ (i = 0,1, …, n) In the selected function type, find f (x) belonging to the selected function type_ i) , make$e_i = f(x_i) - y_i$The sum of squares of I is the smallest

$$\sum_{i=0}^{m} {e_i}^2 = \sum_{i=0}^{m} (f(x_i) - y_i)^2 \tag{3}$$

The value of $f(x_i)$ minimum.

Program Processing Of Data Table

For the table that needs to query parameters in the design process (hereinafter referred to as the number table), the processing method is: the data with small amount is directly programmed; the data with large amount is written into the program in the form of determined table name, field name and field type according to Microsoft Office Access The structure of the database is structured storage, and the tables involved in each module are stored as a database file.

1) Single parameter table processing

For the data table with only one independent variable and a small amount of data, the data can be directly programmed into the array, and the required data can be obtained by querying according to the change of the variable_ The value of $k_p$is shown in Table 1.

Table 1: Row number coefficient of multi row chain

Row number	1	2	3	4	5
k_p	1	1.7	2.5	3.3	4.1

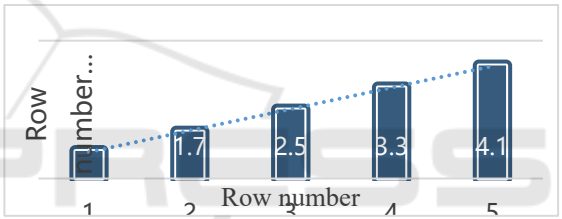

Figure 1: Row number coefficient of multi row chain

As shown in Figure 1, the coefficient of row number increases with the increase of row number. When programming, define a one-dimensional array, store the data in the table in the array, define an integer variable I, according to the row number change selected by the user, according to the change of I value, you can query the array to obtain the row number coefficient k_p.

2) Interpolation query

In the design process, some tables do not list all the data. When variables can not be directly queried in the table to obtain the required data, interpolation query is needed to obtain the required results. As shown in Table 2, it is the query table of envelop angle coefficient

Table 2: Wrap angle coefficient

Wrap angle	180 degrees	160 degrees	140 degrees	120 degrees	100 degrees	90 degrees
k_α	1.00	0.95	0.89	0.82	0.74	0.69

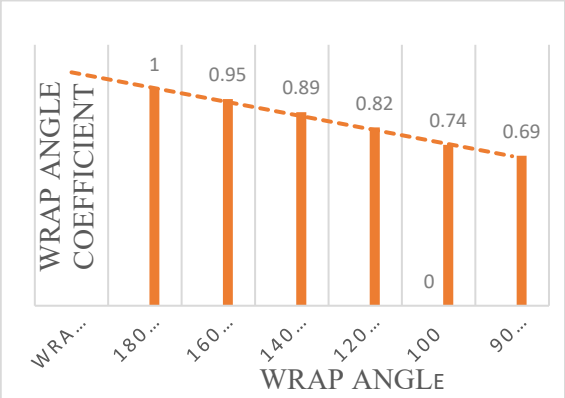

Figure 2: Wrap angle coefficient

As shown in Figure 2, the envelop angle coefficient increases with the increase of envelop angle, and the increase range is linear.

4 TEST AND RESULT ANALYSIS

System Test

Unit test is to test the subsystem at rest and in motion. The main contents of static test include:

1) Consistency of variable type and scope declaration

2) Accuracy of algorithm and formula

3) Is the logic clear

4) Is the symbol consistent

5) Is the jump accurate

6) Is data transmission accurate and consistent

7) Consistency of font style and color

8) Form style consistency

9) Can the code be simplified and the running efficiency be improved

Through the code walkthrough and structure review, the static test found no errors. The dynamic test selects a typical example to test all the steps of design and calculation, and exposes the possible hidden errors of the system by inputting illegal parameters in the test process, and corrects them in time. After the completion of the subsystem test, each subsystem is managed and controlled through a unified interface. The display of each subsystem is controlled through the management database, and each subsystem controls its own display by accessing the database. The single subsystem program cannot run when the main interface of the system is not running.

5 CONCLUSIONS

In this paper, an accurate numerical method based on variable thickness is proposed. The effectiveness, reliability and efficiency of the method are verified by illustration, derivation and analysis, as well as by typical examples and actual mechanical structures in the field of automotive engineering. Although the research of CAD system supporting innovation is still in the research stage, the improvement and improvement of system integrity, flexibility, supporting innovation and collaboration brought by it are remarkable, so its development prospect is broad. Although some stage research results have been achieved, there are still many new problems to be further explored due to the constraints of time and energy.

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