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Development and Optimization of CAD System based on Big Data Technology

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Abstract. The intelligent CAD system, facilities demand analysis and design requirements of system design and realize intelligent design and the key technologies requirement for the process of CAD system. In order to solve a series of problems in the design process of large assemblies and improve the efficiency and quality of the design, this paper has made an in-depth analysis of the characteristics and design techniques of large assemblies, and studied the parametric and modular design technology. The functional units of the large assembly are divided into modules to realize the parametric design and establish the standard model library of the large assembly. On this basis, based on the theoretical basis of recursive algorithm, the automatic update of assembly model, intelligent assembly based on model perception, and automatic generation of engineering drawings and BOM are realized, and a large assembly intelligent CAD system is developed.

Keywords: Intelligent CAD; Parametric design; Modular design.
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1 INTRODUCTION

With the development of CADDCAM technology, the entire design and manufacturing process of products can be completed in the computer. In particular, CAD technology has gradually developed into a mature part structure design and analysis, finite element analysis, virtual assembly and simulation, CNC machining and simulation and other diversified computers on the basis of the development from two-dimensional engineering drawing to three-dimensional model simulation. The auxiliary function enables CADDCAEECAM to gradually integrate and develop into a comprehensive computer-aided design, manufacturing and management system [1]. Therefore, in modern design, complex assemblies with large data capacity (i.e., large assemblies) have become necessary elements for composing products, such as airplanes, automobiles, ships, large molds, large production line equipment, etc., all belong to the category of large assemblies [2, 3].

Big data benefits visibility of information and the process of design and manufacturing engineering through automation. Big data provides the facility to analyze the designs through analytics and its predictions which helps to increase the manufacturing output the lifespan and cycles of a product. Big data volume means the size such as Terabytes Exabyte, Zettabytes of data. The velocity in big data means how frequently e the data is generated. It can be generated in near real-time or streams. The term priority e means all data types like video, audio and identification of radio frequency through sensor readings. The platform such as big data and big data analytics mainly focused on providing the efficient analysis for huge data sets. This analysis helps the industries to gain the inside by extracting the useful information which provides the insights about the situation from data. Industries are rapidly experiencing a huge information flow regularly every day. Most of the generated information left untapped because the traditional application for analytics is not capable for handling such huge volume of data. Please use data can never be adequately analyzed by implementing traditional techniques of data management and warehousing. Computer-aided diagnosis plays a significant role in the management of such huge volume of data. CAD provide the facility for automatically detecting the abnormalities in the data. Recently there exist many research efforts that is performed for the development of CAD system that can automatically detect the insights of the data from big data.

Large assemblies exist in almost every industry and are closely related to the national economy and people's lives. The typical characteristics of large assemblies are: a large number of components, complex structure and assembly relations, and large data capacity. At present, the design efficiency of large-scale assembly has become a key factor affecting the speed of enterprise product update. It is urgent to research and develop large-scale assembly intelligent CAD system and research model lightweight technology.

Section 2 of this paper provides brief information about current trends in Page setup. In Section 3 the CAD system based developed framework is described along with the description of development platform. Section 4 provides the information about design interface along with the system function realization. At last Section 5 concludes the paper with the potentials of CAD systems in the future.

2 LITERATRE REVIEW

Building a directory library based on a neutral model and using it in a plant 3D CAD system can improve library availability and reduce the time required to build a directory library for a particular project. For achieving this Han et al. designed a system that supports the conversion of neutral directory data to plant 3D CAD system local directory data.

For an application of healthcare, the neurological disorder is one of the most challenging tasks to diagnose, monitor and its management because of the complex nervous system. Figure 1 depicts the CAD system for automatic detection from healthcare big data. The produce large volume of healthcare data is critically important to diagnose for the assessment of therapy and its planning. Recently an idea for advanced automated CAD system is evolved for the neurologist in order to detect the abnormality from healthcare data. The CAD system algorithms are designed considering the theories and techniques of pattern recognition and therefore the CAD system is developed as one of the efficient pattern recognition tools. The cat system technologies comprise of three main stages, first stage is preprocessing of data which is followed by feature extraction and the classification stage. The CAD Technology helps the experts for accurately integrating the healthcare data so that the consistency e in the accurate prediction of diagnosis can further be improved along with the reduction in analysis time.

Three data structures are defined for conversion between neutral and domestic directories: neutral data structures for storage devices and material classification and their directories, Data structures for storing mapped data between neutral and local directory data and data structures for supporting information. After defining the data structure, a system to support translation is designed. Finally, a prototype system is implemented according to the design, and the feasibility of the prototype system is verified by using test cases [4].

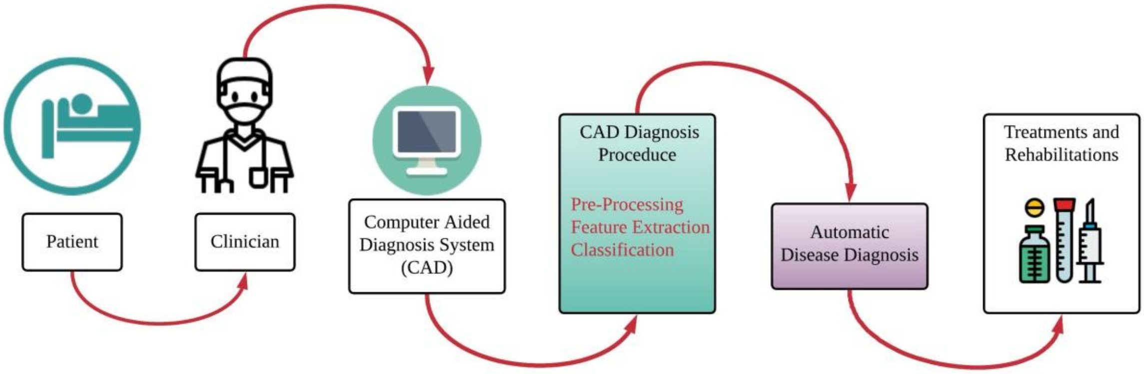

Figure 1: CAD system for automatic detection from healthcare big data.

Venu et al. start from the 3D CAD model represented by AP 203 neutral file format, Developed a step-based feature recognition system. For the identification of B spline surface features and their sub-types. A feature recognition system developed using Java programming language. The product model data represented by STEP AP 203 format is explained by Java standard data access interface (JSDAI). The product model data is explained. And the system can identify B spline surface features, such as B spline surfaces with nodes, quasi-uniform surfaces, uniform surfaces, rational surfaces, and Bezier surfaces.

Combined with stepping NC (STEP AP 238) tool path generation, Application of extracting feature information of B spline surface is discussed [5]. Khosravan et al. designed an eye-tracking interface to develop a paradigm shift CAD system called collaborative CAD (c- CAD) to provide radiologists with a real radiology reading room experience. A new algorithm combining visual tracking data with computer aided design system is proposed. Eye tracking data (gaze) is converted into a signal model to quantitatively and qualitatively interpret gaze patterns [6].

3 INTRODUCTION TO THE OVERALL FRAMEWORK AND DEVELOPMENT PLATFORM OF THE INTELLIGENT CAD SYSTEM

In the development process of the intelligent CAD system, it is first necessary to analyze the design requirements of the system, and determine the system design scheme and its implementation platform. This chapter will determine the design framework of the intelligent CAD system as a whole and the selection of the platform in the process of system implementation according to user needs [7-9].

3.1 System Overall Design Framework

The intelligent CAD system is mainly customized for customers. Therefore, in order to achieve the purpose of complete customization, before developing an intelligent CAD system, it is necessary to understand the user's interface and functional requirements of the intelligent CAD system function, and analyze according to the demand. To design the entire system. The intelligent CAD system developed in this article is mainly to solve various problems that large assemblies appear in corporate design, so as to improve the design efficiency, design accuracy and design diversity of large assembly models, and meet the needs of enterprises for large assemblies. Smart design requirements [10-12].

3.1.1 System overall design requirements

This topic originated from a project developed in cooperation with enterprises. Its purpose is to develop an intelligent CAD system for large assemblies, and integrate assembly model lightweight technology to realize the automatic generation of large assembly 3D models, engineering drawings, and BOM tables, and shorten the design Cycle, improve design efficiency. The lightweight model is used in interactive assembly to simplify the structure of large assemblies and reduce the data capacity to ensure the smooth progress of collaborative design and dynamic simulation. The functional requirements of the system are shown in Figure 2, including the automatic generation of 3D models, engineering drawings, BOM, intelligent assembly based on model perception, and the realization of lightweight technology of assembly models [13-15].

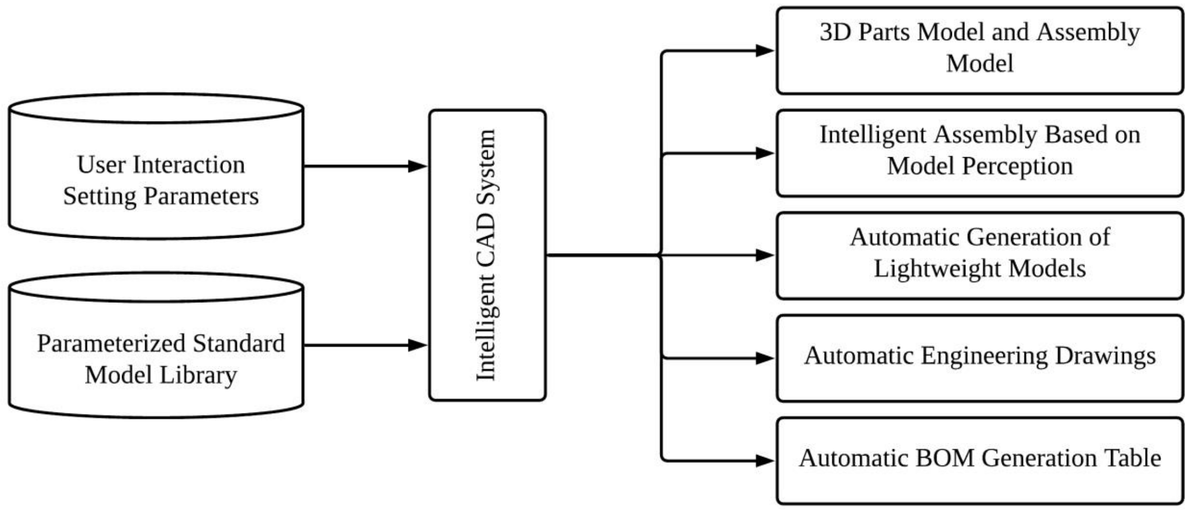

Figure 2: The functional requirements framework of the parametric design system.

3.1.2 Interface design requirements

In the intelligent CAD system, the interface is the window and link between the user and the system. The quality of the interface design directly affects the user's use of the system, thereby affecting the efficiency of using the system design. Therefore, user interface design is an important point in system design, and it must meet the following requirements:

- Design a friendly interface. It is required to be concise, beautiful, and easy to operate. Users can easily use the interface for interactive operations without special training. At the same time, the friendly interface can improve user efficiency [16-17].
- Set user prompt information and data check function. Add prompt information to each function of the interface, that is, when the user holds the mouse on the function button, the purpose, operation mode and data requirements of the function are displayed; when the user enters the data on the interface, the data needs to be checked. If the data does not meet the basic requirements, an error message will pop up to remind the user to modify the data [18-20].

3.1.3 System functional requirements

In the intelligent CAD system, in order to achieve its overall requirements and meet the design needs of users, some main functions must be added to the system, which are described in detail as follows:

- Establishment of standard model library. The model in the standard model library is fully parameterized and linked with the parameter table. The system can directly call the parameterized model in the model library during operation, and then modify the parameters in the parameter table, and the model will follow the modification of the parameter table. And automatically update.
- Automatically generate a three-dimensional model. After the user enters the relevant size parameters and attribute parameters on the interface, the intelligent CAD system will call the corresponding model in the standard model library, drive the update, and generate the required 3D model.
- Automatically generate engineering drawings. After generating the 3D model, it is necessary to generate the engineering drawing of the model at the same time and modify the relevant parameters of the engineering drawing. For the assembly model, it is also necessary to mark the corresponding assembly dimensions [21].
- Automatic assembly function. In this article, the intelligent assembly method based on model perception is adopted, that is, when the user interacts, the model will automatically sense the model that needs to be assembled and match the specific constraints. When the perception is successful, the model will be highlighted and constraints will be automatically added to the model. Realize automatic assembly.
- Realize the automatic generation of BOM. BOM is a key document in product design, so the system needs to automatically generate BOM. When the model design and assembly of the large assembly are completed, it is necessary to automatically read the relevant information in the model, and fill this information into the Excel file in a specific format to generate the BOM document required by the user.
- Lightweight assembly model. For the assembly model that the user needs to simplify, the system is required to generate a simplified model of the assembly model, and carry the assembly information of the assembly model, and replace the original model for assembly, simulation, and collaborative design. To achieve the purpose of simplifying model structure, reducing model data capacity, and hiding key design information.

3.2 Overall System Architecture

The overall design idea of the large assembly is based on the parameterized standard model library, using modular design as the means, and dividing the functional modules of the product through demand analysis, automatically updating the model, intelligent assembly based on model perception, model lightweight, etc. As a key technology, it assists in the completion of product design, and automatically generates design documents such as three-dimensional models, engineering drawings, and BOM tables that meet various applications.

Based on the idea of modular design and the characteristics of large assembly products or equipment itself, the intelligent CAD system can be divided into four parts, as shown in Figure 3: The first part is to generate a parametric meta model library based on the characteristics of the module (Equivalent to standard parts library); The second part is the intelligent design of each unit module. The system selects the appropriate meta model to drive according to the user's parameter settings, and automatically generates the assembly model of the corresponding functional module and its lightweight model, as well as the part model, engineering drawing and BOM; the third part is the product framework (assembly skeleton) design.

The frame module is a bridge that connects each functional module. It is generally delivered by man-machine according to the spatial layout of the product and the assembly method between the functional modules. In this part, a parametric skeleton model can be generated to facilitate the parameter adjustment of each module assembly; the fourth part is the intelligent assembly of each unit module and the skeleton model. It realizes intelligent assembly based on model perception between each unit module and skeleton, and obtains the 3D model, lightweight model and related design documents of the final product.

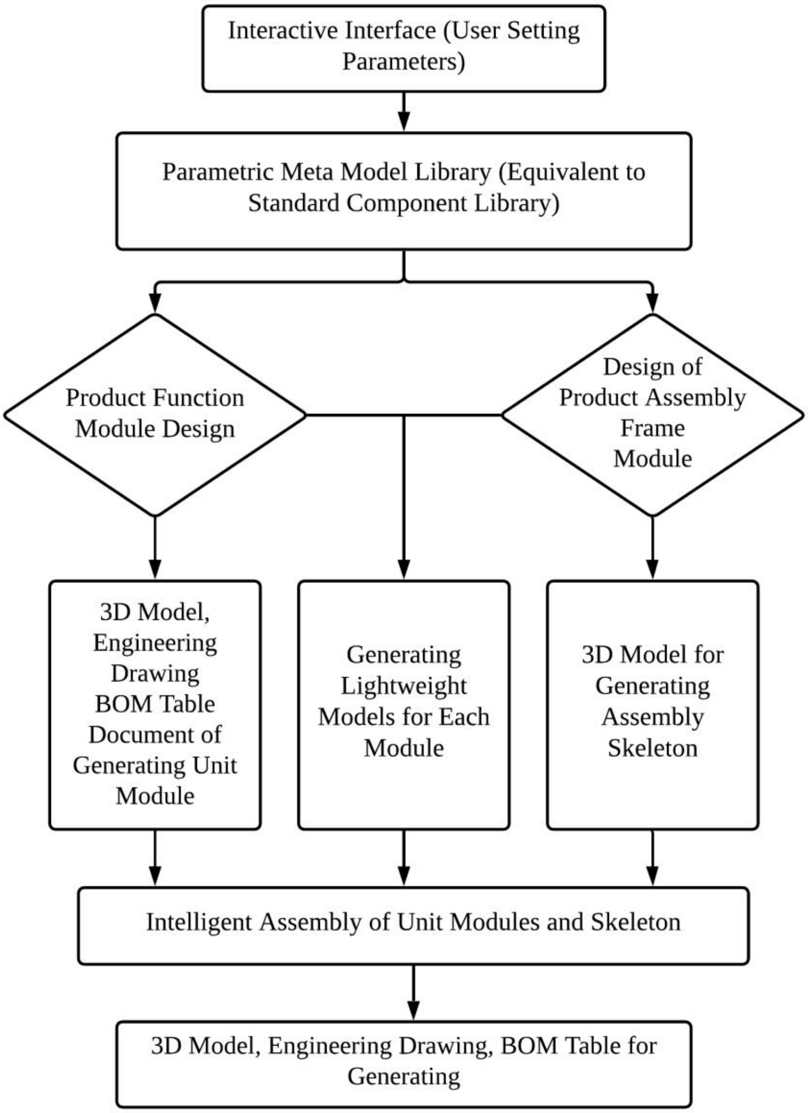

Figure 3: The overall design framework of the intelligent CAD system.

3.3 System Design Scheme Realization Process

According to the overall requirements of the system design and the design framework, the main content of the system design can be derived, including the module division of large assemblies and the establishment of a standard model library, the establishment of a friendly and concise system interaction interface, the module design of each functional unit and the final assembly Lightweight design, model, etc.

4 INTERFACE DESIGN

The interactive interface is the window through which the intelligent CAD system interacts with the user. The quality of the interface design directly affects the effect of the user using the design system. Therefore, the user interaction interface should be designed according to the interface requirements. The intelligent CAD system is a customized system, mainly used for the intelligent design of large assemblies. Therefore, the interactive interface needs to include input boxes for the main size and quantity parameters of the model, and input boxes for customized attributes of the model. The user can set the required model attributes and design information in the interactive interface.

4.1 System Function Realization

Large assemblies need to be designed with parameterized modules. Therefore, a parameterized model library needs to be established through the division of modules, and the functional modules for generating three-dimensional models of different units and the functional modules for final assembly need to be realized in the system. In each function module, it is necessary to realize the functions of automatic model update, automatic generation of engineering drawings and automatic generation of BOM table according to the parameters set by the user on the interactive interface. In the final assembly module, functions such as automatic induction and assembly of the model need to be realized. If users need lightweight models for collaborative design and motion simulation, they also need to generate lightweight models in the system.

4.2 Introduction to the System Development Platform

4.2.1 Overview of Inventor software

In recent years, with the gradual deepening of the application of CADDCAM technology, the application of 3D modeling design software has become more and more popular in enterprises. Inventor, as relatively new CAD application software, is being recognized by most enterprises. Inventor is mechanical design-oriented three-dimensional modeling software launched by Autodesk. It is powerful three-dimensional parametric design software. It combines two-dimensional and three-dimensional design with assembly functions. It is a collection of parametric solid modeling, surface modeling, and assembly modeling. , 2D and 3D are related to each other and can be converted into AutoCAD mechanical design system. It has the following characteristics:

- It combines parametric modeling and adaptive technology. Adaptive technology can change parameters and modify related parts. Make adjustments that meet the design intent to facilitate parametric modeling;
- The technical basis of the Inventor API is Microsoft automation technology, and it is convenient to use many programming languages to write your own programs. Inventor API provides almost all the functional functions of the software provide convenient conditions for secondary development;
- Inventor integrates the powerful functions of AutoCAD two-dimensional drawings, and Inventor's three-dimensional models and engineering drawings are interrelated.
- Inventor's operation interface is relatively simple, focusing on friendliness and easy operation. The functions needed for modeling are easy to find.

4.2.2 Inventor's secondary development technology

Because Inventor uses Microsoft's automation technology, users can write programs in their favorite languages, such as VBA, Visual Basic, Visual C++, Delphi, Perl, Java, etc.

4.3 Overview of Inventor API

A large number of classes are defined in the Inventor API. The model diagram of the Inventor API is shown in Figure 4, which shows the relationship between various classes and objects in the API. Here are the main classes used in Inventor.

- **Application class:** The Application class in Inventor is the entire Inventor application, which is a connection the starting point for Inventor and the classes below it. All objects of Inventor, such as Document, Property, etc., are included in the Application class.

- **Part Document class:** The Part Document class is the class of the part model in Inventor. It contains all the attributes of the part model, the features used to build the model, and other model objects related to the model.
- **Assembly Document class:** Assembly Document is an assembly model class in Inventor. In this class, it contains other sub-component objects and the constraint relationship between sub-components that make up the assembly.
- **Drawing Document class:** Drawing Document class is the engineering drawing class in Inventor. In the engineering drawing class, it includes the size parameters in the drawing, the corresponding 3D model, and the function of exporting to AutoCAD format.

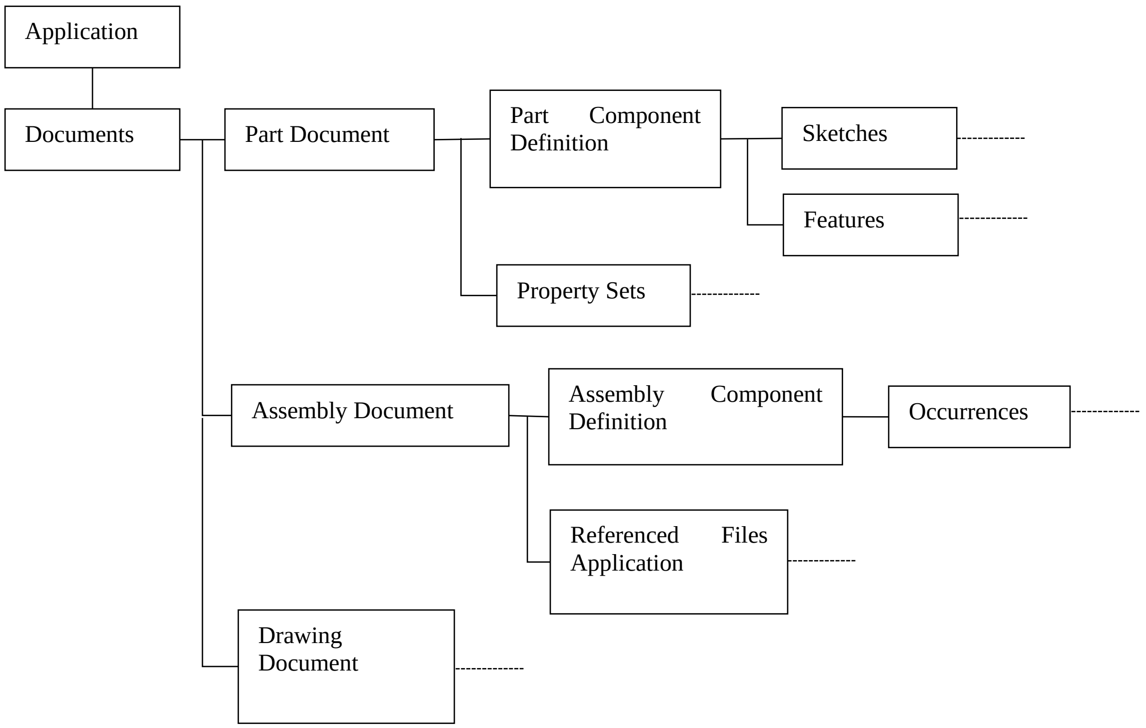

Figure 4: Object model of Inventor API.

4.3.1 COM Introduction

COM (Component Object Model), or Component Object Model, is an object model that uses components as publishing units. This model enables the components of each software to interact in a unified way. A COM component can be a DLL (Dynamic linking library) file, or an EXE (executable program) file. Using COM objects in the program has some advantages as follows:

- **Language independence.** COM is a software framework that relies on binary standards and has nothing to do with programming languages. The definition of the specification does not depend on a specific language. Therefore, the language used when writing the component object and the language used for writing the client program can be different, as long as they can generate executable codes that conform to the COM specification.
- **The encapsulation of the program.** In the COM object, the data is completely encapsulated inside the object. When the interface of the object is not opened, it is impossible for the outside to directly access the data attributes of the object, which ensures the safety of the program code and the stability of execution.

- **Transparency of the process.** The service component objects provided by COM have two process models when they are implemented: in-process objects and out-of-process objects. If it is an in-process object, it runs in the client process. If it is an out-of-process object, it runs in another process space on the same machine or in the process space of a remote machine.
- **Reusability.** The reusability of COM objects can ensure that COM can be used to construct large-scale software systems. It simplifies complex systems into simple object modules.

4.3.2 Develop Inventor program based on COM

Inventor API provides users with 3 secondary development methods, Application Automation, Add-In, apprentice Server, their relationship with Inventor is shown in Figure 5, and various development methods can be successfully implemented required features.

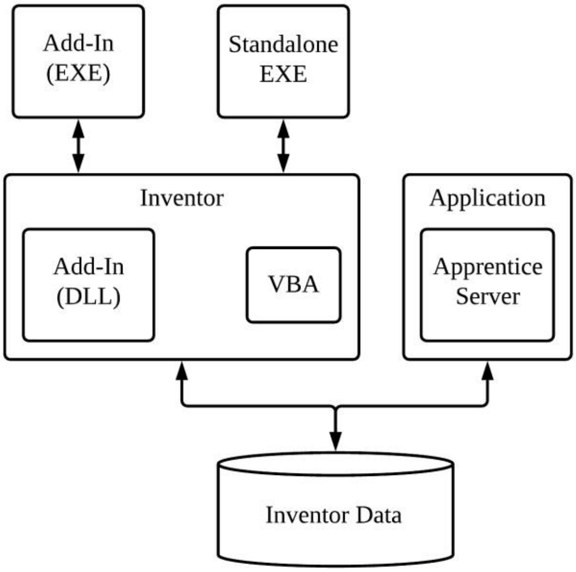

Figure 5: Accessing Inventor through API.

Add-In is a special application in Inventor, which can be loaded when Inventor is started, can freely create menus and buttons, design user interfaces, can freely access Inventor API, and can be implemented with Inventor during operation seamless connection. The basis of the connection between Add-In and Inventor is based on COM technology, and the communication between them is also based on the COM communication function. The interface Application AddIn Server provided in Inventor is closely related to the creation and life cycle of COM components. There are two important functions in the interface, Activate() and Deactivate(). Activate() is called when Add-In is loaded, and Deactivate() is called when unloading.

```
*************The code of Activate() function in Inventor ****************
STDMETHODIMP CUserAddInServer::Active(VARIANT_BOOL FirstTime) {
AFX_MANAGE_STATE(AfxGetStaticModuleState());
m_pApplication=this->m_pAddInSite->GetApplication();
…………Perform the required function in the function
return S_OK;
/************************End***********************/
```

4.3.3 Introduction to Visual Studio 2005

Visual Studio 2005 is an integrated development tool environment launched by Microsoft that integrates the .NET framework. In this integrated development environment, many powerful tools and a variety of programming languages are assembled, such as Visual C++, Visual Basic, Visual C#, Java and HTML etc. [47]. Microsoft Company integrates all development languages in an environment platform, and all language environments share a resource platform and a system framework, which completely changed the previous programming model. How different is Visual Studio 2005 from other versions of Visual Studio before Microsoft? It is not only for developers, but also an enterprise-level application. In the entire program design process, architects, designers, developers and testers can use this system. When using Visual Studio 2005 for program design, the program has a framework, easy to use tools, strong resource integration and sharing, complete auxiliary functions. Features such as easy to link add-in programs, therefore, in the program development of this article, I choose Visual Studio 2005 as the environment for developing program modules, and at the same time call some VB program modules in it, and use mixed programming to complete the system development.

4.4 Use Visual Studio 2005 to Establish and Develop Inventor Program

According to the above introduction to the secondary development technology of Visual Studio 2005 and Inventor, you can use Visual Studio 2005 to establish a COM plug-in linking Inventor and load it in Inventor to realize seamless link with Inventor.

In order to facilitate the user's secondary development and application of Inventor, Inventor provides users with a DLL link template based on Visual Studio 2005. When this template is used to create a DLL project, the user is added to the program to link the COM interface of Inventor. Users can easily design the interface and program function modules they need in the template project. Of course, users can also write their own familiar COM interface to link Inventor according to their own programming habits. Implement the buttons in the plug-in in the established DLL program, and implement their Click events, and design corresponding response program modules for each corresponding button event. After registering the written DLL in the computer, the plug-in will appear when starting Inventor. At the same time, when the button is clicked, the designed user interface will pop up for the user to interact with the system.

5 CONCLUSION

This article mainly introduces the intelligent CAD system design framework, including the demand analysis and design requirements of system design, the process of CAD system to realize intelligent design and the key technologies needed. Introduced the software platform Inventor for system development and its secondary development technology, and explained how to use Visual Studio 2005 to establish a seamless connection with Inventor. In order to achieve various functions in the intelligent CAD system, specific methods and key technologies need to be studied. Such as the establishment of standard model library, automatic model update and automatic assembly method, engineering drawing and automatic generation method of BOM, etc. Through the realization of these key technology algorithms in the intelligent CAD system, the intelligent design process of large assemblies is completed.

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REFERENCES

[1] Bansal, S.: U-healthcare monitoring systems a hybrid cad system design for liver diseases using clinical and radiological data, 2019, 289-314. https://doi.org/10.1016/B978-0-12-815370-3.00012-8

[2] Xie, J.-X.; Cury, R.-C.; Leipsic, J.; Crim, M.-T.; Shaw, L.-J.: The coronary artery disease-reporting and data system (cad-rads): prognostic and clinical implications associated with standardized coronary computed tomography angiography reporting. Jacc Cardiovascular Imaging, 11(1), 2018, 78. https://doi.org/10.1016/j.jcmg.2017.08.026

[3] Abdel, R.-A.-A.-K.; Magdy, E.-M.; Mohamed, Y.-M.; Mohamed, N.-H.: Inter-observer agreement of the coronary artery disease reporting and data system (cad-radstm) in patients with stable chest pain, Polish Journal of Radiology, 83, 2018, e151-e159. https://doi.org/10.5114/pjr.2018.75641

[4] Bae, Y.; Park, C.; Mun, D.; Han, S.: Development of a system to translate catalog data of equipment and materials from a neutral model to a plant 3d cad system, CDE, 23, 2018. https://doi.org/10.7315/CDE.2018.144

[5] Venu, B.; Komma, V.-R.; Srivastava, D.: Step-based feature recognition system for b-spline surface features, International Journal of Automation and Computing, 15(4), 2018, 500-512. https://doi.org/10.1007/s11633-018-1116-0

[6] Khosravan, N.; Celik, H.; Turkbey, B.; Jones, E.-C.; Bagci, U.: A collaborative computer aided diagnosis (c-cad) system with eye-tracking, sparse attentional model, and deep learning, Medical Image Analysis, 51, 2018. https://doi.org/10.1016/j.media.2018.10.010

[7] Barringer, H.; Fellows, D.; Gough, G.; Williams, A.: Rainbow: Development, simulation and analysis tools for asynchronous micro-pipeline hardware design, The Computer Journal, 45(1), 2002, 2-11. https://doi.org/10.1093/comjnl/45.1.2

[8] Hongwei, L.; Qi, C.; Xiaoting, Z.: The convergence of least-squares progressive iterative approximation for singular least-squares fitting system, Journal of Systems Science & Complexity, 31(06), 2018, 218-232. https://doi.org/10.1007/s11424-018-7443-y

[9] Piantadosi, G.; Marrone, S.; Fusco, R.; Sansone, M.; Sansone, C.: Comprehensive computer-aided diagnosis for breast t1-weighted dce-mri through quantitative dynamical features and spatio-temporal local binary patterns, IET Computer Vision, 12(7), 2018, 1007-1017. https://doi.org/10.1049/iet-cvi.2018.5273

[10] Mei, H.; Guo, F.; Chen, H.; Chen, Y.: Visual Exploration of Differences Among DTI Fiber Models, Chinese Journal of Electronics, 27(5), 2018, 959-967. https://doi.org/10.1049/cje.2018.06.015

[11] Pel, A.-J.; Bliemer, M.-C.; Hoogendoorn, S.-P.: A review on travel behaviour modelling in dynamic traffic simulation models for evacuations, Transportation, 39(1), 2012, 97-123. https://doi.org/10.1007/s11116-011-9320-6

[12] Ma, S.; Zhang, Y.; Sun, C.: Optimization and Application of Integrated Land Use and Transportation Model in Small-and Medium-Sized Cities in China, Sustainability, 11(9), 2019, 2555. https://doi.org/10.3390/su11092555

[13] Adnan, F.-A.; Romlay, F.-R.-M.; Shafiq, M.: Real-time slicing algorithm for stereolithography (STL) CAD model applied in additive manufacturing industry, Iop Conference, 342, 2018, 012016. https://doi.org/10.1088/1757-899X/342/1/012016

[14] Zhang, C.; Zhou, G.; Yang, H.; Xiao, Z.; Yang, X.: View-based 3-d cad model retrieval with deep residual networks, IEEE Transactions on Industrial Informatics, 16(4), 2020, 2335-2345. https://doi.org/10.1109/TII.2019.2943195

[15] Haque, A.; Elsaharti, A.; Elderini, T.; Elsaharty, M.-A.; Neubert, J.: Uav autonomous localization using macro-features matching with a cad model, Sensors, 20(3), 2020, 743-. https://doi.org/10.3390/s20030743

[16] Zhu, H.; Liu, Y.; Wang, H.; Zhao, J.: Efficient construction of the medial axis for a cad model using parallel computing, Engineering with Computers, 34(3), 2018, 413-429. https://doi.org/10.1007/s00366-017-0549-3

[17] Lin, X.; Zhu, K.; Wang, Q.-G.: Three-dimensional cad model matching with anisotropic diffusion maps, IEEE Transactions on Industrial Informatics, 14(1), 2018, 265-274. https://doi.org/10.1109/TII.2017.2696042

[18] Han, Z.; Mo, R.; Yang, H.; Hao, L.: Structure-function correlations analysis and functional semantic annotation of mechanical cad assembly model, Assembly Automation, 39(4), 2019, 636-647. https://doi.org/10.1108/AA-09-2017-109

[19] Khosravan, N.; Celik, H.; Turkbey, B.; Jones, E.-C.; Wood, B.; Bagci, U.: A collaborative computer aided diagnosis (c-cad) system with eye-tracking, sparse attentional model, and deep learning, Medical Image Analysis, 51, 2019, 101-115. https://doi.org/10.1016/j.media.2018.10.010

[20] Bergstroem, P.; Fergusson, M.; Sjoedahl, M.: Virtual projective shape matching in targetless cad-based close-range photogrammetry for efficient estimation of specific deviations, Optical engineering, 57(5), 2018, 053110.1-053110.11. https://doi.org/10.1117/1.OE.57.5.053110

[21] Shu, H.; Han, Y.; Huang, R.; Tang, Y.; Zhang, Y.: Fault model and travelling wave matching based single terminal fault location algorithm for t-connection transmission line: a Yunnan power grid study, Energies, 13(6), 2020, 1506. https://doi.org/10.3390/en13061506