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# Research on the Teaching Resource Construction System of Computer VR Online Interactive Experiment Platform for Mechanical Engineering Graphics



**Abstract:** - The introduction of three-dimensional design experiment teaching in engineering drawing teaching. The experimental platform of "network engineering drawing" is established, and the corresponding multimedia teaching software is developed using WebVR, ASP, database and other technologies. The 3D modeling method of the reducer is established by using UGNX and optimized accordingly. In order to solve the problem that UGNX mode introduces packet loss in the simulation system, the model and data are reconstructed separately. Using VisualStudio2019 as the development platform, the 3D modeling of the reducer is realized. The establishment of the engineering graphics design virtual simulation system helps enterprises to simulate operations before actual production and processing. It greatly improves production efficiency and reduces production costs.

**Keywords:** Engineering Drawing; Test System; VR, Web; Computer Aided Instruction.

## I. INTRODUCTION

In recent years, due to the rapid development of computer and modern manufacturing technology, the research of three-dimensional modeling and technology has gradually penetrated into people's life. In the course of engineering drawing, it is necessary to pay attention to the research of spatial modeling, spatial modeling, spatial modeling, etc., in order to improve students' spatial modeling and creative ability. Therefore, the course of engineering drawing is deeply studied, and the course system of engineering drawing is established with students of engineering drawing major as the main body [1]. In western countries such as Europe and the United States, the research on virtual simulation started relatively late. Among them, the platform architecture MCO, Virtualizer Svlis, CODY and CREO are relatively mature virtual prototype simulation systems. In 2014, General Corporation of the United States developed a set of electronic simulation experimental platform based on electronic equipment to realize the simulation of underwater environment detection, underwater oil exploitation and other scenarios, so as to improve the safety and training effect of external engineering operations [2]. In 2015, the German Fraunhofer Institute cooperated with the French Council for Nuclear and Renewable Energy to set up a "virtual assembly" test platform for industrial manufacturing engineering, solar cells and other fields. A 3D modeling method based on computer vision is proposed.

In 2017, NASA used various virtual reality means to build a spacecraft model facility and neutral buoyancy laboratory, which realized real-time acquisition of spacecraft fuel temperature, attitude and other parameters during flight, and carried out visual simulation of the whole process of its in-orbit operation [3]. In addition, the UIC Mechanical Virtual Reality Institute in the United States, the AI and Virtual Reality Laboratory of Bielefeld University in Germany, and the Machine Manufacturing and System Laboratory in Osaka, Japan, have also set up virtual reality courses related to process processing, manufacturing design, decision support, logistics management, etc. For example, the virtual simulation experiment of CODY in Germany is based on the parts library of mechanical manufacturing and electronic manufacturing, and uses universal natural language instructions to interact with it. The Machine Manufacturing Technology and Systems Laboratory in Osaka, Japan is mainly engaged in the research of 3D modeling, virtual manufacturing systems, virtual reality and parallel processing technology, and the establishment of the construction environment of virtual equipment.

At present, the domestic research work on Unity3D virtual simulation technology takes Wuhan University of Technology as the main body and relies on CIMS Technology Center of Tsinghua University and Intelligent Manufacturing and Control Institute of Wuhan University of Technology to build a virtual test platform based on AR technology to realize the simulation and realization of real tests [4]. For example, the national CIMS Engineering Research Center takes the high-speed rapier loom of the enterprise as the research object, and carries

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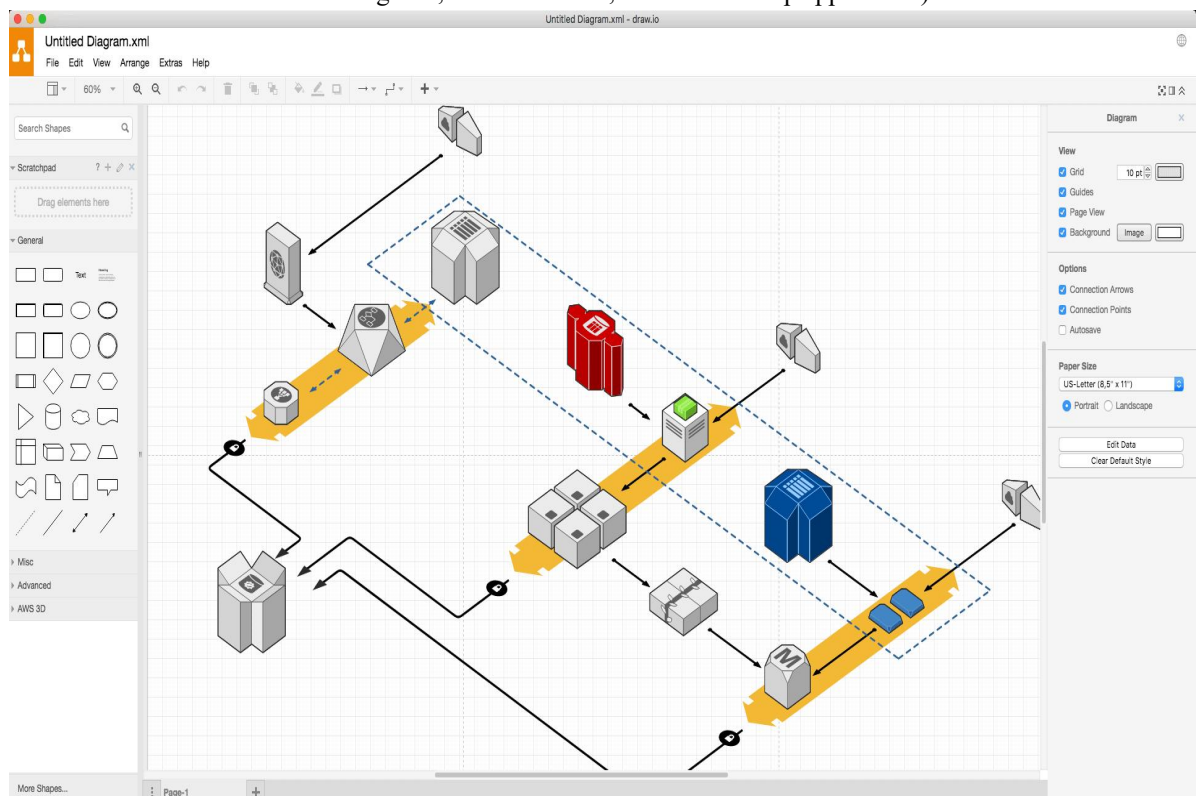
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out the simulation development of the various institutions of the product, and applies it to the development plan formulation and product development implementation process [5]. The Automation and Automation Research Institute of Wuhan University of Science and Technology is mainly devoted to the practical application of product prototype design, virtual layout and virtual assembly in the production process. Later, some researchers used VRML and CREO and other virtual simulation systems to develop a virtual simulation experiment platform for automotive engines and cams, and realized 3D modeling of automotive engines and cams and other structures, which greatly improved the feasibility of virtual test design and simulation, and shortened the time of simulation experiment [6]. In order to allow students to create a sense of immersive participation in the engineering drawing experiment process, and be able to interact with the experiment target in real time. This method is used to establish an interactive situation for creating and guiding simulation experiments, so that readers can have a deeper understanding of the concept of space geometry and the interaction and connection between objects, and generate their own views and opinions on it, so as to promote the construction of knowledge and meaning, thus improving the level and creativity of three-dimensional design and saving a lot of experiment costs.

## II. INTRODUCTION TO THE EXPERIMENTAL TEACHING SYSTEM OF ENGINEERING DRAWING

The course of Engineering Drawing is a basic course for engineering majors, and there is a great fusion relationship between its theoretical courses and practical courses. In the process of experimental teaching, people should pay attention to the comprehensive and profound coverage of the knowledge and methods of drawing, and closely connect with the teaching content of drawing course. The prerequisite for doing a good experiment is to have a solid basic knowledge and theoretical foundation. Engineering Drawing course is a kind of auxiliary education mode based on network VR technology, which is student-centered, student-centered and student-centered [7]. In order to better meet the characteristics and needs of engineering graphics course, this paper divides the experiment into four types: verification type, design type, comprehensive type and research type, and gives the snippet of network browsing. A snippet of its web page is shown in Figure 1 (The image is referenced to Draw.io - The best technical drawing tool, free and online, has now desktop application).



**Fig.1** Snippets of web browsing

### A. Confirmatory test

Confirmatory experiment is the necessary link to lay a good foundation and master basic technology, is the starting point from theory to practical application, and is the basis for training students to discover, analyze and solve problems [8]. Through the test of the projective principle, students learn how to use experimental methods

to study and prove some phenomena and results. Students can understand the basic skills of computer drawing and three-dimensional modeling using software, and establish the concept of three-dimensional modeling.

#### *B. Design experiment*

Design experiments are explorative in theme. The use of simulated 3D design can leave more opportunities for students to think and create, change them from a negative state to a positive learning style, improve their experimental skills and scientific literacy, and consolidate and deepen the theoretical knowledge they have learned [9]. In particular, they can cultivate, exercise and improve their ability to use all kinds of knowledge. In order to meet the different levels of students, flexible teaching content is set up in the teaching.

#### *C. Comprehensive experiment*

Comprehensive experiment is a key link in the training of engineering 3D design for students. The content of the experiment is practical, practical, comprehensive and typical. Students are required to effectively apply the knowledge they have learned, prove the scheme and feasibility of it, and then learn the relevant knowledge and skills of scientific research [10]. It focuses on developing independent thinking and high scientific literacy.

#### *D. Research experiment*

With inquiry experiment as the core, it focuses on cultivating students' innovation and application ability. Through this project, students can understand the process and method of scientific research, broaden their horizon, enhance their independent inquiry ability, and promote their engineering practice, innovation and research ability development. In this experimental system, the setting of each experiment is aimed at the basic knowledge, so that students can gradually integrate these knowledge from complex to simple, from complex to simple [11]. The content of the experiment includes experiment objective, experiment requirement, experiment procedure, experiment tool, experiment result and virtual demonstration. According to the characteristics of engineering drawing course, a cartographic experiment system based on 3D animation is designed. In order to improve teaching efficiency and improve teaching efficiency, this project will study Internet oriented virtual reality (WebVR). The design and development of WebVR in engineering drawing comprehensive test system have realized simulation, real-time interaction, sharing and reusability [12]. With its unique sense of immersion, interactivity and imagination, network VR provides a new learning mode for the independent learning advocated by constructivism, changes the teaching mode of promoting learning by teaching, and enables students to interact and cooperate with the information environment to acquire knowledge and skills.

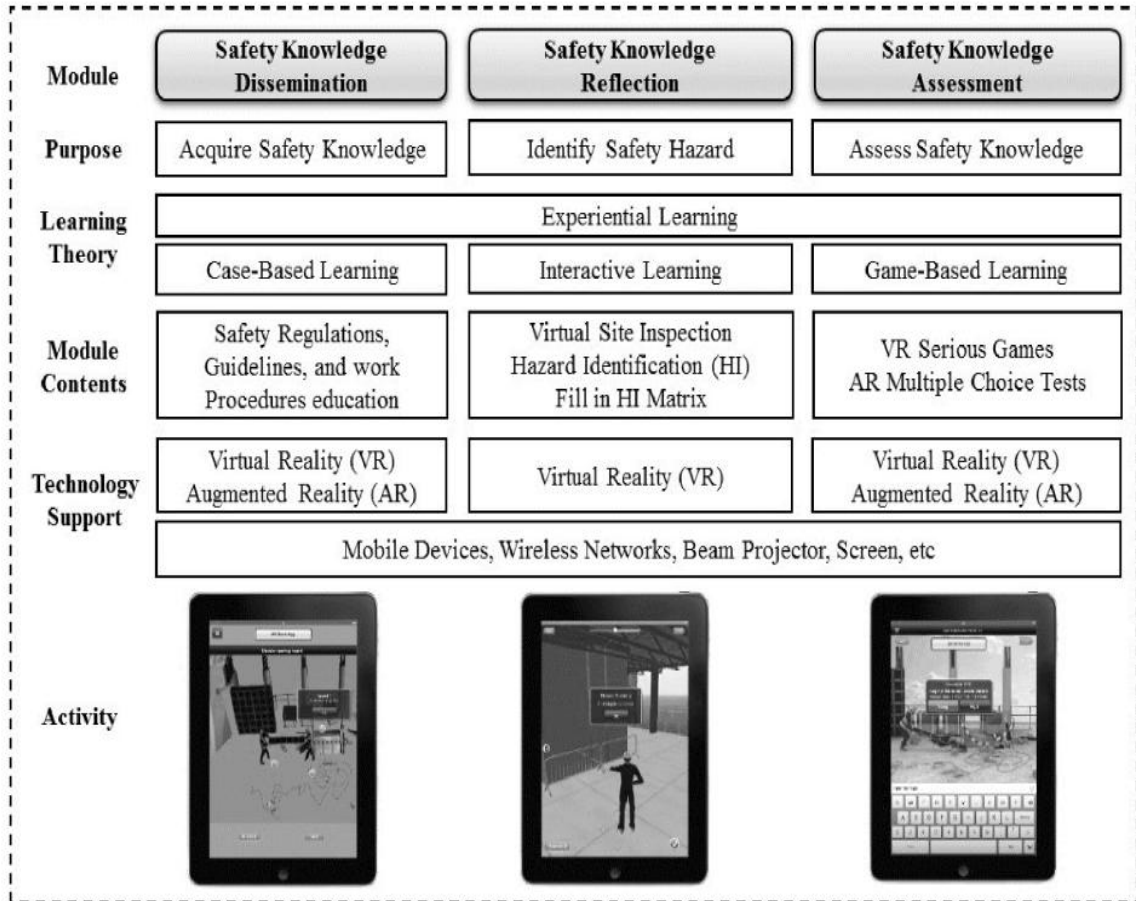
### III. SYSTEM DESIGN IDEAS AND OVERALL DESIGN FRAMEWORK

#### *A. System Framework*

Most of the current online education websites are based on Dreamweaver, FrontPage, HTML, ASP, JavaScript, VB script and other languages for development, its network cost and user demand are high, the page running rate is very low, the user's enthusiasm has been greatly hit. Even tasks such as refactoring have become more onerous. This paper uses ASP.net technology, VisualBasic.net for software design, SQLServer2000 as the background, the use of ASP.net ADO.NET to combine web pages and databases to ensure advanced technology, data security, website stability, and the content and function of the test system integrity [13]. And it is integrated with FrontPage, AutoCAD, FlashMX, Photoshop, 3D MAX, Pro/E and other tools to complete the design and production of human-computer interaction interface. In order to achieve the purpose of human-computer interaction, this study designed a web-based web page with certain browsing function to carry out experimental teaching. Moreover, in the content of the experiment, also adopted a modular way, these experiments as a specific segmentation basis, there is a super connection between each test, can let you quickly jump to any test, so that the page of the website will become more intuitive, more organized, more intuitive, more intuitive, more convenient.

The architecture adopts the architecture of browser, server and database three levels, all the client virtual scene files and interactive control programs are downloaded from the server to the client, the client browser interface through the server and database for data exchange, and some interaction process is carried out on the client, without any communication with the server [14]. Thus, the bandwidth burden of the network is reduced, and unified resource management and system maintenance can be realized. net has a good application prospect in B/S architecture, which has a good application prospect and a good application prospect. The structural block diagram of the whole system is given in Figure 2 (the picture is quoted in A Framework for Using Mobile Based Virtual Reality and Augmented Reality for Experiential Construction Safety Education).

ASP.net, ADO. net and C# are used to access the database, which enhances the security performance of the system. All dynamic data, confidential data and general data are stored in the SQLSERVER database, which can not only ensure the security of the data, but also can quickly access the data, and will not consume the user's resources. The database of the test system is constructed based on the existing Microsoft Office Access 2003, and the functions of database query, sorting, adding and deleting are carried out.



**Fig.2** Overall architecture diagram of engineering drawing auxiliary system

*B. System Hardware and Software*

The system is composed of computer equipment, wearable sensing equipment, CAVE projection equipment, etc. It is divided into base layer, interactive layer and data layer. In this system, the interactive interface between the user and the computer workstation is constructed through the handheld controller and the hybrid dynamic capture server, and the data of the multi-variable mechanism is processed efficiently.

In terms of software, this paper puts forward a method for automatic disassembly and reassembly of various machine products, and introduces a variety of system design methods, which can solve the problems of multi-man-machine interaction assembly, virtual parts inspection and so on. The software is mainly composed of data layer, interface layer, platform layer and application layer [15]. The details are shown in Figure 3 (the picture is quoted in Automated integration of extract-based CFD results with AR/VR in engineering education for practitioners).

The processing of data information is abstracted and classified based on the existing machinery and equipment, which also includes the processing of the input user data, and the standardized form of the parts and production plans of the machinery and equipment [16]. Typically, these files are stored in the form of JSON for easy access by multiple user principals in the system.

The application system mainly includes two aspects: human-computer interaction and three-dimensional visualization simulation. In the visual 3D simulation, Unity3D virtual platform, combined with 3D model import, model mapping, LOD model drawing and other means, realized the structure of mechanical equipment in a 3D environment, human-computer interaction interface layout, and provided interactive feedback, simulation process

display and other functions. The role of the human-machine interaction component is mainly to accept and process the user's input information [17]. In the virtual projection space of CAVE, the human-machine interaction is conducted on the design, production and manufacturing process of mechanical products through wearable perception, wearable perception and other devices, and finally the best arrangement is decided.

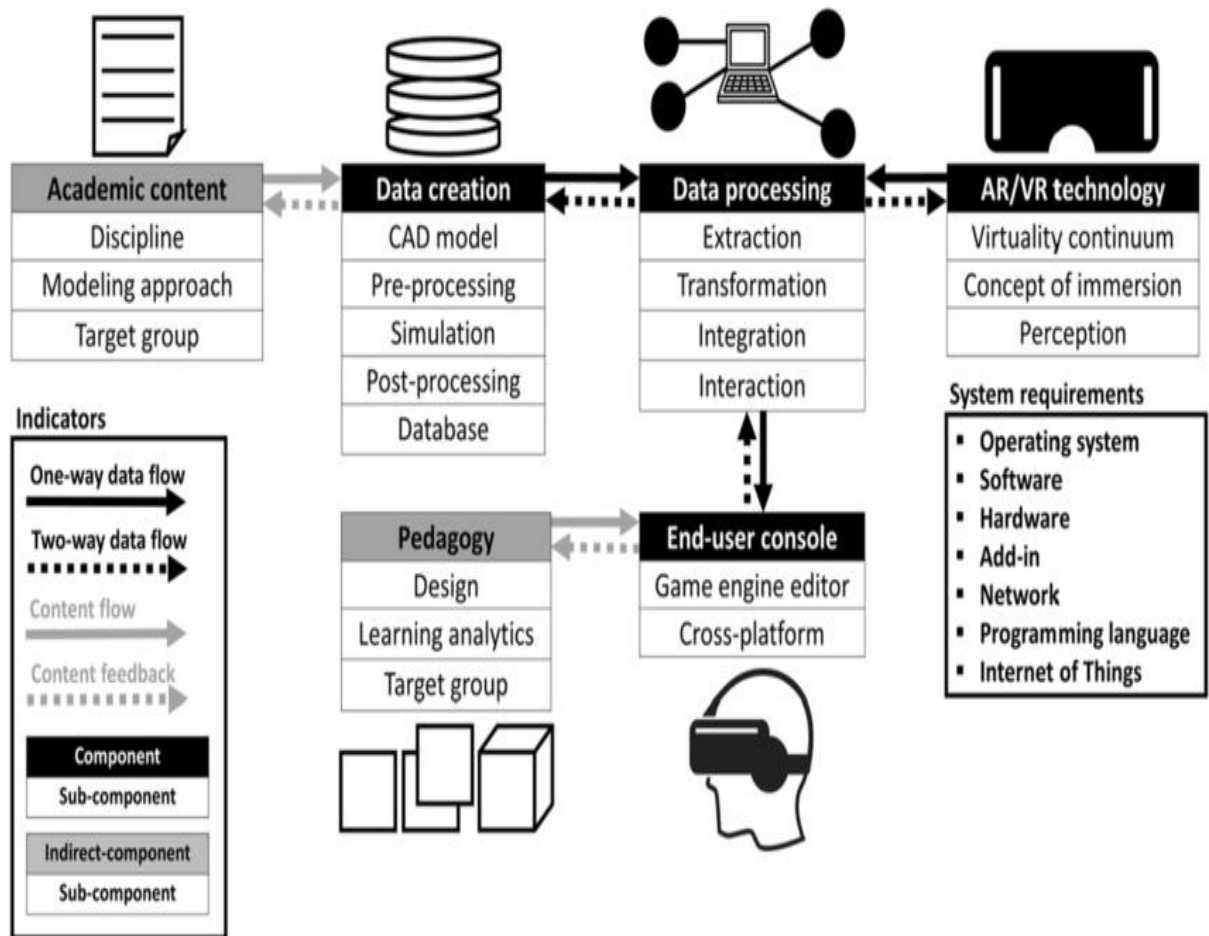


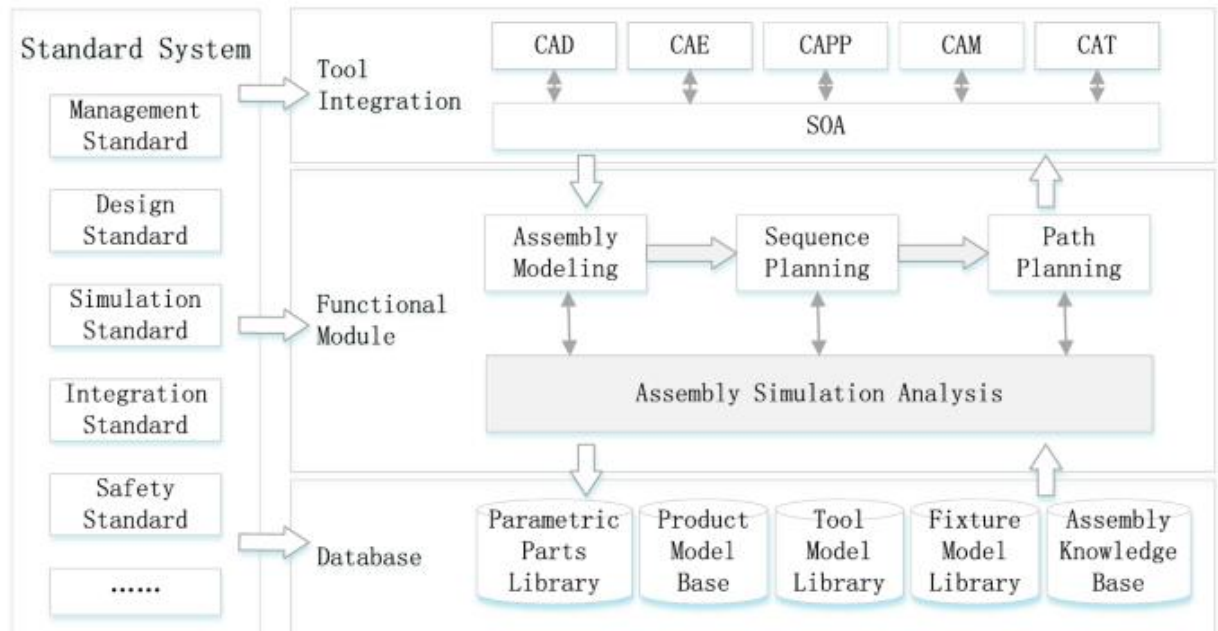
Fig.3 Mechanical design virtual simulation system schematic

C. Research on virtual simulation platform architecture of the system

The virtual simulation technology of mechanical design is widely used in the design department and the production and processing department of enterprises, through the virtual simulation of the production and assembly process of mechanical equipment. The detailed Architecture is shown in Figure 4 (The picture is quoted in Research on Intelligent Manufacturing System Architecture and Key Technology of Radar Complete Machine Assembly).

User access to the interface is the primary obstacle to background checking. This level is to access enterprise staff and other users, the use of database component information, set up a network security communication protocol, TCP/IP screening gateway, to control the data access of the system. Then there is the data layer, the service logic layer, the physical functionality layer, and finally the data layer. The data layer is a simulation module of the type of understanding, which can be used to analyze the disassembly data of the automatic packaging machine and the disassembly data of the reducer through the mastery of the mechanical structure and the familiarity of the parts disassembly process, and also requires the standardization of the data of the mechanical parts in order to support the structural design, production and processing of the parts in the future [18]. The business logic layer is the application part of practical operation. It uses the Microsoft QLServer2008 database management system and chooses Unity3D, VR interaction, 3DSMAX and other software to model network applications and virtual 3D models, and realize the simulation and assembly of enterprise organization design and project production. Design the user interaction logic with the virtual environment. Especially in the development and design of a new mechanical product, the above mechanical structure disassembly and reorganization data can be used to modify the size of the original product parts and optimize the disassembly

operation by using mechanical devices such as automatic packaging machines. The physical functional layer is the inspection level of mechanical products. Through the virtual simulation of the mechanical design system as a whole, the network program and the virtual modeling scene are organically integrated, and rolling bearings, reducers, etc. are tested to find out the mechanical structure and assembly problems in the mechanical design system, and the improvement plan is proposed accordingly.



**Fig.4** Architecture of a virtual simulation system for institutional design

#### D. Mechanical modeling and input

In this system, a 3D simulated virtual environment is first built through a Web page, and then the solid modeling design is carried out around the measurement of bearing and gear parameters and the disassembly and disassembly of the reducer. It is usually through SolidWorks, 3DSMAX, Maya and other modeling tools to build the mechanical model to be used, mainly by inputting the drawn CAD graphic document into 3DSMAX, obtaining the construction information of the object's X axis, Y axis and Z axis, and modeling the height and Angle of the three-dimensional object. Then the vertices, corner points, chamferes and contours are spliced and closed, and finally converted into editable polygons, so as to realize the modeling of three-dimensional objects [19]. Through 3DSMAX, the generated model is output in the form of STL file, and the SolidWorks plug-in is used to optimize the local part of the model, such as reducing the number of models, deleting the part that cannot be seen, deleting the part that has no obvious role in the formation of the model, and then the model is divided into multiple groups, and at the same time, the convergence points and planes in the model are merged. It provides convenience for future LOD drawing.

##### 1) Modeling mapping and baking

Among them, modeling the structure of the machine is the key to ensure the visual effect. The application of light mapping, baking, normal mapping and other methods to virtual environment can strengthen the optimization of virtual scene and model rendering. After using Unity3D to map the Light of the machine, open the Lighting window, select Directional Light, Pointlight, Baked, mixed and real-time time, and select "Baked" from the light source component. Then click the Build key below the Scene interface to bake the machines in the virtual scene. Detailed parameter adjustment is shown in Figure 5 (the picture is quoted in Computers & Graphics, Volume 109, December 2022, Pages 75-87).

In addition, in order to meet the detailed display requirements of computer 3D images, this paper proposes a method based on convex and concave mapping to realize the normal mapping of machine entities. The normal mapping technique optimizes the 3D model by pasting a 2D image over the existing 3D model. Update normals in real time and show additional details on the surface of the model, while the overall shape of the model remains unchanged.

##### 2) LOD rendering of virtual model

LOD rendering, also known as layered detail rendering, is a high-precision real-time rendering of moving objects in a three-dimensional environment. However, when the computer equipment has a great demand for processing equipment such as CPU and GPU, the real-time rendering of complex 3D scenes cannot be realized. LOD is based on 3D modeling as the core, with 3D modeling as the core, to build a variety of high-precision 3D rendering models [20]. For example, LOD technology was introduced into Unity3D, which focused on the binary division and self-cutting surface operation of mechanical rolling bearings, gears and reducers, so as to realize the modeling of various levels of accuracy. LOD placed the same LOD object in a specific position based on the elimination of geometric graphics, and selected component, reposition and LOD group commands on the Unity3D platform, and then clicked Add. The collapse vertices and collapse sequences generated by the method are smoother (Figure 6 is quoted in Using Multi Agent Systems to Computationally Study Set-Based Concurrent Engineering).

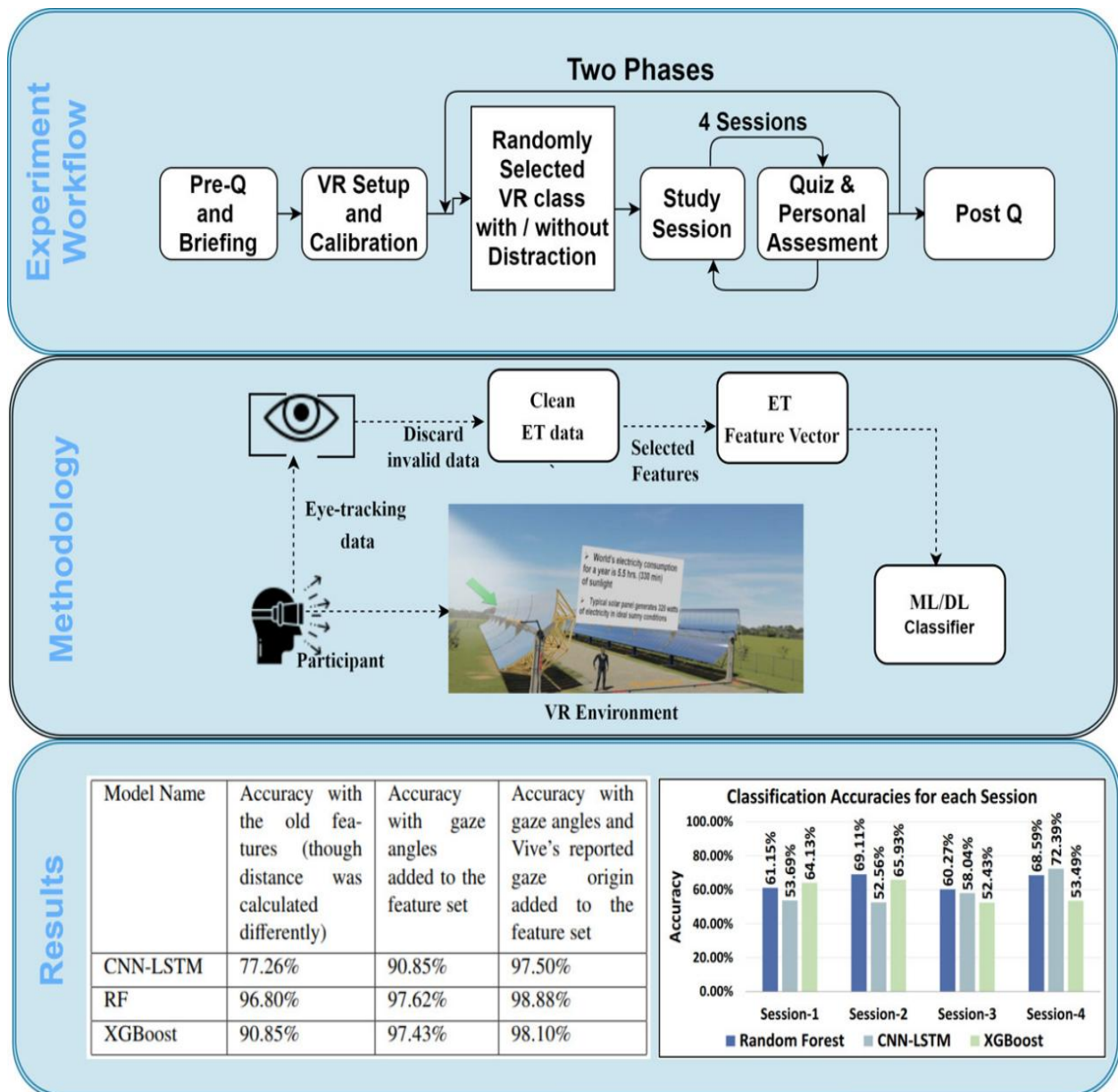


Fig.5 Tuning the machine in a virtual environment

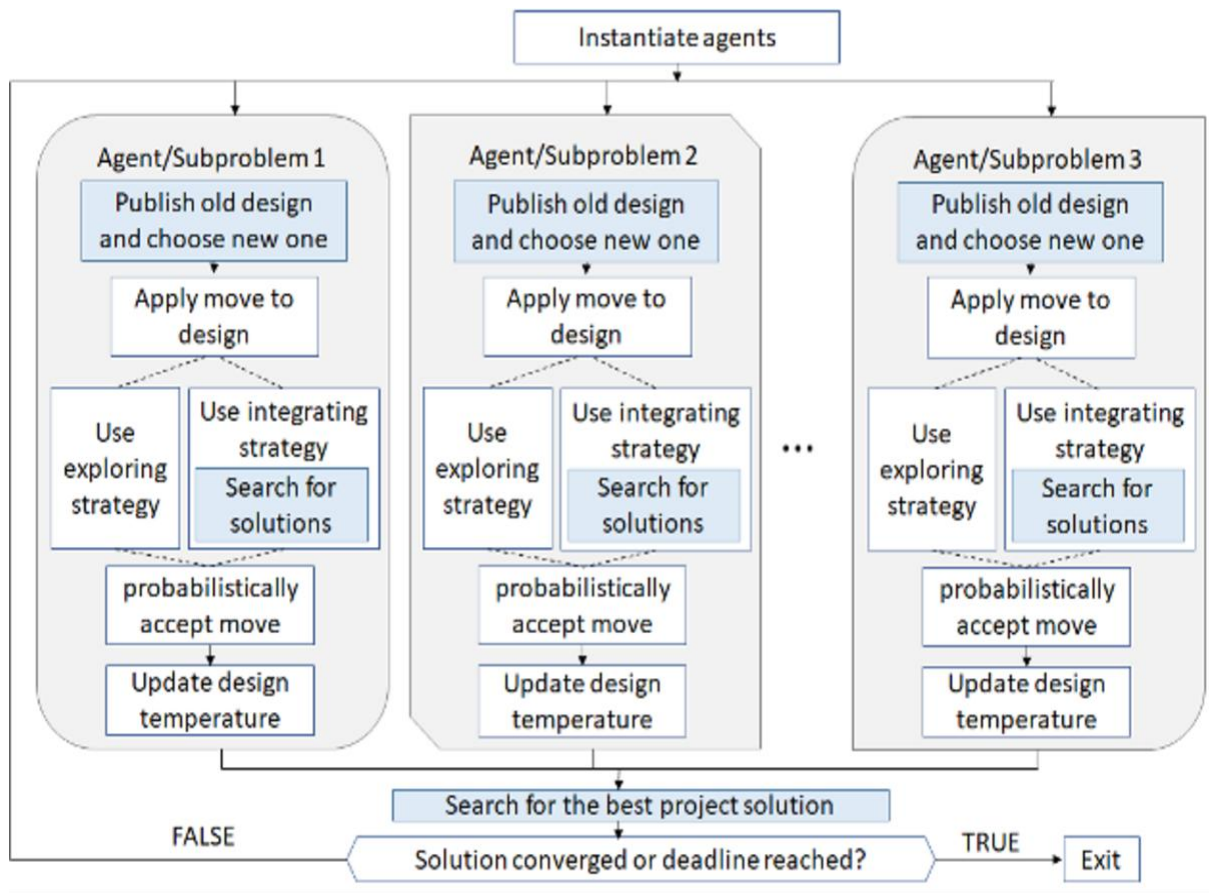


Fig.6 Diagram drawn by LOD

### 3) Occlusion removal in virtual simulation

In the virtual simulation modeling research of mechanical products, different virtual scenes and mechanical disassembly equipment are often produced at the same time, and most of these objects are not within the scope of virtual camera. Therefore, the Unity3D engine can automatically remove some unwanted or uncaptured objects. In the scene, a shaded area composed of cells is generated, in which every cell is a shaded area. Unity3D can only draw objects that can be seen by the camera, but not distant machine-structured objects.

## IV. VIRTUAL SIMULATION OF RV REDUCER ASSEMBLY WITH CARLA OPTIMAL METHOD

Using CARLA learning loop optimization method, RV reducer 3D modeling virtual assembly, structural innovation design and other virtual realization simulation were carried out, and by selecting the strategy to select the loop, the multi-mode control such as component structure design and assembly creation jump was completed [21]. First, the strategy selector is used to find the RV deceleration components required globally, and then the CARLA learning loop is set to 10% environment fitness value to achieve optimal control through interaction. Figure 7 shows the execution of CARLA's loop optimization performance (picture cited in Mathematics 2022, 10(19), 3635).

The structure of RV reducer is modeled based on adaptive reinforcement method of continuous behavior. First, the number of mechanical parts, particle intervals and the number of iterations are initialized. Then using CARLA learning loop, the RV reducer components are segmented particle positioning [22]. By optimizing the genetic algorithm of each individual, the optimal positioning of each individual in the population is obtained. The last steps 5 and 6 are mainly to update the particle swarm velocity and the local optimal and global optimal position, and iterate for many times until successive generations  $m$ , and the fitness value does not change in the virtual environment.



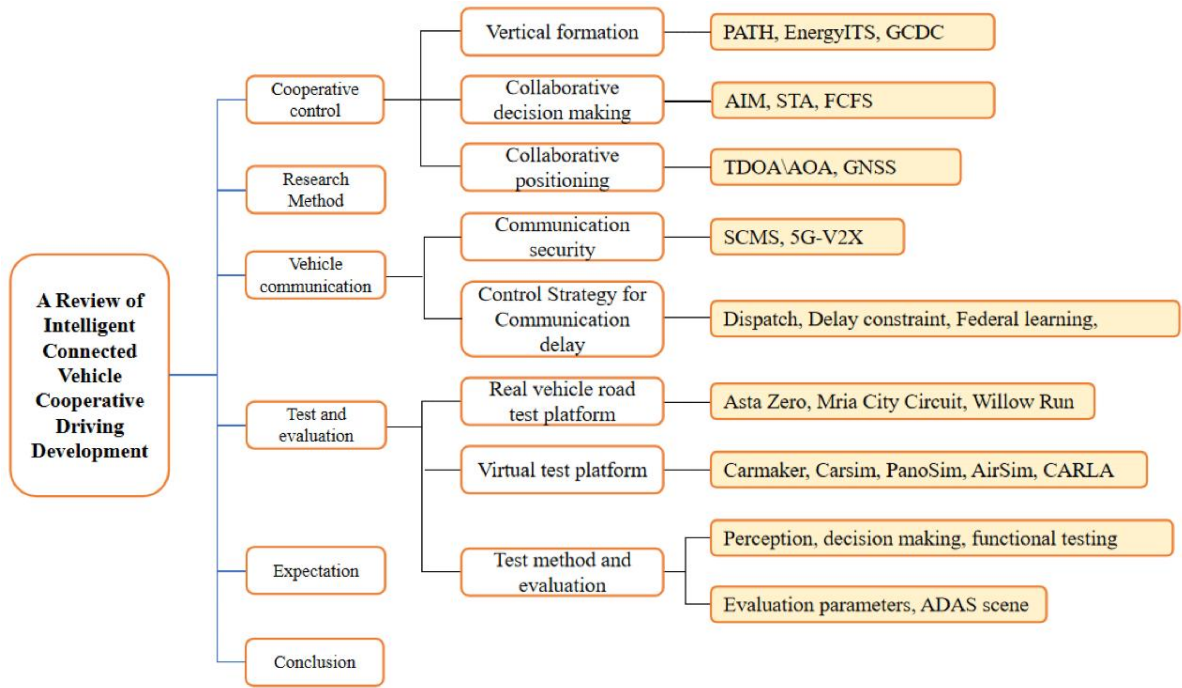


Fig.7 CARLA loop optimization performance execution process

(1) According to each parameter interval, the reciprocal of the difference between the maximum particle values of the mechanical parts slice is taken as the probability density function, and its expression is as follows:

$$g^0(u) = \begin{cases} \frac{1}{u_{\max} - u_{\min}}, & u \in [u_{\min}, u_{\max}] \\ 0, & other \end{cases} \quad (1)$$

Where  $u$  represents the decision behavior and  $g^0(u)$  represents the density function corresponding to each decision behavior.

(2) After the execution of a single decision behavior, determine the position of the slice particle of the RV reducer part structure, the specific formula is:

$$\int_0^{u_i(t)} g_i(u_i, t) du_i = c_i(t)$$

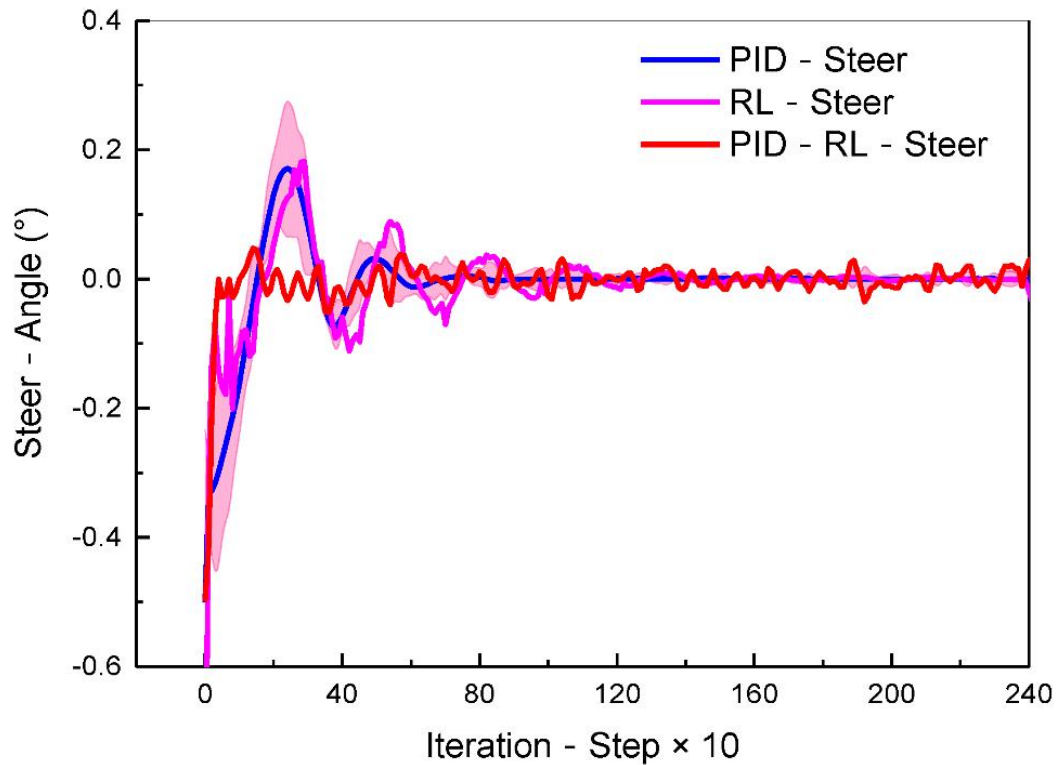
The random number  $c$  ranges from 0 to 1.

(3) Calculate the environmental fitness values of different particles, and the evaluation function of decision behavior performance is as follows:

$$\delta(t) = \min \left\{ \max \left\{ 0, \frac{H_{med} - H(t)}{H_{med} - H_{min}} \right\} \right\} \quad (2)$$

Where  $\delta(t)$  represents the current behavioral generational value,  $H_{med}, H_{min}$  represents the median value and minimum value of the historical generational value set respectively, and behavioral performance evaluation value  $\delta(t) \in [0, 1]$ , the closer the value is to 1, the better the performance, and the closer the value is to 0, the worse the behavior performance.

(4) Localization of the local and global optimal of each generation of individuals, and update them so that they remain unchanged in the virtual scene. The comparison results of iterative execution using Matlab virtual algorithm and CARLA learning loop optimization algorithm are shown below, as shown in Figure 8.



**Fig.8** Iteration of Matlab virtual algorithm and CARLA learning loop optimization algorithm

By training Matlab virtual algorithm several times, its adaptability value increases sharply. Compared with the virtual method of Matlab, this method has better real-time performance and can better solve the modeling problem of RV reducer.

## V. DESIGN AND DEVELOPMENT OF TEST SYSTEM BASED ON WEB VR

### A. Features of VR modeling

Creating a 3D virtual environment with high authenticity on the Internet through VR, giving users an immersive experience with interactivity, interactivity, interactivity, interactivity and immersion, is a very effective online education model. Compared with VR, network VR pays more attention to the combination of online remote transmission and virtual reality, and has the friendly interaction and imagination of human-machine interface. WebVR (WebVR) is a kind of web-oriented VR platform, which realizes the Internet-oriented VR experience by transforming the traditional 2D Web page into a 3D environment similar to the entity. It is an important trend of the current VR technology development. The platform consists of four main modules: 3D modeling, 3D display, interaction and online publishing. Among them, Virtual Reality Modeling Language (VRML) is the core of WebVR. Its working mechanism can be summarized as text description, remote transmission and local operation generation, and it can also provide interactive and Java programs.

### B. 3D solid modeling

When conducting virtual reality education, VRML language is usually used for programming, or 3D modeling tools such as 3 DS MAX, MAYA, etc. 3 DS MAX, etc. 3 DS MAX are used to build virtual environments and objects with realistic feelings, and VRML programs are used to write complex actions. In some complex engineering drawings, it is more practical to use 3D MAX or CAD and other auxiliary design tools to carry out 3D modeling. If the CAD system used has a VRML output interface, it can be output in VRML form; If the CAD software used does not have the function of VRML, you can save it as IGFS, DXF and other commonly used CAD documents, and then convert it into a CAD system with HTML functions to display it in VRML form. Using the above two techniques, it is possible to model a part in a certain type of engineering drawing in three dimensions and convert it into a simulation model that can be executed and run in a computer. VRML language is used to realize the program of the environment such as position, movement, space atmosphere, texture, view point, lighting, sound effect and so on.

### C. Implementation of dynamic interactive programs

In order to realize interactive and dynamic functions, VRML usually uses time sensing technology to work together with various interpolation nodes, and transmits events through the corresponding path through the route between the two nodes. The interaction between VRML and the database is to save the information filled in by the user in the form to the database, and then embed the JavaScript script code into the script code to complete the data processing of the database.

## VI. CONCLUSION

The practical application proves that it is intuitive and interesting to use this software for classroom teaching. Through this system, students can conduct experiments well, exercise their cognition of shapes, understand the system structure and working mechanism of engineering drawing system, and do 3D design well. They can not only skillfully use modern design means, but also better develop their spatial thinking ability. The application of WebVR in online teaching can create a teaching environment advocated by constructionism and help students to construct their own knowledge semantics independently. Therefore, it has a wide range of application values in distance teaching and multimedia teaching.

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