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Study on the Multi-Level Experiment Teaching of NAO Robot Combined with Virtual and Reality

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Abstract: NAO is the most well-known and widely used humanoid robot in education and research in the world. With the development of computer technology and cloud computing, and the establishment of artificial intelligence specialty, robot teaching is more important in artificial intelligence specialty. The artificial intelligence specialty is a new specialty just established in the talent training program of Chinese universities. Its purpose is to cultivate application-oriented talents in China's artificial intelligence industry and promote the construction of first-class disciplines of artificial intelligence. MATLAB is the commercial mathematical software. It is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis and numerical calculation. It is widely used in the experimental teaching of NAO robot. In the teaching of robot theory, kinematics, trajectory planning, dynamics and control are relatively abstract and complex, and there are a lot of formula derivation and differential equations. In order to improve the quality of NAO experiment teaching, this paper analyzes the current situation and existing problems in NAO experiment teaching. In the exploration and practice of robot experiment teaching, NAO robot is taken as the research object, and MATLAB is used to carry out robot simulation and control experiments. The paper presents a multi-level experimental teaching method of NAO robot based on the combination of virtual and Reality. The multi-level includes three levels: basic experiment, design experiment and innovative experiment. The paper describes the design and implementation process of the three-level experimental teaching in detail, and gives the assessment methods, characteristics and effectiveness evaluation of the experimental teaching. The teaching results show that the teaching effect is good, can stimulate students' enthusiasm for learning, and help to cultivate students' programming ability and innovation ability.

Keywords: Experiment Combined, Virtual, Reality, NAO Robot, Multi-Level Experiment Teaching

1. Introduction

With the rapid development of artificial intelligence in China, the Chinese government also attaches great importance to the development of artificial intelligence in 2017, China accounted for 51% of the global emerging artificial intelligence projects, which has surpassed the United States in number. In 2020, the scale of China's artificial intelligence industry has exceeded 150 billion yuan, however, the global AI talent reserve in China is only about 5%, and the global AI talent gap exceeds 5 million.

MATLAB is the commercial mathematical software. It is a high-level technical calculation language for algorithm development, data visualization, data analysis and numerical calculation. It has an interactive environment. The new functions added by MATLAB 2019b including artificial intelligence, deep learning and automotive industry and robotics, which are used to design, simulate, test and deploy UAV (unmanned aerial vehicle) applications.

NAO robot is a very popular humanoid robot. More than 600 universities around the world use NAO robots to teach robot related fields such as programming, electronics, mathematics, machinery, control, image processing, speech recognition and navigation. NAO robots are also used in the soccer standard platform League of RoboCup (world robot soccer competition). Due to the most advanced functions of NAO robots, the participating teams can focus on the developing and testing of algorithms.

Matlab NAO API can control NAO robot by using MATLAB and related toolbox. API enables MATLAB to send

and receive robot data asynchronously through a TCP / IP connection between the host and the robot by wired or wireless. For example, the API may first receive the image captured by the camera installed on the NAO, then use the face detection algorithm in the computer vision toolbox to recognize the face in the image, and finally the API may send a sound signal to the speaker on the NAO, Or it can control the robot to walk towards (or away from) the identified person.

With the continuous development and deepening of information technology, education information has been attached great importance by the country. Two documents in the ten-year development plan of education information clearly point out that colleges and universities should utilize advanced network and information technology, integrate resources, build advanced, efficient and practical higher education information infrastructure, develop and integrate various high-quality education and teaching resources, and select and develop 1500 sets of virtual simulation and training experimental systems. The construction of virtual simulation experiment teaching center in Colleges and universities has become an important part of higher education information.

The Ministry of Education announced the results of the registration and approval of undergraduate majors in ordinary colleges and universities in 2019. Among the newly registered undergraduate majors, the "artificial intelligence" majors added the most. People's University of China, Fudan University, Wuhan University of technology and other 180 universities have added "artificial intelligence" majors, and "artificial intelligence" has become a popular specialty.

Many scholars at home and abroad have conducted relevant research on the NAO robot experiment which combines virtual and reality.

WANG Xin integrates the modeling, kinematics, dynamics, motion control algorithm and real-time simulation of the manipulator into the virtual simulation software by using the graphical user interface function of MATLAB. Based on the simulation of the robot arm, the real robot arm is connected through the interactive function of ROS web page, and the remote control experimental platform of the robot arm is developed. Finally, the feasibility of the experimental platform is verified by the remote control of UR3 manipulator. Using virtual simulation software to simulate the robot arm is a concrete application of the basic theoretical knowledge of the "robotics" course. Through the remote control experiment of the robot arm on the web page, the simulation of the robot arm is combined with the physical experiment, which promotes the teaching reform of the "robotics" course [1].

WANG Zhijie verifies the accuracy of kinematics analysis and the feasibility of motion planning in order to realize the motion control of Dobot manipulator. Firstly, the forward and inverse kinematics of the manipulator is solved theoretically, then the workspace of the manipulator is analyzed based on Monte Carlo method, and the motion planning and simulation verification of Dobot manipulator are carried out by using the robotics toolbox. The simulation results show that the forward and reverse kinematics analysis and calculation results of Dobot manipulator are correct, and the motion planning is reasonable and feasible [2].

ZHU Xinjie discusses the method of combining virtual simulation with practical operation in the industrial robot experiment course. A material handling experiment based on industrial robot is designed, and a virtual simulation scheme based on Mitsubishi RT toolbox3 software and a practical solution with MitsubishiRV-4FL industrial robot as the operating objects are given, which combines virtual reality with reality. The combination has been widely used in the exploratory experimental course for senior undergraduates in the College of mechanical engineering of Zhejiang University. It can not only give full play to the subjective initiative of students in independent learning, but also avoid the disconnection from the reality caused by the complete virtual experiment. At the same time, it enriches the content of the experiment, improves the efficiency of the experiment, and innovates the experimental content [3].

LIU Na analyzes the current situation of the course of industrial robots, proposes the specific contents and implementation methods of the teaching reform according to the talent demand of the new engineering department for the robot industry, and explores how to cultivate talents that meet the needs of the intelligent manufacturing industry [4].

GUO Yanjie integrates the existing robot resources of the mechanical basic experimental teaching demonstration center of Xi'an Jiaotong University by investigating the existing robot experimental courses at home and abroad, and proposes to systematically develop robot experiments by combining various experimental forms, robot mechanism and control. The teaching method is combined with the engineering practice to guide the students to pay attention to the technological frontier and cultivate their innovative consciousness. According to the characteristics of robot experiment, the paper puts forward a method to evaluate the comprehensive ability of students, which promotes undergraduates to have a comprehensive and systematic understanding of robots [5].

Guo Yue applies the CHOREGRAPHE graphic editing program in Nao robot virtual simulation software to the teaching of artificial intelligence robot specialty in higher vocational colleges, which can complete the understanding of artificial intelligence robot, programming practice, command box database and 3D simulation demonstration. It realizes the effective docking of teaching content and working ability, improves the safety and interest of teaching, and lays a good foundation for the follow-up artificial intelligence robot practical training [6].

CHEN Duanjun proposes a multi-level experimental teaching method for the computer language experimental course in view of the current characteristics of independent college students' learning, as well as the differences in different computer language knowledge backgrounds and learning abilities of college students. According to the different computer language knowledge backgrounds and learning abilities of students, students are divided into groups

at first, and then different experiments are designed according to different groups, including basic experiments, consolidation experiments, improvement experiments, comprehensive experiments and design experiments. In addition, the innovation experiment of computer language course should be increased to teach students according to their needs, so that the teaching quality of computer language experiment course can be improved [7].

WANG Dadong designed a shared NAO experimental platform to solve the imbalance between the number of NAO robot equipment and the number of students in Colleges and universities. The platform adopts a multi queue, first come first serve queuing model to realize the time-sharing reuse of NAO robots, and supports the local module and remote module experiments of NAO robots. The platform uses Java technology to realize identity authentication, port forwarding control, state control, traffic statistics and experiment management. For ordinary computer laboratories, large-scale sharing experiments can be realized after installing teacher computer software. The course practice shows that the shared experimental platform supports most of the routine experiments of Nao robots, and has the characteristics of flexible use and good scalability, which improves the efficiency of Nao robots and facilitates the experiment management [8].

From the perspective of hardware design, on the basis of analyzing the robot sensing system, Dong Yang focuses on analyzing the sensing system of typical NAO robot, including audio system, vision system and motion system. Through the analysis of concrete examples based on hardware design, the future robot design is prospected [9].

WANG Yuanjie aimed at the problems that NAO robots have various compiling environments and are not suitable for beginners during the development processes, the experiments were designed with face recognition as the core. Through the analysis and comparison of the more intuitive visual compilation environment and python language compilation developed by the government, a decision was made on the needs and use experience of subsequent development for beginners [10].

In the process of WANG Yuanjie's development, the compilation environment of the NAO robot is diverse, and it is not suitable for beginners to choose. The experiment is designed with face recognition as the core. By analyzing and comparing the more intuitive visual compilation environment developed by the official and Python language compilation, the decision was made on the needs and use experience of the subsequent development of beginners [10].

Aiming at the control problem when the robot arm grasps the object, WEN Shengjun modeled and controlled the motion of the arm with the NAO robot as the operating object. The D-H kinematic modeling mechanism is adopted to establish the kinematic model of the robot arm, and the parameters of the D-H kinematic model are obtained by analyzing the structure of the left arm of the NAO robot. The output of the model is compared with the actual motion trajectory of the NAO robot arm, and the accuracy of the kinematics model of the robot arm is verified. The dynamic model of the robot arm is obtained according to the kinematic model, and an adaptive PD controller is designed based on the model. The simulation results show that the adaptive PD controller has better tracking and robustness than the PD controller to the robot arm motion when there is a large disturbance in the system [11].

YANG Changyue establishes a multi-level and modular experimental teaching system according to the guiding ideology of the new talent training program for polymer materials and engineering specialty of Sichuan University. Aiming at cultivating and improving students' engineering practice ability and scientific and technological innovation ability, and realizing students' transformation from knowledge accumulation to ability so as to discover and create knowledge, the paper introduces some reform measures made by the specialty of polymer materials and Engineering in terms of experimental teaching contents, methods and means [12].

There are many researches on the development and application of the practical teaching platform for industrial robots, which combines virtual with reality.

FENG Lingyun developed a set of practical teaching platform that combines virtual with reality, including physical workstation and virtual workstation, based on the typical application of industrial robots. The practice results show that the practical teaching platform of industrial robot combining virtual with reality is conducive to the reform and innovation of teaching mode and the integration and optimization of practical course content. It has a positive impact on both teachers and students, and can provide reference and reference for relevant colleges and universities to carry out practical teaching [13].

GAO Pan developed a set of virtual and real industrial robot training teaching platform and methods, including robot physical operation platform and virtual simulation platform. The teaching results show that the new platform can fully mobilize students' enthusiasm and participation, and improve students' understanding of robots. It lays a solid foundation for students to learn more advanced robots, and can provide reference for engineering training, especially robot training teaching in relevant colleges and universities [14].

ZHU Xinjie discussed the method of combining virtual simulation and practical operation in the course of industrial robot experiment, and designed a material handling experiment based on industrial robot. The experimental results show that it can avoid the disconnection from the reality caused by the complete virtualization of the experiment, enrich the experimental content, improve the experimental efficiency, and change the experimental form [15].

WANG Shuai built a robot experiment teaching platform based on Mat Lab with the idea of combining virtual with reality, and produced detailed teaching resources such as robotics experiment tutorials, and applied this platform to the basic and advanced experimental teaching of robotics. It lays a foundation for improving the quality of robot engineering talent training under the background of new engineering [16].

Based on the current situation of robot course experiment teaching of artificial intelligence specialty in Wuhan University of technology, the paper introduces MATLAB software into the experimental teaching of NAO robot, takes NAO robot as the research object, adopts different levels of experimental teaching methods, establishes the simulation and control innovation experiment of NAO robot, and realizes the kinematics, trajectory planning, dynamics and control in the theoretical course in MATLAB software.

2. Analysis of Current Teaching Situation

2.1. Current Situation of Theory Teaching

As the core course of artificial intelligence specialty, robot has the characteristics of broad basic knowledge, multiple disciplines, strong practicality and great learning difficulty. In the talent training program of artificial intelligence specialty, the existing teaching syllabus, curriculum system, teaching contents and even teaching methods are difficult to meet the needs of the training objectives of new engineering talents. The following problems mainly exist.

The design of teaching scheme can not closely follow the needs of the industry. The implementation of the current teaching links of robots still adopts the traditional teacher centered, classroom centered and textbook centered models. The combination of theory and practice is not close enough. This model is difficult to adapt to the course nature of wide foundation, multi intersection, practice oriented and strong ability, and the trained students are out of touch with the needs of the industry.

The experimental practice teaching link is weak, and the existing experimental teaching equipment of artificial intelligence specialty is insufficient. Since the establishment of artificial intelligence specialty, the school has introduced talents and purchased equipment from both software and hardware to improve teaching quality. However, new teachers realize that it takes time to develop and utilize new equipment, and there is a process for the establishment, use and improvement of practical teaching links. This actual situation leads to insufficient development and utilization of experimental teaching equipment.

The teaching quality evaluation system is not perfect. In the evaluation system of the curriculum, the emphasis is on whether the teachers teach well, and the output of students' learning achievements is ignored. Cramming teaching affects students' passive learning and their enthusiasm is not high, which results in the decrease of learning efficiency. In the evaluation of teaching quality, emphasis is placed on evaluation rather than improvement. There is no closed-loop evaluation system for performance evaluation, feedback, improvement and implementation, and such evaluation results cannot be really used to improve the quality of curriculum teaching.

The professional development of teachers is seriously inadequate. The school should further develop its teaching and research capabilities. The updating and iteration of teacher knowledge system needs a process. As teachers in ordinary colleges and universities, they are extremely eager to improve their own level to shorten the gap.

Robot course is a multi-disciplinary synthesis, which involves the knowledge of software, hardware, communication and other related fields. It has the characteristics of wide knowledge and rich content. However, the imperfect knowledge system of students makes it difficult for them to learn robot courses. At present, most students have a strong interest in the field of robotics, but junior students who have not comprehensive basic knowledge are not suitable for learning robotics. In other words, robot learning has high requirements on students' basic knowledge, and it is also necessary for junior students to understand robot knowledge. The school can give more lectures on robots to students, cultivate their interests and guide them to learn basic knowledge more realistically.

2.2. Problems in Experimental Teaching

More and more colleges and universities have offered courses related to robotics and robot control for undergraduates. However, due to various reasons such as funds and venues, there is no good plan for robot experiment teaching in the existing teaching. Therefore, there are mainly the following problems in the undergraduate experiment teaching.

The depth of teaching is enough, but the breadth of teaching is neglected. In the undergraduate stage, the education of students is mainly to understand knowledge, so that students can have a comprehensive understanding of robots. However, the current robot experiments, whether in class experiments or open experiments, have relatively few class hours, and students are lack of understanding of the integrity and systematization of robots.

The assessment method is single. At present, as a multidisciplinary course, robotics only focuses on the results of the final experiment, and the assessment of students is not comprehensive, which can not effectively reflect the ability of students.

Students' enthusiasm is not high. Some students are afraid of the tedious dynamic derivation of complex multi joint robots, which leads to the lack of initiative and enthusiasm in the learning process.

The school has difficulty in funding, and the number of physical robots purchased is small, which can not meet the needs of students' experimental teaching.

Therefore, for robot experiment teaching, undergraduate students need to break the restrictions of the course specialty, take the students' comprehensive understanding of robots as the foothold, strengthen learning, and lay a foundation for future learning.

2.3. The Value of Experimental Teaching in Specialty

NAO is the most well-known and widely used humanoid robot in education and research in the world. NAO robot has a rich and powerful function library. Under Linux, windows,

Mac OS and other operating systems, it can be programmed and operated by C++, MATLAB, Python language and choregraph based on graphical interface programming. The application of choregraphe in the teaching of NAO artificial intelligence robot specialty can meet the requirements of artificial intelligence robot course teaching without artificial intelligence robot training equipment. Through the virtual simulation technology, the robot work scene is established, the robot work path planning is realized, and the students can master the artificial intelligence robot technology. Therefore, the application of NAO robot in the teaching of artificial intelligence robot has important application value.

Realize the docking with the work ability of the post. Offline programming and virtual simulation technology are widely used in the operation, debugging and maintenance of artificial intelligence robots. In higher education, it is mainly to cultivate the ability of students to adapt to their jobs in advance, and integrate offline programming simulation technology into the teaching of artificial intelligence robot as a course. In the school, students are trained in offline programming and virtual simulation technology, so as to effectively realize the seamless connection between teaching content and post work ability.

Improve teaching safety in the process of practical training. The control operation of the artificial intelligence robot training equipment needs to strictly follow the safe operation procedures of the robot. If there is any illegal operation, it may cause danger and harm to students or equipment. The CHOREGRAPHE virtual simulation software is used to simulate the actual action on the computer. Although the robot speed is fast, the errors such as path calculation and running joint points can be corrected in time after the problems are found, until it is adjusted to the best state without any danger, which ensures the safety of teaching.

Improve the interest of teaching. Through rich teaching projects, the virtual workstation is created with the CHOREGRAPHE graphic programming system. Let the whole robot control system run autonomously through Python assembly language, and realize the animation of robot motion through virtual simulation 3D, so that students can see the effect of robot simulation exercise, so as to improve students' sense of achievement and enthusiasm.

2.4. Application of Experimental Teaching in Specialty

The versatility of NAO is based on the fact that it can carry out visual programming through ready-made instruction blocks. Therefore, it allows users to explore various fields, use programming programs of various complexity and achieve various effects that users want to experience. The choregraphe graphic programming software in NAO robots is introduced into the teaching of artificial intelligence robots, so that the artificial intelligence robots that students can not touch can be easily presented to students. Students can use the existing instructions in the instruction library, manual language programming, etc. to let the robot complete the specified actions, and can also use software to conduct virtual animation simulation. The programming and debugging of the whole robot system is completed on the computer, which improves the safety of teaching, and further improves the students' interest and motivation in learning, and achieves good teaching results.

The application of NAO robot in the course teaching of artificial intelligence is mainly in the following aspects.

Learn the whole experimental process of artificial intelligence robot through the course system. The virtual simulation course is based on the robot control system to debug and maintain. By using virtual simulation software to build an intelligent system control platform, the robot system can be programmed, simulated and debugged offline. Finally, the simulation program is applied to the robot operation, These are mainly to train students' ability of programming, simulation and debugging of intelligent motor control system, and students' ability of analyzing and solving problems. Relevant courses can be interconnected with artificial intelligence robot foundation and python language assembly.

Let students know artificial intelligence robots through practice. The instruction database of choregraphe, the graphic programming software used by NAO robot, covers a total of 70 instructions of about 11 different types. After importing the robot model into the choregraph, open the 3DNAO interfaces, and the user can input the joint value to move the robot. During the joint coordinate operation, you can see the position of the joint axis of the robot and the current motion angle of each joint axis. Adjust the linear control button to change the rotation angle and distance of the joint bearing. The three-dimensional animation of the robot motion can be used to view the robot application ability, and the operating state of the robot can be observed from multiple perspectives. If the robot is placed in front of the students, they can have a sensory understanding of the NAO robot.

Programming practices. Most of the functions provided by the humanoid robot Nao can be realized through the graphic programming of CHOREGRAPHE. Many different tasks such as turning on the LED, repeating several groups of actions, making sounds, etc. can be supported by the choregraph command, and can be used to perform many different types of robot tasks. However, it is difficult to perform tasks that are not supported by existing instructions. In this case, C / C + + and python can be used to create new instructions.

2.5. The Role of Simulation Experiment Teaching

As a new teaching method, virtual simulation experiment has changed the traditional teaching mode and greatly enriched the educational content, ideas and concepts. With the development of big data, cloud platform and artificial intelligence, virtual simulation experiments are more and more frequently introduced into the classroom and comprehensive experimental teaching. The artificial intelligence major of the school of computer and intelligence of Wuhan University of technology is a newly established major, with too few experimental equipment. If the virtual simulation experiment is introduced into the comprehensive experiment teaching of artificial intelligence, it will have the following functions and

significance to improve the teaching quality.

The virtual simulation experiment solves the problem of insufficient testing equipment in the college, enhances the students' practical ability, and thus stimulates the students' interest in learning.

The virtual simulation experiment has the characteristics of continuity and comprehensiveness. In this way, students can grasp the whole teaching system, practice system and development process system of artificial intelligence as a whole, so as to achieve the goal of mastering knowledge completely.

The virtual simulation experiment is flexible and easy to expand, which is convenient for students to carry out secondary development, so as to stimulate students' creativity. At the same time, it is also conducive to teachers to combine scientific research and teaching, enhance students' ability to engage in scientific research, and cultivate real practical talents.

Specifically, the practical significance of using MATLAB tools to simulate robots is as follows. Although the simulation experiment is to imitate the actual operation, which is quite different from the practical operation and cannot replace the real experiment, it is still very necessary and plays an important role. Because the control system of intelligent robot is complex, only through simulation experiment teaching, students can learn and understand knowledge through continuous imitation and practice. Students improve the teaching quality through in-depth study of artificial intelligence courses. Students can also master robot algorithms, carry out effective design and save time.

It can flexibly change the working space of the intelligent robot to ensure the smooth work and large space for movement and activities. It is difficult to control the experimental site. In the actual operation process, it is not only difficult, but also energy consuming. Through the simulation experiment, it can flexibly change the working space of the intelligent robot, reduce the operation difficulty, and play an important role in ensuring the smooth implementation of the work.

In short, it can provide more opportunities for students to practice and ensure the image and accuracy of knowledge content. The use of simulation experiment teaching can vividly show the control principle and motion mechanism of intelligent robots for students, do a good job in measurement, and create a favorable learning environment for the implementation of artificial intelligence courses. Learning to use virtual simulation experiments can design more modules that meet the needs of artificial intelligence experiment teaching.

3. Multi level Experimental Teaching Design Combining Virtual and Reality

3.1. NAO Robot

NAO is a humanoid robot widely used in the academic field all over the world. Aldebaran robotics opened the technology of NAO to all higher education projects, and established a foundation in 2010 to support teaching projects in the field of robotics and its applications. Teaching robots are usually interesting, challenging and imaginative. NAO, as the right assistant of teaching and learning, is creating the future education mode.

NAO is about 58 cm tall and weighs about 4.3 kg. The body material is industrial plastic. It is equipped with a charger of AC 90-230v / DC24V, which can be used while charging. NAO consists of 25 joints. The actuators used by NAO include Hall sensors, microcontrollers and air core driven DC motors. NAO has many sensors distributed throughout the body, including gyroscopes, triaxial accelerators, impactors, dual channel ultrasonic sensors, infrared sensors, tactile sensors and pressure sensors. These sensors realize NAO balance control, detection, vision, tactile and other functions, and enable NAO to communicate well with the external environment. At the same time, they are also indispensable components for realizing NAO intelligence.

NAO robot is a programmable humanoid robot, which includes integrated cameras, microphones, touch, ultrasonic, infrared and other sensors, and has the ability to comprehensively perceive and interact with the external environment. Universities apply NAO not only in robotics research, artificial intelligence, engineering, mathematics, physics and computer science, but also in sociology and medical care. NAO’s research projects include speech recognition, video processing, pattern recognition, autism treatment, multi-agent system, automation, signal processing, whole body movement and path planning.

NAO hardware is designed and manufactured with the latest technology to ensure the smoothness of NAO action. NAO can be programmed under operating systems such as Linux, windows or Mac OS. The special feature of NAO robot is that it uses embedded processor of Linux and is controlled by C + + or Python language. In addition, NAO robots can be programmed on a variety of platforms and have an open programming architecture. Therefore, different software modules can interact better. No matter what the professional level of the user is, they can program the NAO robot through the image programming platform.

The biggest feature of NAO is its embedded software. Through these software, NAO can carry out sound synthesis, acoustic positioning, detect visual images and colored shapes, detect obstacles with the dual channel ultrasonic system, and generate visual effects or interact with a large number of light emitting diodes.

The versatility of NAO is based on the fact that it can carry out visual programming through ready-made instruction blocks. Therefore, it allows users to explore various fields, use programming of various complexities, and achieve various effects that users want to experience.

NAO robot has a rich and powerful function library. Under Linux, windows, Mac OS and other operating systems, it can be programmed and operated by C ++, MATLAB, python language and choregraph based on graphical interface

programming.

At present, many universities and research institutions around the world have used NAO robots for education and scientific research. The school of computer and artificial intelligence of Wuhan University of technology introduced the NAO robot platform and used it in the second class and skills competition to train students' innovation and scientific research ability.

3.2. MATLAB Simulation

Matlab robotics toolbox is a set of robotics toolbox based on MATLAB developed and maintained by Australian scientist Peter corke. The latest version is version 2022b, which can be downloaded for free on the homepage of the toolbox (http://www.petercorke.com/robot/). Robotics Toolbox provides many important functions in robotics research, including robot kinematics, dynamics, trajectory planning, etc. The toolbox can simulate the robot graphically and analyze the experimental data when the real robot is controlled, so it is very suitable for the teaching and research of robotics.

Virtual simulation experiment is a kind of software and hardware operating environment that can assist and even replace the traditional operation links in the experiment by means of graphics, simulation and virtual reality. It is the development mode of modern experimental teaching, which effectively complements and perfects the traditional experiment, and alleviates the problems of mechanical experimental methods, insufficient content, insufficient experimental equipment and lag. Its advantage is to allow misoperation and obtain "zero" maintenance guarantee, so as to carry out experimental research on equipment vulnerability, comprehensiveness and designability.

Matlab is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis and numerical calculation, mainly including Matlab and Simulink. Simulink has rich dynamic simulation integrated environment toolbox for system modeling, simulation and analysis; The GUI in MATLAB provides a visual and rapid development environment. The user can quickly generate various GUI controls through the mouse, which helps the user easily design various graphical user interfaces that meet the requirements.

The new features of MATLAB R2019b cover a series of new functions of MATLAB and Simulink, mainly including support for artificial intelligence, deep learning and the automotive industry. In addition to the new functions in the robotics system toolbox, R2019b also introduces the navigation toolbox, which can be used to design, simulate and deploy algorithms for planning and navigation. It includes some algorithms and tools for designing and simulating systems that can map, locate, plan and move in a physical or virtual environment. The new ROS toolbox can be used to design, simulate and deploy ROS based applications. In addition, R2019b introduces new products supporting robotics, new training resources based on event modeling, and updates and bug fixes to MATLAB and Simulink product series. R2020b also launched new products based on artificial intelligence (AI) to speed up the development of autonomous systems and quickly create 3D simulation scenes of automatic driving.

3.3. Combination of MATLAB and NAO

Play NAO robot with MATLAB. MATLAB NAO robot API (Application Programming Interface) enables MATLAB to asynchronously send and receive robot data through a TCP/IP connection between the host and the robot.

NAO robot is a very popular humanoid robot. More than 600 universities around the world use NAO robots to teach robot related fields such as programming, electronics, mathematics, machinery, control, image processing, speech recognition and navigation. NAO robots are also used in the soccer standard platform League of RoboCup (world robot soccer competition). Thanks to the most advanced functions of NAO robots, the participating teams can focus on the development and testing of algorithms.

The following work can also be done using MATLAB NAO robot API. The NAO robot can be programmed immediately under the condition of MATLAB only. Robot functions can be added at any time through the additional toolbox. Develop programs through sensors (inputs) and actuators (outputs) on NAO such as microphones, cameras, accelerometers, gyroscopes, sonars, joint position encoders, contact sensors, joint DC motors, LEDs, speakers, etc. Operate the control loop (non real time) at a frequency of 75Hz (or below). The teaching of NAO includes the knowledge of electronics, mathematics, machinery, control, image processing, voice recognition, navigation and other fields.

3.4. Design of Multi-Level Experimental Teaching

Multi-level experimental teaching refers to the need to meet the needs of students at different levels and different requirements in the process of experimental teaching, so that they can complete and achieve their learning objectives matching their abilities and interests through the process of experimental teaching. The implementation of personalized teaching mode not only needs to spend a lot of manpower and material resources, but also may not be able to obtain satisfactory teaching results without effective means.

The proposed multi-level experimental teaching method is to divide the experimental teaching into multiple levels, each level meets the needs of students with different requirements, and there are internal relations between different levels. Lower level experimental teaching is a necessary process to train and improve students' experimental operation skills, strengthen students' understanding of theoretical knowledge at this level, and select talents for higher level experimental teaching. Since human self cognition is a process, lower level experimental teaching provides a platform and opportunity for students' self demand cognition, which can better guide students to continue learning. Multi-level experimental teaching can fully realize personalized teaching under the

condition of limited resources and meet the needs of students at different levels and different requirements. At the same time, it can exercise the students' mind and improve their self cognition in the process of experimental teaching to achieve the goal of all-round learning.

NAO robot experiment teaching is divided into three levels. They are basic experiments, design experiments and innovation experiments. The three levels can meet the needs of students at different levels and meet the purpose of personalized teaching. And there are internal progressive relations among the three levels. The former is the foundation and the latter is the improvement. The former can select suitable students with needs for the latter.

3.4.1. Basic Experiment

The basic experiments are aimed at students with NAO robot knowledge background and average learning ability. Such students are often at a loss when they first come into contact with NAO robots, and feel confused. Therefore, in the design of basic experiments, the cultivation of students' ability to read programs should be put in the first places, and the second is to gradually guide students to write complete programs to realize simple functions.

The content of the basic experiment focuses on the training of basic theoretical knowledge in the design, and the design of the question type focuses on reading and writing the results of the program, filling in the blanks, and writing the simplest complete program. Among them, the topic of reading program and writing results is to give a complete program, so that students can analyze the program and give the functions realized by the program through analyzing the program. Blank filling questions in program design are to set some blanks in a program for students to supplement the whole program. Such questions need to be completed by students on the basis of understanding the program. The topic of writing simple functional programs is to give students a simple requirement, so that students can learn to write programs using the basic framework of the program.

The completion of the basic experimental content helps students to verify the theoretical knowledge learned in class in time and strengthen their understanding and application of theoretical knowledge. The basic experimental design should take into account the characteristics of some students, such as poor consciousness and certain dependence. In the process of experimental design, students' personal information and other contents are appropriately infiltrated into the experimental design, so students' ability to complete experiments independently can be cultivated to a certain extent.

3.4.2. Design Experiment

In order to further develop the ability of students with strong ability, a design experiment was proposed. Design experiments require students to use the knowledge they have learned and the methods they have mastered to design and complete a task in connection with practical problems. The students design the experimental objectives, determine the experimental scheme, design the experimental results and compile the experimental procedures by themselves. The completion of the design experiment is helpful to further strengthen the students' self-learning ability. Design experiments can be an important part of encouraging students to carry out extension learning.

The design of the experimental content focuses on the consolidation of the basic theoretical knowledge and the details, and the design of the experimental questions focuses on the program error correction and the compilation and operation of the complete computer program. The problem of program error correction is to give a program with errors for students to debug and find errors. The setting of program errors focuses on the handling of details, and the students' patience and care are cultivated through error finding and modification. Complete the topic of writing computer programs, and focus on letting students write programs to realize a small function in the design. Through the compilation of functional programs, students' programming ability can be further improved.

3.4.3. Innovation Experiment

The innovative experiment is applicable to students with computer language knowledge background and good learning ability, who have good computer language knowledge foundation. For students who have a good command of computer language knowledge, they need to systematize their computer language knowledge to solve practical problems.

Innovative experiments are generally required by teachers in connection with actual scientific research projects, and then students do a good job of demand analysis according to problems, comprehensively apply the knowledge they have learned to design algorithms, compile experimental programs and run experimental programs, and finally further systematize knowledge through the analysis of program operation results.

Through the completion of the innovative experimental content, students' ability to use computer language knowledge to comprehensively deal with problems is improved, and students' ability to independently learn relevant content is cultivated, so that students can master the whole process of program development.

Compared with the design experiment, the innovation experiment has a higher level, requiring students to design a suitable robot automatic motion control system according to a certain actual demand or a certain performance index. Through basic experiments and design experiments, students can recognize their own strengths. Teaching can find suitable students to make judgments and decide whether students need to choose innovative experiments.

Innovative experiments can also adopt the combination of virtual simulation and robots. Students can complete the formulation and utilization of the experimental scheme after class, verify and adjust the experimental scheme, and then use robots to verify the experimental scheme in the experimental class. Fully stimulate students' enthusiasm for extracurricular learning, maximize the use of limited

experimental hours in class, and focus on training students' practical ability and ability to independently solve complex engineering problems. Through the combination of extracurricular virtual simulation and in class experiments, the experiment maximizes the use of classroom experimental teaching hours, mobilizes students' enthusiasm for extracurricular learning, and also exercises students' practical ability and innovation consciousness.

4. Construction of Teaching Platform on Combination of Virtual and Reality

There are a few NAO robots in the laboratory of the College of computer and artificial intelligence, a large number of PC desktops, and a cloud service platform. How to build a teaching platform with NAO robots as the core, in this way, it can not only be used as a platform for students to learn the basic experiments of the corresponding courses of artificial intelligence, but also as a comprehensive design experimental place for artificial intelligence, and it needs to be built as a training base for student competitions.

The sharing experiment platform uses the teacher's machine to control the network connection of the student's machine to the NAO robot, and realizes the time-sharing robot. Laboratory equipment configuration includes teacher machine, student machine. The teacher machine, the student machine, the NAO robot and the switch are connected to the LAN by twisted pair. Laboratories that support wireless connection can also connect teacher machines, student machines and robots through wireless routers.

The frame design of shared experimental platform is very important. The teacher machine installs software to control the network connection between the student machine and the NAO robot, records the process information using the database, provides Web services for the login, application and query status of the student machine, and has functions such as data processing and statistics. After the student machine queue up to apply for the right to use the robot through the browser, use the acquired designated port of the teacher machine to connect to the NAO robot, and the teacher machine software forwards the connection data to the robot.

There are several ways to share the experimental items applicable to the experimental platform. Basic experiments include file access, remote login and instruction box operation. Motion experiments include joint control and motion control. Speech processing experiments include recording, audio data processing, voice detection, speech recognition and conversation. Image processing experiments include photographing, image processing, face recognition and visual recognition. Sensor experiments include sonar, led and infrared.

5. Realization of Multi-Level Experimental Teaching

5.1. Basic Experimental Teaching

The basic experiment is mainly to familiarize and master the functions of the basic components of the NAO robot. Specifically learn the following contents from the NAO robot entity, so as to facilitate the completion of basic experimental teaching.

5.1.1. Various Basic Functions of NAO Robot

Familiarize yourself with motion control. NAO robot is composed of head, trunk, arm, hand, leg, foot and other components, and the joints connect the two components. Most of the connected components can move relative to each other in two or even three directions, and the movement in each direction is completed by the mechanical structure driven by the motor. The NAO robot uses the rotation set roll, pitch and yaw to represent the motion posture, corresponding to the rotation in the X, y and Z axis directions respectively. The name of each joint is composed of the part name and the pose name. When describing the range of motion of a joint, clockwise rotation along the rotation axis is negative, and counterclockwise rotation is positive, in degrees or radians. The arm limb is connected to the trunk through the shoulder, including the shoulder joint, elbow joint, wrist joint and hand. All joints of the arm are symmetrical. When performing the same joint action of rotating around the x-axis, the rotation angles of the left and right sides are opposite to each other. The hip connects the legs and the trunk, and is used to control the movement of the legs. The legs are connected to the trunk through the hip, including the hip joint, knee joint and ankle joint. All joints of the legs are symmetrical.

Familiarize yourself with audio processing. People have the physiological functions of speaking and listening, or the functions of speech generation and speech / audio recognition. The human vocal organ is composed of throat, vocal tract and mouth. The vocal organ generates air currents of different intensities, controls the vocal cords in the throat to generate vibrations of different frequencies and amplitudes, and generates sound waves. The pronunciation frequency of normal people ranges from 100Hz to 5000Hz. The human hearing organ is the ear. Sound is transmitted into the ear canal to cause tympanic membrane vibration. Mechanical motion is converted into neural signals through the inner ear, and finally transmitted to the brain to recognize different speech meanings. NAO robots can also talk and listen, communicate and talk with people. The sound signals obtained by the microphone are analog and continuous electrical signals, which need to be sampled, quantized and encoded before being stored in the computer.

Understand vision. The visual function of the NAO robot is based on two head mounted cameras. NAOQI provides functions such as taking photos, recording videos, managing video input, image detection and recognition. Naoqi system includes alphotocapture, alvideodevice, alredballdetection,

alfacerecognition, alvideorecorder and other visual modules. Nao robot head has two cameras, which are used to identify objects in the field of view. It can shoot 30 frames of images with a resolution of 1280 * 960 every second at the fastest.

Understand sensors. Sensors of NAO robot include touch sensors of head, hand and chest, infrared ray, sonar, battery and temperature sensors. Naoqi system includes alsensors, albattery, albodytemperature, alchestbutton, alfsr, altouch, alinfrared, alsonar and other related modules. The all sensor module is responsible for generating events corresponding to the sensor. The all sensor module retrieves the sensor data in almemory and generates events according to the sensor value. All sonar module is used for ultrasonic ranging. The NAO robot is equipped with two sets of ultrasonic sensors (or sonar) to measure the distance of obstacles. The contact and touch sensors of the NAO robot include touch sensors installed on the head and hands, buttons on the chest and buffers in front of the feet.

5.1.2. Case Experiment

Design NAO robot perception system. Robot perception system plays a very important role in robot control. By designing this system, students can understand some basic principles of NAO robots. The sensing system is composed of an internal sensor module and an external sensor module, which are used to obtain the internal and external environment state information, so as to determine the operation track, state, position, speed and other information of each part of the mechanical component, and make each part of the mechanical component act according to a predetermined program and work needs. The use of intelligent sensors improves the mobility, adaptability and intelligence of robots. The sensor is composed of auditory sensor, visual sensor, tactile sensor, proximity sensor, gyroscope and accelerometer. This is a typical robot perception system. Nao robot has relatively powerful functions in audio system, vision system, motion system and communication system. This enables it to complete typical behaviors such as sound source measurement, face recognition, walking and climbing, and wireless control. The reason why its various systems can work normally and play a role is not only related to its mechanical structure, part quality, high degree of freedom and other basic hardware characteristics, but also more importantly, it has 17 types of cameras, microphones, ultrasonic infrared systems, inertial units and more than 100 sensors covering the whole body.

Audio system mainly refers to auditory sensor. The audio system includes speakers and loudspeakers. The data acquisition of audio system sensors is realized by Naoqi. Embedded software, cross platform distributed robot framework, these are aimed at developers to improve various functions of NAO. The system does not directly calculate the distance between the NAO and the sound source. Instead, after detecting a sound, it uses the spherical coordinates in the head space to locate the sound in the surrounding space, and then assists the motion system to complete the task of finding the sound source. This is the same as human sound source localization based on binaural effect.

Vision system mainly refers to vision sensor. The vision system includes a camera, an ultrasonic sensor and a light emitting diode. Two identical cameras are installed on the robot's face, and NAO is equipped with four ultrasonic sensors to judge the distance from obstacles in the surrounding environment. Motion system mainly refers to tactile and proximity sensors. The motion system includes a pressure sensor and an inertial unit. The pressure sensor is located on the foot of the robot. According to the measured resistance change, the pressure it bears can be deduced, and the working range is 0-25N. When the audio system, vision system, motion system and communication system of the NAO robot is organically combined. In this way, various designs based on its hardware came into being. It is because the mechanical system, sensing system and sensing system of the robot coordinate with each other that they can complete the tasks of simulating human feeling, manual operation and automatic walking.

5.2. Design Experiment Teaching

5.2.1. Type of Experiment

The robot NAO provides CHOREGRAPHE and telepath. CHOREGRAPHE has a simple graphical interface and can be used to control real robots. Telepath can facilitate users to view the real-time behavior of robots. Aldebaran robotics has also developed Naoqi software, which can be directly connected to the Linux processor operating system on NAO. The purpose is to connect and utilize the hardware functions of the NAO robot. In addition, SDK (software development kit) modules for creating and using Python and C++ programming languages are also provided. Python software is the default programming language of NAO robot. At the same time, C++, MATLAB, Urbi, Net and Visual Basic programming languages can also be used to control the NAO robot.

The designed experimental topics are as follows.

Remote interactive control of NAO robot, positioning algorithm and target recognition based on NAO robot, red ball recognition based on NAO robot, target grasping and sound source localization based on NAO robot, speech recognition based on NAO robot, football movement and basic action of NAO robot, target tracking and face recognition based on NAO robot, etc.

5.2.2. Case Experiment

Design NAO Robot in different versions. NAO robots acquire image information through cameras, process and obtain effective information. NAO robot's well-known face recognition is an interactive function developed based on this design. NAO robot can learn and remember different face information and recognize it.

Python is a high-level, interpretative, interactive and object-oriented scripting language. It is also a cross platform, open source and free interpretative high-level dynamic programming language. It is a general programming language. In addition to being able to interpret and execute, python also supports pseudo compiling the source code into

byte code to optimize the program and improve the running efficiency and keep the source code confidential. Python supports both imperative programming and functional programming. It is an object-oriented program design with simple and clear syntax, powerful functions and easy to learn and use. Python's design is very readable. Compared with other languages, it often uses English keywords and some punctuation marks in other languages. It has more distinctive grammatical structure than other languages. Python is an interpretive language, and there is no compilation in the development process. Python is an object-oriented language, which supports the object-oriented style or the programming technology of encapsulating code in objects. As Python is a dynamic language, the language structure is clear and concise, the library is rich, mature and stable, the scientific calculation and statistical analysis are powerful, and the production efficiency is higher than that of C, C + + and Java.

Take face recognition as an example, and how to write such a code to complete the compilation of a program that greets a person when he sees his face.

First, a class is constructed, named humannegreetermodule, whose main task is to set face recognition and feedback. Among them, the subscribe to event function defines the response to the facedetected event, and the onfacedetected function is a specific execution task, which calls the TTS file to output text to speech, and completes the function of greeting [10]. The specific steps of each process will be clearly seen, which resources are called and what functions are realized. In addition, the experiment can also be completed with graphical programming examples.

Graphical programming is an official programming method. In the special compilation software choregraph, the programming is based on the instruction box provided by the official, and the programming can be completed by wiring.

CHOREGRAPHE is the program software that can write programs, link with NAO, burn programs, and link with webots to simulate and execute programs.

Through the software interface, the posture information of the robot and the program information on the robot will be intuitively seen.

Also take face recognition and voice greeting as an example, use visual programming to re program. First, find the required module in the instruction box library. The instruction box is divided into two parts, list and remarks. Then, through the operation, the writing of this small program is very simple. It can be found that there are exactly two modules that find faces and voice speech, and they can be connected to complete the operation.

From the structure, it is obvious that visual programming is simpler than python programming. In contrast, visual programming has a simpler structure and a clearer process sequence, which can be said to be a programming method very suitable for novices to understand robots.

5.3. Innovative Experimental Teaching

5.3.1. Experiment on Combination of Virtual and Reality

Comprehensive experiment refers to a kind of compound experiment in which students comprehensively train the contents, methods and skills of experiments by using one or more course knowledge after mastering relevant basic theoretical knowledge and skills. Comprehensive experimental teaching has always been one of the reform directions of experimental teaching in higher education. NAO robot platform is also widely used in the research of human robot interaction, especially in the research of infants. A further research area of NAO robots is to control humanoid robots using brain computer interface technology.

The comprehensive experimental topics are as follows.

Use NAO robot to imitate learning and dancing in human infant interaction, research on interaction of autistic children, research on NAO robot as a long-term partner of hospitalized children, including NAO robot's bimodal emotion calculation system, NAO robot's digital recognition, NAO robot's visual attendance system design, NAO robot's soft pen calligraphy handwriting experiment, etc.

5.3.2. Case Experiment

Motion is modeled and NAO Robot Arm is simulated. Combine MATLAB with NAO robot to complete the motion modeling of NAO robot arm.

The kinematics model of the NAO robot arm is established by using D-H method, and then the dynamics model is obtained according to Lagrange equation, and then simulated by MATLAB. It is divided into the following three aspects.

First, the structure of NAO robot arm is analyzed.

The NAO robot arm has 5 degrees of freedom, the shoulder has 2 degrees of freedom for pitching and rolling, the elbow has 2 degrees of freedom for deflection and rolling, and the wrist has 1 degree of freedom for deflection. The specific structural diagram of the left arm of the NAO robot can be referred to Figure 1 of document [11].

Secondly, the kinematics model of NAO robot arm is established.

For a robot's mechanical arm, kinematics describes the analytical relationship between the joint position and the position and direction of the end effector, including the position, speed and acceleration of the mechanical arm and their derivatives relative to time, without considering the forces and moments that make the mechanical arm move. The kinematics of the manipulator includes forward kinematics and inverse kinematics. The forward kinematics of the robot arm describes the angle value of the known joints of the robot arm, which is used to calculate the end pose of the robot arm. For the forward kinematics, its solution is uniquely determined, that is, after each joint variable is given, the end pose of the robot arm is uniquely determined.

D-H is a classical kinematic model describing the structural motion parameters of the manipulator. Its transformation matrix is described by four parameters, α, β, a and d. The transformation matrix from the coordinate system i to the coordinate system i-1 is a function only related to the joint variable q_i. The forward kinematics equation is constructed by the following homogeneous

transformation matrix, as shown in formula (1).

$$A^{i-1}(q_i)=\begin{bmatrix}\cos\alpha_i & -\sin\alpha_i\cos\beta_i & \sin\alpha_i\sin\beta_i & a_i\cos\alpha_i\\ \sin\alpha_i & \cos\alpha_i\cos\beta_i & -\cos\alpha_i\sin\beta_i & a_i\cos\alpha_i\\ 0 & -\sin\beta_i & \cos\beta_i & d_i\\ 0 & 0 & 0 & 1\end{bmatrix} \quad (1)$$

The total homogeneous transformation matrix t of the NAO robot arm motion is shown in formula (2).

$$T_n^0(q)=A_1^0(q_1)A_2^1(q_2)\bullet\bullet\bullet A_n^{n-1}(q_n) \quad (2)$$

The rotation mode of the elbow and wrist around the y-axis only affects the posture of the end of the robot arm, but does not affect the position of the robot arm in the three-dimensional space. Therefore, these two rotation joints are ignored, and the rotation of the shoulder around the z-axis is not considered in this study.

According to the above kinematic D-H model parameters, the forward kinematics solution of the NAO robot arm is first obtained, and then the relationship between the position of the end of the NAO robot arm and the angle of each joint is obtained in the joint space. The forward kinematics equation of the arm is shown in formula (3).

$$T_0^2=A_1^0A_2^1\begin{bmatrix}\cos(\alpha_1+\alpha_2) & 0 & a_2\cos(\alpha_1+\alpha_2) & a_1\cos(\alpha_1)\\ \sin(\alpha_1+\alpha_2) & 0 & a_2\sin(\alpha_1+\alpha_2) & a_1\sin(\alpha_1)\\ 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 1\end{bmatrix} \quad (3)$$

The end position of the robot arm is shown in formula (4).

$$\begin{cases}x=a_2\cos(\alpha_1+\alpha_2)+a\cos\alpha_1\\ y=a_2\sin(\alpha_1+\alpha_2)+a\sin\alpha_1\end{cases} \quad (4)$$

Finally, the kinematics model of the NAO robot arm is verified.

Use robotics toolbox to carry out simulation experiments on the operation model of Nao robot arm in MATLAB. Robotics toolbox is designed by scientist Perter corke. It provides many functional modules, such as trajectory generation module, kinematics module and dynamics module, which greatly facilitates people's research on robots.

According to the D-H parameters of the two joints of the left arm of the NAO robot, a simple two joint robot model is created using the robotics toolbox in MATLAB. The fixed-point control of the NAO robot arm includes setting the starting position q_0, and the arm naturally hangs down when the robot stands. At the same time, the target position q_1 is set and the sampling time t is set. In this way, the simulation results can be completed.

6. Multi-Level Experimental Examination

According to the characteristics of the NAO robot experiment course, the corresponding assessment methods and standards are formulated, and the experimental process and results are assessed as a whole. In addition to emphasizing the importance of the experimental process, more attention is paid to the analysis, synthesis and judgment of the experimental results, especially the thinking and understanding after the experiment. Students are required to express the experimental results in professional terms. On the contrary, failing experiments are given greater encouragement. As long as students can analyze the reasons for failure and put forward their own opinions and correction plans, they can also be rated as excellent grades. According to the characteristics of multi-level experimental teaching, different assessment methods are adopted according to different levels.

Study examination method of basic experiment. The basic experiment is a qualitative experiment. According to the understanding of the experimental problems, the NAO robot basic experiment course adopts the method of practical operation, written examination and ordinary examination. The examination of the experiment is in the form of a test question bank. During the examination, the students immediately select the test questions, focusing on the students' practical operation ability, understanding and analysis of the experimental principle.

Study examination method of design experiment. The design experiment reflects the programming ability and the correctness of the experimental results, which can qualitatively describe the control problems.

The design experiment adopts the assessment method of "target plus link plus report". The specific assessment content involves data collection, scheme design, software and hardware design, assembly and debugging, testing and optimization, data analysis and report writing. The experimental assessment is carried out item by item, taking into account the difficulty of topic selection, design process, design results and design report.

For the combined design experiment, the focus is on examining the students' ability to draw up experimental plans and solve problems, to independently find possible ways to flexibly use equipment, to consult literature, to do things by themselves, and to raise problems, analyze problems and solve problems. The instructor's assessment of students' comprehensive application ability mainly includes comprehensive judgment ability, understanding of problem-solving strategies, enthusiasm and scientificity of their thinking process, and the level of experimental papers.

Study examination method of research innovation experiment. In innovation training and scientific research, students should dare to think, say and do, and should not pay too much attention to research results. Focus on the training of students' research ability, creative thinking. It does not set specific indicators, and comprehensively evaluates the innovation and orderliness of students' scientific research activities and problem-solving strategies from topics selection, literature research, experimental design, specific experimental operation, analysis and discussion.

The innovation experiment is an open-ended experiment. Because each group of students has different types of experiments and different functions, the evaluation index cannot be determined by a single one. In the experiment as a whole, it is first necessary to distinguish the difficulty of project completion, and then evaluate the project completion degree, so as to obtain the overall experimental results. Finally, according to the contribution of each team member, the student's grades are given. Students who get rewards for participating in electronic design competitions will be given credit rewards according to the policy of the college, and their credits will be exempted from relevant courses after being confirmed by the lecturer.

Study the experimental evaluation methods of information resource sharing platform.

The information resource sharing platform is oriented to the students of the whole material discipline group, and implements resource sharing and all-weather opening. Students come, learn and practice at any time, without time and space restrictions. Students are qualified as long as they reach the specified time of online and computer access.

7. Characteristics and Effectiveness Evaluation of Experimental Teaching

The extension and expansion of traditional experimental teaching is realized by filling up the solid with the virtual.

It breaks through the time and space limitation of traditional robot experimental teaching and improves the efficiency and effect of its experimental teaching. Robot experiments have a long cycle, high requirements for environment and places, and are limited by time and space. Traditional experimental teaching only takes 2-4 class hours. The development of robot virtual simulation teaching experiment platform is helpful to break the space-time limit in the process of experimental teaching, enable students to systematically and comprehensively understand and master the basic knowledge and skills of Nao robots in a short time, and cultivate students' innovation ability. Expand the teaching content of exploratory experiments and improve the autonomy of students in experimental design. Through repeated experiments to optimize the design and operation, the optimal control parameters of the NAO robot are selected as the real experimental conditions to achieve the organic integration of virtual simulation and real experimental teaching.

Scientific research feeds back teaching and is closely related to production practice. Over the years, the NAO robot scientific research team has made a number of robot related scientific research achievements and accumulated a large amount of experimental data, which provides strong data support for the development and construction of the virtual simulation platform. The system builds a dynamic experimental model based on logical discrimination and mathematical model, which is systematic, open, interactive, interesting and fault-tolerant. It can reflect the progressiveness of project construction and integrate with production practice.

Study the combination of virtual reality and diversification of assessment system. Virtual simulation and real experimental operation are combined. For example, NAO robot mainly focuses on real experiments, which can be real but not imaginary, while the control parameters of the robot focus on the virtual experiment results and grades of students. The assessment is not based on the highest survival rate as a single indicator, but on multiple indicators, which is more in line with production practice. In addition, fault tolerance should be highlighted as much as possible, and students should be allowed to do some wrong experimental processing design, with emphasis on assessing their experimental operation process.

Enhance students' subjective initiative and creativity. In addition to the whole process experimental links, the system also sets up exploratory experimental links. According to the parameters of each link of the NAO robot, the system designs a separate experimental module for students to carry out experiments purposefully, This breaks the traditional teaching mode of simply step-by-step teacher doing plus student watching teacher acting plus student imitating or teacher speaking plus student doing, and changes into a mode of students thinking and doing and designing experimental schemes at will. In this way, through the feedback of experimental results, they can promote their thinking and cultivate their innovative ability. Through this process of experiment design, result feedback, finding problems, optimizing experiment design and solving problems, students' scientific experimental methods are cultivated, their professional knowledge horizons are expanded, and their subjective initiative and creativity in learning are stimulated.

Share resources and build a platform for students' independent learning and interaction between teachers and students. The virtual simulation experiment platform can facilitate students' online learning, simulate and restore the teaching effect of real experiments, and expand the scope of benefits. Through the platform, students can carry out experimental operations anytime and anywhere. Before the experiment, students learn about the purpose and principle of the experiment and other related basic professional knowledge through the preview module in the platform. After the experimental class, consolidate the contents learned in the experiment by optimizing the experimental design and operation. At the same time, teachers and students can also interact through online communication to improve the pertinence and effectiveness of learning. Teachers can clearly understand students' mastery of relevant professional knowledge and skills through the experimental platform, so as to provide reference for targeted experimental teaching in the future.

8. Conclusion

The multi-level experimental teaching of NAO robot better meets the requirements of students with different foundations,

abilities and development goals in the process of robot experimental teaching, and realizes the classified teaching objectives for different students. The teaching content conforms to the cognitive laws and learning abilities of students at different levels in the College of computer and artificial intelligence, and has achieved good results.

In the process of basic experimental teaching, the experimental teaching mode of low starting point, multiple steps and levels is realized, Quite a number of students with poor foundation and weak ability are no longer afraid of the experimental process. By completing the low difficulty experimental process, they gain a great sense of achievement, gradually cultivate their interest in experiments, and enhance their motivation and confidence in learning. Students with good foundation and strong ability have gained space to further improve their ability and have strengthened their courage to make progress towards difficult experiments. At the same time, it also urges students to understand and compare the requirements of the three grades when deciding on grade selection, and gradually develop the habit of preview before experiments. After carrying out the layered basic experimental teaching, the overall level of students' experimental ability has been greatly improved.

In the stage of improving and innovating the hierarchical experimental teaching, the experimental center provides students with sufficient experimental conditions, rich curriculum contents and diversified teaching methods. This greatly improves students' practical application ability and innovation ability. In recent years, college students have actively participated in college students' electronic design competitions and achieved excellent results. Robot experiment teaching has effectively improved the college students' robot experiment ability and cultivated a number of students with good application ability and innovative spirit. Virtual simulation experiment can effectively solve the problems existing in the experimental teaching of universities at home and abroad. It plays an important role in expanding the experimental teaching content, improving the experimental teaching mode, and improving the experimental teaching effect.

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References

[1] WANG Xin, WANG Xinqing, WEN Yan, LI Shiqing, WANG Jirong. Virtual reality combination experimental platform of manipulator based on MATLAB and ROS. Experimental Technology and Management. 2022, 39 (2): 188-192.

[2] WANG Zhijie, DU Yu-fan, YANG Mo, QIN Tao. Motion Planning of Dobot Manipulator Based on MATLAB Robotics Toolbox. Mechanical research and Application. 2022, 34 (172): 49-51.

[3] ZHU Xinjie, WANG Qingjiu, GU Daqiang, YANG Jiangxin. Experimental teaching method of industrial robot based on combination of virtuality and reality. 2020, 37 (10): 167-190.

[4] LIU Na, HAN Huanqing, MO Weiqiang, LI Lin. Teaching Reform and Practice of the Industrial Robotics Based on Emerging Engineering Education. EDUCATION TEACHING FORUM. 2020. 12, 162-164.

[5] GUO Yan jie, GUI Liang, JIN Yue. Exploration of robot experiment teaching for undergraduate students. LABORATORY SCIENCE. 2015. 2, 18 (1), 131-134.

[6] Guo Yue. Application of Nao based robot in the teaching of artificial intelligence robot in Higher Vocational Education. Popular Science. 2019. 4, 125-126.

[7] CHEN Duanjun, YAO Mei-ling, LIU Min. Exploration on Multi-level Experiment Teaching of Computer Language Course in Independent Colleges. EDUCATION AND TEACHING FORUM. 2021, 100-103.

[8] WANG Dadong, WANG Peng, SUN Mingchen, LIU Qian, WANG Xiaoyu. Design and implementation on NAO robot sharing experimental. Journal of Jilin Normal University (Natural Science Edition). 2020. 5, 41 (2): 129-134.

[9] Dong Yang, Su Han, Li Tianyi. From the NAO Resources to See the Design of the Robot. Robot technology and Application. 2020, 28-30.

[10] WANG Yuanjie, LIN Du, XIAN Hao. Analysis of Various Programming Methods Based on NAO Robot. RESEARCH AND EXPLORATION IN LABORATORY. 2019, 38 (3): 42-45.

[11] Wen Shengjun, ZHAI Rui, GUO Guangfu, KANG Liangqi, ZHU Jing, Kinematics Modeling and Control of NAO Robot Manipulato. JOURNAL OF ZHONGYUAN UNIVERSITY OF TECHOLOGY. 2018, 29 (1): 83-88.

[12] YANG Changyue, CAI Xufu, ZHOU Tiannan, QIAN Zhiqi, ZHAO Changsheng. Structure and Reform of Multi-layer and Multi-module Experimental Teaching System. Experiment Science and Technology. 2015, 13 (2): 119-122.

[13] FENG Lingyun, LIU Kai. Development and application of virtual-actual practical teaching platform for industrial robot. Experimental Technology and Management. 2021. 5, 38 (5), 223-229.

[14] Gao Pan, Zou Yin, Tang Chao, Liu Yangkai, Wang Xiaojun. Industrial Robot Training and Teaching Platform and Method Combining Virtual and Physical. MECHANICAL & ELECTRICAL ENGINEERING TECHNOLOGY. 2022. 9, 51 (9), 116-120.

[15] ZHU Xinjie, WANG Qingjiu, GU Daqiang, YANG Jiangxin. Experimental teaching method of industrial robot based on combination of virtuality and reality. Experimental Technology and Management. 2020. 10, 37 (10), 167-170.

[16] Wang Shuai, Wu Chengdong, Jia Zixi, Han Bing, Zhang Hualiang. Design and teaching practice of robot experiment teaching platform based on virtual reality. China modern educational equipment. 2021. 4, 69-72.