Application of Mobile Robot Virtual Simulation Platform in Teaching Management

Yihan Xie*

{15995380022@163.com*}

Suzhou Industrial Park Institute of Service Outsourcing/Academic Affairs Office, Jiangsu Province, City of Suzhou, 215123, China

Abstract. In order to understand the application of mobile robot virtual simulation platform, this article proposes an application research of mobile robot virtual simulation platform in teaching management. This virtual simulation platform is suitable for course teaching and has multiple advantages: universal interface, easy to use, flexible configuration, intuitive interface, etc. Secondly, through the adaptation of communication interfaces, this virtual simulation platform has the ability to control physical robots, achieving an experimental teaching technology that combines virtual and real, and applying it to course teaching. In this case, quickly loading the scene into memory to determine the rendering accuracy is very important for system speed, so it is usually necessary to add some additional controls to optimize the data structure, such as organizing the scene into a tree structure according to space, and using its hierarchical structure to traverse some scenes that need to be displayed. Finally, this article relies on the virtual simulation platform, adopts a task driven teaching method, and combines the teaching content in and out of class to conduct theoretical and experimental teaching of intelligent robot courses. This teaching method enables students to participate more actively in learning, cultivating their hands-on ability and problem-solving ability. This virtual simulation experimental platform provides new methods and ideas for the experimental teaching of intelligent robot courses, better assisting classroom teaching and improving students' learning outcomes.

Keywords: Mobile robot; Virtual simulation; Teaching management.

1 Introduction

Among all kinds of robots, mobile robot has become the research frontier in the field of intelligent robots because of its flexible mobility, environmental adaptability and wide application, and it has a wide range of application needs in dangerous environment exploration and sampling, battlefield reconnaissance, urban disaster relief and other fields. At the same time, the emergence of virtual reality technology has realized the natural and harmonious interaction between people and information space, which provides a new description method for realizing large-scale visualization of complex data. The combination of mobile robot and virtual reality technology greatly expands the application space of mobile robot technology. Through virtual reality simulation, people can simulate the working environment of virtual robot, analyze its performance, find design defects in time and improve them, and optimize the task program, thus avoiding many unnecessary losses. Therefore, the design and implementation of virtual simulation platform for mobile robots has become a research

ICMEIM 2023, September 08-10, Wuhan, People's Republic of China

DOI 10.4108/eai.8-9-2023.2340050

hotspot in the field of robotics. Robotics is a new technology developed after World War II. In 1958, an American company produced the world's first industrial robot, which opened the prelude to the development of robots. In 1967, Japan Heavy Industries Company purchased the production license of robots from the United States, and Japan began the upsurge of manufacturing and developing robots. With the wide application of robots in industry, strengthening the experimental teaching of robot platform and improving the control ability of learners to robots have become the most important task of robot teaching, and thus the robot teaching platform has been derived[1-2].

2 Modeling technology of virtual simulation environment

The basis of virtual reality simulation system is to establish a realistic three-dimensional virtual environment model, which mainly includes three-dimensional visual model and three-dimensional auditory model. Among the factors that affect the fidelity of virtual reality environment, the fidelity of three-dimensional visual model occupies an important position, so the author mainly discusses the establishment of three-dimensional visual model. Three-dimensional visual modeling mainly includes geometric modeling, motion modeling, physical modeling, behavior modeling and model segmentation (management). The virtual reality modeling cycle is shown in Figure 1.

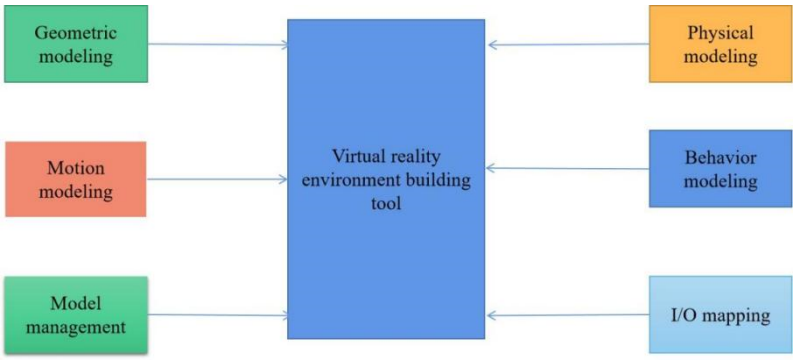

Figure. 1. Virtual Reality Modeling Cycle

Because virtual reality modeling needs real-time simulation and operation, it is very different from modeling. On the one hand, in addition to modeling, virtual reality modeling should pay attention to many details, such as degrees of freedom, level of detail model, etc., in order to make the model move realistically; On the other hand, in order to improve the real-time calculation efficiency and performance speed of the system, virtual reality simulation modeling usually uses texture technology to improve the fidelity of the model, instead of blindly improving the model complexity and the number of polygons like modeling modeling[3].

2.1 Real-time 3D scene generation and optimization technology

In the scene generation, in order to ensure the speed, it is necessary to transfer the required relevant information into memory, judge the visibility and detail level of the object, and decide whether to draw or not and the drawing accuracy, so as to simplify the drawing of complex models. In this case, it is very important for the system speed to quickly transfer the scene into memory and judge the drawing accuracy, so it is usually necessary to add some extra controls and optimize the data structure, such as organizing the scene into a tree structure according to space, and traversing some scenes that need to be displayed by using its hierarchy.

2.2 Design and Implementation of Virtual Reality Simulation Platform for Mobile Robot

(1)Construction of 3D Virtual Scene

The construction of virtual environment is not only the technology to realize the virtual reality simulation system, but also the key step to establish the virtual reality simulation system. Therefore, the first thing to be done is to model the scene in three dimensions. Three-dimensional scene construction is the construction of scene database, which mainly includes the following steps: material preparation, three-dimensional model construction and post-processing. In this paper, OpenGL is used to build three-dimensional virtual scene, and its process is shown in Table 1.

Table 1. Flow chart

Material preparation	data acquisition	pretreatment
Build a three-dimensional model	Build a model	Remove the residual surface
Post processing	Model test	Model optimization

The principle of robot modeling is the same as that of scene modeling, but as a direct medium for users to interact with virtual scenes, its modeling will be more detailed. For mobile robots, the most common chassis type is crawler, which uses the crawler to contact the ground and uses the differential between the left and right crawler to realize steering. This design has the advantages of reliable structure, simple control, strong cross-country passing ability and adaptability to various terrains, so this design idea is also adopted to establish a three-dimensional solid model of the mobile robot by using 3ds Max. After the robot model is obtained, it is imported into the scene editor (WED) just like the building model[4-5].

(2)Process steps

Using VC++2010 as a development tool, the script is edited through the script editor (SED) of 3D Game-Sudio. The specific steps are as follows:

1)Load the scene and define the camera position.

2)Detect whether the user continuously operates through the keyboard (whether the six keys W, A, S, D, Q and E are pressed), and W, A, S and D are four control keys, namely, up, down, left and right. "Q" and "E" are the control keys for lens left and lens right respectively.

3)Judging whether the "Ctrl" key is pressed, wherein the "Ctrl" key is the control key of the mouse lens; if the "Ctrl" key is pressed, the viewing angle is changed through the movement

response of the mouse, and the distance of the viewing angle is controlled by the mouse wheel; And when the CtrI key is released, the viewing angle at this time is automatically maintained.

4)It is judged whether the "Z" key is pressed, and the "Z" is the control key for resetting the viewing angle. If the "Z" key is pressed, the viewing angle will be returned to the preset viewing angle 1.

5)It is judged whether the "X" key is pressed, and the "X" is the preset control key for reversing.

6)Go back and do step ② again until the "Esc" key is pressed, and "Esc" is the control key for exiting the program. When "Esc" is pressed, exit the program.

Through this script, the virtual reality simulation platform of mobile robot controlled by standard computer keyboard will be realized. In this platform, the mobile robot model can be controlled to move freely, and the observation angle can be controlled by mouse or keyboard, and it can be switched to two preset perspectives.

(3)Architecture of Virtual Simulation Platform

The overall structure of the mobile robot virtual simulation platform is shown in Table 2. Interact with the simulation platform through general robot API interface programming, so as to separate the actual sensor and actuator. The sensor adapter separates the user interface from the simulation environment or the real environment, and submits the collected data to the user for use after appropriate processing, so that the control logic program can be switched between two running environments. Sensors are used to interact with real environment or virtual environment to obtain information such as distance, position and status. The actuator sensor does a similar job to the sensor adapter, and the actuator changes the behavior of the robot in response to the instructions generated by the user control program. The communication layer encapsulates the interface of external communication, analyzes, packages and distributes message packets, and uses adaptation technology to control the entity robot through user code. The simulator provides the simulation experiment function for the whole system. This virtual simulation platform adopts the client-server architecture, which can regard the simulator as a server and the virtual robot as a client, and they are connected by the basic communication protocol of TCP/IP. Multiple virtual robots can run in the same simulator, so the virtual simulation platform has the ability of multi-robot simulation[6].

Table 2. Structure of robot virtual simulation platform

Virtual environment	sensor	Actuator	Virtual robot
true environment	Actuator	sensor	Real robot
Communication layer	Sensor configuration	sensor	Universal robot

3 Simulation module of virtual simulation platform

Virtual simulation platform is a modular simulation system, which mainly includes map module, sensor module, motion module and simulation task scheduling module.Map module provides a virtual environment for robot simulation, and its main function is to represent, store,

edit and analyze the environment. In the start-up stage of robot virtual simulation platform, map module is called to provide virtual environment for the operation of virtual robot. At present, the module mainly describes the wall, static obstacles, dynamic obstacles and targets. The mobile robot is composed of many kinds of sensors, such as sonar, laser rangefinder, pose sensor, odometer, collision sensor, speedometer and image collector. Because this simulation platform is 2D graphics simulation, it does not support the simulation of image collector for the time being. At present, the virtual sensors have been realized: encoder, odometer, collision sensor, speedometer, virtual compass, sonar sensor and laser range finder. Based on the commonly used SICK LMS200 model, the laser rangefinder completely simulates the configuration parameters and communication data structure of SICK LMS200 laser rangefinder[7-8]. Motion module is the core module of robot virtual simulation platform. The motion module and kinematics calculation module encapsulate the details of the robot motion process, so that the client only needs to send the motion task request of setting linear speed and angular speed to the server through the API interface. Task scheduling module is the core of robot virtual simulation platform. The scheduling module implements a task scheduling queue, which is similar to batch task scheduling queue or print scheduling queue. In the robot virtual simulation platform, any request is regarded as a task, which is arranged in the task scheduling queue according to execution time or priority. Execution time takes precedence over priority, and each task is executed in sequence.

4 Hybrid virtual simulation and experimental teaching of solid robot

The platform is applied to the teaching of intelligent mobile robots. The running interface of the virtual simulation platform of mobile robot has a clear and intuitive simulation interface and simulation data output, which can analyze the data of the simulation operation, intuitively understand the simulation operation of mobile robot kinematics model, motion control and planning navigation and other related knowledge points, and then verify and analyze the control logic written by itself.

In the process of teaching experiment, the mode of "task-driven autonomous learning" is adopted, and based on the simulation and experiment platform, the experimental teaching of the course is carried out through the teaching method of combining reality with reality. Each task involves several knowledge points of the course and contains several learning modules. According to the functional requirements of the learning module, we learn relevant knowledge after class, and carry out hands-on practical ability learning and intensive training on the simulation platform. In the process of learning, teachers can actively explore and study with questions. Then, in classroom teaching, teachers focus on explaining the difficulties of each module and solving the practical problems encountered. Through programming, the functions indicated by tasks are realized in the simulation system, which expands the depth and breadth of understanding of robot-related knowledge and arouses the enthusiasm of learning[9-10].

5 Conclusion

In this paper, a virtual simulation platform for mobile robots is developed to meet the experimental teaching needs of intelligent mobile robots, which is practical. This paper

describes a simple, interesting and low-cost virtual simulation platform for mobile robots. The platform is easy to carry out experimental practice after class, which can effectively mobilize enthusiasm and enhance practical ability. In the process of simulation experiment, we will encounter all kinds of problems. Through in-depth thinking, we can improve the learning quality of intelligent robot knowledge and exercise the ability to solve problems. The virtual simulation experimental platform provides new methods and ideas for the experimental teaching of intelligent robot course, and better assists classroom teaching.

Acknowledgments. 2022“Jiangsu Province Social Science Application Research Excellent project "university ideological and political education special topic\Research on the countermeasures of Innovation and Entrepreneurship Education in Colleges from the Perspective of "Educating Five Domains Simultaneously"， 22SZC-056

References

[1] Ding, T. , Zhang, Y. , Ma, G. , Cao, Z. , Zhao, X. , & Tao, B. . (2022). Trajectory tracking of redundantly actuated mobile robot by mpc velocity control under steering strategy constraint. Mechatronics, 84, 1(0)2779-.

[2] Nguyen, T. H. , Nguyen, X. T. , Pham, D. A. , Tran, B. L. , & Bui, D. B. . (2023). A new approach for mobile robot path planning based on rrt algorithm. Modern Physics Letters B, 37(18)14.

[3] Ren, C. , Li, C. , Hu, L. , Li, X. , & Ma, S. . (2022). Adaptive model predictive control for an omnidirectional mobile robot with friction compensation and incremental input constraints:. Transactions of the Institute of Measurement and Control, 44(4), 835-847.

[4] Yang, Y. , Lin, Z. , Yue, M. , Chen, G. , & Sun, J. . (2022). Path planning of mobile robot with pso-based apf and fuzzy-based dwa subject to moving obstacles:. Transactions of the Institute of Measurement and Control, 44(1), 121-132.

[5] Li, Y. , Liu, C. , Gao, J. , Tao, B. , Zhao, X. , & Yan, S. , et al. (2022). Kinematic modeling and control of mobile robot for large-scale workpiece machining:. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 236(1-2), 29-38.

[6] Joki, A. , Petrovi, M. , & Miljkovi, Z. . (2022). Semantic segmentation based stereo visual servoing of nonholonomic mobile robot in intelligent manufacturing environment. Expert Systems with Applications, 1(9)0, 116203-.

[7] Zou, Q. , Cong, M. , Liu, D. , & Du, Y. . (2022). Brain-inspired cognitive map building for mobile robot. International Journal of Robotics & Automation14(1), 37.

[8] Yao, S. , Liu, R. , & Yao, Y. A. . (2022). Design and analysis of a multi-mode mobile robot based on schatz linkages. Mechanism and Machine Theory, 1(6)9, 104651-.

[9] Abbasi, A. , Mahmoudzadeh, S. , Yazdani, A. , & Moshayedi, A. J. . (2022). Feasibility assessment of kian-i mobile robot for autonomous navigation. Neural computing & applications14(2), 34.

[10] Foroughi, F. , Chen, Z. , & Wang, J. . (2021). A cnn-based system for mobile robot navigation in indoor environments via visual localization with a small dataset. World Electric Vehicle Journal, 12(134), 1-22.