International Core Journal of Engineering Volume 7 Issue 6, 2021
ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

Research on Key Technology of Virtual Simulation of Minimum Processing Unit

Zhouwei Zhang

Sichuan University of Science & Engineering, Yibin Sichuan 644000, China.

Abstract

Taking the minimum machining unit consisting of horizontal machining center, CNC lathe, robot arm and material conveying line as the object, the virtual reality simulation technology was researched, and a hardware based on Untiy3D engine and STM32 was proposed, using C# and C language. The design of a virtual real-time simulation system developed by programming. The research includes: 3D modeling and optimization processing, model and scene loading, motion simulation, virtual reality synchronization, VR hardware production and display. The test results show that the system has strong real-time and immersive feeling, can detect complex process routes, and has applicability to the FMS flexible production line with intelligent management, intelligent control and intelligent alarm.

Keywords

Untiy 3D; Virtual Real-time Simulation; Minimum Processing Unit; VR.

1. Introduction

At present, China's manufacturing industry is further developing from automation to digitization, information and intelligence [1], but the traditional manual monitoring and scheduling work mode is difficult to meet the needs of dynamic scheduling, online monitoring, fault diagnosis, intelligent alarm, etc. [2]. Virtual reality simulation technology uses virtual technology, communication technology, processing technology and computer technology to simulate the production equipment and production process in the virtual environment [3]. Therefore, the application of more economical and effective virtual reality simulation technology to realize the simulation, monitoring and early warning of the production line is of great significance to the intelligent upgrade of the production line.

In foreign countries, Wang et al. [4] proposed a networked monitoring system structure for manufacturing systems. "In this system, not only industrial robots can be simulated" but also the working process of industrial robots can be monitored based on the three-dimensional visualization environment. Tilbury et al. [5] based on a three-dimensional virtual environment "gradually join physical simulation and communication interfaces" to achieve a virtual environment in which manufacturing system simulation and monitoring are integrated. In recent years, China's manufacturing industry has gradually carried out flexible and intelligent upgrades of production lines. Yang Jianyu et al [6] proposed a research method for virtual machine simulation, monitoring and teleoperation integration of robots. Zhang Wenxiang et al [7] developed a three-dimensional simulation system for industrial robots using VC++ and Open GL. The domestic application is mainly applied to the on-site programming and debugging of robots. The deep research and application in the virtual simulation of production lines is not enough.

The purpose of this paper is to further improve the monitoring and design system of the flexible production line, and carry out the research on the key technology of virtual simulation for the minimum processing unit composed of horizontal machining center, CNC lathe, robot arm and material conveying line, and put forward the research technology route.as shown in Figure 1. First,

ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

build 3D models and optimize processing in SolidWorks and CINEMA 4D environments, import scenes into Unity3D environment, and finally load production line data to achieve production line motion simulation and collision detection. In addition, virtual display of VR devices is added. It provides an important reference for further improving the monitoring system and design system of the production line.

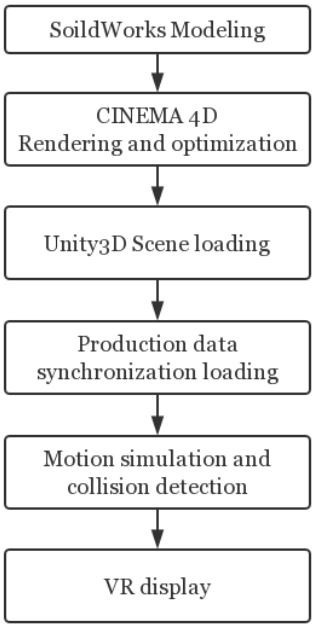

Figure 1. Research technology road map

2. 3D modeling and optimization

The Unity 3D selected in this paper is a comprehensive game development platform that can realize 3D video, architectural visualization, real-time 3D animation, etc., but the platform can only achieve basic geometry creation, which does not meet the actual production requirements [7]. In the field of engineering, software that can create complex combination structures, coordination relationships, and accurately express motion poses are PRO.E, UG, SolidWorks, 3D MAX, CINEMA 4D, etc. [8]. This article uses SolidWorks, which is more compatible with Unity3D, as the modeling platform, and CINEMA 4D as the rendering platform.

Taking the 3D modeling and optimization processing of CK3050 CNC lathe as an example, as shown in Figure 2, the flow chart of 3D modeling and optimization of CK3050 CNC machine tool is shown. The Unity 3D platform supports API function calls to control the movement of CNC machine tools, robots, conveyor belts, etc. through scripting languages. Therefore, the CK3050 CNC machine tool can not be completed by integral modeling, and the whole machine tool can be separated into mechanical parts such as bed, base, column, beam, work table, spindle box, tool holder, automatic tool changer, waste bin, feed mechanism, etc. After the modeling is completed, the constraint relationship is added to assemble the assembled body. Import 3D models created by SolidWorks into the CINEMA 4D environment as .wrl files. The basic steps to complete the optimization process in CINEMA 4D are: add color, reflection, specular and other material ball parameters; add floor; add lights; add sky; render settings. It is worth noting that the internal components are not rendered to reduce the file size and the processing power of the computer; the independent light source is added to the robot arm to ensure the stability of the image recognition camera; to ensure the consistency of the model, SolidWorks, CINEMA 4D, The unit in Unity 3D is set to cm.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

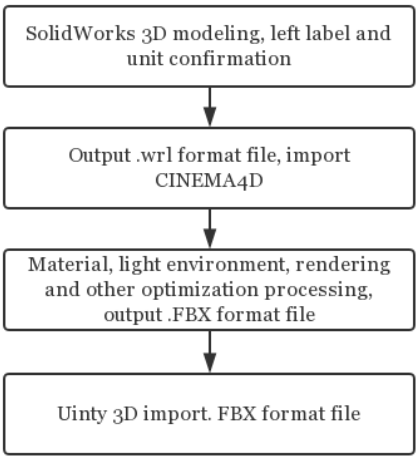

Figure 2. Flow chart of 3D modeling and optimization of CK3050 CNC machine tool

3. Scene loading and motion simulation

3.1 Scene loading

The virtual simulation of the minimum machining unit includes two parts: a virtual minimum machining unit and a virtual environment. The virtual environment includes lighting, machining processes, and work pieces to be machined. Import the smallest machining unit into CINEMA 4D, delete all the material balls imported by SolidWorks, and make no changes to the geometry, splines, etc. Because the minimum processing unit depends on the server instead of the industrial computer, the fineness is set to meet the server requirements. The minimum processing unit after import is shown in Figure 3. The SolidWorks material ball deletion interface is shown in Figure 4.

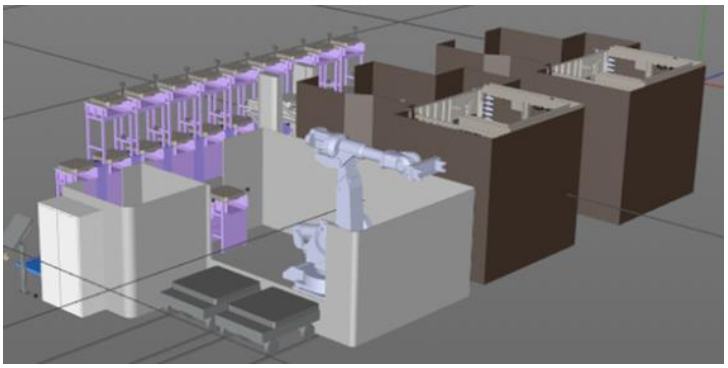

Figure 3. Minimum processing unit

Figure 4. SolidWorks material ball delete interface

ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

According to the nature of the parts, the numbers and English are used for naming and classification, and the uniqueness of the naming is guaranteed when classifying. According to the classification of the parts and the material properties, create a material ball library. Pay attention to the angle and position of the light source when lighting. The resolution is set to 1280X720, 30FPS. The comparison of the minimum machining unit before and after the scene is added is shown in Figure 5.

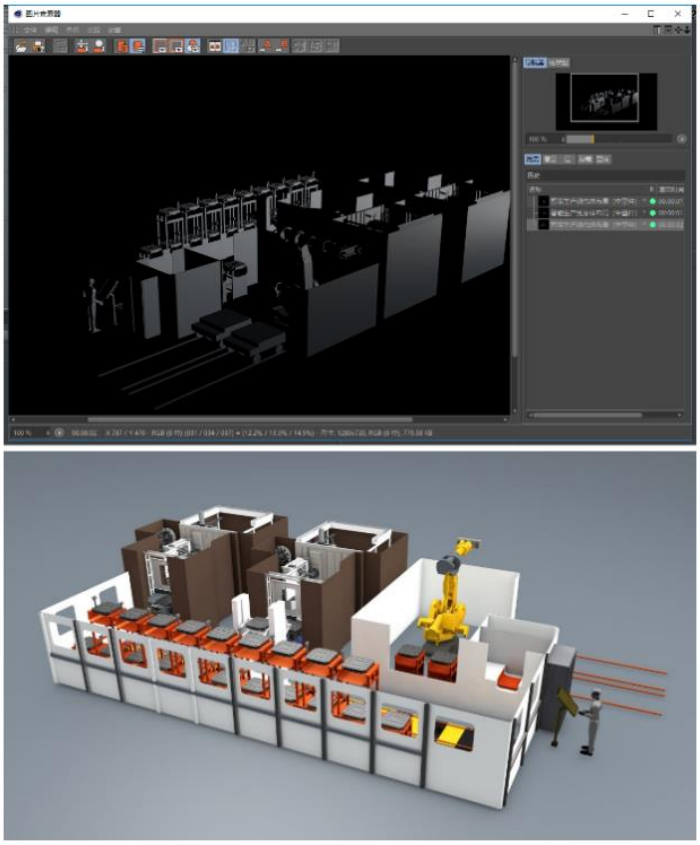

Figure 5. Comparison of the minimum processing unit before and after Unity3D graphics optimization processing

3.2 Unity3D graphics optimization processing

Import the. FBX format file into Unity3D and see the model file in the project directory. In order to make the scene more realistic, the shadows and reflections after the addition of the light source are processed, so that the light source in the scene produces a natural and harmonious lighting effect according to the energy transfer mode. At the same time, the corresponding material uses BRFD to achieve lighting rendering. In this virtual reality system, parallel light sources are used to illuminate the smallest processing unit in the entire scene.

3.3 Motion Simulation

Unity 3D supports C#, Java and Boo development languages. This article chooses C# language for programming, and IDE chooses Micorosoft Visual Studio2018. Unity 3D scripts are the core components of the entire virtual simulation. Each script executes its own life cycle and can be combined with each other and without intervention [9]. The script is mounted on the virtual minimum processing unit component, and the same object can be mounted with different scripts. After the script is hung on the object, the runtime will immediately execute the initialization synchronization method Awake(), and the Start() method will be next. Frame execution. For example, by writing a code with initial motion speed and direction of motion, it is mounted on the material to move the material along the material conveyor. The material motion image is shown in Figure 6.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

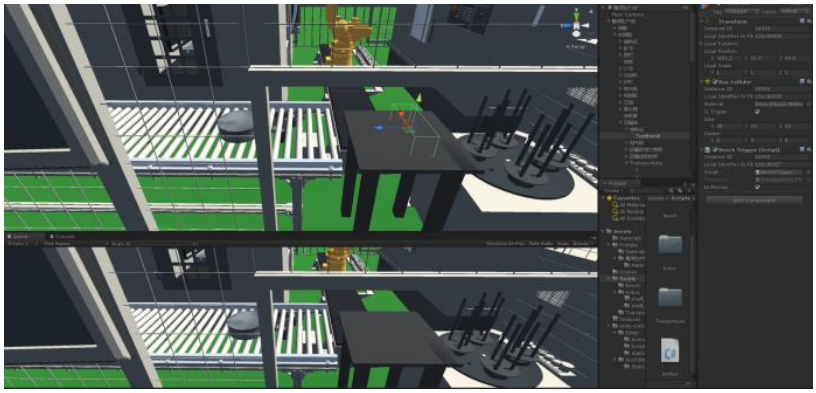

Figure 6. Material motion image

4. Synchronization function

The virtual minimum processing unit is connected with the real production line using the TCP/IP communication protocol. The Socket function binds the communication address and the port pin, and uses the dual-thread method to realize the sending and receiving of information; setting two message queues to receive the information and send the information respectively. The information needs to be judged by the message classifier to determine the object and type; all the messages are glued and processed, and the specific information structure is set as the judgment basis of the message integrity.

Unity 3D provides three lifecycle update methods: Update(), Late Update(), and Fixed Update(). In this paper, the related methods of updating virtual simulation are placed in the Fixed Update() function, and Fixed Update() is relatively fixed. Generally, normal programs optimize time-consuming operations, resulting in small-scale frequency fluctuations, and appropriately extending the interval of update time, which makes the update relatively smooth.

5. VR display

In three-dimensional space, describing the position and attitude of an object requires the displacement of the three axes of x, y, and z and the amount of rotation around the three axes [10]. The virtual minimum machining unit has basic functions such as movement and rotation, including the mobile door of the door, the movement of materials, the rotation of the robot, the rotation of the spindle box, and the rotary tool change of the tool magazine. According to the characteristics of the minimum machining unit, posture recognition can be realized by determining the direction of movement and the amount of displacement, the axis of rotation, and the amount of rotation.

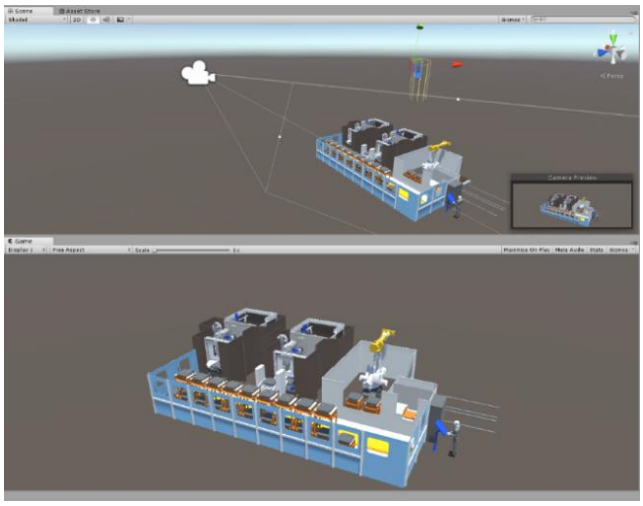

Figure 7. Unity3D camera image (top) and VR image (bottom)

ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

After obtaining the attitude angle of the VR glasses by using the mpu6050 gyroscope, the cosine matrix, the quaternion and the Euler angle are sequentially transformed, and the Kalman filter is processed to obtain the stable Euler angle data, and then the Euler angle is transmitted through the HC-05 Bluetooth. Into the Unity 3D environment. In the Unity3D environment, the serial communication script is mounted on the Main Camera component. The script controls the camera to move left and right and left and right by controlling the mobile member method Translate() function and the rotation member method Rotate() function of the Transform class of the main camera. The VR image and the Unity3D camera image are shown in Figure 7.

6. Conclusion

This paper mainly studies the virtual reality simulation technology of the minimum processing unit. Through the three-dimensional modeling and optimization processing, model and scene loading, motion simulation, virtual reality synchronization, VR hardware production and display, the minimum processing unit virtual is realized. Development of realistic simulation systems and research on key technologies. With the advantages of discrete manufacturing and intelligent manufacturing becoming more and more obvious, the demand for FMS flexible intelligent real-time virtual simulation system integrating 5G technology will become the main development trend. At present, traditional manufacturing relies on manual equipment debugging and production line debugging. Therefore, the research on the key technology of virtual simulation of minimum processing unit has important reference value for building flexible production lines with intelligent management, intelligent control and visualization. This paper mainly studies the virtual reality simulation technology of the minimum processing unit. Through the three-dimensional modeling and optimization processing, model and scene loading, motion simulation, virtual reality synchronization, VR hardware production and display, the minimum processing unit virtual is realized. Development of realistic simulation systems and research on key technologies. With the advantages of discrete manufacturing and intelligent manufacturing becoming more and more obvious, the demand for FMS flexible intelligent real-time virtual simulation system integrating 5G technology will become the main development trend. At present, traditional manufacturing relies on manual equipment debugging and production line debugging. Therefore, the research on the key technology of virtual simulation of minimum processing unit has important reference value for building flexible production lines with intelligent management, intelligent control and visualization.

Acknowledgments

This work was financially supported by the Innovation fund of postgraduate, Sichuan University of Science & Engineering (y2019002)

This work was financially supported by the Innovation fund of postgraduate, Sichuan University of Science & Engineering (B50104436)

References

[1] WANG Bo, LI Bai-chun, YANG Jian-yu, YU Tian-biao, WANG Wan-shan. Simulation and monitoring of a 6R industrial robot for intelligent manufacturing. Journal of Harbin Engineering University, vol.40(2019), 366-372.

[2] LI Kun, XU Jian-ping, SUN Wei, ZI Li-min, YIN Zuo-sheng, WANG Wei. Development and Application of FMS800 Flexible Production Line. Machine Tool & Hydraulics. vol.9(2017),23-25.

[3] LU Ye. Simulation Design of Robot Flexible Manufacturing Line Based on RobotStudio. Modular Machine Tool & Automatic Manufacturing Technique, vol.6(2016),158-160.

[4] Wang Li-hui. Planning towards enhanced adaptability in digital manufacturing.journal of computer integrated manufacturing, vol.24(2011),78-390.

[5] HARRISON S H. Virtual fusion: the integration and analy-sis of simulation and real process for manufacturing process deployment.Michigan:University of Michigan, vol.3(2011),20-106.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202106_7(6).0027

[6] YANG Jian-yu, XIE Hua-long, HAN Xiu-feng, WANG Wan-shan. Robot Simulation and Real-Time Monitoring Based on Virtual Reality. Journal of Northeastern University (Natural Science), vol.34(2013), 1634-1637.

[7] CHEN Xue-mei. Unity 3D mobile game development. Electronic Technology & Software Engineering, vol.23 (2016), 71-72.

[8] Zhang Wen-xiang, Zou Feng-shan, Qu Dao-kui, et al.Research of Key Technologies on 3D Simulation System of Industrial Robot.Proceedings of the 7th World Congress on Intel-ligent Control and Automation, 2008.

[9] XU Zhi-gang, HU Chang-ying. Virtual Vehicle Test Field Roaming System Based on Unity3D.Computer Technology and Development, vol.5(2019), 112-115.

[10] GAO Guo-xue, GAO Hui, JIAO Xiang-dong, ZHOU Can-feng, WANG Long. Study on Virtual Reality Simulation Technology of Welding Robot Based on the Unity3D. Modular Machine Tool & Automatic Manufacturing Technique, vol.3(2018), 19-22.