ISSN: 2664-9640

Research on Gordian Techniques of Virtual Real-time Simulation for Brewing Equipment Manufacturing Production Line

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Abstract

Facing the serious problem of data islands,low data utilization and difficult data analysis of production management in traditional production lines.To enhance the visualization and intelligence level,this article takes the brewing equipment manufacturing production line as the research object,studying the virtual real-time simulation technology. With the Untiy3D engine and STM32 microprocessor, the 3D modeling and optimization processing of the production line, model and scene loading, and virtual reality synchronization are completed. , motion simulation, electronic signage and VR display. The 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

Brewing equipment; Untiy3D; virtual real-time simulation; VR display.

1. Introduction

In the 21st century, with the proposal of Germany's "Industry 4.0" [1], "Made in China 2025" [2] and other manufacturing strategic plans, the manufacturing Industry is further developing from automation to digitalization, information and intelligence [3]. The traditional manual monitoring and scheduling mode has been unable to meet the actual production and manufacturing needs, and the production line with intelligent functions such as online monitoring, virtual simulation, dynamic scheduling and intelligent alarm has become the focus of the manufacturing industry [4]. Therefore, the research of virtual real-time simulation technology to realize the real-time simulation, monitoring and collision detection of the production line has important guiding significance and application value for the intelligent upgrade of the production line.

In foreign countries, Wang et al. proposed the networked monitoring system structure of industrial robot motion simulation and three-dimensional visualization monitoring of motion process for the manufacturing system [5]. Based on virtual environment, Til Bury et al. integrated physical simulation and communication to realize the integration of manufacturing system simulation and monitoring [6]. In recent years, China's manufacturing industry has gradually upgraded the flexibility and intelligence of production lines. Yang Jianyu et al. adopted virtual reality technology to realize the visual operation monitoring, virtual motion simulation and online control of industrial robots [7]. Zhang Wenxiang et al. realized the construction of industrial robot 3D simulation system on Open GL platform with VC++ high-level programming language [8]. Gao Feng et al. realized the communication between Object ARX secondary development software package and Auto CAD platform through Visual C++6.0 platform, developed a convenient CNC machining simulation software system, and completed the organic combination of Auto CAD platform and CNC system simulation [9]. However, the shortcomings of the above research lie in: mainly explore the application of virtual simulation

ISSN: 2664-9640

technology in robot, a few explore the application of virtual simulation technology in CNC machine tools, and the deep research and application of virtual real-time simulation of production line is slightly insufficient.

Therefore, this paper takes brewing equipment manufacturing production line as the object. Firstly, a virtual simulation environment of brewing equipment manufacturing production line is created with the help of Solid Works platform, Cinema 4D platform and Unity 3D platform. Then using TCP/IP technology to connect the virtual environment and the real scene in real time; Finally, VR equipment and electronic Kanban are used to realize visual display of production data. In the exploration process, the single machine motion simulation and the production line processing process simulation are realized. Combined with the visualization means, the visualization degree of the production line is enhanced, which provides an important reference for further improving the monitoring system and design system of the production line.

2. Introduction of production line and Unity3D

Brewery intelligent equipment manufacturing line is mainly responsible for the rough finishing of the outer surface of the disk-shaped boss parts. The production and processing process is shown in Figure 1 (arrows indicate the flow direction of the workpiece). The main equipment of the production line includes CK3050 CNC lathe, 828D CNC machining center, manipulator, material table, material conveying line, etc. The three-dimensional model and layout of the production line for brewing intelligent equipment manufacturing are shown in Figure 2. In the processing process of Φ30mm disc boss parts, the cylindrical hair parts are firstly transferred to the NC machining center for machining the boss surface by the robot, and finally transferred to the next station by the robot hand and the material conveying line.

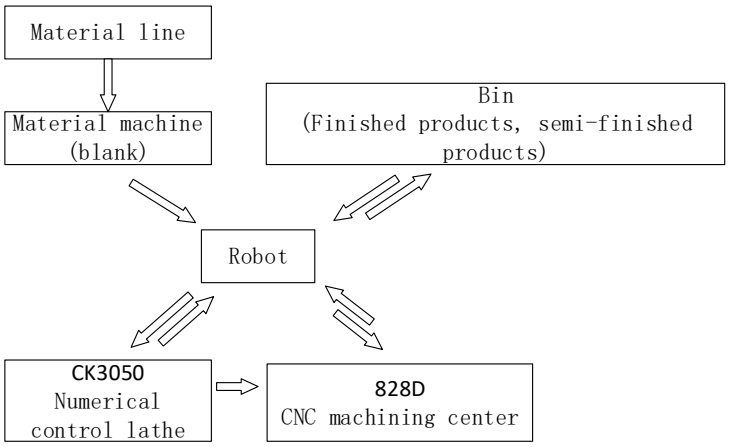


Fig. 1 Production and processing flow chart

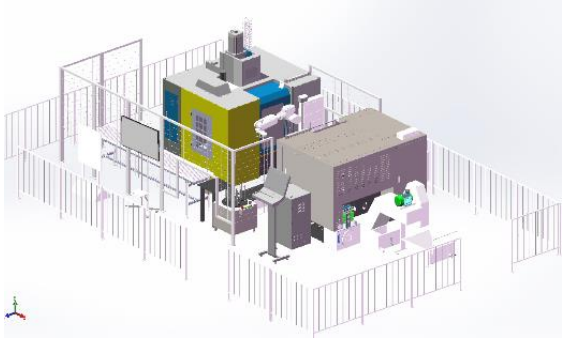


Figure 2 Brewery intelligent equipment manufacturing production line (3D model and layout)

Unity3D platform is a virtual reality environment development platform that supports C# high-level programming language with excellent compatibility performance. It integrates coordinate

transformation, physical system, light and shadow, sound effect, particle system, graphic rendering and other powerful functions, and supports optimization algorithm to realize collision detection. It is a comprehensive game development platform that is simple to get started and widely used in game development, building model building, animation design and other fields [10]. However, the geometric model creation function of Unity 3D platform is single, and it is difficult to create a model with complex geometric structure, which cannot meet the actual production requirements [11]. In the field of engineering, software capable of creating complex geometric structures, matching constraint relations and expressing motion posture include Pro/Engineer, Unigraphics NX, Solid Works, 3D Max, Cinema 4D, etc. [12]. Therefore, this paper adopts Solid Works, which is more compatible with Unity3D, as the modeling platform, and CINEMA 4D as the rendering platform.

3. 3D modeling and optimization

The Unity 3D platform supports API function calls to control the movement of CNC machine tools, robots, material transfer lines and other equipment through scripting language. Therefore, the equipment of the production line needs to be divided into independent component units, and the three-dimensional modeling is completed on the Solid Works platform, and the coordination and constraint relations of the parts are added and assembled into the whole. Then, the model optimization is completed on the CINEMA 4D platform. In order to shorten the time, considering the limited processing capacity of the computer, the inner surface of the internal parts of the equipment is not rendered on the premise of not affecting the industrial use; An independent light source is added to the mechanical arm to ensure the exposure stability of the image recognition camera. To ensure model consistency, the units in Solid Works, Cinema 4D and Unity 3D are set to CM.

Taking CK3050 CNC lathe 3D modeling and optimization treatment as an example, CK3050 CNC lathe is divided into bed, column, feed mechanism, beam, workbench, headstock, automatic tool changing device, tool, tool storehouse, waste storehouse and other mechanical parts, and the constraint relationship is added after the completion of modeling in Solid Works environment to assemble the body. Import the model file in.wrl format into the Cinema 4D environment to complete the optimization process. The basic steps are: add Color, Reflection, Specular and other material ball parameters; Add the floor; Add lights; Add the sky; Render Settings. The three-dimensional modeling and related optimization process of CK3050 CNC lathe are shown in Figure 3.

The 3D model creation and optimization of production line can be realized by combining Solid Works platform and Cinema 4D platform, which can avoid rendering problems such as color difference and image noise on Solid Works platform, and model creation problems such as complex geometric model creation steps and difficult matching relationship addition on Cinema 4D platform.

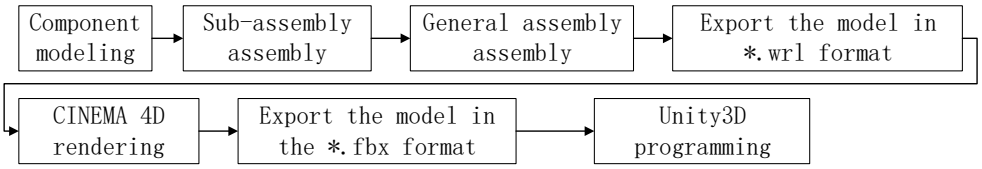


Fig. 3 3D modeling and related optimization process of CK3050 CNC machine tool

4. Construction of virtual production line for brewing intelligent equipment manufacturing

After 3D modeling and related optimization of the production line, the data format compatibility of each platform is solved. In order to ensure the maximum integrity of the model

ISSN: 2664-9640

data, the model file is saved as. FBX file format, the Unity 3D platform overload model file data, and then through the scene loading, graphics optimization processing, virtual and real synchronization, motion simulation to achieve the construction of virtual production line.

4.1. Scene loading

The virtual simulation of production line includes two parts: virtual production line and virtual environment. The virtual environment includes illumination, processing technology and workpiece to be processed. Import the production line model file into Cinema 4D environment, delete all the material balls imported by Solid Works, and leave no changes to the geometric structure, splines, etc. Since the production line relies on the server rather than the IPC, the refinement is set to meet the requirements of the server. The imported production line model is shown in Figure 4. The Solid Works material ball deletion interface is shown in Figure 5.

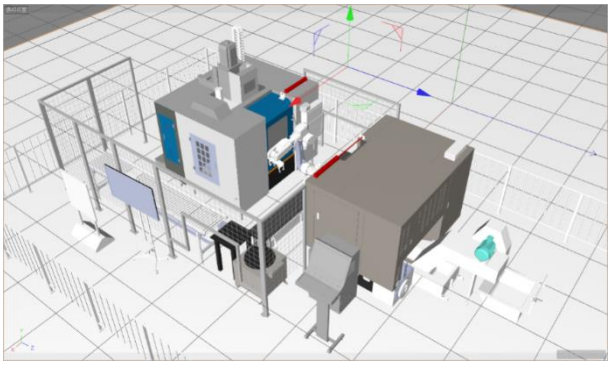
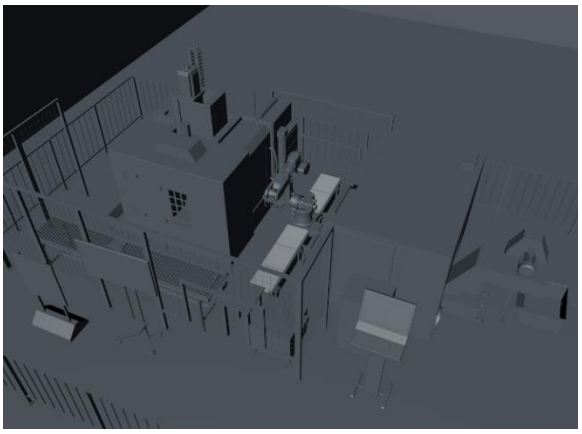


Fig. 4 Production line model

Figure 5 Solid Works material ball deletion interface

According to the nature of the parts, the uniform naming and classification rules of the combination of numeric characters and English characters are adopted to ensure the uniqueness of the naming and classification of the parts. Establish material ball library according to parts classification and material properties, pay attention to the Angle and position of light source when lighting, and set 1280X720 resolution (XGA display), 30Fps(Hz). The comparison of production line screen effects before and after lighting scene is added is shown in Figure6



ISSN: 2664-9640

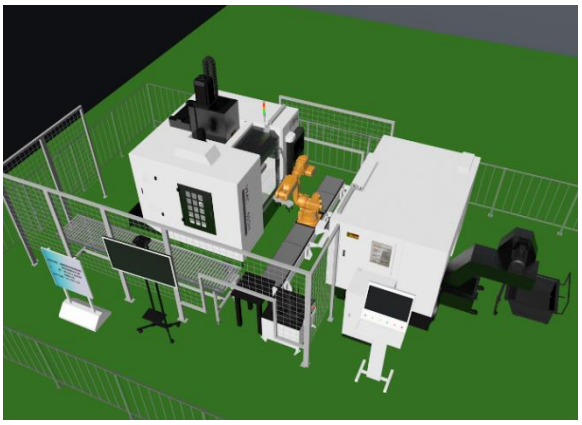


Fig. 6 Comparison of production line screen effects before and after lighting scene addition

4.2. Optimization of production line model on Unity 3D platform

Import the. fbx format file into Unity3D, and you can see the model file in the project directory. In order to make the scene more realistic, the shadow and reflection that appear after adding light source are processed to make the shadow and reflection in the scene meet the law of light transmission and energy transmission, so as to achieve the lighting effect of natural light in reality. At the same time, the material used for the relevant lighting rendering was BRFD. In this virtual reality system, a parallel light source is used to illuminate the smallest processing unit in the whole scene.

In each Game Object of Hierarchy in Unity3D, Mesh Render component of model visual display includes an important shadow control Lighting component. After the light source is added, the Receive Shadows option and the CAST Shadows option in the Lighting component Settings bar can be set to Receive and reflect Shadows. Parameter setting of Lighting component is shown in Figure 7.

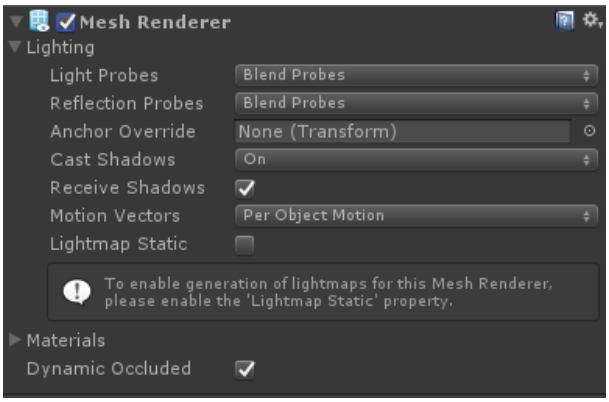


Fig 7 Lighting component parameter Settings

4.3. Motion Simulation

This text chooses C# language to carry on the Unity 3D platform programming, IDE chooses Microsoft Visual Studio2018. Scripts are the core components of the whole virtual simulation. Unity3D platform provides many scripts with complete life cycle. Virtual production line components can mount scripts, while the same component allows scripts with different functions to be mounted. When the motion script is mounted on the material, the material can move along the direction of the conveyor belt. During the movement, the initialization method Awake() will be executed immediately, and the Start() method will be executed in the next frame. Throughout the script execution life cycle, the Update() Update, Late Update() Update, and Fixed Update() Update methods are provided. Update() and Late Update() are immediate updates, and each script updates at a variable rate and can interact with each other. The time - consuming or delayed operation of the previous script update directly affects the update time

of the next frame of animation or action. In this paper, all relevant methods for updating the virtual production line are included in the Fixed Update(). Although Fixed Update() is a relatively Fixed Update with a small range of frequency fluctuations, the Update time can be appropriately extended to achieve a relatively smooth Update effect [13]. The image of material movement is shown in Figure 8.

Fig. 8 Motion image of material

The simulation results of material movement show that the material to be machined can move smoothly along the material conveying line, and there are no problems such as image noise, stagnation, material jitter and movement direction deviation during the movement process.

4.4. Virtual and real synchronization

TCP/IP communication protocol is used to complete data transmission between virtual production line and real production line. TCP/IP layer description and corresponding protocol are shown in Table 1 [14]. In order to meet the real-time demand of data transmission as the guide, this paper chooses the UDP/IP protocol composed of ARR protocol, IP protocol, UDP protocol and ICMP protocol as the communication protocol of data transmission. In the Unity3D platform, Socket function is used to bind the communication address and port pins, and the two-thread method is adopted to realize the information receiving and receiving. Two message queues are set up to receive information and send information respectively. Both messages need to be judged by message classifier for objects and types. All messages are sticky, and a specific information structure is set as the basis for the judgment of message integrity.

Table 1 TCP/IP layer description and corresponding protocols

TCP/IP layer	Corresponding to the agreement
Application layer	HTTP, FTP, etc
Transport layer	TCP, UDP
Network layer	IP, ICMP, IGMP
Link layer	Device driver, interface card

5. Virtual display of brewing equipment manufacturing production line

In three-dimensional space, the position and attitude description of an object requires the calculation of each displacement and rotation of the object relative to the coordinate axes of X, Y and Z space [15]. The human head also has the basic state of movement and rotation, including azimuth translation, left and right rotation, up and down rotation and so on. According to the motion characteristics, the attitude recognition can be realized by determining the relative linear displacement and relative rotation between the object position and each coordinate axis.

VR glasses attitude acquisition hardware adopts STM32F103C8T6 as the main control chip. The detailed parameters of the chip are Cortex-M3 core, 72MHz, 20480BRAM, 48-pin, 32-bit, LQFP package [15]. The attitude solver adopts MPU6050 gyroscope, the measurement range of

MPU6050 gyroscope is ±1000°/ s (DPS), the measurement range of accelerometer is ±2g, and the communication protocol is 400KHZIIC.

In this paper, the main function modules are initialized on STM32 chip, and the DMP module register is configured through IIC bus, so that the DMP module periodically reads the attitude data, and saves the processing results in the DMP register. At the same time, the external interrupt is generated, which causes the main program to read the quaternion of the attitude from the DMP register. After normalization processing, the data is transformed into the Euler Angle of the current attitude, which is sent to the HC-05 module through the serial port and transmitted to the Unity 3D platform. The procedure flow of VR glasses attitude Euler Angle acquisition is shown in Figure 8. In Unity3D platform, the serial communication script is mounted on the Main Camera component, and the script controls the Camera to move forward and backward and left and right through the Translate() function and Rotate() function of the moving member method built into the Transform class that controls the Main Camera. VR glasses images and images captured by Unity 3D camera scripts are shown in Figure 9.

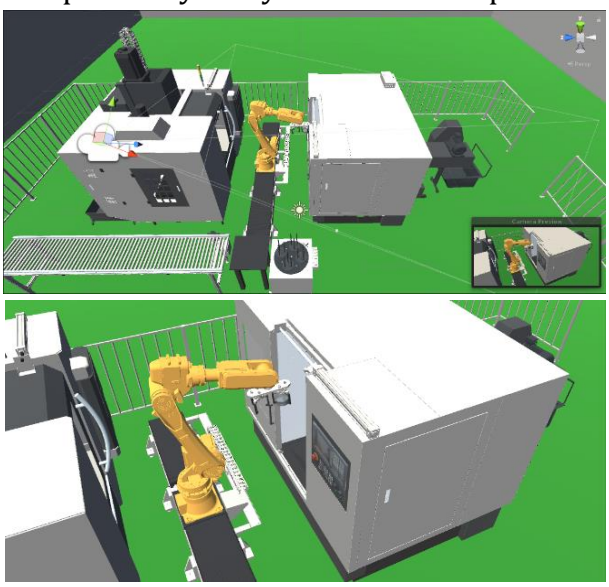


Fig 9 Unity3D camera position image (top) and VR image (bottom)

The simulation results show that VR equipment and electronic Kanban can synchronously display the grasping process images, but the display ability of VR equipment is stronger than that of electronic Kanban, and it has a stronger sense of introduction and impact.

6. Conclusion

This paper takes the zero-stage production line of brewing equipment manufacturing plate as the research object, studies the virtual real-time simulation technology, and draws the following conclusions:

(1) Through the application of Solid Works model creation, Cinema 4D graphic rendering and Unity 3D virtual scene creation, a relatively real virtual environment can be created, and the production process data can be loaded into the Unity 3D platform. The real-time motion synchronization of each production equipment in real scene and virtual scene can be realized, which enhances the visualization ability of the production line.

(2) Through the application of VR equipment, the real-time production scene is transformed from two-dimensional plane to three-dimensional space, so that the wearer can have a deeper understanding of the production line in a way full of immersive and realistic sense.

(3) According to the requirements of processing technology, the machining process simulation of unmachined parts can be realized through virtual simulation technology. Machining process

simulation can effectively reduce the production line faults caused by unreasonable processing task layout and improve the utilization rate of production equipment.

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