The Simulation and Realization of Palletizing and Handling Production Line by Industrial Robot Based on Augmented Reality Technology

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Abstract: In recent years, robot technology has received the attention from world academic field, industry and government. There is an increasing demand for applied talents in robot, so the rapid cultivation of high-end talents in robot is one of important tasks for colleges and universities. Besides, simulation system of industrial robot, as powerful instrument for analyzing and studying industrial robot, plays a positive and critical role in classroom teaching and enterprise training. This paper, taking current palletizing and handling production line by industrial robot in Southeast University Chengxian College as the research object, based on augmented reality technology, realizes virtual interaction by programming by virtue of Unity 3D software development platform. Taking training teaching into account, and combing the practical application in factory, a 3D virtual simulation system based on six-axis industrial robot is developed in this paper. In order to augment the sense of reality in entire virtue scene, this system, with the three dimensional modeling software, 3DMax, performs 1:1 three dimensional virtual simulation modeling according to palletizing and handling production line by industrial robot, so as to further improve the experience of learners and help their robot operation and application study.

1. Introduction

With the emerging concept of Industry 4.0 and Made in China 2025, and the increasing labor cost, the strategies of automatic production line and the replacement of labor by robot become the priority for the development of factory, so more and more industrial robots are applied in factory production. According to data released by International Federation of Robotics (IFP), the sales of robot in the whole world in 2018 reaches $16.5 billion, with an amount of 422,000 robots, increasing by 6% than that in 2017. Due to the explosively increasing application of industrial robot, high-end applied talents in the field of industrial robot also are in short supply. Enterprises pay every cost to conduct the training related to robot techniques on employees, which puts forward new requirements for the cultivation of talents in industrial robot technology. In April 2016, Ministry of Industry and Information Technology, National Development and Reform Commission and Ministry of Finance jointly issued *Development Plan of Robot Industry (2017-2021)*, which proposed that a better robot industry system shall be formed within five years in China, with a target of 100 robots for 10,000 people in 2020 and 20,000 talents in the design and application of robot. Given the demand for talent cultivation, Southeast University Chengxian College purchases two palletizing and handling workstations of production lines by industrial robot, and conducts relevant teaching and training.

Traditional teaching modes are mainly PPT lecture and exercises, where teachers instruct relevant knowledge points and matters needing attention in classroom first, then guide students to lab for exercises. However, this mode is faced with multiple teaching difficulties in practical teaching of robot.

In terms of safety, on the one hand, students' wrong operations probably destroy the structure of robot, even endanger their safety, especially when more than one students operate one robot.

On the other hand, from the perspective of training effect, constrained by limited robots and time for training, students have limited time to operate robot.

Augmented Reality, AR is a new technology to seamlessly integrate information from real world with virtual world. It, by virtue of science technology like computer, simulates entity information

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difficult to perceive in real world in a certain range of space and time, and overlaps, to apply virtual information to real world to be perceived by human. Based on traditional teaching mode that apply robot in training, this paper makes full use of virtual simulation software of robot and forms the new teaching mode with “virtual and realistic” concept. The software, as auxiliary teaching method, can greatly enrich traditional teaching mode. The integration of virtual simulation software throughout the teaching is beneficial for students to grasp basic operations before practically operating, and consolidate the learned knowledge by simulation software, in this way, the effect of teaching and training can be significantly enhanced.

2. Overall Scheme Design of AR Virtual Simulation System

In the application in production, industrial robot is always responsible for handling materials from one equipment to the other one. The palletizing and handing production line designed in this system takes the “five-flower palletizing”, where robot is required to handle stainless square box on transfer belt in production line to palletizing area, perform it in the form of five flowers, and handle it in palletizing area in order to transfer belt to form a palletizing and handling cycle. In this way, the work task can be completed with the cooperation between robot and production line. From this paper, students can understand the coordinated work of robot and general automatic production equipment, and deepen their understanding of robot work pace.

2.1 The determination of virtual simulation scheme

Unity 3D is an cross-platform game development and Virtual Reality engine developed by Unity Technologies. The bottom graphics library is Direct X and Open GL. In Windows system, Direct X is selected by Unity 3D editor in default. In Unity 3D, all API of Direct X and Open GL can be applied. When adopting Unity 3D, resources such as model and images shall be introduced and then create virtual world through scene creating module of Unity.

3D Max is three dimensional design software developed by American Autodesk, providing three dimensional modeling, mapping and rendering, animation production, etc. Before introducing model in Unity 3D for scene creation, the model shall be mapped and rendered in 3D Max, then exported as “.FBX” format. In this way, Unity 3D can direct introduce FBX document, and save to corresponding information such as grid, material and animation.

The real scene of palletizing production line shall be firstly analyzed in detail; professional knowledge points and function requirements related to workstation shall be concluded and summarized to develop main content of virtual simulation. Based on this, the modeling targets from real scene is selected according to content of virtual simulation and present its virtual model vividly. Next the appropriate three dimensional modeling software is selected for three dimensional 1:1 scene modeling in accordance with characteristics of modeling target. Then the model is produced by three dimensional modeling software of 3D Max. Finally, by virtue of Unity 3D virtual simulation software development platform, and with professional knowledge and three dimensional model combined, three dimensional scene walkthrough, human-machine interaction and other functions are added to create virtual simulation system oriented to object.

2.2 The function design of virtual simulation system

AR technology is characterized by the integration of virtual and real scene to augment users’ perception and recognition of real world, which is nowadays mainly presented by mobile device such as phone or tablet computer. As an important instrument for teaching training and application of robot, in this system, in terms of function design, basic requirement, teaching training and the application of robot shall be taken into account at the same time. Basic function requirement is the core of simulation system of robot workstation and the basis for realizing other functions, including basic structure and work principle of robot, and the components of palletizing and handling production line. In order to satisfy the need of teaching training, the simulation of robot simulation system shall be stronger, including the real sense of virtual scene, teaching interface and the authenticity of teaching operation. Besides, the application of robot requires programme code

generated from simulation system to operate in real teaching system. At the same time, programme generated from real teaching can realize trajectory simulation and scene validation in simulation system software.

According to the analysis of above demand, the entire simulation system can be divided into system function, demonstration function and teaching application function.

Firstly, system functions. It consists of robot structure recognition, control cabinet parts and safety education. Structure recognition module is mainly to introduce all parts in detail, and can realize the simulation operation of each axis by touch interaction operation, accompanying by robot movement sound effect. The control cabinet parts present the components of robot control cabinet and detailed operation procedures, including servo driver, controller, and switch, accompanying by background interpretation language. Safety education is mainly to introduce safety matters needing attention when operating robot.

Secondly, demonstration functions. The basic teaching function of robot simulation system include the module of demonstrator component, menu key, function key and axis operation key. Components are presented by highlight flashing and device name tag at the same time, playing on a continuous loop and presenting operation procedures of demonstrator with interpretation language.

Thirdly, teaching application function. It consists of workstation component module and process procedure module, displaying device components of palletizing and handling production line. Each device is presented by highlight flashing and device name tag at the same time, played on a continuous loop. Process procedures module is presented by three dimensional animation simulation and background interpretation, displaying procedures of depalletizing and palletizing of palletizing and handling workstation by industrial robot. The three dimensional animation procedure is in accordance with actual operation. The optoelectronic switch in transfer belt can be highlighted in red color when detecting the signal of workpiece.

3. The Design and Development of Virtual Simulation System Software

3.1 The creation of 3D virtual simulation model

In terms of virtual simulation of system, the first thing to do is to create a 3D virtual scene model consistent with real work scene to be effectively presented. The ESTUN ER16 industrial robot is selected as design prototype in this paper to create virtual model of robot. The robot is six-degree-of-freedom serial robot, characterized by compact structure, large work space and carrying capacity, and high accuracy and efficiency.

Considering the immersion and authenticity of the integration of virtuality and reality in AR system, it is necessary to map 1:1 model according to real palletizing and handling production line, and field measurement by human can be adopted when essential. Detail pictures of components shall be taken in field by high-definition camera. Field measurement is mainly to measure overall layout of workstation, including dimensions of main parts and distances between them. Picture-taking by camera shall take the angle not in mess, so as to provide material for post mapping.

3D Max three dimensional modeling software is applied to map all details of virtual model of palletizing and handling production line by industrial robot, and implement assembly. 3D modeling, by virtue of geometric description, creates a specific 3D image for actual object, and realizes realistic effect by light, color and rendering. Materials taken can be processed to be model mapping material by Photoshop software for use, then introduced to 3D Max according to actual original measurement angle for model mapping. Besides, 3D Max software can be used to analyze and produce depalletizing and palletizing process of palletizing and handling production line by industrial robot.

3.2 The establishment of AR system

The three characteristics of AR is the combination of virtuality and reality, real-time interaction and three dimensional register. At present, there are various AR system development, including

three dimensional engines such as OpenGL, Unity3D and OSG, suitable for windows, linux and other mobile devices. Unity 3D software development platform is selected in this paper for interaction software development.

Aiming at realizing the effect of AR system, AR framework of Vuforia SDK by Qualcomm Incorporated is selected in this system, specifically: To apply for a License Key in Vuforia platform, then create database of identification object, that is actually the added identification picture in advance. In this system, a picture of palletizing and handling production line by industrial robot is considered as identification picture. The database requires to download and introduce engineering project, then enter the realization process of Unity 3D. A new engineering file shall be created, three dimensional model created by 3D Max and FBX file saved by animation shall be introduced. The pose and dimension of model shall be adjusted and introduced by Unity 3D, and animation parameters shall be set. Vuforia SDK Assert database downloaded including specific identification picture is then be introduced to engineering file of Unity 3D, original Main Camera deleted, AR Camera added, and light adjusted, so as to simulate real environment light and augment experience. The three dimensional model required to be displayed in identified picture shall be added in field of vision, script language is created by C# programming language according to developed virtual simulation content. Finally, application icon, name and adaptive device of software are set correctly according to requirement, then packetized to produce .apk file. Till now, the entire interaction software is realized.

3.3 The transfer and project launch of AR virtual simulation system platform

Multiple launch methods of platform vision are provided in Unity 3D, which can be installed by scanning QR code of apk programme by mobile device like smartphone or tablet computer. Taking Android system as an example for launch test, open File->Build Setting editing setting dialogue box, choose Android icon, and click Switch platform button, then users can transfer to Android platform. Connect Android phone to development computer, click Build And Run button, then it can be launched to mobile terminal.

4. Conclusion

Based on the analysis and study of current robot simulation software, this paper, from the perspective of education training and actual application, proposes an overall design scheme of robot simulation system based on AR technology, and conducts in-depth research on critical technologies. Taking the real palleizing and handling production line workstation by industrial robot as an example, the creation method of virtual simulation system of industrial robot based on AR technology is presented, and the application of AR technology is studies and realized. This method combines virtual simulation and actual experiment scene, and highlights real experience. According to requirements of system, Unity 3D development platform is selected, system development environment is established, AR system is designed and realized, thus providing fresh experience for students' learning by platform transfer and project launch, and positively promotes the popularization and spreading of applying industrial robot.

The learning environment of virtual simulation system of palletizing and handling production line workstation established in this paper is advantageous in reducing costs, requiring no expensive hardware support and concern for the number of students. In this way, each student has the opportunity of participating in operation, breaking the limitations of time and space, and performing learning and operation at any time. In terms of actual teaching effect, it can better solve the bottleneck of talent cultivation of industrial robot, and realize the immersion teaching of industrial robot.

By virtue of AR technology as the mean of teaching media innovation, a virtual time-space learning environment of industrial robot work task for Industry 4.0 is created, so as to satisfy the demand of training teamwork cooperation capability of high-quality and application-oriented talents. It is believed that this system platform will be promoted to other teaching area, contributing to Made in China 2025.

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