2023 IEEE International Conference on Sensors, Electronics and Computer Engineering (ICSECE)

Design and Implementation of Industrial Auxiliary System Based on Hololens

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2023 IEEE International Conference on Sensors, Electronics and Computer Engineering (ICSECE) | 979-8-3503-1373-4/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICSECE58870.2023.10263394

***Abstract*—In order to solve the problem of untimely and incomplete information acquisition of production site staff, this paper proposes an industrial auxiliary system design method based on Hololens, analyzes the overall design framework of industrial auxiliary system, constructs the functional modules of the system, and takes the flexible assembly line as an example for research and development. Based on the information visualization demand analysis of the manufacturing integration platform, the overall architecture and functional modules of the industrial auxiliary system are designed. The wearable AR device is used as the information display device, and human-computer interaction is carried out by means of gesture interaction and voice interaction. Wireless communication is adopted to realize information transmission between AR equipment and production line equipment. The registration and tracking method based on improved ORB algorithm is adopted to realize the auxiliary assembly function. The system has good immersion and interactivity, and effectively improves the efficiency of information acquisition of production site personnel. The practical application effect is significant.**

Keywords—AR, industrial auxiliary system, industrial visualization, feature matching, Hololens

I. INTRODUCTION

Industrial vis ualization technology is an important part of intelligent manufacturing at present. It can not only display manufacturing information, but also conduct complex industrial management. Industrial visualization technology can help factories realize the comprehensive management of different production equipment, and monitor the workshop status, equipment status and production status on a daily basis. It can also deal with various unexpected conditions, such as equipment failure, and thus realize digital and intelligent production [1]. The traditional industrial visualization display devices are mostly fixed position screens such as computers and large screens. At present, with the development of intelligent factories, the requirements for information display are also becoming higher and higher. The traditional display methods can no longer meet the needs of some new production environments.

Augmented Reality (AR) technology is a technology that integrates the real world and virtual information. It presents virtual information in the operator's field of vision without affecting the acquisition of real world information, so as to enhance the real scene [2]. In industry, AR technology is widely used in training workers [3], auxiliary assembly [4], facility monitoring [5], remote guidance [6], and other fields. Linh et al. [7] verified the possibility and limitations of AR equipment in the field of industrial visualization by transmitting and displaying multi-sensor data of mobile robots. Matthias et al. [8] proposed the steps and optimization methods of developing AR applications in smart factories.

II. REQUIREMENTS ANALYSIS OF MANUFACTURING INTEGRATED PLATFORM AUXILIARY SYSTEM

A. Introduction to manufacturing integration platform

In this paper, a flexible assembly experimental system is selected as the manufacturing integrated application platform. The manufacturing system is composed of the conveyor lines of two Inovance robots, an Automated Guided Vehicle(AGV), a tower storage system, the system's main console, and the manufacturing execution system. The platform combines industrial robot technology, machine vision technology, automatic logistics technology and Manufacturing Execution System (MES) technology. According to the workspace and production process, the layout of automatic workpiece processing system is shown in Fig. 1.

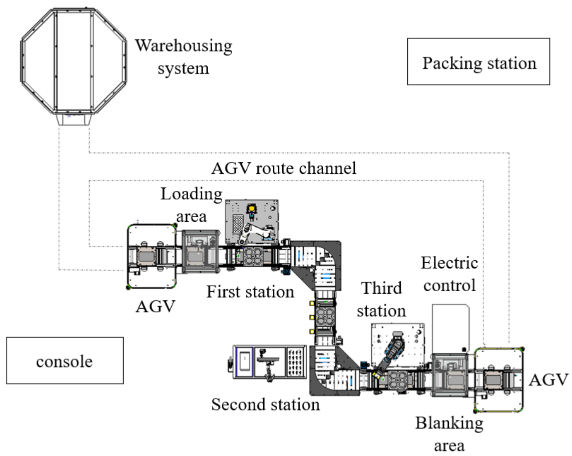


Fig. 1. Layout of intelligent manufacturing integration platform

B. Auxiliary system demand analysis

1) Ensure the real-time performance of the information visualization system

In order to obtain information through AR equipment on the production line, the first thing is to ensure the real-time nature of the information. In actual production, many people on the production line need to make their own judgments based on real-time information to ensure low information acquisition delay, which is helpful to improve production efficiency.

2) Be able to obtain system fault information

Determine the fault location at the first time. When there is a fault in the integrated platform, it is difficult to quickly determine the fault location because of the complexity of the production environment and the scale of the production line. It is often necessary to check multiple stations and the central control system to solve the problem. If you can determine the location of the fault at the first time on the production line, you can quickly arrange the production at your own location to reduce the loss of the fault and the delay of production.

3) Ensure the vision of the real world

When the production environment is very complex, the wearing of AR equipment can not affect the vision and cause production safety problems. It is very important to ensure sufficient vision of the real world environment while obtaining information, which is mainly ensured by the UI design of the information display interface. In the actual production of the production line, it is necessary to obtain information and operate the equipment at the same time, which can greatly improve efficiency without looking down at paper documents or screens.

4) Convenient and fast interaction

The most reliable interactive gesture operation of AR system has high recognition accuracy and rapid response. However, users on the production line may not be able to complete the operation by hand. It is necessary to replace the click operation with the voice interaction function, which is easily affected by the environmental noise and reduces the accuracy and sensitivity of recognition. Therefore, the combination of the two can solve the interaction problems in most scenarios.

5) Provide auxiliary information to guide production line operators

On the production line, some stations need to complete relatively complex operations manually. At this time, AR can be used to obtain information. You can learn these complex operations by viewing the instructions while operating, and gain a more intuitive learning experience than written teaching or video teaching, which can also save training costs and facilitate users to learn repeatedly.

III. SYSTEM ARCHITECTURE AND DEVELOPMENT ENVIRONMENT

A. System architecture design

It is necessary to consider the relationship between the entire intelligent manufacturing platform and the software and hardware of the auxiliary system, as shown in Fig 2, which is the overall design diagram of the enhanced display auxiliary system proposed in this paper. First, the operator wears a headworn AR glasses device and uses the page and operation mode in the software to conduct human-computer interaction. During the use of the equipment by the operator, the AR glasses equipment is connected with the industrial control computer of the intelligent manufacturing integrated platform through wireless communication, sending a request to obtain data from the industrial control system, and presenting it to the operator through the designed User Interface (UI) menu. The industrial control computer and manufacturing equipment on each station are connected by wire. In addition, the Red, Green, Blue (RGB) depth camera captures the depth image of the operation station of the production line equipment and transmits it to the computer equipment for registration, tracking and calculation for auxiliary assembly and other functions. The computer will transmit the result of registration tracking to the AR display device and present the result of registration tracking to the operator.

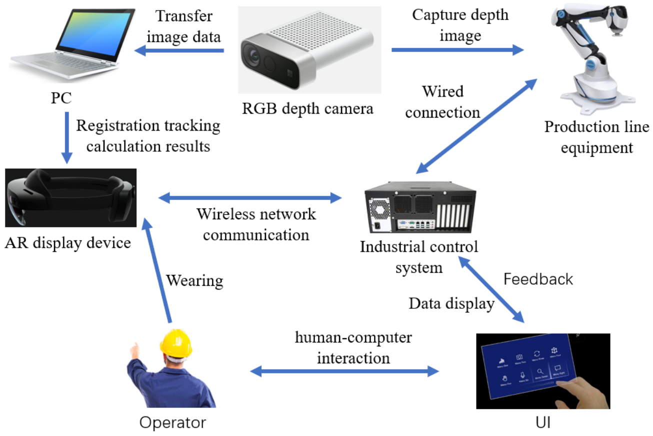


Fig. 2. System architecture

B. System function module

Based on the analysis of auxiliary system functions, in order to facilitate the development of system software, the system is divided into three modules: data visualization module, human-computer interaction module and other modules.

1) Data visualization module

In the data visualization module, there are three parts to implement. The first is the production line information data display, that is, the production line information is displayed in the operator's view in the form of AR in an appropriate way. The second is the virtual UI interaction panel. Complex production line data cannot be displayed in one page. At this time, it is necessary to design multi-level menus for the UI panel to ensure multi-level data display. The third is to carry out TCP communication with the central control computer of the manufacturing platform to obtain the production line data or send instructions to the manufacturing platform.

2) Human-computer interaction module

The AR assistant system provides three interaction modes, namely, hand ray click interaction, hand model touch interaction and voice interaction. The three operation modes can be used at the same time, or some interaction modes can be closed according to the need, which depends on the use scenario and the usage habits of the operator.

3) Other module

Other modules are additional functions beyond the main modules, and are additional parts of the actual demand of the intelligent manufacturing integration platform based on the laboratory environment. Including auxiliary assembly, photo retention and error information reminder. Auxiliary assembly refers to giving operators some tips and guidance to assist in the assembly of complex products. The photo retention part is to take and save the images in the field of vision, including the objects in the real world and the AR part, so that the operator can record the situation in real time. The error message reminder part is that when an error message occurs in a certain link of the production line, it will be alerted in a more eye-catching way in the operator's field of vision, so as to facilitate the operator to obtain the error information at the first time and make decisions.

IV. System construction and function realization

A. System construction and development

The system display terminal adopts Microsoft's headworn display device Hololens2, which is a wearable integrated holographic computing device. As shown in Fig 3, Hololens2 is a complete holographic AR device, which can independently realize the holographic image display and calculation of AR without any external hardware.

Fig. 3. Microsoft HoloLens 2

Select Unity engine, Mixed Reality Toolkit (MRTK), Visual Studio 2019 and Opencv for software development platform. As shown in Fig 4.

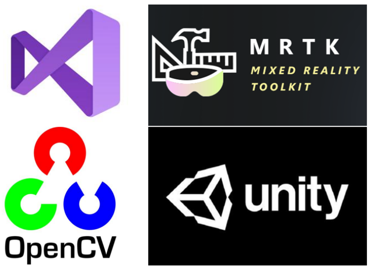


Fig. 4. Software development platform

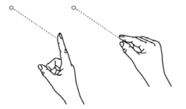
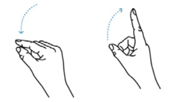
The system uses Unity engine to develop AR application software, including virtual image rendering and simple animation development, and uses Graphical User Interface (GUI) components for UI interface development, and uses MRTK to assist development. Use the image processing algorithm interface in OpenCV library to realize the improved tracking registration method, and process the relevant images in the auxiliary assembly module. Use Visual Studio software to write code, debug programs, and deploy programs to Hollens2 devices.

B. System function realization

1) Human-computer interaction design

The AR assistant system designed in this paper provides three interaction modes, namely, hand ray click interaction, hand model touch interaction and voice interaction. The gesture interaction is shown in table I. The hand ray is a line drawn from the tip of the finger, connected with a cursor to determine the pointing position, and click through certain gestures. The touch of hand model refers to that the operator moves his hand to the position in the field of vision where he needs to click, and makes a finger click gesture to complete the click operation. The voice interaction is that the operator speaks specific keywords in Mandarin to complete specific operations.

TABLE I. Gesture description

Gesture name	Gesture diagram	Gesture meaning
Hand ray		Aim the hand ray at the holographic image, and then pinch the thumb and forefinger.
Click		Tap the holographic image in the field of vision with the index finger
Drag		Keep pressing, moving the hand is a drag operation.

2) Communication function

The manufacturing platform on which the auxiliary system is based has mature communication methods and strict communication specifications, as shown in Fig 5, which is the schematic diagram of the network topology of the integrated platform. The experimental platform mainly uses the socket communication mode based on TCP/IP protocol to realize the data interaction between the client and the server, and obtains, updates information and sends control instructions by sending requests to the production management system. The message format of the sending request needs to send the specified JSON format message to the specified IP address in strict accordance with the requirements of the integration platform.

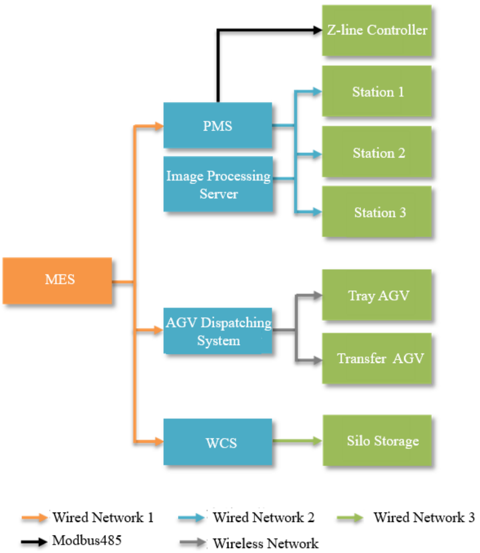


Fig. 5. Communication structure

3) Auxiliary assembly function

The auxiliary assembly function is based on the 3D tracking registration method. In this paper, feature point matching is adopted to realize feature recognition and tracking registration, and the traditional ORB (Oriented FAST and Rotated BRIEF) algorithm is improved based on the requirements of real-time and stability of the system. FREAK (Fast Retina Keypoint) descriptor was used to describe feature points in the stage of feature point description, and PROSAC (Progressive Sample Consensus) algorithm was used to replace RANSAC (Random Sample Consensus) algorithm to remove mismatched points.

First, the auxiliary assembly function interface is entered. At this time, the depth camera transmits the pose information at this moment to the AR glasses device through the wireless network, and then the AR glasses device will render the preloaded holographic model in the system to a specific position in the user's field of vision according to the pose information. At this time, the user can complete the assembly step according to the auxiliary assembly information displayed in the visual field. After the assembly step is completed, the user gives interactive feedback through voice or gesture to instruct the system to render the auxiliary assembly information of the next step, and the user continues the assembly operation until all the assembly steps are completed. Fig 6 shows the implementation effect of auxiliary assembly function.

Fig. 6. Auxiliary assembly

4) Information display function

As shown in Fig 7, the main menu interface allows users to enter different secondary menus to obtain the required information.

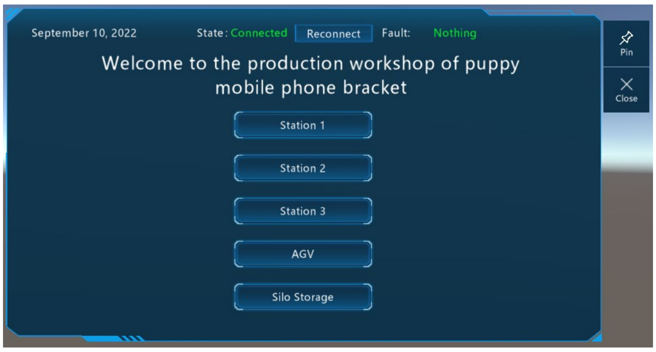


Fig. 7. Primary menu interface

As shown in Fig 8, the station menu will display the progress process of the current workpiece assembly logo operation, which is displayed at the bottom. After communicating with the station equipment, the step information, test results, production records and detected LOGO angle information will be displayed in the menu. At the right end of the interface are the signal indicator bar and the interactive control bar. The signal indicator bar can remind the user of the operation mode and fault information of the current station equipment, while the interactive control bar is used to control the operation of the equipment and debug the equipment.

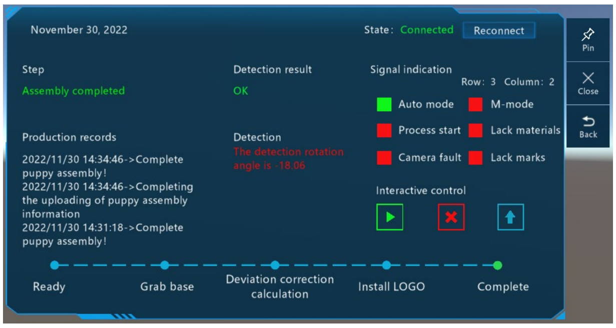


Fig. 8. Station menu interface

V. Conclusion

This paper presents an industrial manufacturing assistant system based on Hololens. The system can help the staff on the production line to obtain production information, equipment information and assembly guidance information more conveniently. The proposed industrial auxiliary system has greater advantages than the traditional industrial information acquisition methods: (1) Free the hands of production line user to obtain information in real time without affecting production line operation. (2) The user can get the reminder of equipment failure and production problems in the first time. (3) Many auxiliary functions such as photo card retention and auxiliary assembly can further improve the user's production efficiency. The system has good practicability, but it still needs to be improved to meet the needs of different production environments in the actual more complex production environment.

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