Application of AR Technology in Aircraft Maintenance Manual

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Abstract. The readability, interactivity and generality of aircraft maintenance manual directly affect maintenance cycle and cost. This paper presents the application of augmented reality technology in the development process of aircraft maintenance manual. The overall framework and functional requirements of the development of augmented reality intelligent maintenance system are given. Taking the leakage inspection procedure of AMM manual as an example, the process of augmented reality technical manual aircraft maintenance publication is explored.

1. Introduction
Augmented reality (AR) technology combines the equipment maintenance model with the real world, and relates the relevant maintenance manual, intuitively and vividly guides each step of work on site, provides a lot of information for maintenance personnel in real time, greatly simplifies the work difficulty of maintenance personnel, and improves the work efficiency [1-3]. In the field of VR (virtual reality) and AR services, early virtual validation and training of disassembly, maintenance and assembly procedures can guide maintenance in real time and save considerable maintenance costs.

In 2015, Boeing adopted AR technology to reduce the impact of assembly harness errors. 45 students were divided into three groups, using AR glass, PAD and paper manual respectively. Students had 0.5, 1 and 8 times in the first assembly. In 2017, GE used AR technology test to tighten the B-Nut, and the working efficiency increased by 8-12%. IETP manual realizes the digitization of technical manual, its interactive function and the intellectualization of technical manual. The contents of the aircraft maintenance manual can be used in the form of video and audio to realize virtual replacement, service, inspection, test and troubleshooting maintenance operations, and the IETP aircraft maintenance manual can be realized by combining AR technology [4-6].

2. AR Intelligent Maintenance System
The aircraft intelligent maintenance system based on AR auxiliary operation mainly realizes the recognition of objects in different aircraft maintenance scenarios through AR intelligent glasses, and then the analysis of electronic aircraft maintenance manual and the call of data information through the instructions of maintenance personnel (gesture, voice, etc.), and can send the virtual and real images in AR glasses to the expert system through the central server Unified, realize remote expert guidance. System includes the functions as follows:

(1) Realize the interactive display of physical image and multimedia data;
(2) The AR data is driven and controlled by gesture and voice command;
(3) Realize the object image capture and feature intelligent recognition in the aircraft maintenance scene;
(4) Realize the storage and control of AR multimedia data based on S1000D standard;
(5) Realize data transmission between AR wearable device and S1000D standard database;
(6) Realize the interface navigation and module reading function of AR electronic manual;
(7) Realize the communication between AR wearable devices and local servers, and the AR data transmission between multiple PCs and local servers;
(8) Realize AR data release of windows system and Android system.

For different maintenance scenarios, the objects in the scene are intelligently recognized to achieve virtual reality matching, and an operable multi-level UI interface is provided to call the aircraft maintenance data, and to support the recognition of voice, gesture and other different forms of instructions.

Fig.1 System hardware topology

It supports fast navigation retrieval and consumable material parts query by voice, and can query the required information parts by voice, and recommend maintenance tools for them.

The operator can interact through gestures (only supported by AR glasses hardware equipment), voice and other ways, including interface interaction, virtual object interaction. The AR display interface includes the main interface, navigation and retrieval interface, consumable material part library interface, tool part library interface and hand operation interface.

After obtaining the instruction, the data acquisition of aircraft standard technical documents can be realized through the analysis of XML file, including different types of data such as corresponding text, picture, audio, video.

The AR display terminal/ mobile phone terminal can read the technical manual data from the central server, and can transfer the real-time picture (virtual scene and real scene) in the AR glasses to the central server. The central server can transfer the real-time picture in the AR glasses to the expert assistant terminal, and the expert assistant terminal will return the auxiliary result data (3D annotation, voice, etc.) to the server, and display. The display terminal displays in real time to assist operators in operation or maintenance.
2.1. Basic framework of AR intelligent maintenance system

The aircraft intelligent maintenance system based on AR auxiliary operation adopts the architecture of "bottom support, function module, application, presentation experience". The technical structure mainly includes:

(1) The bottom support module mainly includes basic rendering engine, space sensing, real-time position tracking and human-computer interaction;

(2) The function module provides the technical ability of content management and business management for the overall application of the intelligent repair system of aircraft based on AR auxiliary operation;

(3) Scenario application, which specifies the applicable business scenarios of intelligent aircraft repair system based on AR auxiliary operation.

(4) Present the experience, users conduct maintenance and process operation through AR smart glasses or mobile terminals, and remote experts conduct remote guidance through expert assisted terminals.

IETP data, assembly sequence and three-dimensional model are imported into AR equipment as data package, and AR interactive aircraft maintenance manual is realized by importing AR format data package and enhancing information display.

2.2. Function development of AR intelligent repair system

2.2.1 Application function development of AR intelligent repair system

In the AR wearable device, it has the application function of technical publication AR data, and the application function should have the following contents:

(1) After obtaining the graphic, voice or gesture commands, it can read the technical publication data and display it in the wearable device according to the established style, mainly including the following functions;

(2) Read the aircraft sortie information and filter the data content of the applicable aircraft manual;

(3) Read the version status and other information of aircraft data;

(4) Display the text, image or voice content of the aircraft manual program according to the operation instructions;

(5) Display the data content of tools, equipment and aviation consumables in the aircraft manual according to the operation instructions;

(6) Display the warning data content of the aircraft manual according to the operation instructions.

Be able to read and parse XML technical documents based on S1000D standard, mainly including the following data content:

(1) MPP,AIPC,SDS data module of aircraft maintenance program;

(2) Public source database data module, including area, cover, consumables, tools and equipment, warning and warning information;

(3) Applicability data module.

Develop a graphic library of general symbols for aircraft maintenance, such as special meaning display graphics, including warning and warning, consumables, tools and equipment, etc.

Develop a general virtual action library for aircraft maintenance, such as a dynamic library with instruction meaning, including common tools such as torque wrench, operator, etc.

2.2.2 Data module preparation management function of AR intelligent repair system

On the basis of the technical publication preparation management platform based on S1000D standard, the preparation and management functions of audio and AR multimedia image information are supplemented, mainly including:

(1) Realize the function of technical text conversion audio of S1000D standard;

(2) Realize audio and AR multimedia storage and state control on S1000D standard technical publication preparation management platform.
2.2.3 Network transmission requirements of AR intelligent repair system

Build the intelligent repair network of AR auxiliary operation aircraft, and transmit technical data to wearable equipment through the network based on Technical Publication CSDB. Its main functions include:

1. Realize the transmission of technical publication data to AR wearable devices through the network for data display;
2. Realize the transmission of video data captured in AR wearable device to technical publication database;
3. Set up AR data transmission among AR equipment, local server and multi-point PC.

2.3. AR system software function

The functions of AR intelligent repair system include: AR instant imaging, space virtual reality fusion, AR instant communication, multi-person/multi-machine collaboration.

AR software provides standard data interface and data-driven platform.

Real time data-driven ability: organize and standardize the data of technical publications to create a database view that conforms to the visual presentation. Transfer data through a distributed architecture. Database association is to establish a cross reference relationship between the data in the database and the data to be replaced in the scene, so that the content queried by the database can correspond to the content of the object in the scene.

Data interface platform, according to the system settings to achieve a variety of data collection in accordance with the specified strategy, the collected data model in accordance with the rules of standardized processing, the processed data into the original database. According to different data sources, different collection plug-ins can be developed. For example, the data plug-ins of the network management system can read the web service of the business system, and the system collection plug-ins can read the HTML web page information of the specified website or the specified system data.

3. Development experiment of AR aircraft maintenance manual

Figure 2 shows the effect of the AR manual for hydraulic valve leakage procedure. The operation interface of the development example is shown in Figure 2(a), and the effect of AR electronic maintenance manual is shown in Figure 2(b), and the effect of remote expert guidance system for timely communication is shown in Figure 2(c) and figure 2(d).
(1) The maintenance personnel wear AR glasses, select the maintenance scene through gestures or voice instructions, and the AR manual guides the next step in real time.

(2) When it is necessary to ask for help from a remote technical expert, the remote assistance function is used to transmit the front-end aircraft maintenance picture to the expert terminal, waiting for the expert to give valuable opinions, and the expert can mark and prompt the front-end picture.

4. Conclusion
From the perspective of aircraft maintenance design, this paper discusses the framework of AR intelligent maintenance system. System development and application requirements, data module preparation and management functions, and AR intelligent repair system network transmission requirements are given. Also the software function of system is discussed. Finally, the development and application process of the leakage program example of hydraulic valve in MPP electronic AR manual is given.

The results show that AR technology can be applied to aircraft maintenance manual. AR intelligent maintenance system can greatly improve labor efficiency.

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