Research on AR assisted aircraft maintenance technology

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Abstract. This paper introduces the application of AR assisted technology in aircraft maintenance. This paper specifically introduces the system architecture of an AR assisted aircraft maintenance system, expounds the software design and scene content of the AR assisted aircraft maintenance system, and analyzes the functional module development and difficult technologies of the system.

1. Introduction
Augmented Reality (AR) is a new technology that integrates real world information and virtual world information seamlessly[1]. AR Technology has been gradually applied to the maintenance and training of new aircraft such as Boeing and Airbus. For example, the B787 virtual maintenance training system (VMT) uses the aircraft original data to simulate the real aircraft through the virtual simulation technology, which is used for the training of pilots, maintenance personnel and dispatchers. It can simulate all the control panels and switches in the cockpit, and realize various functions such as cockpit warning, flight management system functions, animation of system schematic diagram.

Airbus applies AR technology to water pipe installation, cabin connector and cabin development. In the development of cabin, Airbus uses AR technology to superimpose virtual design concepts and user configurations on the design prototype/sales prototype, which can quickly enable designers and users to experience the final effect and reduce the manufacturing cost of the prototype.

This paper combined with the design and development standards of civil aircraft software, constructs an AR assisted aircraft maintenance system, effectively solves the problems of real-time display of maintenance guidance, remote assistance and on-site real experience.

2. System Architecture
The AR assisted aircraft maintenance system adopts the architecture of "bottom support, function module, application, presentation experience". The technical structure mainly includes:

- The bottom support module: providing basic technical service, mainly including basic rendering engine, space sensing, real-time position tracking and human-computer interaction;
- The function module: providing the technical ability of content management and business management;
- Scenario application: specifying the applicable business scenarios of AR assisted aircraft maintenance system.
- Presentation experience: users conduct maintenance and process operation through AR glasses or mobile terminals, and remote experts conduct remote guidance through expert assisted terminals.
3. Software Design

3.1. Software architecture

In order to facilitate the modification, expansion and integration of the software system, the MVC software framework is adopted in the software development. MVC is the abbreviation of Model-View-Controller[2].

The specific development process includes the design and implementation of communication layer, view layer, model layer and controller layer.

- The design of communication layer includes two parts: the first part is external communication, namely, the communication between the client (AR client, mobile client, expert assistant) and the server; the second part is internal communication of the client, namely, the communication between the layers.
- The design of view layer includes model construction and interface design.
- The model layer is mainly used for receiving and processing real-time data and data access.
- The controller is mainly used to control the user interface data display and update the model object status when the staff conduct human-computer interaction of the system.

3.2. Scene design

The system scenarios includes cockpit, landing gear, instruction record, navigation system.

(1) Example of cockpit operation guidance scenario:
It is divided into cockpit site, server and expert computer.

- Maintenance personnel enter the cockpit, combine the real with the virtual, select the cockpit scene by hand gestures, and the virtual image is displayed in the AR experience terminal. At the same time, the contents of the maintenance instruction manual is displayed on the AR terminal.
- Through the expert computer and live presenter screen real-time synchronization, and the synchronization content is presented on the PC in the way of real virtual combination.
- When maintenance personnel encounter problems, maintenance personnel can call remote experts on site through AR terminal, and remote experts connect through PC to check the site conditions. At the same time, remote experts interact with on-site maintenance personnel with voice, image and text to give timely guidance, so as to realize two-way interaction between the remote end and the site.

In operation of the four scenarios, the application types of AR assisted aircraft maintenance system include aircraft component assembly training, component maintenance assistance and remote assistance guidance.

- Aircraft component assembly training: with the aid of AR intelligent display terminal, the specific aircraft components can be identified intelligently, and then virtual assembly and training can be realized through text, picture, animation and voice.
- Aircraft component maintenance assistance: identify objects with the aid of AR intelligent display terminal, and guide steps, select tools, prompt maintenance scheme for maintenance objects in the form of text, picture, animation, voice.
- Remote assistance guidance: in case of problems that cannot be solved on site during the maintenance process, remote expert can be called for remote maintenance guidance.

3.3. Interface design

The AR assisted aircraft maintenance system is realized by MVC architecture, which ensures high cohesion and low coupling between software modules, and also has certain interface extensions. The interface functions supported by this system are as follows:

- Extension of maintenance scenario;
- Extension of general symbol mark graphic library for aircraft maintenance;
- Extension of special meaning display graphics library;
- Extension of dynamic graph base with instructive meaning;
- Extension of voice library.

4. Functional Module Development

4.1. AR real time imaging

The software system provides rendering services at the bottom layer. The software captures real-time images in the AR system, collects audio and video streams from clients (AR system, mobile phone, pad, PC), virtual shared data provided in the AR system, and visual presentation content, and makes rendering of these contents into a high-precision real-time stream through unified coding, transmission, decoding and distribution to different terminals for playback.

4.2. Integration of space and reality

The software adopts SLAM method, namely, real-time location and map building technology[3]. This kind of technology does not need to prestore the scene information, but completes the construction and tracking of the scene in the running phase. Its advantage is that it does not need to prestore the scene, can track a wide range and can complete the reconstruction of the scene structure while tracking.
4.3. **AR instant messaging**
The software mainly uses MCU service, FORTC service, signaling service, WEB service and AR device video and audio overlay service to develop video and audio communication services, supports video and audio communication with low delay and high quality communication effect.

4.4. **Multi-person and multi-machine cooperation**
The software determines a spatial anchor point in the real scene, so that the hologram and the real scene are well combined. By sharing the spatial anchor information of one AR device to other AR devices, multiple AR devices located in the same real scene can render holograms at the same physical location in the real scene, so that multiple people can share the same hologram, which is convenient for multiple people to work together, locate together and share the experience of hologram.

5. **Difficult Technology Development**

5.1. **Model lightweight technology**
In order to meet the needs of the project and improve the running fluency of AR assisted aircraft maintenance system, lightweight work is carried out based on CATIA digital model\[4\]. The lightweight method is as follows:

- In order to reduce the number of triangle faces, the model routing structure is modified (the vertexes of triangle face are placed at the turning point of the structure as much as possible, and unnecessary vertexes and lines are deleted from the flat surface).
- The lightweight software Topgun is used to reconstruct the surface structure.
- By using Maya baking function, bake normal map showing fine structure, and normal map is used to restore the complete details of the original model.

5.2. **Human computer interaction technology of speech recognition**
In order to improve the operation fluency of AR assisted aircraft maintenance system, human-computer interaction technology of speech recognition is used. The development mode of speech recognition is as follows:

- Speech feature extraction: the kernel engine of speech recognition converts the input speech data from a simple sample point value to a series of feature parameter vector sequences.
- Acoustic modeling: In the acoustic model, the model sequence with the largest matching probability with the feature parameter vector sequence is transformed into the corresponding text sequence, which is the result text of the speech recognition\[5\].

6. **Conclusion**
To sum up, through the research and application of AR assisted aircraft maintenance system, it is helpful to exploit the application value of AR and other advanced technologies in the fields of aircraft manufacturing, aircraft maintenance and training. The application of AR and other cutting-edge technologies helps to solve many problems in civil aircraft customer service, including the presentation and management of technical manuals based on S1000D\[6\], the form of customer problem guidance and the whole customer service system process, which helps to form an integrated and intelligent customer service system.

**References**
[1] Azuma R T. A survey of augmented reality [M]. MIT Press, 1997.
[2] Ren Zhongfang, Zhang Hua, et al. Overview of the Research in Model-View-Controller Pattern[J]. Application Research of Computers, 2004,10:1-4(in Chinese).
[3] Shirt Dianxi, et al. Dynamic adaptive simultaneous localization and mapping technique for scene change[J]. SCIENTIA SLNICA Technologica, 2018,12:1373-1391(in Chinese).
[4] Zhang Wenyan. Research on Application Model of Lightweight Digital Model in Civil Aircraft
Service[J]. Science and Technology Innovation Herald, 2017, 05: 124-125 (in Chinese).

[5] Graves A, Mohamed A, Hinton G. Speech recognition with deep recurrent neural networks[C].
Proceedings of ICASSP, 2013: 6645-6649.

[6] International specification for technical publications S1000D[S]. Issue 4.2, ASD, 2016.