The design of an equipment induction maintenance system based on AR technology

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Abstract. Aiming at the problems of short time, heavy task, difficulty and few professional maintenance personnel, a set of induced maintenance system based on augmented reality technology is developed. Based on AR technology, the research and development of a kind of equipment induction maintenance system is to integrate hardware and software, using augmented reality, human-computer natural interaction, virtual prototype and interactive electronic manual and other technologies, to provide an operating environment for maintenance personnel to combine virtual information assisted guidance and physical operation synchronously, and to guide maintenance personnel more efficiently for the realization of "Human-centered " maintenance. It is of great significance to complete the maintenance task.

1. Introduction
A certain type of equipment has high technical content, many maintenance items and complicated repair procedures. The requirements for maintenance personnel are particularly high. Based on this, an augmented reality induced maintenance system is developed. Compared with traditional maintenance, the advantages of augmented reality guided maintenance are mainly reflected in the following aspects.

(1) Augmented reality guided maintenance can shorten the training time of maintenance support personnel, and improve equipment maintenance support experience and reduce equipment wear. It saves manpower and material resources of all kinds of support and greatly saves the consumption of resources. [1-3]

(2) Provide safe working environment. Real equipment maintenance may bring all kinds of dangers due to some mis-operation. With the help of the system, the maintenance support personnel can operate in strict accordance with the operation steps, so that there will be no unnecessary accidents in the process of equipment maintenance.

(3) Real time information exchange with maintenance personnel. Augmented reality (AR) guided maintenance can make maintenance personnel remind and answer the actions, maintenance methods and problems of maintenance support personnel through voice, video image, 3D animation and other forms. It overlays the operation steps on the operator's display in the form of virtual information to guide their maintenance work.
2. System framework
The system uses augmented reality technology in 3D environment to realize operator immersion and interactive auxiliary information prompt of equipment maintenance. The system combines the theory of pattern recognition and computer vision, and uses efficient image retrieval and matching algorithm to realize real-time tracking and reconstruction of multiple natural scenes on the terminal. The induced maintenance system is realized by C++. The system relies on Maya and 3ds Max to develop 3D model and 3D scene. The system relies on OpenCV, which is an open source visual database, to complete the visual image processing work such as optical flow field calculation and image matching. The system uses UKF (unscented Kalman filter) to fuse the vision inertial data to track the camera's position and attitude. The system uses the speech recognition package of windows to recognize the speech and complete the input of the speech instruction. The system uses the method of vision and inertia to recognize the gesture of the operator. The main research scheme is shown in Figure 1.

![System main block diagram](image)

**Figure 1.** System main block diagram

The maintenance assistance system is divided into six modules. The workflow control module of maintenance assistant task network is the core. Command interpretation module and motion sensing module are data input. The information enhancement module is output. With the help of scene analysis module and information acquisition module, the whole augmented reality maintenance assistance process is completed. The command interpretation module processes the interactive commands sent by
maintenance personnel, and transforms the interactive commands into requests for maintenance operation guidance.

The motion sensing module is used to monitor and acquire the user's interactive input, and read the data of position sensor, camera and other peripherals. It explains the changes from the real environment of the user, and updates the environment related data such as location, viewpoint location, etc. to provide the system with the change data of the user's scene.

Scene analysis module can continuously track the change of maintenance scene, and analyze the change of real scene of maintenance personnel. It provides the basis for the control module to extract the virtual information corresponding to the scene change through the information acquisition module. According to the results of scenario analysis, the information acquisition module is oriented to specific maintenance tasks. It obtains technical data related to maintenance scenarios from maintenance data base and case / knowledge database, and manages the obtained information. The information enhancement module completes the information output of the whole guidance system, and enhances the real environment of maintenance personnel by using the virtual information of maintenance guidance.

The workflow control module of maintenance assistant task network is the core of the whole maintenance guidance system, which has two functions. 1. Controlling the maintenance induction process, responding to the input information, managing the output information, and maintaining the whole system; 2. Dealing with possible conflicts between modules.

3. Main technology

3.1. AR implementation mode

There are two main ways to realize AR: optical perspective and video perspective. At present, the headwear equipment on the market usually adopts one or two of the two ways. Video perspective devices are handheld devices. Optical perspective is to display computer-generated digital images on a layer of translucent lenses in front of your eyes, so that Real scene and virtual information appear on the retina at the same time. Video perspective technology is to record the real scene into the computer through the camera, integrate and compress it with the virtual object, and then present it in front of the user. Both have advantages and disadvantages. The real scene in optical perspective is more natural and direct because it is not processed by computer. Although it is simple to realize, there are some problems, such as low positioning accuracy, inaccurate matching, delay in display and so on. Because of the integration of video perspective, the matching is accurate and the final display effect is highly synchronized. It can further process the generated display results according to the user's needs, but it is difficult to achieve, and some of the reality is lost.

This system adopts the optical perspective augmented reality system. Optical perspective AR includes optical perspective helmet display, image workstation and head tracking equipment. As shown in Figure 2, the dotted box part is the schematic diagram of the optical perspective helmet, which includes a small projection device for projecting virtual information and a semi reflective and semitransparent lens. Through it, the wearer can not only see the real environment outside, but also see the virtual overlay information displayed above. The virtual information is generated by the graphic workstation on the right and transmitted to the optical perspective helmet. The head position tracker is used to get the three-dimensional coordinates of the head, so as to calculate the eye coordinates and provide real-time accurate coordinate information for the virtual information superimposed in three-dimensional space. The vision based tracking camera uses ordinary cameras, which will be fixed directly above the helmet. This system uses the 3D registration algorithm based on logo to locate the fixed camera on the helmet, so as to locate the helmet. It replaces the complicated position tracker and makes the whole system more concise.
3.2. Interactive electronic technical manual
The basic functions of IETM include auxiliary maintenance function, auxiliary training function and auxiliary user technical data management function. The contents of IETM include system technical manual, operation manual, maintenance manual (maintenance outline volume, maintenance procedure volume, fault report and fault isolation volume, illustrated Parts Catalogue volume), personnel training manual. It is an information system to assist maintenance and support work through electronic technical documents and data. Its functions mainly include troubleshooting, entering the page through intelligent query, zooming in and scrolling through the page text, and providing hot links. It uses a variety of references through links, and can drive information interactive logical links through dialog boxes. Through the integrated database with expert support system, it can realize the auxiliary fault diagnosis and removal ability, and reduce the demand for technical experts and experienced personnel. In the augmented reality maintenance guidance, the manual is required to have the characteristics of the fifth generation interactive electronic manual. The manual can adapt to voice and other multi-channel intelligent driven retrieval methods, so that the content of the maintenance manual can be "active".

3.3. Data flow of maintenance auxiliary system
As shown in Figure 3, the interactive system issues interactive commands. In the current scene image, the feature of the operating object is extracted and recognized with the digital prototype to obtain the pose information of the object. For the identified target, the appropriate enhancement information is matched from the virtual prototype database and the case / manual database, and transformed and rendered. Using augmented reality registration algorithm to complete the fusion display of virtual and real information. [4-5]
3.4. Service assistance enhancement information display

In order to display various enhanced information better, the maintenance guidance system provides the following two information display modes. (1) Information registration based on user helmet. The information display position is fixed relative to the helmet display worn by the maintenance personnel. The most commonly used information of this kind is instruction, identification, warning, etc. They indicate the content of the work or give safety tips. (2) Information registration based on real equipment. The information display position is fixed relative to the real equipment, such as overlaying 3D graphics on the real equipment, displaying the assembly relationship between parts, or indicating an area of the equipment with arrows. This information can explain the function of the device, the process of disassembly and assembly, or draw the user's attention to an area of interest.

3.5. Software development

The engine developed by AR technology is unity3d (U3D). Unity3d is a multi platform integrated development tool for visualization, real-time 3D scene and other types of interactive content. It is a comprehensive integration of professional game engine, development language for C#. The 3D scene software is Maya and 3DS max. 3ds Max is a full-featured three-dimensional computer graphics software developed by AutoDesk media and entertainment department. It runs on Win32 and win64 platforms and is mainly used to make three-dimensional models, characters, device animations, persona animations, and various special effects. Author ware and Adobe Photoshop (PS) are used to design and beautify human-computer interface. SQL Server software is used for database development and management.

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