Fully digital wind farm monitoring and inspection system based on AR augmented reality technology

Xinyue Xing*
School of Mechanical Engineering, North China Electric Power University, Baoding, China

*Corresponding author e-mail: xingxinyuec@163.com

Abstract. The wind power is a vigorously developed clean energy in China recent years. It’s installed capacity of our country is increasing year by year. Since 2012, the new wind power installed capacity in China has became the first place all around the world. By the end of 2016, our wind power installed capacity has added a total of 87 million 580 thousand kilowatts. Besides the rapid growth of wind power, there are still many problems in China's wind power business. In order to solve the following problems: the inspection environment of the wind farm equipment is quite complex, the efficiency is not high enough, and the statistical data of the inspection is not good enough, this paper puts forward the "full digital monitoring and inspection platform of wind farm based on AR augmented reality" as the solution of the problems. The project implements fan positioning, model-assisted inspection, process recording, and expert remote assistant APP functions. It promotes the development of wind farm detection and inspection, which can greatly improve the inspection efficiency of wind farms and reduce the workload of inspectors.

1. Introduction
In recent years, China's wind power industry has developed rapidly. In China's power generation, wind power accounts for an increasing proportion. In order to ensure the operation efficiency of the wind turbine and the distribution of the wind power equipment are very scattered, the daily operation and maintenance work is relatively large [1]. In view of the above problems, this paper proposes a construction scheme for the full digital monitoring and inspection platform of wind farm based on AR augmented reality technology.

AR Augmented Reality (Augmented Reality, hereinafter referred to as AR) was first proposed in the 1970s. Augmented reality technology is a technology for real-time calculation of the camera position angle, and then combined with the image, audio, video and 3D models related to the captured image. Literature [2] introduces three main characteristics of augmented reality technology: 1) AR is the integration of real and virtual world information; 2) AR technology can interact in real time; 3) AR is to add positioning in 3D scale space Virtual object. There are a large number of AR devices on the market. The more mature AR glasses are as follows: Vuzix, Sony's mirror SmartEyeglass, Microsoft's HoloLens MR head display. These AR glasses have been used to varying degrees in different environments. HoloLens is highly developed in conjunction with Unity 3D and Visual Studio, using C# scripts, so this project was developed using HoloLens [3-6].
human science and technology after the industrial revolution, mankind is increasingly dependent on electricity, and the demand for electricity has continued to rise. Literature [7] shows us the future of energy and power development in the world. Clean energy power generation will increasingly become the focus of attention and the key points of development. According to incomplete statistics in [9], in 2014, the global installed capacity of new wind power was 52.52GW, a year-on-year increase of 44%. The total installed capacity of wind power in the world has reached 371.34GW, an increase of 16.6%, and wind power accounted for 3.4% of the total. According to the literature [10], China has surpassed the United States to become the world's largest power producer by the end of 2012. The total installed capacity of electric power in the country has reached 1.14 billion KW. According to the literature [8], in the 13th Five-Year Period and the following period, China's power demand still has a relatively large development space. It is estimated that by 2020, the national electricity demand will reach 7.6 trillion to 8.4 trillion KW. By 2030, this figure will reach 10 trillion to 11.8 trillion KW.

This project is a problem for the labor increase of the inspection personnel. Combined with the existing AR augmented reality technology, the multi-communication technology builds a fully digital wind farm monitoring and inspection platform based on AR augmented reality technology to reduce the labor of the inspection personnel improves the efficiency of the inspection work. The project finally realized wind turbine positioning, model auxiliary inspection, process recording, and expert remote assistant APP function. The development of wind farm detection and inspection has been promoted, which can greatly improve the efficiency of inspection of wind farms and reduce the workload of inspection staff.

2. Related technology introduction

2.1. Fan positioning

Since the inspector needs to select a specific fan to be processed, a fan positioning technology is needed to locate the fan and distinguish the different fans. There are a variety of positioning technologies, and this paper analyzes the suitability of different positioning technologies and the project.

When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

Two-dimensional code scanning method, the different two-dimensional codes pasted on the fan are scanned by the device to obtain the ID of the swept fan, and then the data of the detected fan is obtained from the database according to the fan ID. This method is recommended as a small-scale, low-cost application principle, but not suitable for long-term or large-scale applications[11-12].

Signal recognition method, the fan continuously sends the RF signal of its own fan ID to 360 degrees, the inspector equipment acquires and recognizes the signal, and locates the fan by identifying the signal direction and the signal strength, but the prior art small device locates the signal. It is difficult and the signal strength is extremely susceptible to weather, not a stable solution[13].

Map latitude and longitude identification method, the latitude and longitude of the fan is determined at the time of installation, and the latitude and longitude coordinate dot matrix of the wind farm fan is pre-stored in the system database, and the system performs GPS positioning of the inspector through the inspector wearing equipment to obtain the patrol inspector. The latitude and longitude address. However, in the current technology, there is a certain error in the acquisition of the latitude and longitude data of the inspector, which will affect the accuracy of the identification. However, based on the special case where the distance between the wind turbines is large, the small amplitude error can be tolerated.[14]

Combined with the actual situation of the project and the current technical feasibility analysis, the map latitude and longitude identification method is more feasible. This project develops the fan positioning function through the latitude and longitude identification method combined with the Baidu map API.
2.2. Model assistance

In order to quickly find a solution to the problem, 3D modeling of the fan is required. The inspector improves the efficiency of fault resolution by observing the model and combining the fan model data displayed in real time. Document [15] introduced 3Ds MAX (3D studio MAX). The software focuses on the production of textures and does not meet all the requirements of this project. Reference [16] introduced Unity 3D, a fully integrated modeling tool and game engine that supports DirectX 11 and Mecanim animation tools. Unity 3D supports C# language and JavaScript scripts, and developers can use both languages for rapid development. Because of its support for the C# language, Unity 3D has a high degree of development fit for Microsoft HoloLens.

Because Unity 3D is modeled using C# as the scripting language and has a higher degree of fit with the HoloLens development used in this project, this project uses Unity 3D as the model engine for the entire program.

2.2.1. A subsubsection. The paragraph text follows on from the subsubsection heading but should not be in italic. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

2.3. Process Record

The State Grid Corporation has strict assessment systems for the employees of the grid companies and the power plants under their jurisdiction, as well as the regulatory requirements for behavioral operations. In order to meet the requirements of the grid company and the wind farm for the inspection procedures of the inspection personnel, the project adds the inspection function record function. The inspection APP calls the head-mounted camera to shoot, and the priority is stored locally. After the inspection is completed, the video of the complete inspection record will be uploaded to the data service system database for registration through HTTP or UDP protocol.

2.4. Expert system

The possibility of failure during the inspection process can be said to be endless, and it is almost impossible for the inspection staff in the field to fully understand all the causes of the failure. Moreover, the wind farm site is generally located in the suburbs, and there is a long distance from the wind farm control center, and telephone communication may not be able to fully describe the situation in the language. Therefore, the system provides an expert system to assist the inspectors to solve problems that cannot be solved on site.

2.5. Data processing service system

This system runs different functional modules on different platforms. For example, the fan is positioned on the MicroSoft HoloLens platform. The patrol end of the special machine system runs on the Android platform. The expert system expert side, the process record view runs on the web page. In order to ensure the uniformity and authenticity of the functional modules of different platforms, the system requires a common data processing service system.

3. Software design

All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper. As show in Fig. 1 and Table 1, three scheme comparing.
References are cited in the text just by square brackets [1]. Two or more references at a time may be put in one set of brackets [3, 4]. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under heading references, see our example below.

3.1. Database design
The platform database is developed using the SqlServer2008 database for storing user data of the entire platform, fan position lattice, fan parameter data, fan operation data, fan abnormal code and data. The database is named DB_Fan.

3.2. Model scene design
The model scene was developed using Unity 3D for display on the HoloLens heads, and the auxiliary inspectors learned more about the internal structure of the fan and the operational status of the detailed components. Quickly discover the details of the faulty components of the abnormal fan. This can improve the inspection efficiency.

The model scene is divided into two parts: fan positioning and selection scene and fan internal construction scene. 1) The fan positioning scene constructs the wind motor pole model, then obtains the position information of the inspector, matches the latitude and longitude lattice data of the wind turbine of the corresponding power plant, and queries the wind turbine latitude and longitude information within 100 meters from the inspection personnel, and then the scene world The coordinates of the match are matched, and the model is displayed at the corresponding position, which basically coincides with the position of the corresponding fan, and the allowable distance error is less than 5 meters. When the gaze light spot contacts the fan model, the corresponding fan ID is displayed to help the patrol personnel identify the fan. 2) Fan internal structure The scene model displays the internal structural model image of the selected fan and the overall operating data of the fan. When the gaze light contacts a detailed component, the display interface displays the name of the gaze component. The head display recognizes the click gesture, and when the component is clicked, the display interface displays the model image enlarged by the component and displays the real-time data information of the component.

3.3. Functional design
Fan positioning: the fan positioning process first acquires the latitude and longitude data of the patrol personnel, and builds the AR model world according to the latitude and longitude values of the patrol personnel. Then, the wind turbine latitude and longitude lattice data of the wind farm is read and matched to the AR model world according to the latitude and longitude of the inspection personnel. Calculate the wind turbine that is 100 meters away from the inspection personnel and display the fan model. Then, according to the latitude and longitude information of the inspector's movement, the displayed fan model is updated in real time. The fan model and the corresponding fan unit have an error of 5 meters within the tolerance limit.

Model assistance: the fan model drawn by Unity3D is displayed at the corresponding position after obtaining the fan information of the position according to the positioning. When the gaze light spot contacts the fan model in the AR world, the ID of the selected fan is displayed on the display interface. HoloLens identifies the inspector's click gesture and performs a click event. When the inspector selects a certain fan and recognizes the click event, the AR world enters the internal structure of the fan.

Process Record: when the inspector opens the AR inspection software, the software calls the HoloLens head-mounted camera to record and record the real-time operation of the inspector, and save the video to the HoloLens local memory. After the patrol is completed, the video recorded during the patrol process is uploaded to the background and saved for use in the background.

Expert System: when the inspector encounters an unsolvable problem at the scene, he uploads the current problem and the problem fan ID to the expert system. The expert display page can obtain the fan model and the real-time display data of the fan through the problem fan ID. The transfer can be observed
and solved according to the model of the problem fan. The expert system adopts the Android+web hybrid development method to facilitate the use of different terminals.

Reporting System: when the reporting system is used to process server-side background data statistics, it needs to process the selected data content and generate an Excel spreadsheet.

4. Conclusion
I want to focus on the current power industry, especially the rapid development of the wind power industry, and the relatively backward and inefficient wind farm detection and inspection system. Combined with the current more innovative AR augmented reality technology, the basic functions of the all-digital wind farm detection and inspection platform based on AR augmented reality technology are realized. The project realized wind turbine positioning, model auxiliary inspection, process recording, and expert remote assistant APP function. The development of wind farm detection and inspection has been promoted, which can greatly improve the efficiency of inspection of wind farms and reduce the workload of inspection staff.

Acknowledgments
I am grateful to Teacher Mei Huawei for providing me with the direction and experimental platform of the paper and for making very pertinent revisions to my article. As an undergraduate student, I was very fortunate to have contacted the real engineering project and trained my professional skills in the project.

References
[1] China's hydropower, wind power, photovoltaic power generation installed capacity ranks first in the world [J]. Hydropower Plant Automation, 2017, 38 (03): 26.
[2] Hou Ying, Xu Weiwei. Overview of Augmented Reality Technology [J]. Computer Measurement & Control, 2017, 25(02): 1-7+22.
[3] Vuzix M100 glasses debut at CES2013 shoulders Google [J]. China Media Technology, 2013 (01): 23.
[4] Another smart glasses SonySmartEyeglass [J]. Microcomputer World, 2014 (04): 86.
[5] Liu Jing. Microsoft launched Win10 PC to release HoloLens [J]. Computer and Network, 2017, 43 (Z1): 26.
[6] Li Qionghui, Guo Jiwei, Wang Yukun. Prospects for World Energy and Power Development in 2030 [J]. Power Technology Economics, 2009, 20(04): 4-9.
[7] International Energy Agency. World energy outlook 2008 [EB/OL]. http://www.iea.org/Textbase/about/copyright.asp.
[8] Bai Wenbin. Status Quo and Prospects of World Wind Power Development [J]. Sci-Tech Information Development & Economy, 2012, 22(22): 129-132.
[9] Shen Dechang. Recent development of the world wind power industry and its forecast for the next five years [A]. China Wind Power Equipment Branch of the Agricultural Machinery Industry Association Wind Energy Industry (No. 7 of 2015) [C].: , 2015: 5.
[10] Wu Ping, Guo Wei, Jin Chunjie, Su Ying, Xu Wu. Discussion on the status quo and solutions of electric power and energy in China [J]. Electric Technology, 2018, 19 (05): 1-4+14.
[11] Zhong Yang, Li Waiyun, Jin Yu. A Two-Dimensional Code Scanning Recognition Algorithm Based on CIS [J]. Information Technology, 2016(12): 139-141+146.
[12] JIANG Shuqiang, ZHAI Qing, WANG Shuhui. Overview and Prospect of Image Recognition Technology for Intelligent Interaction [J]. Computer Research and Development, 2016, 53(01): 113-122.
[13] ZHANG Zhengchao, LI Yingsheng, WANG Lei, CHEN Yubin. Review of Radar Emitter Signal Recognition [J]. Ship Electronic Engineering, 2009, 29(04): 10-14.
[14] Tian Yangjun. Research on automatic recognition of point symbols and buildings in scanned topographic maps [D]. Chang'an University, 2003.
[15] Yuan Xutuo Shi Songxin Deng Jianchun (Huazhong University of Science and Technology,
Wuhan430074); Development of the Visual Design System for Wall Material Production Line Based on Virtools [J]; Computer & Digital Engineering; 2010-10

[16] REN Guo-Dong; CHEN Lin-Hua; TAO Xue-Feng; FANG Xian-Xing; SINOSOFT Co. Ltd.; Hangzhou Arts & Crafts Museum.; Virtual Museum Information Visualization System Based on Unity3D [J]; And Applications; 2013-09.