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Construction and Practice of VR-Based Power Quality Interactive Experience Center

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***Abstract*—With the continuous advance of China's intellectual creation 2025, power supply transform from high reliability to high quality. In this paper, the VR-based power quality interactive experience center was built to dredge the cognitive contradiction and build a new process for power quality event processing. Firstly, the practicability of building power quality interactive experience center via VR was analyzed. Then, focusing on the design architecture and display layout, the building scheme of the VR-based power quality interactive experience center was studied. Finally, the construction results of the VR-based power quality interactive experience center were presented and its application results were analyzed. The construction and practice indicate that building power quality interactive experience center via VR can solve the inherent problem of large area occupation and high cost. Meanwhile, it can provide multiple perception and build a new process mode for the power quality event.**

Keywords—virtual reality; power quality; interactive experience center; building scheme; benefit analysis

I. INTRODUCTION

Accompanied by the continuous promotion of "China Intelligence 2025", the precision manufacturing industry represented by semiconductor manufacturing is developing rapidly. The demand of power quality in the whole society is getting higher and higher. According to the survey, the economic losses caused by power quality problems is as high as 20 billion to 30 billion US dollars each year [1].

Power quality is a complex system issue. Abnormal changes in any link may cause power quality problems. As shown in Fig.1, abnormal changes in any link may cause power quality problems. Power quality is a systemic problem. The management of power quality problems requires the joint efforts of power companies, equipment manufacturers and customers [2]. However, when the power quality problems occur, the user habitually put all the blame on the power company, even use extreme measures to complain Power Company. However, the actual situation may be that the relative equipment configuration is unreasonable, and the voltage tolerance is too low to suffer the normal power quality problems.

The power phenomenon is abstract and inaccessible. In order to make the public understand the power quality phenomenon, it is necessary to establish a more concrete power quality experience center. At present, physical power quality exhibition hall has been established in some areas, but such physical exhibition hall generally has such problems as large floor area and huge investment of people and property. At the same time, there are problems such as poor experience and inability to experience in the physical exhibition hall. VR (virtual reality) is a new technology, through wearing VR glasses, data gloves and other sensing devices, people can get "immersive" experience in the created virtual world [3].

VR technology has been widely used in all walks of life, both at home and abroad. The usage of VR technology in the brain system are described in paper [4]. In literature [5], VR was used to study the design and application type of rehabilitation medicine products from the view of user experience. Literature [6] studied the home display methods based on VR. Methods of how to combine VR technology with AR (Augmented Reality) technology in technical education was studied in literature [7]. Literature [8] studied panoramic image based VR modeling technology and its implementation. As an important breakthrough point for next-generation technology, VR has been valued by all walks of life. However, the current research of VR usage on power quality is still blank and needs to be further researched and practiced. Aiming on the power quality experience, the design architecture of VR, display layout, display content and the current construction effectiveness was expound in this paper.

II. FEASIBILITY

VR is a kind of computer simulation system that can create and experience the virtual world. Using computer to generate a virtual environment, VR is a system simulation of multi-source information fusion, interactive 3D dynamic visualization and physical behavior[9]. Its purpose is to immerse the experiencer to get an immersive feel[10]. The VR can achieve virtual environment, perception and various natural skills via various hardware and software equipment[11].

The simulation environment is a computer-generated, real-time, dynamic, three-dimensional, realistic image[12]. The three-dimensional dynamic model involved in the power quality interactive experience center can be completely realized in the virtual scene.

Perception means that VR should have the perception of people. In addition to the visual perception generated by

computer image technology, there are perceptions such as hearing, touch, force perception, motion, and even smell and taste[13]. The power phenomenon is inherently abstract and inaccessible. Ordinary physical power experience venue is difficult or need to spend a lot of financial and material resources to achieve multi-dimensional perception. In the VR environment, this multi-sensing experience can be easily implemented. Natural skills refer to the person's head turning, eyes, gestures, or other human actions. Then, the computer processes these actions into the corresponding data and respond.[14] In the virtual experience of power quality phenomena, various human actions, including pace, actions, and language can be captured. Then, the virtual interactive experience center responds accordingly.

III. Construction of Power Quality Interactive Experience Center

A. Design Architecture

Power Quality Interactive Experience Center set up a principle hall, living room, production hall, hall management. The power quality is shown from the physical concept to to the entire process of governance programs. The framework of Power Quality Interactive Experience Design Center is shown as Figure 1.

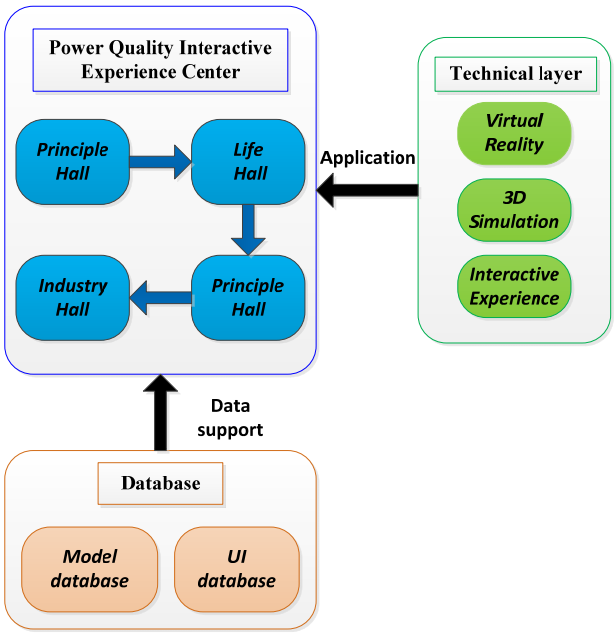


FIGURE I. DESIGN ARCHITECTURE OF INTERACTIVE EXPERIENCE CENTER

The power quality interactive experience center is virtualized. The database contains information on power quality that needs to be presented to the experiencers, including text, images, videos, sounds as well as 3D model data of each venue. Based on this database, the principle hall can be specifically constructed to elaborate the principle of power quality, build the scene where the living hall and production hall reproduce the power quality problems, and construct the governance office to spread the concept of joint governance. With the aid of virtual reality technology, 3D model simulation technology and scene interaction technology, the free-scale reduction and multi-angle switching of the experience and the constructed model are realized to provide an immersive experience.

B. Layout and Content

(1) Principle hall

The principle hall embodies the "Principle Analysis" link to show the generation mechanism of power quality problems. The overall layout of the principle hall looks like a "U" shape shown as Figure 4(a). The panels are set up at the entrance to provide viewers an overview of power quality issues; a large screen is set at the corner to shown the developments and hazards of power quality issues in the form of video; an sand table showing voltage sag problems is designed to provide interactive experience of power quality issues.

(2) Life hall

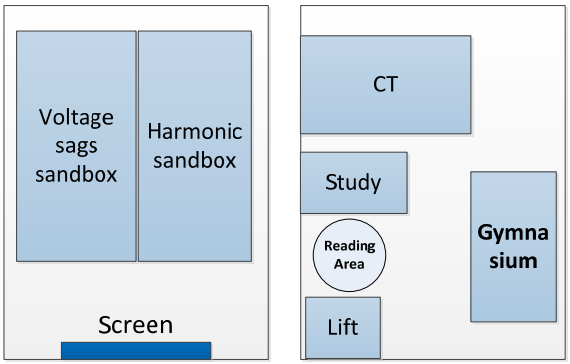
Living Hall belongs to the "Scene Reappear" link, which mainly shows the impact of power quality problems on daily life. The overall layout of the principle hall looks like a "Z" shape shown as Figure 4(b). In addition to the exhibition board, various scenarios related to our life such as CT room, stadium, study and elevator are set. In addition, the power quality literature review area is also set.

(3) Industry hall

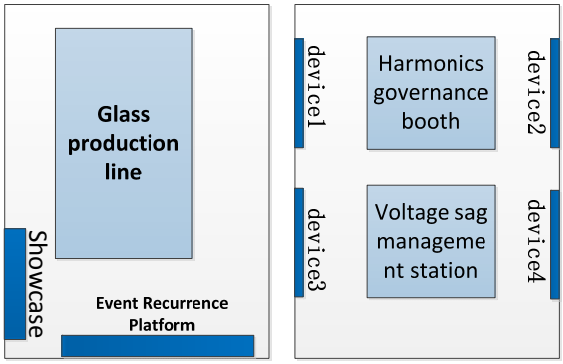
The production hall is also part of the "scenario reappearance", which mainly shows the impact of power quality problems on industrial production. The overall layout of the industry hall looks like a "Z" shape shown as Figure 4(c). Production hall set up a glass production line to reflect the impact of voltage sag on the precision manufacturing enterprises; it set display panels to reflecting the impact of industrial production harmonics on the power system and the hazards.

(4) Administration hall

The administration hall embodies the “governance in right areas” link, demonstrating the mechanism and effects of power quality control equipment. The overall layout of the industry hall looks like a "8" shape shown as Figure 4(d). It shows the physical model of each control device. A booth was set up to reflect the effect of harmonics and voltage sags on the control device.



(a) Principle Hall (b) Life Hall



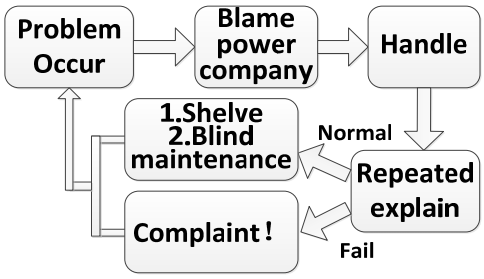
(c) Industry Hall (d) Administration Hall

FIGURE II. LAYOUT OF INTERACTIVE EXPERIENCE CENTER

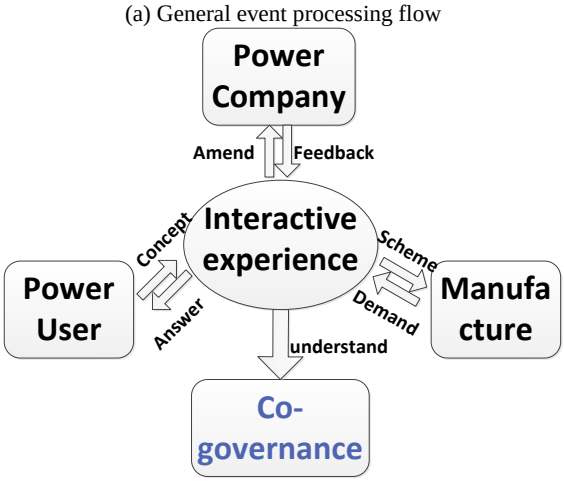
IV. PRACTICAL RESULTS

A. Implementation Effect

VR Virtual Power Quality Interactive Experience Center is flexible, portable and easy to implement. On the one hand, it can provide effective solutions for long-term cognitive conflicts and accident handling difficulties between the maintenance professional and the customers. On the other hand, it can build a new process for power quality event processing shown as Figure 3.



(a) General event processing flow



(b) New event processing flow

FIGURE III. THE PROCESSING FLOW BEFORE AND AFTER THE BUILDING OF THE INTERACTIVE EXPERIENCE CENTER

In short, building a power quality interactive experience center via VR technology can promote and popularize the concept of power quality, strengthen the power company's communication and communication with customers, help maintenance personnel to quickly lock the cause of the accident, solve the blind operation and maintenance issues of blindly changing the mode of operation and providing power cut program.

B. Benefit Analysis

(1) Economic benefits

Physical showroom covers an area of 300~500m^2, which needs huge construction costs. According to previous research, the construction of a one-square-meter physical showroom will cost about 20,000 yuan. Building via VR technology costs shorter time, less manpower and financial resources. The cost is about 2.5% of physical showroom, which means that he construction cost is about 500 yuan. Investment costs significantly reduce.

Take the virtual exhibition hall constructed by this project as an example. The cost savings of building an experience center is:

$$20000 \times 400 \times (1\text{-}2.5\%) = 7.8 \text{ million}$$

(2) Social benefits

- It enables customers to fully understand the power quality problems, and highlight the common governance, cooperation and win-win governance philosophy.
- It enables customers to understand the power company from a professional point of view, approving the governance of power quality issues.
- It can provide an effective means to find out the cause of an incident and to study governance methods for operation and maintenance personnel.
- It can spread the most comprehensive and effective treatment program.

C. Application and Promotion

The space of virtual experience center is not limited by space. It has been applied to the power quality lab, operation and maintenance department and customer service center. In the scope of power companies, the results can be applied to power quality related laboratories, maintenance and repair departments, customer service centers, and power supply business offices. It also can be used for popular education and public education in social sciences.

V. CONCLUSION

Based on dredging the cognitive conflicts between users and power companies and constructing a new process of power quality incident handling, the VR technology is firstly used to build a power quality interactive experience center.

- It is feasible to apply VR technology in the construction of power quality experience center. In addition to having all the features of the Physical Experience Center, it also enables a multisensory experience

- A construction scheme of virtual power quality interactive experience center is provided from the design architecture, the display content and layout.
- The virtual power quality interactive experience center can clear the cognitive contradiction between power companies and users, and build a new process for handling events.
- Its economic and social benefits are significant, and it can be widely promoted.

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