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Digital Technology and Intelligent Operation and Maintenance Plan for Large Venue Sound Reinforcement System

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Abstract: ***With the rapid development of technology, digital technology has gradually penetrated into various fields, especially playing an increasingly important role in the sound reinforcement system of large venues. The traditional sound reinforcement system can no longer meet the high requirements of modern large venues for sound quality, coverage, and stability. Therefore, the introduction of digital technology has become an inevitable trend in the development of large-scale venue sound reinforcement systems. With the support of digital technology, intelligent operation and maintenance of venue sound reinforcement systems have become possible. On the basis of promoting fine sound processing in venues, remote monitoring and intelligent operation and maintenance have also been achieved through networked control systems, which play an important role in ensuring the stable operation of venue sound reinforcement systems.***

Keywords: Large venues; Sound reinforcement system; Digital technology; Intelligent operation and maintenance.

1. Introduction

In some current venues, traditional sound amplification systems are still used for sound amplification and expansion, and there are still problems with poor sound quality and uneven volume, which cannot meet the unique auditory experience pursued by the audience and have brought many troubles to the relevant venue operators. To solve the above problems, intelligent operation and maintenance based on digital technology framework has become a practical and feasible solution. This article will explore in detail the application of digital technology in the sound reinforcement system of large venues in this context, and analyze how to implement the design and implementation of intelligent operation and maintenance solutions in specific implementation.

With the rapid development of technology, the application of digital technology in various fields is becoming increasingly widespread, and intelligent operation and maintenance solutions for large venue sound reinforcement systems have become a research hotspot. This article aims to explore the application status, technical characteristics, and changes brought about by digital technology in the intelligent operation and maintenance of large venue sound reinforcement systems through literature review.

Firstly, it can be seen from existing literature that significant progress has been made in the application of digital technology in large venue sound reinforcement systems. The sound reinforcement system of modern sports venues generally adopts digital products, such as digital mixing consoles, audio signal processors, power amplifiers with DSP plug-in boards, etc. These devices not only improve the technical performance of the system, but also lay the foundation for digital network transmission. The digital network transmission method not only simplifies the transmission pipeline and layout, but also greatly improves the reliability and operational convenience of the system[1-9].

Secondly, intelligent operation and maintenance, as a product of the combination of digital technology and venue operation and maintenance, is gradually becoming a new trend in the operation and maintenance of large venue sound reinforcement systems. The intelligent operation and maintenance platform utilizes advanced technologies such as the Internet of Things, cloud computing, and big data to provide real-time monitoring, data analysis, and fault warning for the sound reinforcement system, achieving intelligent and efficient operation and maintenance work. For example, Kunshan Football Stadium adopts the intelligent control platform provided by Yike International - ezCloud, which is based on 5G, Internet of Things, and cloud computing technology, providing a simple and technological experience in control, management, use, and maintenance, greatly improving the efficiency and reliability of venue operation and maintenance [10-16].

In addition, the literature also points out that the application of intelligent operation and maintenance solutions in large venue sound reinforcement systems not only improves the system's operation and maintenance level, but also promotes the intelligent transformation of overall venue operation and management. Through the intelligent operation and maintenance platform, venue managers can real-time monitor the operational status of the sound reinforcement system, quickly respond to fault alarms, and optimize system configuration through data analysis to enhance user experience. At the same time, the intelligent operation and maintenance platform can also be integrated with other intelligent systems of the venue, such as lighting, ventilation, safety monitoring, etc., to achieve comprehensive intelligent management of the venue [17-22]. By employing a combination of meta-path guidance, attention-weighted aggregation, and neighbor sampling, the MPAAGN model innovatively addresses computational efficiency and accuracy challenges in large-scale graph classification, offering potential applications in any field with complex graph-structured data [23]. By utilizing REEGWO for optimizing CNN-BiLSTM models, this paper offers a unique method for enhancing predictive performance, applicable to any domain needing refined deep learning optimization techniques [24].

In summary, the application of digital technology in intelligent operation and maintenance solutions for large venue sound reinforcement systems not only improves the technical performance and operation efficiency of the system, but also promotes the intelligent transformation of overall venue operation and management. In the future, with the continuous advancement of technology and the expansion of application scenarios, intelligent operation and maintenance solutions will be widely used in more large venues, providing strong support for the sustainable development of venues.

2. Application of Digital Technology in the Sound Reinforcement System of Large Venues

2.1 Digital Signal Processing Technology

Digital signal processing technology has become the core technology of modern audio technology,

which can adjust and process audio signals, and improve sound quality and clarity. The technical principle is to analyze and modify the sound signal in a digital way, simulate common distortion problems in technology, and repair them according to the characteristics attached to the sound. In practical applications, digital signal processing technology mainly utilizes the following processing methods to achieve sound optimization: (1) digital filtering technology. The core principle of this technology is for users to eliminate unnecessary frequency components, such as background noise in venue sound, and analyze them using principal component analysis to clearly convey the main sound and solve the problem of sound distortion. (2) Balanced processing. This processing method is mainly used for energy balance in various audio signals, in order to adjust the energy of the audio signal, so that the human ear will not feel significant differences in sound quality when receiving sound, providing a more natural and pleasant auditory experience. (3) Delay processing. Delay processing originates from the audio processing methods in traditional venues, while digital information processing technology has improved it by allowing it to adjust the temporal distribution of sound based on its spatial propagation characteristics, and transform the distribution according to a specific Fourier transform, enabling the sound to spread evenly in larger venues.

At the same time, digital signal processing technology has built a complete system framework in terms of sound system design, sound reproduction, and noise control, while improving the audio quality of venues (as shown in Figure 1). In large venues such as concerts, theaters, and sports arenas, the technology framework attached to digital technology can make the sound processing methods more diverse, thereby solving the existing problems in sound quality and filling the gaps in the original sound through technology.

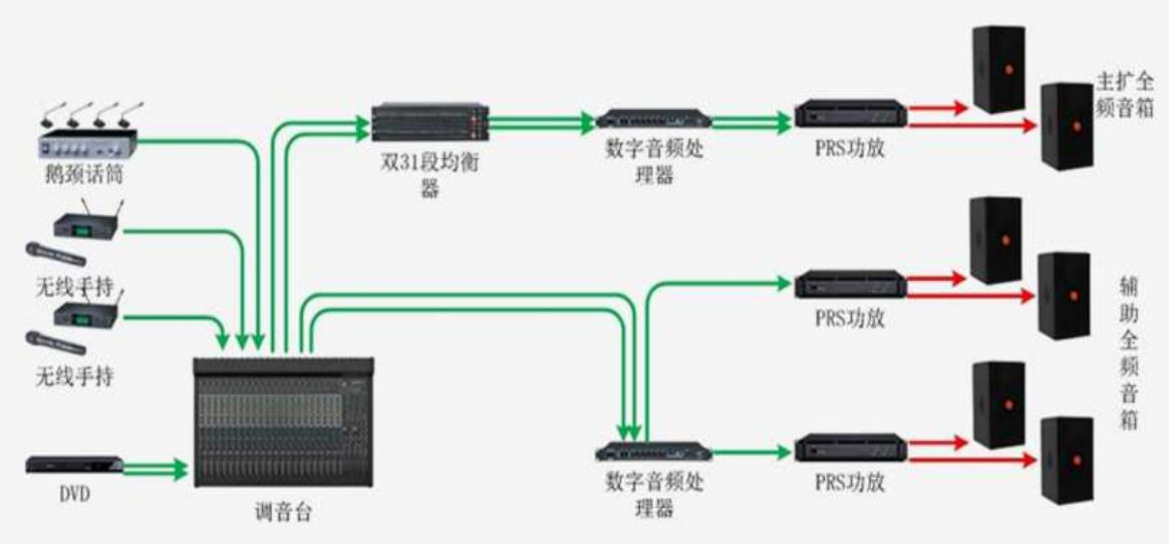

Figure 1: Demonstration of the technical framework for the application of digital information processing technology in venues

2.2 Networked Sound Reinforcement System

The networked sound reinforcement system has similarities with digital signal processing technology, both of which rely on the application of modern network technology to intervene at the technical level to achieve audio signal transmission control. But the difference is that this technology can improve the performance of traditional sound reinforcement systems in multiple aspects. Compared with traditional analog sound reinforcement systems, networked sound reinforcement systems apply signal processing technology from the Internet of Things, allowing signals to be transmitted with high fidelity and low distortion rate characteristics. They separate unique digital signals from the electromagnetic

interference frequency band of daily life, minimizing the impact of signal attenuation. Secondly, the significant feature of networked sound reinforcement systems is that each component can be connected to the same network, which improves system scalability on the basis of simplifying system wiring and installation. Specifically, any component of the system (microphone, speaker, mixing console) can be easily added and removed to reduce its impact on the system.

The networked sound reinforcement system supports remote control and monitoring, greatly enhancing the flexibility and reliability of the system. The operator can remotely monitor the operating status of the system through the network, and promptly detect and solve problems. For example, in large-scale events, technicians can adjust the volume and sound quality in real-time in the control room to ensure the audience's auditory experience. In addition, remote monitoring also means that in the event of a system failure, technicians can quickly perform remote diagnosis and intervention, reducing the need for on-site maintenance and thus improving the operational efficiency and stability of the system.

2.3 Virtual Sound Field Technology

The core principle of virtual sound field technology lies in precision digital signal processing (DSP) and scientific speaker layout optimization, in order to create immersive sound effects in various venues, simulate natural auditory environments, promote sound effects close to the sound distribution in the real environment, and enhance the listening experience of the audience. In terms of technical operation, it is essentially a three-step process of capturing, analyzing, and processing audio signals. Based on the logical arrangement of operations, it accurately simulates multi-dimensional sound scenes, including pitch and volume adjustment, as well as echo reverberation effect simulation, so that sound effects can propagate in a more stable way in three-dimensional space (refer to the "soliton" sound wave propagation model). On the basis of technical operation optimization, this technology can also achieve comprehensive operation of virtual sound field through the layout optimization of speaker equipment. According to the optimal ratio position of the speakers, they are scientifically placed (the speakers are planned according to the optimal path of the sound field environment), and the sound is simulated and analyzed at the farthest and closest points of the venue to achieve uniform distribution, ensuring that the difference in sound experience for the audience is about 10%. At the same time, it is necessary to consider the specific structure and acoustic characteristics of the auditorium in the layout of the speakers, as well as the location of the audience, and incorporate them into the simulated scene to achieve the best sound coverage effect.

3. Design and Implementation of Intelligent Operation and Maintenance Solutions

3.1 Remote Monitoring and Fault Diagnosis

The use of sensor technology attached to network connections to achieve remote monitoring and fault diagnosis of sound reinforcement systems is a significant achievement of the integration of modern information technology and traditional audio equipment, which can be applied in the intelligent operation and maintenance of venues. The specific implementation should follow the "three-step" strategy: (1) introducing network connectivity technology. The introduction of technology enables the sound reinforcement system to realize data transmission and reception in the Internet integrated system, which means that the system administrator can monitor the system in real time with the help of mobile devices attached to the Internet at any place with network coverage. (2) Application of sensor technology. The main application of sensors is to use sound sensing sensors to endow the sound

reinforcement system with self detection and reporting functions, continuously monitor various indicators of the sound reinforcement system (voltage, current, temperature), and immediately issue alarms when relevant abnormal situations occur in various indicators. (3) Building the remote fault diagnosis capability of the system. When the system malfunctions, specific means need to be used to analyze the fault. Therefore, when installing sensors, it is necessary to analyze the data collected by the sensors in the system logs, so that administrators can quickly locate the problem and remotely troubleshoot it in some cases, shorten the fault recovery time, reduce on-site maintenance needs, and lower maintenance costs.

3.2 Data Analysis and Predictive Maintenance

Big data analysis technology has been widely promoted and applied in the modern information age, and is no exception in the operation and management of sound reinforcement systems. Its application is mainly to improve work efficiency and reduce various costs of operation and maintenance through efficient algorithms. The current sound reinforcement system contains a large amount of data content. Although this type of data content exists in the form of sound, it can essentially be transcoded into data. Big data analysis technology can collect and process the data attached to the operation of the sound reinforcement system based on the analysis of the transcoded data. According to a specific transcoding method, the system performance parameters, usage frequency, and fault records in the data code can be summarized together as the basis for subsequent maintenance and optimization work. On the basis of collection, it is necessary to conduct in-depth analysis, which can be done using feature analysis mode and resolution analysis mode. Extract key information based on two analysis methods to identify the degree of system wear and estimate the service life of vulnerable components. The above information will be fully applied to assist system administrators in accurately predicting the maintenance needs of the sound reinforcement system and achieving early intervention. For example, considering a simple application scenario, by analyzing the usage status of system components, predicting which components will fail in the future, and replacing and reinforcing them in advance before they fail, to avoid sudden shutdowns caused by system failures and achieve prevention in advance.

On this basis, big data analysis can also transcode some specific data and use it for optimizing the performance of the sound reinforcement system. It can track and analyze the system operation data for a long time, explore potential bottlenecks and improvement points in system performance, and then optimize the system in a targeted manner to improve overall system performance.

3.3 Automated Operation and Intelligent Optimization

To achieve intelligent operation and maintenance in large venues, essential technologies include automated operation and maintenance and intelligent optimization. Specifically in the field of sound reinforcement systems, the introduction of the above-mentioned technologies is not only a future development trend, but also a key factor in improving system performance and efficiency. Automated operation and maintenance technology can enable the sound reinforcement system to automatically perform daily operation and maintenance tasks without human intervention. It can replace system monitoring, maintenance, and troubleshooting without relying on manual technical fitting, greatly improving the reliability of the sound reinforcement system, reducing problems caused by human operation errors, and fully realizing the "automation" mode.

Intelligent optimization technology enables the sound reinforcement system to automatically adjust its parameters and configurations according to different usage environments and requirements through

advanced control algorithms and optimization strategies. For example, in different situations, the system can automatically adjust the volume and sound quality according to changes in the acoustic environment to ensure the best auditory effect. Intelligent optimization technology can also help the system monitor and analyze data in real time, predict and solve potential problems, and further improve the stability and response speed of the system.

4. Advantages and Problems of Digital Technology and Intelligent Operation and Maintenance

4.1 Advantage Analysis

Digital technology and intelligent operation and maintenance have many advantages in the sound reinforcement system of large venues. Firstly, digital technology can improve the quality and restoration of sound transmission. At the same time, branch technologies such as digital signal processing, network transmission, and audio encoding and decoding under digital technology can also eliminate noise problems in the analog signal processing process, providing a good auditory experience for large-scale venue performances. Secondly, intelligent operation and maintenance solutions can improve the efficiency of system operation and maintenance. The traditional operation and maintenance management methods usually require a large amount of manpower and material resources, and are prone to delays and errors. However, the use of artificial intelligence, the Internet of Things, and big data analysis technologies can solve the related problems contained in traditional sound reinforcement systems, achieve real-time monitoring, fault diagnosis, and prediction of the system, and improve operation and maintenance efficiency and response speed. Thirdly, digital technology intelligent operation and maintenance solutions have scalability. Digital technology can continuously improve the original functional performance of the system based on software algorithm upgrades, in order to adapt to changing needs, especially in scenarios with high requirements for sound reinforcement. This expansion performance can achieve "real-time satisfaction of needs". The intelligent operation and maintenance solution can also be adjusted and optimized according to the actual situation, adapting to the requirements of different venue equipment, so that the sound reinforcement system of large venues can meet the constantly developing needs and be implemented according to sustainable development strategies.

4.2 Analysis of Proposed Problems

Although digital technology and intelligent operation and maintenance have brought many advantages to the sound reinforcement system of large venues, they also face some problems: firstly, the application of digital technology requires high-performance hardware equipment in the relevant application venues, which naturally come with complex system integration. Among them, the application of technologies such as digital signal processing, network transmission, and audio encoding and decoding requires strong computing and storage capabilities to support, high bandwidth network support, and a network speed of 10M/s to achieve basic expansion. The system integration configuration also requires professional technical personnel for operation and management, but the number of personnel in this area is relatively small. Therefore, the application of digital technology requires full support from all aspects. Secondly, the implementation of intelligent operation and maintenance solutions requires sufficient data support and algorithm optimization. Intelligent operation and maintenance rely on a large amount of data collection and analysis to achieve accurate monitoring and prediction of system performance. This requires continuous optimization and improvement of algorithms to improve the accuracy and efficiency of fault diagnosis decisions. Therefore, the implementation of intelligent operation and maintenance requires sufficient data

foundation and relevant professional algorithm research and development capabilities, which is also consistent with the first requirement. Thirdly, the promotion and application of digital technology and intelligent operation and maintenance face the issue of training acceptance. The introduction and application of a new technology requires relevant personnel to receive training and learning according to the technical core, as well as new requirements for their management and usage abilities. Therefore, it is necessary to enhance the acceptance of digital technology and intelligent operation and maintenance solutions in the industry market, in order to promote their widespread application in large venue sound reinforcement systems.

5. Conclusion

In summary, the application of digital technology and intelligent operation and maintenance solutions in the sound reinforcement system of large venues can bring clear and pure sound experience to the audience, improve sound stability, and contribute to the sustainable development of the venues. In the future, with the continuous innovation and development of technology and the continuous expansion of related technology applications, sound reinforcement systems will operate in an efficient, stable, and intelligent manner. At the same time, by introducing integrated IoT technology and cloud computing technology, venue managers can also remotely control the sound reinforcement system, achieving complete operation and maintenance management without manual labor.

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