Environmental Noise Monitoring and Management in the Context of Artificial Intelligence

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Abstract: With the acceleration of urbanization, the problem of environmental noise pollution has become increasingly serious, seriously affecting the quality of life and physical and mental health of residents. This paper systematically discusses the progress and challenges of the application of artificial intelligence technology in environmental noise monitoring and management. In the field of monitoring, traditional methods such as sound level meters, remote sensing technology and noise sensors are practical, but there are limitations such as low spatial and temporal resolution, and insufficient data processing efficiency, etc. AI technology realizes efficient classification, source identification and accurate prediction of noise data through machine learning and deep learning algorithms, and significantly improves the real-time and accuracy of monitoring. In terms of management, traditional technologies such as sound insulation, sound absorption and noise elimination combined with intelligent optimization algorithms (e.g. genetic algorithms, particle swarm optimization) and simulation models can dynamically optimize the noise reduction program and improve the management effect. The integration of AI and traditional technologies provides a new way of controlling the source and blocking the propagation path of noise pollution by means of data-driven analysis, model prediction and optimization of strategies. However, the problems of high data quality dependence, insufficient model interpretability and computational complexity still need further breakthroughs. Future research should focus on multi-technology synergistic innovation to promote the development of environmental noise monitoring and management in the direction of intelligence and efficiency, and provide technical support for building livable urban environment.

Keywords: Artificial intelligence; Environmental noise; Monitoring; Governance.

1. Introduction

With the rapid development of science and technology, artificial intelligence technology has achieved remarkable results in various fields, and the field of environmental noise monitoring and governance is no exception. In recent years, China's urbanization process has accelerated, population density has increased, and activities such as transportation and industry have been expanding, resulting in increasingly serious environmental noise problems. Environmental noise not only affects people's quality of life, but also may have a negative impact on physical and mental health. Therefore, it is of great practical significance to study environmental noise monitoring and governance in the context of artificial intelligence.

2. Environmental Noise Monitoring Technology

2.1. Noise monitoring methods

2.1.1. Sound Level Meter Monitoring

Sound level meter monitoring is a commonly used environmental noise monitoring method. A sound level meter is an instrument used to measure the intensity of sound, which can convert sound signals into electrical signals and display the sound level of noise. The principle of sound level meter monitoring is to measure the sound pressure level of the noise through the sound level meter, and then assess the intensity of the noise based on the magnitude of the sound pressure level.

Sound level meter monitoring has the following advantages: firstly, sound level meter is a non-invasive monitoring method, which will not have any impact on the noise source. Secondly, the results of sound level meter monitoring are objective and accurate, and can truly reflect the intensity of noise. In

addition, sound level meter monitoring is easy to operate and does not require specialized knowledge to carry out. However, there are some limitations of sound level meter monitoring. Firstly, sound level meter can only measure the sound pressure level of noise, but not other characteristics of noise, such as frequency distribution. Secondly, sound level meter monitoring is greatly affected by environmental factors, such as temperature and humidity, which can affect the accuracy of the monitoring results. In addition, sound level meter monitoring can only measure instantaneous noise, and cannot measure the cumulative effect of continuous noise [1].

In general, sound level meter monitoring is a commonly used method of environmental noise monitoring, with the advantages of simple operation, accuracy and reliability, but there are some limitations. In practical application, the appropriate monitoring method can be selected according to the need, such as used in combination with other monitoring methods, in order to improve the accuracy and reliability of the monitoring results.

2.1.2. Remote Sensing Monitoring

Remote sensing technology monitoring is a monitoring method based on the principle of electromagnetic wave radiation, through different types of remote sensing platforms (such as satellites, airplanes, drones, etc.) carrying sensors to obtain the surface characteristics of information, so as to realize the monitoring of environmental noise. Remote sensing technology has the following characteristics and advantages in environmental noise monitoring.

First of all, remote sensing technology has a broad monitoring range, which can realize the monitoring of environmental noise distribution in a wide range of areas, and is conducive to grasping the overall environmental noise level [2]. Through remote sensing technology, global or regional environmental noise maps can be obtained, providing

scientific basis for policy making and environmental management. Secondly, remote sensing technology has a high spatial and temporal resolution. With the development of remote sensing technology, the spatial resolution of the remote sensing platform is constantly improving, which can obtain finer surface information. At the same time, remote sensing technology can also realize real-time or high-frequency monitoring, which helps to capture the instantaneous changes in environmental noise and provides an effective means for tracking and management of environmental noise pollution sources. In addition, remote sensing technology has lower cost and higher efficiency in monitoring environmental noise. Compared with traditional ground monitoring methods, remote sensing technology does not need to set up a large number of monitoring stations on the ground, thus saving human, material and financial resources. At the same time, remote sensing monitoring can realize rapid data acquisition and processing, shorten the environmental noise monitoring cycle and improve the monitoring efficiency. However, remote sensing technology in environmental noise monitoring also has certain limitations. For example, the noise monitoring capability of remote sensing sensors is limited by sensor sensitivity and resolution, and may not be able to accurately identify low-intensity noise sources. In addition, remote sensing technology may be affected by atmospheric and terrain factors in the process of data processing and analysis, resulting in errors in the monitoring results.

In summary, remote sensing technology has a broad application prospect in environmental noise monitoring, but further improvement and optimization of sensor performance, data processing methods and other aspects are still needed to improve the accuracy and reliability of environmental noise monitoring.

2.1.3. Noise sensor monitoring

Noise sensor monitoring is an important technical means for environmental noise monitoring and management. Noise sensor is a device that can convert sound signals into electrical signals, and the noise level in the environment can be obtained by monitoring the output signal of the noise sensor. There are many types of noise sensors, including sound level meters, micro-vibration meters, sound sensors and so on.

The monitoring principle of noise sensors is mainly based on the physical characteristics of sound, such as sound pressure, sound speed and the propagation characteristics of sound waves. Noise sensors can convert sound signals into electrical signals, which are then processed and analyzed by the data acquisition system to obtain parameters such as the sound pressure level of the noise, the sound speed, and the propagation characteristics of sound waves [3]. These parameters can be used to assess the intensity and characteristics of noise and provide a scientific basis for environmental noise management.

Noise sensor monitoring has the following advantages: firstly, noise sensors can monitor environmental noise in real time and provide real-time data, which helps to find and solve problems in time. Secondly, noise sensors have high measurement accuracy and stability, which can provide reliable data support. In addition, noise sensor monitoring can realize remote monitoring and automated control to improve monitoring efficiency. However, noise sensor monitoring also has some limitations. First, the installation and maintenance of noise sensors require specialized knowledge and skills, and require regular calibration and maintenance. Second, noise

sensor monitoring can only obtain localized noise information, and there may be a blind spot for monitoring complex noise sources. Therefore, in practical application, it is necessary to combine other monitoring technologies and methods, such as acoustic simulation and remote sensing technology, to improve the comprehensiveness and accuracy of monitoring.

In conclusion, noise sensor monitoring plays an important role in environmental noise monitoring and management. By monitoring the noise level in real time, it can provide a scientific basis for noise management, which helps to improve the quality of the environment and improve people's quality of life. In the future, with the development of artificial intelligence technology, noise sensor monitoring will be more intelligent and efficient, providing more advanced technical support for environmental noise management.

2.2. Application of artificial intelligence in noise monitoring

2.2.1. Machine learning algorithm

Machine learning algorithm is an important branch in the field of artificial intelligence, which automatically learns and extracts features from data by training models, and then realizes the prediction and classification of unknown data. In environmental noise monitoring and management, machine learning algorithms play a crucial role [4].

First of all, machine learning algorithms can be used for classification and identification of noise data. By training on a large amount of noise data, the model can learn the features of different noise types and distinguish them. In this way, in practical applications, we can input the collected noise data into the trained model to quickly and accurately identify the type of noise, so as to take targeted management measures. Second, machine learning algorithms can be used for noise prediction. By analyzing historical noise data, the model can find out the relationship between noise and variables such as time and location, and build a prediction model. In this way, we can know in advance the noise level in a certain area in the future period of time according to the prediction model [5], which provides a scientific basis for noise management. In addition, machine learning algorithms can also be used for the evaluation of noise management effects. Through the comparative analysis of the noise data before and after the treatment, the model can assess the actual effect of the treatment measures, thus providing a reference for optimizing the treatment program.

In China, many researchers have achieved significant results in machine learning algorithms in the field of environmental noise monitoring and treatment. For example, some researchers have conducted in-depth studies on noise monitoring data preprocessing, feature extraction and model training, and proposed a series of efficient and reliable machine learning algorithms. However, due to the complexity of the environmental noise problem, machine learning algorithms still face some challenges in practical applications, such as uneven data quality and numerous noise types. Therefore, future research needs to further explore machine learning algorithms adapted to the characteristics of different environmental noise to improve the accuracy and efficiency of monitoring and management.

2.2.2. Deep learning algorithms

Deep learning algorithm is an important technology that has rapidly developed in the field of artificial intelligence in recent years. It realizes automatic feature extraction and classification recognition of input data by simulating the

structure and function of the neural network of the human brain. In environmental noise monitoring and management, deep learning algorithms have a wide range of application prospects.

First of all, deep learning algorithms can automatically learn complex features from a large amount of noise data, thus improving the accuracy of noise monitoring. Traditional noise monitoring methods mainly rely on manual extraction of features, which is limited by human experience and knowledge, and it is difficult to capture the hidden laws in noise data. Deep learning algorithms, on the other hand, can automatically learn advanced features in noise data through multi-layer neural network models, improving the accuracy and stability of noise monitoring. Secondly, deep learning algorithms can realize real-time monitoring and prediction of noise. By building a noise monitoring model based on deep learning algorithms, noise data can be captured in real time and predicted in real time, so that noise pollution problems can be found and solved in a timely manner. In addition, deep learning algorithms can also predict the future trend of noise levels by analyzing historical noise data, providing a scientific basis for noise management. In addition, deep learning algorithms can also assist in the optimization of noise management measures. Through the data analysis of the noise management effect, deep learning algorithms can find out the deficiencies in the management measures and put forward corresponding optimization programs. For example, in terms of noise source identification and localization, deep learning algorithms can automatically identify the location and type of noise sources based on noise data characteristics, providing effective guidance for noise management. However, deep learning algorithms also have some challenges in environmental noise monitoring and management. First, deep learning algorithms require a large amount of training data to achieve good performance, and there are often difficulties in acquiring environmental noise data. Secondly, deep learning algorithms have higher computational complexity and higher requirements for hardware equipment, which may have some limitations in practical applications [6].

In summary, deep learning algorithms have great potential and application value in environmental noise monitoring and management. With the continuous development and optimization of technology, it is believed that deep learning algorithms will play a more important role in the field of environmental noise monitoring and governance.

2.2.3. Integration of artificial intelligence and traditional monitoring technology

The integration of artificial intelligence technology and traditional monitoring technology brings new opportunities and challenges for environmental noise monitoring. Traditional monitoring technology such as sound level meter monitoring has the advantages of easy operation and low cost, but its data processing capacity is limited and easily disturbed by environmental factors. Artificial intelligence technology, especially machine learning and deep learning algorithms, has powerful data processing and pattern recognition capabilities, and can realize the rapid analysis and processing of large amounts of noise data.

In environmental noise monitoring, artificial intelligence technology can establish a noise prediction model through the training and learning of historical noise data to achieve accurate prediction of noise levels. In addition, AI can identify noise sources and take appropriate measures to manage them through real-time analysis of noise data. For

example, using real-time data collected by noise sensors, combined with machine learning algorithms, it can realize the rapid positioning and identification of noise sources, so as to take targeted management measures. At the same time, the integration of artificial intelligence technology and traditional monitoring technology also needs to face some challenges. For example, the acquisition and labeling of noise data requires a lot of manpower and time, and the quality and completeness of noise data have an important impact on the accuracy of the model. In addition, the interpretability of AI models is also an issue, especially in environmental noise management, where the decision-making process of the model needs to be explained and validated.

Overall, the integration of artificial intelligence technology and traditional monitoring technology provides new ideas and methods for environmental noise monitoring and management. By making full use of the data processing and pattern recognition capabilities of AI, the accuracy and efficiency of environmental noise monitoring can be improved, providing technical support for the realization of sustainable environmental noise management. However, it is also necessary to note the problems and challenges that exist in the practical application of artificial intelligence technology, and to promote the development of environmental noise monitoring and governance technology through continuous research and improvement.

3. Environmental Noise Management Technologies

3.1. Noise management methods

3.1.1. Sound insulation and noise reduction technology

Acoustic noise reduction technology is a common noise management method, the main principle of which is to set up acoustic barriers on the noise propagation path, so as to reduce noise propagation by absorbing the energy of incident sound waves, reflecting them or transmitting them.

The implementation of sound insulation and noise reduction technology mainly depends on the design of sound insulation materials and sound insulation structures. Sound insulation materials usually have high sound absorption coefficient and sound insulation capacity, which can effectively absorb and block the propagation of sound waves. Sound insulating structures, on the other hand, include a variety of sound insulation barriers, sound insulation chambers, sound insulation enclosures, etc., which can be designed with different structures and shapes according to the characteristics of noise propagation and the requirements of treatment to achieve the best sound insulation effect [7].

Sound insulation and noise reduction technology has a wide range of applications and can be used in construction, transportation, industry and other fields. In the field of construction, sound insulation and noise reduction technology can be applied to walls, floor slabs, windows and other parts to reduce the interference of indoor noise to the outdoor. In the field of transportation, sound insulation and noise reduction technology can be applied to highways, railroads, urban rail transit, etc. to reduce the impact of traffic noise on the surrounding environment. In the industrial field, sound insulation and noise reduction technology can be applied to factory workshops, equipment installations, etc., in order to reduce the harm of industrial noise on the health of workers and the surrounding environment.

The sound insulation noise reduction technology has the

advantages of simple implementation and remarkable effect, but it also has certain limitations. For example, the installation of sound insulation barriers may affect sightlines and landscapes, and the construction of sound insulation chambers and enclosures may increase costs and space occupation. Therefore, in practical application, it is necessary to select appropriate sound insulation and noise reduction technologies and programs based on specific treatment requirements and conditions and comprehensive consideration of various factors.

In conclusion, sound insulation and noise reduction technology is an effective noise management method, which can significantly reduce the noise interference to people's life and work and create a quieter and more comfortable environment through reasonable design and implementation.

3.1.2. Acoustic noise reduction technology

Acoustic noise reduction technology is an effective method of environmental noise management, the main principle is to absorb sound energy through acoustic materials, which will be converted into heat or other forms of energy, thereby reducing the spread and impact of noise. Acoustic noise reduction technology has the following characteristics and advantages in practical application:

First of all, the acoustic noise reduction technology has a high noise reduction effect. Compared with other noise reduction technologies, the absorption effect of acoustic materials on low and medium frequency noise is better, which can reduce the noise level in a larger range. In addition, the acoustic noise reduction technology can also select the appropriate sound-absorbing materials and structures according to the characteristics and sources of the noise, in order to achieve the best noise reduction effect. Secondly, the acoustic noise reduction technology has a wide range of application. Whether indoors or outdoors, whether in industrial noise management or urban noise management, acoustic noise reduction technology can play an important role. For example, in highways, subway tunnels, buildings and other occasions, through the reasonable design and layout of sound-absorbing materials, can effectively reduce the impact of noise on the surrounding environment and residents. Once again, sound-absorbing noise reduction technology has a long service life and good stability. Acoustic materials usually have good weather resistance and corrosion resistance, and can adapt to a variety of harsh environmental conditions. At the same time, the design and construction of acoustic noise reduction structures are also more mature, ensuring the long-term stability of the treatment effect. However, the acoustic noise reduction technology also has certain limitations. For example, the absorption effect for high-frequency noise is relatively poor, and the thickness and weight of sound-absorbing materials may have a certain impact on buildings or equipment. In addition, the management cost of acoustic noise reduction technology is relatively low, but it needs to be designed and constructed according to the actual situation, which may lead to an increase in the overall cost.

In summary, acoustic noise reduction technology has important roles and advantages in environmental noise management. Through rational design and application of sound-absorbing materials, it can effectively reduce the impact of noise on human life and work and improve environmental quality. However, it is also necessary to pay attention to its limitations in practical application, and comprehensively consider various noise reduction

technologies and methods to achieve the best noise management effect.

3.1.3. Anechoic noise reduction technology

Anechoic noise reduction technology is an important method to reduce environmental noise, and its main principle is to take measures at the sound source or in the noise propagation pathway, so that the noise energy can be attenuated or absorbed, so as to achieve the purpose of reducing noise.

Anechoic noise reduction technology includes sound absorption, sound insulation and anechoic three aspects. Sound absorption refers to the noise energy in the propagation process is absorbed and converted into heat energy, thus reducing noise. Sound insulation refers to the noise energy is reflected, refracted or absorbed in the process of propagation, so as to prevent the propagation of noise. Anechoic refers to changing the way of sound wave propagation, so that the sound wave is refracted, reflected or absorbed, so as to reduce the noise. Anechoic noise reduction technology has a wide range of applications, including construction, transportation, industry and other fields. In the field of construction, anechoic noise reduction technology can be applied to walls, ceilings, floors and other building materials to reduce indoor noise. In the field of transportation, anechoic noise reduction technology can be applied to roads, bridges, tunnels and other transportation facilities to reduce traffic noise. In the industrial field, anechoic noise reduction technology can be applied in industrial facilities such as plants, machines and equipment to reduce industrial noise. Anechoic noise reduction technology has the advantages of significant effect, easy installation, long service life and so on. However, the application of anechoic noise reduction technology also has certain limitations, such as high cost and complicated construction. In addition, the actual effect of noise reduction technology is affected by a variety of factors such as noise characteristics and environmental conditions, so in the actual application of the need to choose the appropriate noise reduction technology and program according to the specific circumstances.

In summary, noise reduction technology is an effective method of environmental noise management. With the continuous development of science and technology and the improvement of people's awareness of environmental protection, the application of noise reduction technology in the future will be more extensive, and will play an important role in improving environmental noise pollution.

3.2. Application of artificial intelligence in noise management

3.2.1. Intelligent optimization algorithm

Intelligent optimization algorithm is an optimization method that simulates the biological evolution process in nature, mainly including genetic algorithm, particle swarm optimization algorithm, ant colony algorithm, bee algorithm and so on. These algorithms play an important role in environmental noise management and can help us find the optimal noise management program.

Genetic algorithm is a kind of optimization algorithm based on biological genetic mechanism, which generates new solutions by simulating the process of genetic inheritance, mutation and natural selection of organisms, and gradually converges to the optimal solution. In environmental noise management, genetic algorithm can be used to optimize the layout and parameter settings of noise management

equipment to achieve the best noise reduction effect.

Particle swarm optimization algorithm is a kind of optimization algorithm based on group behavior, which realizes the search for the optimal solution by simulating the social behavior of groups such as bird flocks and fish flocks. In environmental noise management, particle swarm optimization algorithm can be used to find the best noise management strategy and improve the noise management effect.

Ant colony algorithm is an optimization algorithm based on the foraging behavior of ants, which realizes the search for the optimal solution by simulating the pheromone transfer mechanism of ants. In environmental noise management, the ant colony algorithm can be used to optimize the layout and parameter settings of noise management equipment to improve the noise reduction effect.

Honeybee algorithm is an optimization algorithm based on the honey harvesting behavior of honeybees, which realizes the search for the optimal solution by simulating the honey harvesting process of honeybees. In environmental noise management, the honeybee algorithm can be used to find the best noise management strategy and improve the noise management effect.

The application of intelligent optimization algorithms in environmental noise management can substantially improve the management effect and reduce the management cost, which has a wide range of application prospects. However, these algorithms still have some problems in practical application, such as high computational complexity and difficult parameter setting. Future research can further improve these algorithms to enhance their application in environmental noise management.

3.2.2. Noise management modeling and simulation

Noise management modeling and simulation play an important role in environmental noise control. Through the establishment of mathematical models of noise propagation and diffusion, the distribution and change rule of the noise field can be analyzed and predicted. Simulation technology can simulate the implementation effect of noise management measures and assess the feasibility and effectiveness of different management programs.

Noise management models mainly include sound source model, propagation model and reception point model. The sound source model describes the characteristics of the noise source, such as sound pressure level, frequency distribution and directionality. The propagation model describes the process of noise propagation in the air, including the phenomena of sound wave attenuation, diffraction and reflection. Receiving point modeling describes the sound pressure level and auditory perception of noise at the receiving point.

By building these models, noise control measures can be simulated. The simulation technique can model the implementation of different control measures, such as sound insulation, sound absorption and sound deadening. By comparing the simulation results of different scenarios, it is possible to assess which treatment solution is more effective and to optimize the design and implementation of the treatment measures.

Noise management models and simulations are of great significance in practical applications. First, they can help decision makers better understand and analyze noise problems and provide scientific basis for noise management. Second, they can save experimental costs and time, and avoid risks and uncertainties in practical operation. Finally, they can provide innovative ideas and methods for noise management and promote the development of noise control technology. However, there are some limitations of noise management modeling and simulation. First, the accuracy and reliability of the model depends on the quality and accuracy of the input data. Second, the simulation results are affected by modeling assumptions and simplifications, which may differ from the actual situation. Therefore, it is necessary to carefully select and validate the model in practical applications, and adjust and optimize it with the actual situation.

In conclusion, noise management modeling and simulation play an important role in environmental noise control. By establishing and applying these models, noise problems can be better analyzed and solved, and the effect and efficiency of noise management can be improved. With the development of artificial intelligence technology, noise management models and simulation will be further improved and optimized to provide stronger support for environmental noise control.

3.2.3. Integration of artificial intelligence and traditional management technology

The development of artificial intelligence technology brings new opportunities and challenges for environmental noise management. On the basis of traditional governance technology, the integration of artificial intelligence with it can improve the efficiency and effect of noise governance. First of all, artificial intelligence can quickly identify the main sources and influencing factors of noise pollution through the analysis of a large amount of noise data, providing data support for the development of targeted governance measures. Secondly, artificial intelligence can use machine learning and deep learning algorithms to establish noise prediction models to achieve early warning and accurate control of noise pollution. In addition, artificial intelligence can be combined with optimization algorithms to provide optimal solutions for noise management, such as proposing effective management strategies for noise source control, path blocking and propagation attenuation. At the same time, the integration of artificial intelligence and traditional governance technology also faces some challenges. On the one hand, the acquisition and processing of noisy data requires a lot of time and resources, and noisy data often has noise and missing problems, which puts forward higher requirements for the training and application of AI models. On the other hand, the lack of interpretability of AI models may lead to lower trust in the models by implementers of governance measures and the public, affecting the evaluation and promotion of governance effects.

Despite the challenges, the integration of AI with traditional governance technologies still has a broad development prospect. With the progress of technology and the depth of application, it is believed that AI will play an increasingly important role in environmental noise monitoring and governance, contributing to the improvement of human living environment and quality of life.

4. Conclusion

In the future, with the continuous development and improvement of artificial intelligence technology, its application in environmental noise monitoring and governance will be more extensive and in-depth. We can look forward to the emergence of more intelligent and efficient noise monitoring systems and governance programs to create

a more tranquil and comfortable living environment for human beings. At the same time, it is also necessary to strengthen the research and development and promotion of artificial intelligence technology to improve its practical application in environmental noise management, and make greater contributions to sustainable development and environmental protection.

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