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Abstract: In this paper, a landscape noise environmental assessment method based on life cycle assessment is designed. The audio features of landscape environment are extracted, the landscape noise is identified and processed by HSCW window function, the evaluation indexes of the three main stages of landscape life cycle are selected by LCA method, and the grey interval of the evaluation indexes is clustered to realise the noise environment evaluation. The experimental results show that the maximum accuracy of landscape noise monitoring can reach 96.4%, the minimum time-consuming of noise environment evaluation is 17.6 min, and the maximum evaluation accuracy can reach 96.9%, which is significantly higher than the two methods. It shows that this method has high noise monitoring accuracy, short evaluation time-consuming, high evaluation accuracy and good practical performance.

Keywords: life cycle assessment; LCA; landscape architecture; noise environment; noise assessment.

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1 Introduction

Landscape architecture is a complex system, which plays an important role in the optimisation of landscape environment in the construction of city appearance environment (Lai, 2019). At present, landscape architecture is generally built on the basis of natural landscape for citizens to have a relatively relaxed place during leisure, which is higher than natural landscape (Li, 2021). However, with the improvement of living standards, people's requirements for quality of life are also gradually improving, which also makes people's demand for landscape architecture construction environment gradually increase. A good living environment is an important indicator to measure people's quality of life and comfort. The main factor affecting the construction of landscape architecture in the city appearance environment is noise pollution, which has obviously affected the construction of landscape environment (Li et al., 2018; Yu and Dong, 2019). The noise generated during people's leisure activities in landscape architecture seriously affects people's quality of life, but it can be controlled to a certain extent through landscape greening, waterscape sculpture and other settings. Therefore, it is necessary to evaluate the noise in the landscape to measure the environmental state of the area.

Therefore, Li et al. (2019) design a kind of environmental noise assessment method based on multi-channel acoustic channel, the method through multi-channel acoustic channels to gather the noise of the environment information, and then the noise preamplifier and filter processing, on the basis of the noise information package sent to the control centre, to analyse and evaluate the noise information by the control centre. However, it is found in practical application that this method has the problem of low precision of noise monitoring in landscape architecture. In Song (2019) design a method based on graphics superimposed noise environment evaluation method, this method takes the noise affected zone features the graph is standard, on the basis of noise contour drawing, will be a single feature units divided into multiple small piece of ground objects, using the noise influence degree coefficient of each unit is affected by the noise of the characterisation, The influence of noise environment is evaluated by the comprehensive influence area of noise. However, in practical application, it is found that this method takes a long time to evaluate the noise environment. In Zeng and Hu (2020), a traffic noise environmental impact prediction method is designed for the virtual community. This method establishes a unified data source on the basis of collecting relevant traffic, terrain and environment data, and provides a unified data processing platform for environmental noise assessment. Then, the 3d virtual scene was constructed based on virtual reality technology, and the environmental noise in the virtual scene was obtained by noise map technology, and then the impact of the experimental noise was evaluated. However, it is found in practical application that the accuracy of noise environment assessment is low.

Aiming at the problems of low accuracy of landscape noise monitoring, long time-consuming process of noise environment assessment and low accuracy of noise environment assessment in traditional assessment methods, a new method of landscape noise environment assessment based on life cycle assessment (LCA) is designed, and the corresponding noise environment optimisation measures are put forward. LCA is a standardised assessment method for the whole process, which is widely used in the field of pollution assessment. In this paper, the LCA method will be used to screen the relevant landscape noise environmental assessment indicators. The general idea of this paper is as follows:

1 extract the audio features of the landscape environment, identify and process the landscape noise, and filter the noise signal component

2 the LCA method is used to screen the noise environment assessment indicators in the three main stages of landscape design, cluster the grey interval of the assessment indicators, and obtain the landscape noise assessment results

3 comparative experiments are used to verify the performance of this design method with high noise monitoring accuracy, short evaluation time and high evaluation accuracy

4 the countermeasures to solve garden noise pollution are put forward: strengthen the construction of garden noise pollution prevention and control system, strengthen the construction of garden functional areas, strengthen garden noise monitoring, and strengthen the publicity and technical level of noise pollution prevention and control.

2 Landscape architecture noise environment assessment method based on LCA

2.1 Noise identification of landscape architecture

The noise identification process is mainly divided into the following two stages:

1 Extracting audio features of landscape architecture environment. This study uses sensor technology to collect audio information of landscape architecture. Due to the problem of spectrum leakage in the actual collection process, Hannning self-convolution window was used to replace Hannning window and Mel filter to obtain the characteristic value of HSCW-MFCC as the audio information of landscape architecture.

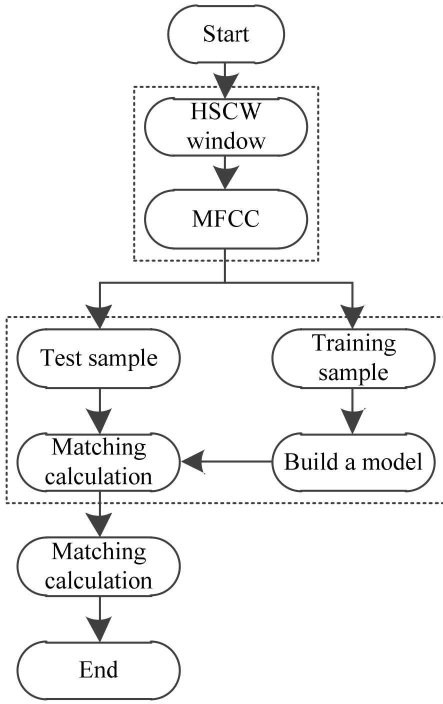
2 Noise recognition. In general, when audio perception is higher than 1,000 Hz, audio information presents nonlinear characteristics (Wang et al., 2018; Guo et al., 2018). Therefore, in order to better identify the noise signal of landscape architecture, in the process of its processing, it is mainly described by Mel scale. The approximate relationship between the perceived frequency and the actual frequency of the noise signal is as follows:

$$f' = 260g\left(1 + \frac{f}{100}\right) \quad (1)$$

In formula (1), f' represents the perceived frequency of the audio signal, and f represents the actual frequency of the audio signal.

Mel cepstrum coefficient analysis method is mainly used to calculate spectrum characteristics through nonlinear division method (Liang, 2020). In the pre-processing stage of environmental audio signals, abnormal audio signals need to be intercepted through Hanning window. However, in the process of actual operation, there will be a serious spectrum leakage problem. After the signal is intercepted, the frequency will be leaked, resulting in obvious differences in the suppression effect of each window function on spectrum leakage. Therefore, it is necessary to select the window function that meets the conditions according to the actual situation of landscape architecture environment.

Figure 1 Flow chart of noise identification in landscape architecture



In this study, spectrum characteristics of HSCW window and Hanning window were compared respectively. The formula W of frequency domain of second-order HSCW window with data length d is as follows:

$$W = \frac{1}{2} c \times n^{-v(d-1)} \left(\omega - \frac{2}{d} \right)^2 \tag{2}$$

In formula (2), c represents the window frequency response curve of the audio signal in the landscape environment, n represents the amount of audio data, and v represents the attenuation rate of the sidelobe, ω represents the clustering weight of audio signal. The side lobe performance of two different window functions can be obtained through the above process (Liu et al., 2020). Among them, HSCW window has significantly better suppression effect on spectrum leakage than Hanning window, and has significantly higher accuracy of noise signal extraction. Therefore, the HSCW window function is used to complete the recognition and processing of landscape garden noise, and the specific process is as follows:

Step 1 Pre-weighting. Because the high frequency SNR of audio signal is low, the high frequency component and SNR of signal are increased by pre-weighting. The pre-weighting process H is as follows:

$$H = 1 - \varphi W h^{-1} \tag{3}$$

In formula (3), φ is between 0.95 and 0.98, and h represents the high-frequency component of the audio signal.

Step 2 Frame processing. The data point whose value is in the range of 100 to 300 ms is set to the frame length, and 1/10 of the frame length is selected as the frame shift.

Step 3 Windowing. HSCW windowing is implemented for different frame data (Zhang et al., 2019).

Step 4 Perform fast Fourier transform processing on the audio signal x_i processed above, thus, the audio spectrum FT is obtained, and the signal form is also converted from time domain to frequency domain. The corresponding process is as follows:

$$P(X) = FT\left(\frac{x_i}{n}\right) \tag{4}$$

In formula (4), $P(X)$ represents the frequency domain information of audio signals in landscape architecture environment.

Step 5 Calculate the energy spectrum, the process is as follows:

$$E = FT\left(P(X) \times \frac{x_i}{H}\right) \tag{5}$$

In formula (5), E represents the energy spectrum of audio signal in landscape architecture environment.

Step 6 Filter out the noise signal components through Mel filtering, and the process is as follows:

$$x_N = \frac{2(I - E_N)}{E_N - (E_{N-1})} \tag{6}$$

In formula (6), I represents the number of filters, E_N represents the spectral energy of noise signal, and its calculation process is as follows:

$$E_N = \frac{x_N \times L}{p} \times \left(d \times \frac{f_{\max} - f_{\min}}{d+1}\right) \tag{7}$$

In formula (7), $f_{\min}$ and $f_{\max}$ represent the lowest sampling frequency and the highest sampling frequency of the filter respectively, L represents the window width in the process of discrete Fourier transform, and p represents the sampling rate.

Through the above calculation, the spectral energy of noise signal is obtained, which realises the effective identification of landscape noise information, and lays a good foundation for landscape noise evaluation below.

2.2 Application of LCA method

LCA is a whole-process standardised assessment method, which is widely used in the field of pollution assessment (Gao et al., 2019). In this study, noise in landscape architecture was considered as a kind of noise pollution. Therefore, LCA method could be used to screen relevant environmental assessment indicators for noise in landscape architecture.

First of all, the life cycle of landscape architecture is simplified into the following major stages:

1. Design stage. This stage mainly considers the functional layout of land use and traffic planning and design, including the density of landscape architecture, the rationality of building function zoning and passenger/vehicle flow.
2. Construction phase. This stage mainly considers the layout design of garden plants.
3. Operation phase. In this stage, the relationship between entertainment activities and noise environment is mainly considered, including the noise of audio and video equipment that may be transmitted and the construction noise of stage/landscape facilities (Zeng and Hu, 2020).

Therefore, this study screened the following evaluation indicators based on LCA method, as shown in Table 1.

Table 1 Evaluation index system of noise environment in landscape architecture

Level indicators	Secondary indicators
Traffic noise factor E_1	Traffic noise
	Vehicle noise
Garden plant factor E_2	Reasonable plant configuration
	Plant sound absorption
	Green barrier
Recreational factors E_3	Noise of audio and video equipment
	Stage/landscape construction noise
Factors of functional layout of land E_4	Landscape architecture intensive
	The rationality of building function zoning

On this basis, the above four items and indicators are represented as LCA indicators, and the sum of life of noise environment assessment of landscape architecture is obtained as follows:

$$LAC(E) = E_1 + E_2 + E_3 + E_4 \tag{8}$$

On this basis, according to the numerical situation of (LAC(E)), combined with the specific secondary index division, the landscape noise environment assessment index system is constructed to realise the application of Lac method.

2.3 Assessment of noise environment in landscape architecture

Based on the above designed index system and the monitoring results of noise signal of landscape architecture, the noise environment of landscape architecture is evaluated in the following process:

1 Traffic noise factor E_1. This index is mainly reflected by passenger flow noise e_{11} and vehicle noise e_{12}, and its calculation process is as follows:

$$E_1 = \alpha\left(e_{11} + e_{12}\right) \tag{9}$$

In formula (9), α represents the weight value of traffic noise factors.

2 Garden plant factor E2. The index includes the rationality of plant allocation e_{21} Plant sound absorption e_{22}. Greening barrier function e_{23}. The calculation process of three secondary indicators is as follows:

$$E_2 = \beta\left(e_{21} + e_{22} + e_{23}\right) \tag{10}$$

In formula (10), β represents the weight value of garden plant factor index.

3 Factors of recreational activities E_3. This index includes two secondary indicators, noise e_{31} of audio-visual equipment and noise e^{32} of stage/landscape construction. The calculation process is as follows:

$$E_3 = \mu\left(e_{31} + e_3\right) \tag{11}$$

In formula (11), Cheng, γ represents the weight value of recreational activity factor index.

4 Factor of functional layout of land E_4. This index includes two secondary indexes, landscape building density e_{41} and rationality of building function zoning e_{42}. The calculation process is as follows:

$$E_4 = \chi\left(e_{41} + e_{42}\right) \tag{12}$$

In formula (12), χ represents the weight value of land functional layout factor index.

In order to avoid affecting the reliability of the evaluation results due to the differences between different index data, cluster the above indexes (Ma et al., 2019; Cheng, 2018) and the process is as follows:

Step 1 Assume that the clustering weight of the second level index a is ω_a, and its evolution law function is $f(a) = 0.04$.

Step 2 If the sample information corresponding to the second level indicator a is x_a, calculate its interval clustering coefficient, and the process is as follows:

$$\Psi_a^n = \left(\sum\nolimits_{a=1}^{n} f(a) \times x_3\right) \tag{13}$$

Step 3 Classify sample information x_a by using the interval clustering coefficient, so as To complete the clustering operation of evaluation indicators.

On this basis, the interval clustering of indicators was comprehensively analysed, and then combined with the four first-level indicators and 9 second-level indicators designed above, the noise environment assessment process of landscape architecture was constructed as follows:

$$G = \left(\sum_{a}^{n} \Psi_{a}^{n} LACE \right) \times \omega a \tag{14}$$

Through the above calculation, the calculation method of landscape noise environment assessment is obtained to realise the assessment of landscape noise environment.

3 Experiment and result analysis

In order to verify the practical application performance of the above LCA-based noise environment assessment and optimisation method for landscape architecture, the following experimental test process is designed.

3.1 Experimental setup

This experiment is carried out in MATLAB 10B simulation platform. A landscape garden in the east of the city is selected as the experimental object, and the environmental noise information detection data of the landscape garden for a total of 30 days in June 2019 are selected as the experimental data. In this data, the sampling times of environmental noise information is 10 times a day, a total of 300 environmental noise information data, and the interference signal-to-noise ratio is 10 db–15 db. In order to avoid too single experimental results, the environmental noise assessment method based on multi-channel sound channel in Li et al. (2019) and the noise environment assessment method based on graph superposition method in Song (2019) are compared to complete the performance verification with this method.

3.2 Experiment indicators

In this experiment, three indicators of noise monitoring accuracy, noise environment assessment time and noise environment assessment accuracy of landscape architecture were compared. Among them, the precision of noise monitoring in landscape architecture can reflect the reliability of different assessment methods from the side. The higher the precision of noise monitoring in landscape architecture, the higher the reliability of assessment methods. The time-consuming process of noise environment assessment can reflect the real-time performance of different assessment methods. The less time-consuming process of noise environment assessment, the higher the real-time performance of assessment methods. The accuracy of noise environment assessment can reflect the effectiveness of different assessment methods. The higher the accuracy of different assessment methods is, the higher the effectiveness of assessment methods is.

3.3 Results and analysis

Taking the accuracy of landscape noise monitoring as the index, the reliability of different evaluation methods is verified. Among the 300 environmental noise information data, 10~50 data are randomly selected for testing. Under different experimental conditions of 10 data, 20 data, 30 data, 40 data and 50 data, the statistical results of landscape noise monitoring accuracy of different methods are tested, as shown in Table 2.

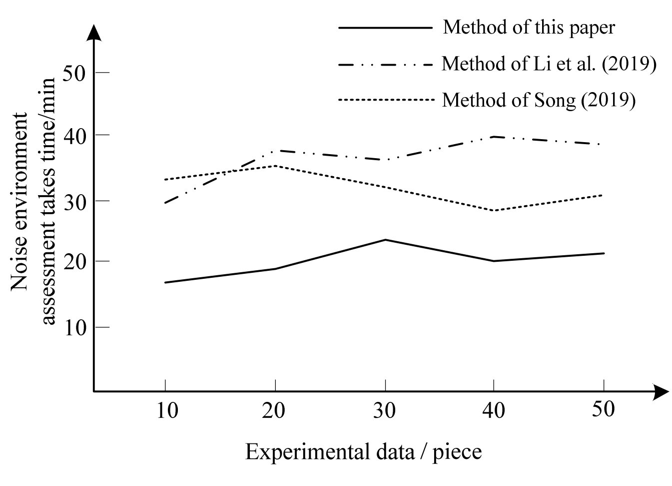
Table 2 Comparison of precision of noise monitoring in landscape architecture with different methods (%)

Experimental data/piece	*Method of this paper*	*Method of Reference Li et al. (2019)*	*Method of Reference Song (2019)*
10	96.1	81.6	81.8
20	96.4	88.8	86.5
30	92.8	90.0	87.2
40	93.1	86.7	88.8
50	95.1	84.3	84.9

According to the results shown in Table 2, when the experimental data are 10, the accuracy of landscape noise monitoring of this method is 96.1%, the accuracy of landscape noise monitoring of Li et al. (2019) method is 81.6%, and the accuracy of landscape noise monitoring of Song (2019) method is 81.8%; When the experimental data are 30, the accuracy of landscape noise monitoring of this method is 92.8%, the accuracy of landscape noise monitoring of Li et al. (2019) method is 90.0%, and the accuracy of landscape noise monitoring of Song (2019) method is 87.2%; When the experimental data are 50, the accuracy of landscape noise monitoring of this method is 95.1%, the accuracy of landscape noise monitoring of Li et al. (2019) method is 84.3%, and the accuracy of landscape noise monitoring of Song (2019) method is 84.9%.

During the experiment, the accuracy of landscape noise monitoring of this method is always maintained at more than 92.8%, up to 96.4%, which is always higher than the other two methods, indicating that the noise monitoring accuracy of this method is higher than the two traditional methods.

Figure 2 Comparison of time consuming process of noise environment assessment by different methods



On this basis, taking the time-consuming of noise environmental assessment process as the index, 10~50 data are randomly selected from 300 environmental noise information data to test to verify the timeliness of different assessment methods. The time-consuming statistical results of noise environment assessment process of different methods are shown in Figure 2.

On this basis, taking the time-consuming of noise environmental assessment process as the index, 10~50 data are randomly selected from 300 environmental noise information data to test to verify the timeliness of different assessment methods. The time-consuming statistical results of noise environment assessment process of different methods are shown in Figure 2.

It can be seen from the results shown Li et al. (2019) that when the experimental data are 10, the noise environment assessment process of this method takes 17.6 min, the noise environment assessment process of Li et al. (2019) method takes 29.8 min, and the noise environment assessment process of (2019) method takes 33.1 min; When the experimental data are 30, the noise environment assessment process of this method takes 23.8 min, the noise environment assessment process of Li et al. (2019) method takes 36.9 min, and the noise environment assessment process of method takes 32.5 min; When there are 50 experimental data, the noise environment assessment process of this method takes 20.5 min, the noise environment assessment process of Song et al. method takes 39.1 min, and the noise environment assessment process of reference (Song, 2019) method takes 31.7 min.

In the whole experimental process, the noise environment assessment process of this method takes at least 17.6 min and at most 23.8 min, which is always kept below 24 min, which is much lower than that of the other two methods. It shows that the assessment time of this method is shorter than that of the two traditional methods.

Taking the accuracy of noise environment assessment as the index, the effectiveness of different methods is verified. Among the 300 environmental noise information data, 10~50 data are randomly selected for test. The statistical results of noise environment assessment accuracy of different methods are shown in Table 3.

Table 3 Comparison of accuracy of noise environment assessment by different methods (%)

Experimental data/piece	*Method of this paper*	*Method of Li et al. (2019)*	*Method of Song (2019)*
10	96.4	88.2	85.3
20	96.9	87.1	87.0
30	94.1	87.6	86.8
40	94.3	88.2	87.9
50	95.5	86.3	86.2

It can be seen from the results shown in Table 3 that when the experimental data are 10, the noise environment assessment accuracy of the method in this paper is 96.4%, the noise environment assessment accuracy of the method in Li et al. (2019) is 88.2%, and the noise environment assessment accuracy of the method in Song (2019) is 85.3%; When the experimental data are 30, the noise environment assessment accuracy of this method is 94.1%, the noise environment assessment accuracy of Li et al. (2019) method is 87.6%, and the noise environment assessment accuracy of Song (2019) method is 86.8%; When there are 50 experimental data, the noise environment assessment accuracy of this method is 95.5%, that of Li et al. (2019) method is 86.3%, and that of method is 86.2%.

In the experimental process, the noise environment assessment accuracy of this method can reach 96.9% at most and 94.1% at least. The assessment accuracy is always maintained at more than 94%, which is completely higher than the other two traditional methods, indicating that the assessment accuracy of this method is higher than the two traditional methods.

Through the above experiments, it can be concluded that the landscape noise environment assessment method based on LCA designed in this paper can monitor the landscape noise with a maximum accuracy of 96.4%, the noise environment assessment process takes at least 17.6min, and the maximum assessment accuracy can reach 96.9%, indicating that this method has high noise monitoring accuracy, short assessment time The evaluation has high accuracy and good practical performance.

4 Measures to solve the environmental noise of landscape architecture

In recent years, Chinese Governments at all levels have carried out a lot of work in strengthening noise environmental management. In order to strengthen the effect of noise environmental control of landscape architecture, the following solutions are put forward, which will help to improve the noise management of landscape architecture.

1 Strengthen the construction of noise pollution prevention and control system in landscape gardens. The difficulty of noise environmental control lies in the insufficient legal and policy basis of environmental law enforcement. Due to the lack of law and policy, environmental law enforcement is faced with many difficulties. Therefore, according to the actual situation of landscape architecture, relevant departments should timely introduce specific management methods for environmental noise, public facility noise and other aspects, and strengthen policy publicity.

2 Strengthen the construction of landscape functional areas. Strengthening the construction of landscape functional areas is an effective way to alleviate environmental noise pollution. According to the requirements of different activities, to select or create appropriate environmental conditions can be roughly divided into dynamic area and quiet area. Separated by trees, shrubs and flowers. Therefore, relevant departments should promote the adjustment of the structure of landscape functional areas and minimise the impact of noise through functional area planning.

3 To strengthen the noise monitoring of landscape architecture. In the future, relevant garden management departments should continue to increase the scale of noise monitoring network under the policy guidance and requirements, improve the quality of noise monitoring, improve and expand the scope and frequency of noise pollution monitoring, and effectively discover and regulate noise pollution sources.

4 To strengthen the publicity and technical level of noise pollution prevention and control. Relevant garden management departments should publicise the harm of noise pollution to the public through various channels and ways, fundamentally improve the quality of noise pollution prevention and control, and guide the public to take the initiative to comply with China’s noise pollution prevention and control laws and regulations. In addition, scientific research on noise pollution prevention and control should be strengthened, new noise monitoring devices should be

developed, and the timeliness and technology of noise pollution prevention and control in landscape gardens should be continuously improved.

5 Conclusions

In order to solve the problems of poor reliability, real-time and low effectiveness of traditional assessment methods, a landscape noise environment assessment method based on LCA is designed in this paper. In this method, the noise of landscape architecture was identified on the basis of extracting the audio characteristics of landscape architecture environment, and then the noise signal components were screened by Mel filtering. Then LCA method was used to simplify the life cycle of landscape architecture into three main stages: design, construction and operation. Based on this, specific evaluation indicators were screened out and the final evaluation results were obtained on the basis of grey interval clustering of evaluation indicators.

According to the experiment, the highest accuracy of the method for noise monitoring of landscape architecture can reach 96.4%, the minimum time of noise environment assessment is 17.6 min, and the maximum assessment accuracy can reach 96.9%, indicating that method of this paper has the advantages of strong reliability, high real-time performance and high effectiveness.

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