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Research on Feature Extraction and Perception Model Construction of Urban Forest Landscape Based on Multi-scale Wavelet Transform

Honghao He[1,*]
[1] School of Fine Arts, School of Design, Zhaoqing University, Zhaoqing, Guangdong, 526061, China
Corresponding authors: (e-mail: hechen20241001@163.com).

Abstract Based on the Empirical Wavelet Transform (EWT) method, this paper explores the mathematical derivation process of signal modes at different scales. The multi-scale wavelet transform method is proposed and used as the feature extraction method for urban forest landscapes. Then, three theoretical contents related to line spectrum extraction, namely line spectrum frequency band estimation, time-frequency analysis and spectrum refinement, are expounded. With the technical support of the above methods, the collection and extraction of sound sources in urban forest parks are carried out. For the sorted sound source data set, time-domain and frequency-domain analyses and wavelet noise reduction are carried out. Subsequently, taking Guangzhou Baiyun Mountain Forest Park as the research object, the perception frequency, perception intensity and sound energy distribution of urban forest parks were analyzed to construct a natural sound perception model. The results show that among the 9 frequently extracted features, the water source landscape received the most subjective favorability evaluation from tourists and received a score of more than 0.9 in multiple scenic spots. Research indicates that in the process of urban landscape design, more attention should be paid to the maintenance of natural landscapes to assist in the development and construction of its tourism industry.

Index Terms line spectral features, multi-scale wavelet transform, natural sound perception model, Forest Park

I. Introduction

With the continuous intensification of urbanization, people's mental stress is also constantly rising, and their desire for the natural environment is becoming increasingly strong. Most of the conventional parks in cities do not have forest landscapes as a support, so their authenticity and natural wildness are relatively low, and they cannot meet people's needs to get close to nature and wild animals and plants. Meanwhile, the low-level development of forest parks cannot fully exert the special value of forest parks. Therefore, the diversified functional urban forest plant landscape has become an important part to relieve people's mental stress . Different from the conventional urban. City park Urban forest park, as a transition from natural forest to artificial green space, is a multi-functional complex type of green space that integrates ecology, recreation, landscape, and production [1]. Therefore, the quality of the landscape in a city forest park directly affects people's visiting experience.

Meanwhile, urban forest parks, as an important component of urban green infrastructure, their significant ecological benefits directly affect the sustainable development of the city. The landscape features of forests have become an important place for people to get close to nature and relieve physical and mental stress. Therefore, the quality of its landscape directly affects the landscape style of the city and people's living standards [2]. Exploring the influencing factors of the plant landscape quality in urban forest parks has important theoretical significance and practical value for improving the landscape quality of urban forest parks.

Natural acoustic landscape is the natural acoustic environment of a place perceived by people, which is characterized by the results of the behavior and interaction of natural factors [3], [4]. Natural sound is the sound formed by various natural geographic factors, which can bring pleasant physical and mental feelings to visitors [5]. The natural sound of Baiyun mountain city forest park is mainly composed of wind, water, birdsong, insects, etc. The types of sound sources are more diverse, which to a large extent brings visitors closer to nature and creates a park space rich in natural interest [6]-[8]. The traditional methods of park landscape feature extraction mostly rely on manual measurements and the analysis of two-dimensional plans, and these methods have limitations such as low efficiency, limited accuracy, and difficulty in adapting to complex terrain [9]-[12]. The combination of multi-scale wavelet transform and acoustic parameter spectrum analysis can quickly obtain the spatial features of the natural acoustic landscape in Baiyun mountain city forest park.

In this paper, we first describe in detail the rich arithmetic of empirical wavelet transform and extend its decomposition of different modes of sound source signals to form a multi-scale wavelet transform method. At the same time, it discusses the basic principle of line spectrum feature extraction in acoustic features as the analysis method of acoustic parameter spectrum. Secondly, the natural acoustic landscape feature extraction method is applied to collect and record a variety of sound sources in Baiyun mountain city forest park, and carry out the time domain and frequency domain analysis of sound sources as well as wavelet noise reduction. Then, we analyze the perceived frequency and perceived intensity of sound sources with high frequency, analyze the distribution of sound energy, and establish a perception model. Finally, a questionnaire survey was conducted to evaluate the favorability of tourists to the sound source landscape in Baiyun mountain city forest park.

II. Natural soundscape feature extraction method

II. A. Empirical wavelet transform

The empirical wavelet transform (EWT) inherits the advantages of EMD and wavelet transform, and it separates the different modes of the signal by adaptively dividing the signal Fourier spectrum and constructing filters on each segmented interval to form a filter bank. Different modes have different scales of the spectrum, so the most important part of the EWT is the division of the Fourier spectrum, i.e., the division of the filter boundary to obtain the upper and lower boundary values of the filter, and the division of the spectrum has a direct impact on the analysis of the signal. Secondly, based on the results obtained from the spectrum division, the filter bank is constructed. The empirical wavelet transform does not use a cyclic approach, but a one-time decomposition of the signal contains the inherent modes, so the calculation speed is faster. It completes the multi-scale wavelet transform of the signal by decomposing and calculating the modes at different scales.

The EWT accurately extracts the intrinsic modes of the signal by adaptively segmenting the Fourier spectrum of the original signal, constructing orthogonal wavelet filters in each segmented interval, and obtaining the amplitude-frequency modulation component of the Fourier spectrum with tight support.

Assuming that the time-domain discrete signal is f, and the Fourier transform is performed on this signal, the EWT takes the minimum between successive great maxima of the Fourier spectrum of the signal as the boundary of the filter, and notates the acquired boundary value as ω_n, n being an integer, $n \in [0, N]$. Assuming that the signal consists of N number of modes, the Fourier spectral range $[0, \pi]$ can be divided into N number of contiguous segments, and the number of boundaries to be determined is $N-1$. These boundaries then form N number of narrowband bandpass filters, each with an upper boundary of ω_n and a lower boundary of ω_{n+1}, where $\omega_0 = 0$ and $\omega_N = \pi$. Each segmented segment is noted as $\wedge_n = [\omega_n, \omega_{n+1}]$. So, $\cup_{n=0}^{N} \wedge_n = [0, \pi]$.

After obtaining the filter boundary ω_n, the empirical scale function and empirical wavelet function of the functional form of the filter are constructed on the region $2\tau_n$ centered at ω_n. The boundary delineation of the Fourier spectrum and the constructed empirical wavelet filter bank are shown in Fig. 1, which can be computed to obtain a low-pass filter $\hat{\phi}_1(\omega)$ and an $N-1$ band-pass filter $\hat{\psi}_n(\omega)$.

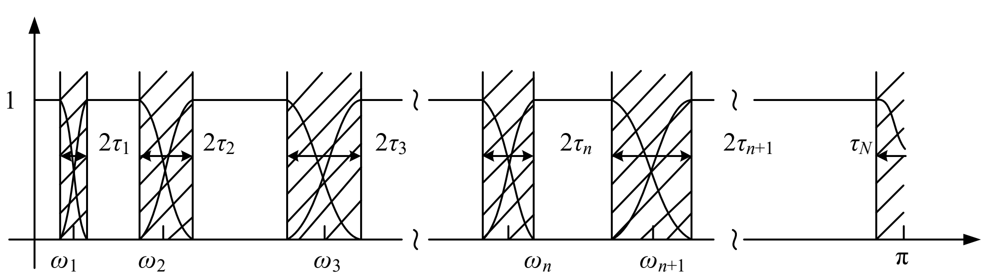

Figure 1: Boundaries division of Fourier spectrum and filter banks

For $\forall n > 0$, the empirical scale functions and empirical wavelet functions constructed by Gilles are specifically represented as in Eqs. (1) and (2):

$$\hat{\phi}_n(\omega) = \begin{cases} 1 & if\ |\omega| \le \omega_n - \tau_n \\ \cos\left[\frac{\pi}{2}\beta\left(\frac{1}{2\tau_n}(|\omega| - \omega_n + \tau_n)\right)\right] & if\ \omega_n - \tau_n \le |\omega| \le \omega_n + \tau_n \\ 0 & otherwise \end{cases} \quad (1)$$

$$\hat{\psi}_n(\omega)=\begin{cases}1 & if\,\omega_n+\tau_n\le|\omega|\le\omega_{n+1}-\tau_{n+1}\\ \cos\left[\frac{\pi}{2}\beta(\frac{1}{2\tau_{n+1}}(|\omega|-\omega_{n+1}+\tau_{n+1}))\right] & if\,\omega_{n+1}-\tau_{n+1}\le|\omega|\le\omega_{n+1}+\tau_{n+1}\\ \sin\left[\frac{\pi}{2}\beta(\frac{1}{2\tau_n}(|\omega|-\omega_n+\tau_n)\right] & if\,\omega_n-\tau_n\le|\omega|\le\omega_n+\tau_n\\ 0 & otherwise\end{cases} \quad (2)$$

where $\tau_n=\gamma\omega_n$ and the function $\beta(x)$ is an arbitrary $C^k\left[(0,1)\right]$ function with equation (3):

$$\beta(x)=x^4\left(35-84x+70x^2-20x^3\right) \quad (3)$$

When $\gamma<\min_n\left(\frac{\omega_{n+1}-\omega_n}{\omega_{n+1}+\omega_n}\right)$, $\left\{\phi_n(t),\{\psi_n(t)\}_{n=1}^N\right\}$ constitutes a tightly supported frame on $L^2(R)$ space.

The approximation coefficients of the signal can be obtained from the inner product of the signal and the empirical scale function as in equation (4):

$$\begin{aligned}W_f^\varepsilon(0,t)&=\langle f,\phi_1\rangle\\&=\int(f(\tau)\overline{\phi_1(\tau-t)}d\tau)=(\hat{f}(\omega)\hat{\phi}_1(\omega))^\vee\end{aligned} \quad (4)$$

The detail coefficients of the signal can be obtained from the inner product of the signal and the empirical wavelet function in equation (5):

$$\begin{aligned}W_f^\varepsilon(n,t)&=\langle f,\psi_n\rangle\\&=\int(f(\tau)\overline{\psi_n(\tau-t)}d\tau)=(\hat{f}(\omega)\hat{\psi}_n(\omega))^\vee\end{aligned} \quad (5)$$

where the $\hat{\phi}_1(\omega)$ and $\hat{\psi}_n(\omega)$ functions are the Fourier transforms of $\phi_1(t)$ and $\psi_n(t)$, respectively.
For this reason, the reconstructed signal can be calculated from Eq. (4) and Eq. (5) as in Eq. (6):

$$\begin{aligned}f(t)&=W_f^\varepsilon(0,t)*\phi_1(t)+\sum_{n=1}^N W_f^\varepsilon(n,t)*\psi_n(t)\\&=(W_f^\varepsilon(0,\omega)\hat{\phi}_1(\omega)+\sum_{n=1}^N W_f^\varepsilon(n,\omega)*\hat{\psi}_n(\omega))^\vee\end{aligned} \quad (6)$$

where * denotes the convolution and $\hat{W}_f^\varepsilon(0,\omega)$ and $\sum_{n=1}^N\hat{W}_f^\varepsilon(n,\omega)$ are the Fourier transforms of $W_f^\varepsilon(0,t)$ and $\sum_{n=1}^N W_f^\varepsilon(n,t)$, respectively.

The signal f is decomposed to obtain the empirical modes f_k as in Eqs. (7)-(8):

$$f_0(t)=W_f^\varepsilon(0,t)*\phi_1(t) \quad (7)$$

$$f_k(t)=W_f^\varepsilon(n,t)*\psi_n(t) \quad (8)$$

II. B.Basic Principles of Line Spectrum Extraction

II. B. 1) Line Spectrum Band Estimation

The underwater target radiated noise spectrum is composed of continuous and line spectra, and the line spectrum features that need to be extracted are generally characterized by an energy 10-20 dB higher than the nearby continuous spectrum. Therefore, the method of energy criterion can be used to determine the possible range of the line spectrum. The energy threshold threshold is first set to obtain a range of frequency values where all line spectra may exist. Then, the line spectrum values generally exist at the extreme values, so using this feature, a portion of the frequency values are eliminated, and the remaining frequency values are sorted according to the numerical magnitude, and each frequency value is regarded as the center frequency of the line spectrum, and according to the Doppler shift formula, such as Equation (9), the corresponding frequency range of each frequency is calculated:

$$f = f_{mid} + f_{mid}\frac{v\cos\theta}{c} \quad (9)$$

where f is the theoretical instantaneous frequency of the line spectrum subject to the Doppler effect. f_{mid} is the center frequency of the line spectrum. v is the real speed of the target at the current moment. θ is the direction of the target motion speed and the angle between the sonar and the target line. c is the underwater speed of sound. Finally, the resulting frequency range, there is an intersection of the part of the merger into a frequency band, so as to obtain all the possible existence of the line spectrum of the frequency band, in order to avoid excessive merger, the use of the formula (9) to calculate the maximum frequency deviation that may be generated in the band, so as to judge whether there is an intersection of the merger but the merger of the resulting frequency range of the two bands are larger merged.

Assuming that the upper frequency limit of the obtained frequency band is $f_{\max}$ and the lower frequency limit is $f_{\min}$, the line spectrum will have a certain broadening in the frequency domain rather than a fixed frequency value due to the influence of the Doppler shift. In order to encompass all possible frequency bands of the line spectrum as much as possible, and prevent the real line spectrum from appearing at the border of the obtained frequency band, according to equation (9), the center frequency of the line spectrum is first taken as $f_{\min}$ and $\cos\theta$ as -1 to widen the lower boundary of the frequency band, and then the center frequency of the line spectrum is taken as $f_{\max}$ and $\cos\theta$ as 1 to widen the upper boundary of the frequency band, so that the frequency values of the bands where the line spectrum might be found can meet the requirements of equation (10):

$$f_{\min} - f_{\min}\frac{v}{c} \le f \le f_{\max} + f_{\max}\frac{v}{c} \quad (10)$$

In this way, a wider range of frequency bands is obtained, reducing the possibility of missing line spectra by labeling the band in which the line spectrum is located as Line Spectrum Location Band 1 to distinguish the bands in which the subsequently obtained line spectra are located.

II. B. 2) Time-frequency analysis

The methods for obtaining time-frequency maps include Short-Time Fourier Transform (STFT), Wavelet Transform, and Wigner-Ville distribution. Among them, the basic algorithm of STFT is Fourier transform, which is simple to calculate and has strong interpretability of physical meaning, so this method is used to obtain the LOFAR map of the signal. It is defined as equation (11):

$$STFT_s(t,\omega) = \int s(\tau)g^*(\tau - t)e^{-j\omega\tau}d\tau = \langle s(\tau), g^*(\tau - t)e^{j\omega\tau}\rangle \quad (11)$$

where $g(\tau)$ is the window function and $s(\tau)$ is the signal.

In fact, the STFT uses the window function $g(\tau)$ to intercept the signal $s(\tau)$, and by constantly moving t, that is, constantly moving the position of the center of the window function $g(\tau)$, and respectively, the Fourier transform of the intercepted signal, to obtain the Fourier transform of the signal at any t moment, the set of these Fourier transforms is $STFT_s(t,k)$, i.e., the desired time-frequency diagram.The discrete form of STFT is equation (12):

$$STFT_s(n,k) = \sum_{m=-\infty}^{\infty} s(m)g^*(m-n)e^{-j2k\pi m} \quad (12)$$

II. B. 3) Spectrum refinement

Affected by the time-frequency disallowance principle, as in equation (13):

$$\Delta t\Delta f \ge \frac{1}{4\pi} \quad (13)$$

where Δt is the time resolution, which is actually the window length L of the time window, and Δf is the frequency resolution, which is calculated as in equation (14):

$$\Delta f = f_s / nfft \quad (14)$$

where f_s is the sampling rate, $nfft$ is the number of data points for Fourier transform, and in STFT, it is the length of the signal obtained after the original signal is truncated. Obviously, the time resolution and frequency resolution of STFT cannot be optimized at the same time, and they are inversely related, i.e., the longer the window length is, the longer the intercepted signal is, the lower the time resolution is, the higher the frequency resolution is, and the shorter the window length is, the shorter the intercepted signal is, the higher the time resolution is, the lower the frequency resolution is.

In order to obtain the instantaneous frequency of the line spectral features, the time resolution of the STFT is set to 1s, i.e., the time window length of the intercepted signal is taken to be 1s, and at this time, the frequency resolution is exactly 1 Hz. However, the frequency offset can be introduced from Eq. (9) as in Eq. (15):

$$\Delta f = f - f_{mid} = f_{mid} \frac{v\cos\theta}{c} \tag{15}$$

where f_{mid} is below 1000Hz on most occasions, v is usually less than 20m/s, and c is usually around 1500m/s. In real waters, the more common scenario is that the target moves at a lower speed and radiates a lower frequency line spectrum, at this time, its frequency deviation is often less than 1 Hz. At this time, the STFT can not observe the frequency shift of the line spectrum feature, and thus needs a higher frequency resolution. Analyzing from the principle of STFT, higher frequency resolution can be obtained by reducing the sampling frequency and growing the time window, but the former will lead to a narrower frequency analysis range, and the latter requires larger memory and longer time. For this reason, the method of spectral refinement is chosen to obtain finer frequency resolution and to facilitate the extraction of line spectral instantaneous frequencies. Commonly used spectral refinement methods include Zoom-FFT and chirp-Z transform (CZT).

III. Natural Sound Feature Extraction and Perception in City Forest park

III. A. Measurement point selection and sound level measurement

Combined with the main tour routes, distribution of attractions and different landscape types in Baiyun mountain city forest park, 85 sound level measurement points were selected for this measurement, with an average spacing of about 1,000m, more evenly distributed in the park.

The measurement time is from 8:00 a.m. to 12:00 p.m. on May 20~25, 2022 (outdoor temperature of 12℃~20℃), June 20~25 (outdoor temperature of 26℃~34℃), September 20~25 (outdoor temperature of 9℃~21℃), and December 20~25 (outdoor temperature of 0℃~5℃), and the average of the three days' measurements is taken as the measurement result. To avoid excessive fluctuations in the number of visitors, the measurements were taken on weekdays with clear weather and light winds.

AWA5688, a class 2 sound level meter, was used for sound level measurement and GPS positioning measurement at each measurement point, and a sound calibrator was used for calibration before measurement. During the measurement, the probe of the sound level meter was 1.2m from the ground, and each measurement point was continuously measured for 3min, and the data were recorded every 1min, and the data included the equivalent continuous A sound level LAeq, the minimum sound level Lmin and the maximum sound level Lmax unit dB, which can reflect the average sound environment level in the area.

III. B. Sound source recording and processing

Field recordings were synchronized with sound level measurements to record the type and clarity of sounds that could be heard at each measurement point (divided into 3 levels: very clear, not too clear, and not heard). Multi-scale wavelet changes were applied to the records for sound source feature extraction. There are 13 types of sounds in Baiyun mountain city forest park, which are categorized into natural, living and artificial sounds according to the sound source.

Natural sound is the sound formed by various natural geographic factors, which can bring pleasant physical and mental feelings to visitors. Baiyun mountain city forest park natural sound is mainly composed of wind, water, birdsong, insects, etc., the sound source type is more diverse, to a large extent, the distance between visitors and nature, creating a natural interesting park space. Life sound is the sound produced by people in the process of touring, different functional subdivisions, life sound source and sound level difference. The life sound in Baiyun mountain city forest park mainly consists of conversation, music, broadcasting, footsteps, children's playfulness, recreational activities, etc., which is the most energetic sound in the park. Artificial sound is the sound made by people using equipment. Baiyun mountain city forest park artificial sound mainly consists of cruise ship sound, mowing the lawn sound, urban road traffic noise, etc., part of the area sound level is higher or lasts a long time, easy to make the tourists feel bored and produce a sense of distance.

III. B. 1) Time and frequency domain analysis

The WAV files from the data acquisition were auditioned, edited, and analyzed to generate waveform and spectrograms. The sound frequency analysis is shown in Figure 2 and the amplitude analysis is shown in Figure 3.

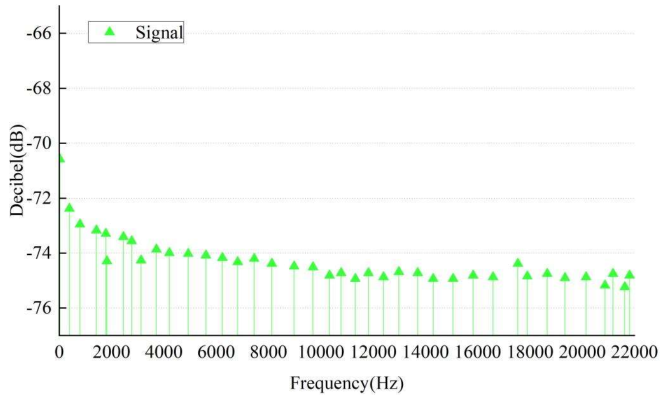

Figure 2: Sound frequency analysis

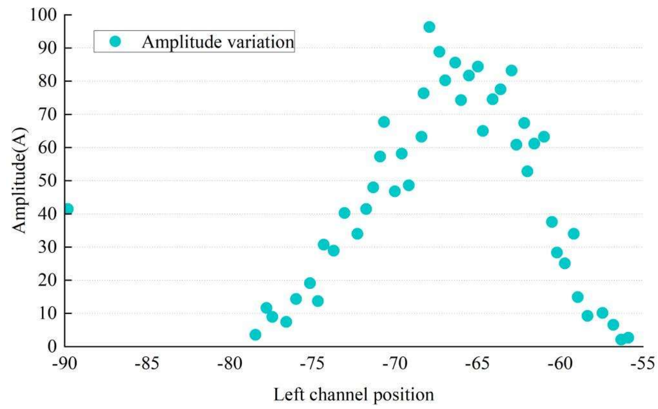

Figure 3: Left channel amplitude analysis

III. B. 2) Wavelet Noise Reduction

Wavelet noise reduction works by removing the noise from the signal. The noisy signal is first decomposed using multilevel wavelet decomposition. Then it has some detail coefficients as limits and finally, the approximation coefficients and altered detail coefficients are used to reconstruct the signal. After 6 levels of Hear wavelet processing the signal, non-smooth is still prominent. The results of wavelet noise reduction for WAV files are shown in Fig. 4.

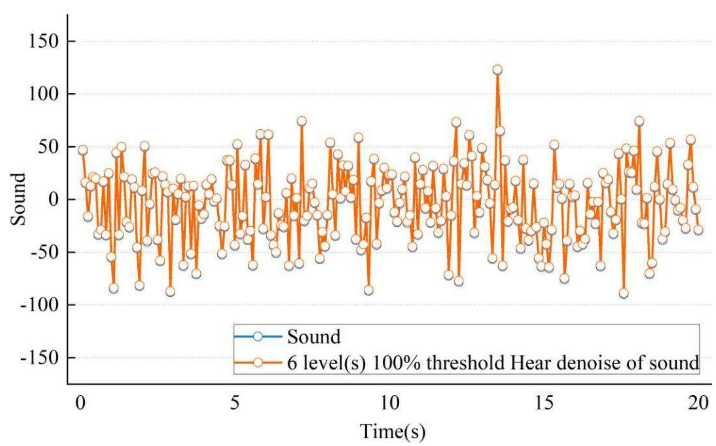

Figure 4: Wavelet noise reduction processing

III. C. Perceptual analysis and model construction

Based on the collection and analysis of natural sound characteristics in Baiyun mountain city forest park above, this section further analyzes the perceived frequency and perceived intensity of sound sources with higher frequency of occurrence, and at the same time analyzes the sound energy distribution of natural sounds with higher preference by tourists. Combined with the above analysis results, the natural sound perception model of Baiyun mountain city forest park is constructed.

III. C. 1) Perceived frequency

Based on the natural sound data collected and analyzed above, the sound sources with higher frequency of occurrence were selected as (S1) traffic sound, (S2) human speech, (S3) construction sound, (S4) radio music sound, (S5) opera sound, (S6) water sound, (S7) wind sound, (S8) birdsong and (S9) cicadas. After calculating the perceivable probability P of each sound in Baiyun mountain city forest park, the statistics of the perceived frequencies of sound sources in the park of Baiyun mountain city forest park for the four seasons are shown in Figure 5.

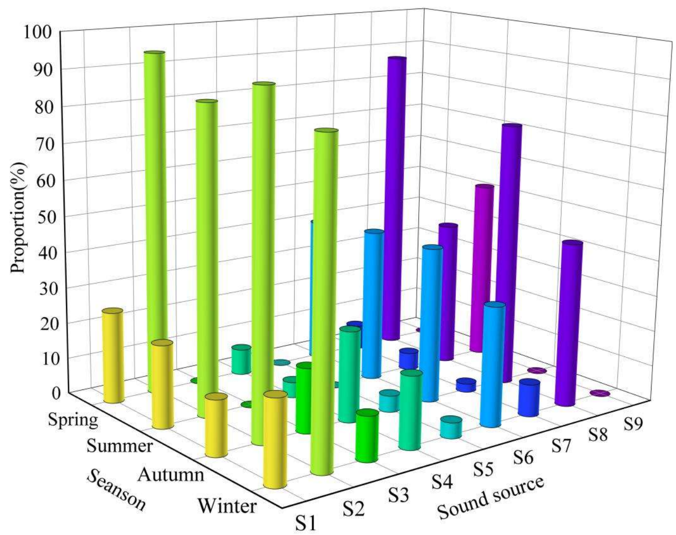

Figure 5: Sound perceived frequency

By analyzing the perception of sound sources in the park in four seasons, it was found that the highest frequency of perceived sound sources in Baiyun mountain city forest park was (S2) human voice in the spring as high as 94.7%, and the lowest was (S7) wind sound in the fall, which was perceived only once in the fall. Perceived sound sources included more human and mechanical sounds and fewer natural sounds.

Human sounds were more prevalent at all sites in the park and did not vary much from season to season. (S1) Traffic sounds were perceived at measurement points close to the entrance and were perceived least in the fall. (S3) Construction sounds were audible in the fall and winter, with no construction in the spring and summer. (S4) Radio music sound is more easily perceived in fall and winter, which shows that the ambient background sound is higher in spring and summer, which masks the radio sound.

Geographic sound perceptions were relatively stable among natural sounds, including (S6) water sounds due to the lower water level line in spring and winter, some rivers and creeks were depleted, and dynamic water features were reduced, including the least dynamic water features in winter. Wind sound was perceived in all four seasons, with the highest perception in winter and the lowest in fall. Perceptions of biological sounds, on the other hand, were more affected by season, e.g., (S9) Cicadas were only perceived in summer. (S8) Bird song was perceived significantly higher in spring and fall than in summer and winter. Few fifth sound sources were perceived.

III. C. 2) Intensity of perception

The perceptual order of the collected sound sources was quantified: very strong (-2), strong (-1), fair (0), weak (-1), weak (-2), resulting in the perceptual intensities of the sound sources shown in Fig. 6. After comparing the perceptual intensities of the sound sources in Baiyun mountain city forest park, it was found that the perceptual intensities of the water sounds were the highest in (S6) in fall, and the perceptual intensities of the traffic sounds were the lowest in (S1) in spring. The perceived intensity of human speech among the human voices was consistently high and slightly lower in the fall. (S1) traffic sounds had the highest perceived intensity in the fall and the lowest in the spring. The perceived intensity of radio music sounds was significantly higher in the fall and winter than in the spring and summer. (S5) Opera sounds had higher perceived intensity in winter than in fall. The perceived intensity of (S6) water sounds was generally higher in natural sounds, and was significantly higher in fall and winter than in spring and summer, again because the background sound was higher in spring and summer, and there was some masking effect on stream water sounds. (S7) Perceived intensity of wind sound was higher in summer and fall and lowest in spring. (S8) Birdsong had the highest perceived intensity in the spring and the lowest in the fall. (S9) Cicada sounds were perceived more strongly in summer.

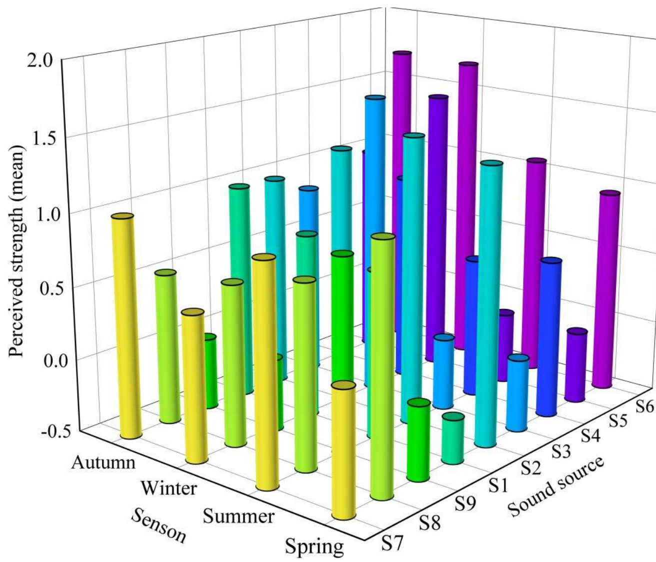

Figure 6: Perceived intensity of sound source

III. C. 3) Natural sounds

In addition to the classic natural sounds analyzed above, there are other natural sound landscape elements in Baiyun mountain city forest park, which are loved by tourists despite their low frequency. This subsection selects the top five natural sound landscape elements for analysis, and the selected natural sound landscape elements are: the sound of spring water, the sound of birds, the sound of cicadas, the sound of wind blowing bamboo leaves, and the sound of rain hitting bananas. Among them, the sound of cicadas mostly exists in the green space and can only be heard in summer, the sound of birdsong is common, the sound of wind blowing bamboo leaves is in the bamboo forest in the mountains, and the sound of rain hitting plantains exists in the park compound. The sounds were ranked according to visitor preference: the highest preference was for the sound of spring water, and the lowest was for the sound of cicadas.

Because the spring water sound has the highest preference, this paper records the spring water sound in different spots of Baiyun mountain city forest park, measures the sound pressure level, frequency spectrum and sound satisfaction data, and extracts the dynamic water feature data for summarization. Take the most characteristic dynamic water features to draw the spectrum in Figure 7, the selected attractions are: (A1) Yellow Stone Village, (A2) Wulongzhai, (A3) Camel's Peak, (A4) Five Fingers Peak and (A5) Tianmen Mountain.

It can be seen that the sound energy distribution is more uniform, 50-250Hz sound energy has decreased, the greater the sound pressure level of the water features, the closer the spectrum is to flat, tends to white noise.

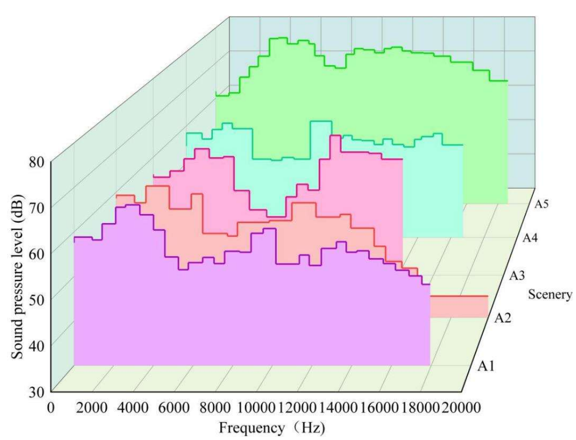

Figure 7: Dynamic waterscape spectrum

III. D. Subjective favorability evaluation results

On the basis of the above natural sound landscape feature extraction and perception analysis of Baiyun mountain city forest park, 20 landscape nodes in Baiyun mountain city forest park are selected for questionnaire survey in this section, 200 questionnaires are issued to ordinary tourists, 178 effective questionnaires are retrieved, and the questionnaire validity rate is 89%. The selected scenic spots are, in order: Hundred Dragon Stairs, Qiankun Pillar, Generals' Platform, Tianzi Pavilion, Star Picking Platform, Three Sisters Peak, Six Wonderful Pavilions, Five Fingers Peak, He Long's Tomb, Camel's Peak, Misty Sea Golden Turtle, Yellow Stone Cottage, Golden Whip Creek, Bewitching Terrace, Tianbofu, Wulongzhai, Conch Peak, the Grand Canyon, Huanglong Cave, and Tianmen Mountain. The questionnaire content is the subjective goodness evaluation of tourists on 9 subjective goodness evaluations of high frequency of occurrence of (S1) traffic sound, (S2) human voice, (S3) construction sound, (S4) radio music sound, (S5) opera sound, (S6) water sound, (S7) wind sound, (S8) birdsong and (S9) cicadas in 20 landscape nodes, and each item is full of 1 point (very dislike: 0-0.19 points, don't like: 0.2-0.39 points, average: 0.4-0.59 points, like: 0.6-0.79 points, very like: 0.8-1 points). Based on the results of the tourists' ratings of the sound sources in the attractions, the weights of the sound source types in the landscape nodes are summarized in Table 1.

Table 1: Park landscape node sound source type proportion

Node	S1	S2	S3	S4	S5	S6	S7	S8	S9
1	0.16	0.22	0.16	0.06	0.12	0.63	0.94	0.63	0.85
2	0.23	0.12	0.47	0.23	0.13	0.9	0.91	0.91	0.79
3	0.05	0.29	0.11	0.43	0.42	0.84	0.83	0.79	0.72
4	0.58	0.03	0.05	0.2	0.49	0.78	0.91	0.72	0.84
5	0.05	0.48	0.35	0.26	0.6	0.72	0.76	0.82	0.72
6	0.15	0.47	0.22	0.32	0.11	0.66	0.92	0.73	0.98
7	0.48	0.29	0.34	0.21	0.07	0.83	0.97	0.89	0.88
8	0.26	0.06	0.3	0.03	0.33	0.73	0.69	0.94	0.73
9	0.36	0.56	0.14	0.59	0.53	0.7	0.99	0.88	0.73
10	0.47	0.49	0.22	0.21	0.32	0.69	0.84	0.83	0.67
11	0.03	0.53	0.1	0.59	0.55	0.78	0.78	0.75	0.63
12	0.16	0.18	0.33	0.48	0.45	0.95	0.78	0.77	0.69
13	0.58	0.18	0.21	0.35	0.31	0.68	0.98	0.86	0.69
14	0.04	0.15	0.39	0.12	0.06	0.82	0.78	0.96	0.68
15	0.2	0.37	0.03	0.08	0.3	0.95	0.98	0.84	0.8
16	0.27	0.29	0.19	0.26	0.39	0.77	0.86	0.9	0.76
17	0.4	0.15	0.16	0.47	0.26	0.86	0.98	0.74	0.82
18	0.42	0.15	0.14	0.36	0.13	0.77	0.83	0.81	0.88
19	0.36	0.05	0.16	0.57	0.36	0.94	0.94	0.69	0.81
20	0.12	0.49	0.24	0.52	0.02	0.66	0.9	0.85	0.81

Observing Table 1, on the whole, sound sources of category (S1)-(S5) harvested lower scores in the evaluation of tourists' favorability, with the highest being only 0.6, which is the sound of the opera in the Stargazer's Terrace. On the other hand, the natural sound sources in categories (S6)-(S10) had higher scores overall, all at 0.6 and above, with (S6) water sound receiving the best performance in terms of scores, obtaining ratings of more than 0.9 within multiple attractions.

IV. Conclusion

In this paper, based on the empirical wavelet transform method, which is stable in signal decomposition, convenient in calculation and faster in speed, the different scale modes of the sound signal are decomposed, and the multi-scale wavelet transform method is extended. At the same time, it combines the basic principle of line spectrum extraction to realize the extraction of natural sound landscape features of Baiyun mountain city forest park. By applying the feature extraction method, collecting and forming the sound source data set of Baiyun mountain city forest park, analyzing the perceived frequency and perceived intensity of the sound source, and proposing the natural sound landscape perception model of Baiyun mountain city forest park. Combined with the natural sound landscape feature extraction method designed in this paper, the natural sound landscape feature extraction and perception model of Baiyun mountain city forest park.

In the evaluation of tourists' favorability of natural sound landscape in Baiyun mountain city forest park, the water sound obtains a large range of 0.9 evaluation score, and a variety of artificial sound sources have a lower rating of up to 0.6. It shows that the abundance and dimension of the natural sound species are of great significance for the development of the tourism industry in Baiyun mountain city forest park.

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