Research on Sorting Method of Marine Domestic Waste Based on BP Network

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Abstract. The feature extraction method of the acoustic wave of different objects in the marine domestic waste is elaborated in this paper, the intelligent recognition model and algorithm of the material based on neural network is established, and sorting tests on common objects such as glass and plastic are conducted, the effect of this sorting method is verified to provide a new idea for the intelligent sorting of marine domestic waste.

Keywords: Sorting method, domestic waste, BP network.

1. Introduction
There are clear requirements for the sorting management of domestic waste in ship regulations, but in the actual waste sorting management process, many problems are faced. Marine domestic waste mainly includes residual food, beverage bottles, packaging boxes and other waste. In the process of waste disposal, sorting is a complex task, the research on the intelligent identification and sorting of objects can help to solve these problems. In allusion to the corresponding characteristics of different objects, different methods are used for sorting, for example, food waste can be sorting from other objects by cutting and sieving; metal waste can be sorted by electromagnetic induction sensors. However, the sorting effect of related sensors when sorting glass and plastic waste is not very ideal. This paper combines the cepstrum acoustic wave feature analysis and BP neural network sorting technology to study the intelligent sorting method of different objects in waste.

2. Sorting Methods of Marine Domestic Waste Based on Cepstrum Acoustic Wave Feature Extraction

2.1. The structural characteristics of time domain and frequency domain of knocking sound
The knocking sound on the object sample is a typical transient sound, the key to the sorting and recognition of this kind of impact sound is feature extraction. The traditional method of impact sound feature extraction is mainly based on spectral features of time-frequency analysis, but its effect is limited. With the in-depth study of extracting perceptual features based on the principle of human hearing, the spectral centroid, spectral centroid bandwidth, and discordance can realize the recognition of sound waves. In the process of research, it was found that the frequency domain and time domain characteristics are complementary in describing the impact sounds of different objects.
The research object of this paper is to study the transient sound produced by striking metal, glass and plastic samples of the same size with metal balls under the same conditions. Through repeated acoustic signal acquisition of samples of three objects, the corresponding typical time domain and frequency domain diagrams are shown in Fig.1. It is found from the figure that the duration of the knocking sound of glass and aluminum plates is longer, the duration of plastic knocking sound is shorter, and the attenuation rate is faster; in the frequency domain, the frequency spectrum of plastic knocking sound is mainly concentrated in the low frequency band below 3 kHz, the frequency spectrum of knocking sound of glass and aluminum plates is widely distributed in the range of 0-13 kHz, and the frequency band is relatively wide.

The extraction link of acoustic wave features is particularly important in sorting problems. Acoustic wave properties are multidimensional, and are affected by both the time domain structure and the frequency domain structure of the sound signal. This paper first extracts the relevant timbre characteristics of the impact sound for sorting, including time domain features, frequency domain features, and features extracted from the sound wave signal with Mel cepstrum analysis, the feature library is established and use BP neural network to learn and train it, and then classify different objectsand check the sorting effect.

![Fig. 1 time domain and frequency domain diagram of the knocking sound of three materials](image-url)
2.2. Mel cepstrum characteristic coefficient

Cepstrum analysis technology is a very useful method, which is widely used in acoustic signal processing, compared with the time domain, the cepstrum coefficient changes little in the cepstrum domain. Since the cepstrum is the inverse Fourier transform of the logarithmic power spectrum of the acoustic signal and it is a time domain function, this function is called cepstrum. The Mel frequency based on the human ear's auditory characteristics is a very important timbre characteristic, and the relationship with the linear frequency is shown in the following formula:

\[ f_{\text{mel}} = 2.595 \times \lg(1 + f/700) \]

In formula (1), \( f_{\text{mel}} \) is the Mel frequency, and \( f \) is the linear frequency.

The Mel Frequency Cepstrum Coefficient (MFCC) takes human auditory characteristics into consideration, and first maps the linear spectrum to the Mel nonlinear spectrum based on auditory perception, and then converts it to the cepstrum. A large number of studies have confirmed that this parameter is very suitable for acoustic wave recognition, and the MFCC parameter extraction process is shown in Fig.2, the specific calculation process is as follows:

![Fig. 2 extraction process of MFCC parameter](image)

(1) Conduct pre-emphasis, framing on acoustic signals; (2) Obtain the frequency spectrum corresponding to each short-term analysis window through FFT; (3) Mel spectrum is obtained by the Mel filter bank; (4) Cepstrum analysis is conducted on the Mel frequency spectrum to obtain the Mel frequency cepstrum coefficient MFCC.

2.3. Characteristic values of other acoustic waves

In the analysis of acoustic characteristics, spectral features such as spectral centroid, spectral flux, spectral reduction value, and crest factor are also conducive to improve the accuracy of object sorting. The spectral centroid is the average frequency by energy weighting in a certain frequency range, it is the center of gravity of the frequency components and reflects the brightness of the sound, the higher the spectral centroid, the brighter the sound. The calculation formula is as shown in the following formula.
\[ SC = \sum_{n=1}^{N} f(n)P(E(n)) \]

(2) In the formula, \( f(n) \) is the corresponding frequency after the signal (n) Fourier transform; \( N \) is the length of the DFT; \( E(n) \) is the discrete time domain signal, \( x(n) \) is the corresponding spectral energy after Fourier transform. \( P(E(n)) \) is the probability value of the energy of each point on the total energy. Spectral flux is the envelope area of the frequency spectrum of sound signal and reflects the sum of the energy of each band component in the signal. In this paper, the spectral flux in the entire frequency band as a recognition feature. The calculation formula is as shown in the following formula:

\[ SF = \sum_{n=1}^{N} \Delta f(n)E(n) \]

In the formula, \( \Delta f(n) \) is the difference between the two frequencies of the signal \( x(n) \) after Fourier transform. As spectral amplitude increment, SF has been used for musical tone recognition. The spectral reduction value (SRO) indicates the degree of tilt of the frequency spectrum and reflects the specific frequency at which the sound energy starts to decrease, it is often used to distinguish knocking sounds. The calculation method of SRO is shown in the following formula:

\[ \sum_{n=1}^{R} E(n) = C \sum_{n=1}^{N} E(n) \]

In the formula, \( R \) is the specific frequency point at which the sound energy starts to fall, namely the spectral reduction value; \( C \) is an empirical coefficient, and \( C=0.75 \) in this paper. 75. Crest factor (CF) is an important parameter in the recognition of sound signals, and reflects the importance of the maximum amplitude of the signal in the entire envelope, it is defined as the ratio of the maximum amplitude of the signal to the effective value of the signal.

3. Marine Sorting Method of Marine Domestic Waste Based on BP Network

The acoustic wave feature recognition process based on pattern recognition is as follows: first, the recognized sound wave is converted into an electrical signal and input to the recognition system; after preprocessing, the feature signal is extracted mathematically; the extracted feature signal can be regarded as the pattern of the acoustic wave; comparing this acoustic wave pattern with a known reference pattern, and obtaining the best matching reference pattern as the recognition result of this segment of acoustic wave. This paper uses BP neural network achieve effective sorting of these three types of sound waves. After acoustic feature extraction, each segment of acoustic feature signal is composed of 16-dimensional sonic feature signals (including 12-dimensional MFCC feature coefficients, SC, SF, SRO, CF). Combined with the feed-forward characteristics of BP multilayer neural network, the acoustic signal sorting algorithm modeling mainly includes three steps: construction, training and sorting of BP neural network, the algorithm flow is shown in Fig.3.
Fig. 3 flow chart of the sorting algorithm of acoustic signal

3.1. **BP neural network model establishment**
Firstly, the structure of BP neural network is determined according to the characteristics of system input and output data. Three types of acoustic wave characteristic signals are extracted according to the cepstrum coefficient method. Different acoustic wave signals are identified by 1, 2, and 3, and the extracted signals are stored in data1.mat, data2.mat, data3.mat. In the mat database file, each group of data is 17 dimensions (the first dimension is the category identification, and the last 16 dimensions are the sonic characteristic signals). Because the acoustic wave characteristic input signal has 17 dimensions and there are 3 types of speech signals to be classified, the structure of the BP neural network is 17-12-3, that is, the input layer has 17 nodes, the hidden layer has 12 nodes, and the output layer has 3 nodes. There are 500 sets of sonic characteristic signals, 350 sets are randomly selected as training data and 150 sets of data are used as test data.

3.2. **MATLAB implementation of BP neural network**
According to the BP network theory, the BP network-based acoustic feature sorting algorithm is programmed in MATLAB. First, The load function is used to extract the acoustic characteristic data from the acoustic characteristic database of data1.mat, data2.mat and data3.mat, and construct a 500X17 matrix; randomly extract 350 sets of samples from the matrix as training samples and 150 sets as prediction samples; use the function to conduct data normalization on the training samples; construct 17- 12-3 BP network structure initializes the weights and learning rate, and defines the learning rate 0.1. The error is 0.01 and the number of cycles is 10. The network is trained with training samples, and the correction weight threshold is calculated based on the errors, and analyze the sorting ability of BP neural network based on the sorting results.

The acoustic signal sorting algorithm based on BP neural network has high accuracy. The sorting of plastics is ideal, Less than 3% of the plastics are misclassified as glass or metal. The sorting results of glass plate and metal are relatively low, mainly due to the similarity of the two types in the time domain and the frequency domain. The above results conform to the conclusions drawn by the human ear during
subjective listening, it was found that plastics are quite different from the other two types of impact sounds and easy to identify, while knocking sounds of glass and metal are similar and easy to misclassify.

4. Conclusion
This paper studies the knocking sound color characteristics of plastic, glass and metal materials when they are struck, based on this, the BP neural network is used to verify the sorting algorithm of marine domestic waste, and high sorting accuracy rate is obtained, acoustic recognition technology has laid a good foundation for further research on sorting algorithm of marine domestic waste.

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