Liquor Identification System Research based on Wavelet Neural Networks

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Abstract: Detection and control of the liquor ingredient is the key technology on liquor quality control. Artificial recognition system is composed by the gas sensor array and wavelet neural networks in this paper. It can be able to identify the main component of the liquor by simulating biological olfaction, and gives quality evaluation or category of the liquor.

Keywords: wavelet transform; neural networks; liquor Identification; DSP

1. Introduction

China has long history and culture of liquor, with one of the wine culture ancient in the word, and also is the main production and consumption of liquor. The main components of liquor is alcohol and water, other minor components accounting for 1 to 2% of the total, which has been detected to 342 kinds, mainly are: alcohols, aldehydes, acids, ketones, aromatic compounds, etc. Liquor has a rich in trace elements, different trace elements contained in different liquor. Detection and control liquor ingredient is the key in liquor quality control[1-2]. First we use chromatographic techniques to gather wine samples and analyze the data, obtained liquor content of trace elements features and main components, to get liquor fingerprint. We use gas sensor array and wavelet neural networks method to simulate biological olfaction for achieving recognition of liquor.

2. Liquor Identification System Structure

Liquor identification system is composed on arrange array of sensors, A/D conversion circuit, digital signal processors, Fig. 1 is the flow diagram of liquor recognition system. Sensor array converts detected signals to digital signals after A/D conversion circuit, transmitted to the digital signal processor for processing, and outputs the result.

According to the process liquor recognition system, we designed TMS320C6655 DSP chip for processing the core, with the entire column of the array sensor, A / D conversion circuit, interface circuit, memory circuit, input and display circuit to achieve liquor recognition system. In the whole structure design, we use the modular design, as shown in Fig. 2.

Gas sensor is an equipment for detecting specific component and concentration, and converts it into an appropriate signal. Individual gas sensors when testing complex mixed gas composition, are unsatisfactory in agility, the ability to distinguish and adaptability to the environment[3]. In order to extract sufficient sample information to enable the result accurate and reliable, we use the gas sensor array to simulate biological olfactory system. Take advantage of multiple gas sensors with different selective, realized response of the gas with complex components, thus different characteristics to form a feature vector, which has a stronger information processing capabilities, better resolution accuracy and affordability for harsh environments than the artificial olfactory system. The designed gas sensor array includes ten gas sensors, a humidity sensor and a temperature sensor. In the selection of gas sensors, gas-sensitive is required, with different sensitivity requirements, which making sensor array on the whole measured gas to form a high-dimensional response pattern, and can make full use of selective gas sensors to highlight single dimension of a certain amount of information in response to the gas composition, making the results are more accurate and reliable.

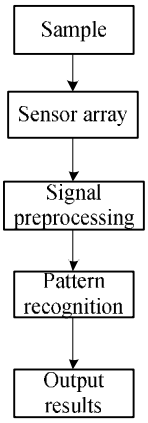


Figure 1. Flow diagram of liquor recognition system

We choose TI's TMS320C6655 in signal processing of recognition system. TMS320C6655 is one of the high-

speed floating-point DSP with better computing power. It is based on KeyStone multicore architecture, core speeds up to 1.25GHz, while integrating C66x core, memory subsystems, peripherals and accelerators system. Due to its high performance and low power programmable application, it is a small, high performance processor ideal, widely used in fields such as test and automation, medical imaging, etc. [4].

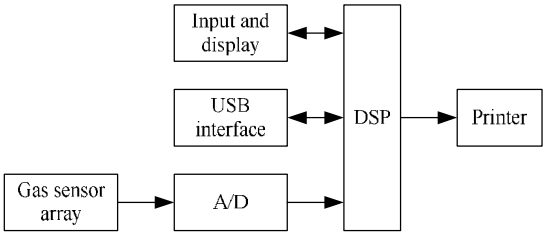


Figure 2. Structure diagram of liquor recognition system

A / D converter is AD7329. It is an 8-channel, 12-bit unsigned successive-approximation ADC; be true bipolar analog input signal; each analog input channel supports independent programming; its maximum throughput speed serial interface is up to 1 MSPS.

3. Wavelet Transform

Wavelet transform is a powerful signal analysis tools after the Fourier transform. With wavelet transform multi-resolution analysis of the characteristics, namely the use of a family of wavelet functions to represent a signal or function, the data will be broken down into a series of bands, and signal processing and analysis can be done in different frequency bands, eliminating lengthy, achieving signal Reconstruction [5-6]. It overcomes the shortcomings of the Fourier transform, with certain windows adaptation. And the signal can be analyzed at different scales, which has been applied in the field of pattern recognition, speech analysis, image processing and so on.

Wavelet function is defined as: assume $j(t)$ is square integrable functions ($j(t) \in L^2(R)$).If $\bar{j}(w)$ meets the condition:

$$C_j = \int_R \frac{|\bar{j}(w)|^2}{|w|} dw < \infty \quad (1)$$

$j(t)$ can be called the basic wavelet or mother wavelet function [5-6].

In liquor recognition system, most of the measured signals obtained are interspersed with noise, when the useful signal is weak, easily overwhelmed by noise. Thus affecting the results of the analysis. Whether denoising effect good or not affects the accuracy of the final result. Wavelet transform has capability to characterize local features of signals in time domain and frequency domain. It does convolution with signal and a family of functions which have good localization properties in the time domain and frequency domain, so that the signal is decomposed into a set in a different band and time period components. The process of removing the signal to noise using wavelet transform is to extract useful signal with containing noise[5-7], shown in Fig. 3.

Denoising through wavelet transform is generally divided into three steps:

(1) Select the appropriate wavelet functions and transform numbers for noisy data decomposition.

(2) Determine wavelet coefficients threshold of the wavelet layers, and process the threshold.

(3) Composite the signals after denoising.

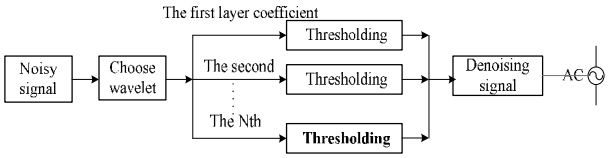


Figure 3. Denoising process using wavelet transform

4. Neural Networks

Neural networks called artificial neural network, is a method of the human brain abstract, simplified method to simulate a human intelligence from the microscopic structure and function. Three basic elements of artificial neural network neurons are network topology, network training and learning algorithms. It has advantages of a massively parallel processing, distributed storage, and self-learning and reasoning ability, and easy to be realized for hardware, which obtain many professionals' attentions, and has made the successful application in many fields [7].

Multilayer feedforward neural networks, namely BP neural network is generally used. It consists of input layer, hidden layer and output layer, through the back-propagation and weights adjusting to make good role mapping between input and output. Learning process consists of the forward propagation of signals and backward propagation of errors.

5. Wavelet Neural Networks

The common pattern recognition methods in liquor identify are based on statistics and artificial intelligence. Statistical methods commonly are principal component analysis and cluster analysis; Artificial intelligence methods commonly are wavelet transform, artificial neural networks, genetic algorithms. In this paper we use wavelet neural networks which combine wavelet transform theory with artificial neural network.

Wavelet transform and neural networks are complementary. Combine the wavelet transform and neural networks, compose a system better than the individual wavelet transform and neural network. For example, reducing the

memory requirements, increasing fault tolerance and generalization ability of neural networks, and neural network learning speed and approximation ability is greatly improved and so on.

Wavelet neural networks can be divided into two categories according to the characteristics of combining wavelet transform and neural network. The first one is separate connection of both, wavelet transform and neural networks fill the whole system, the input feature vector of neural network is provided by wavelet transform, and forward processing of neural network is achieved depending on wavelet transform system. The second is the integration of both. We use the second [10-12]. In the design, we choose multi-layer feedforward neural networks. Neurons in the input layer of the neural network can be assumed by required problems and data representation, where is the number of sensors in gas sensor array. The number of neurons in the output layer can be set according to the type of coding approach, it is equal to the main parameters which we will identify. If the numbers of hidden layer units are too small, the network may be unable to achieve the training requirements, with a bad sample identification and fault tolerance; Otherwise too many units make network learning time too long. In the initial design, we put enough hidden layer units, through learning the useless hidden layer gradually removed, which has not been reduced to shrink. Learning process consists of forward propagation of signal and backward propagation of error. Through the two processes, constantly adjusting the weight until the output error is in a range or reaching the number of learning. Thresholds and weights in hidden layer neural networks is denoted respectively by translation and scale parameters of the wavelet function, and the entire wavelet function is used to indicate the excitation function of hidden layer nodes in neural network, as shown in Fig. 4. Flow chart of wavelet neural network algorithm is shown in Fig. 5.

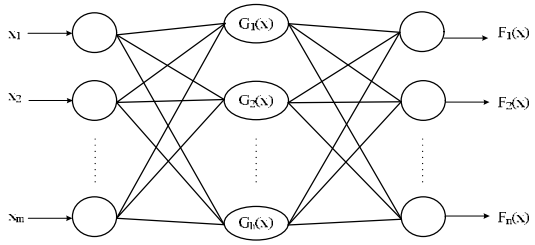


Figure 4. Wavelet neural networks structure

We use MATLAB to generate a series of random signals, which are input of the system model to generate training data, as shown in Fig. 6. The training and verification results are in Fig. 7, width and height of the random input signal are displayed with "input"; "plant output" is system model output; output error between system model and neural network is displayed with "error", wavelet neural network model output using "NN output" for display. Seen from Fig. 7, wavelet neural network can achieve better results.

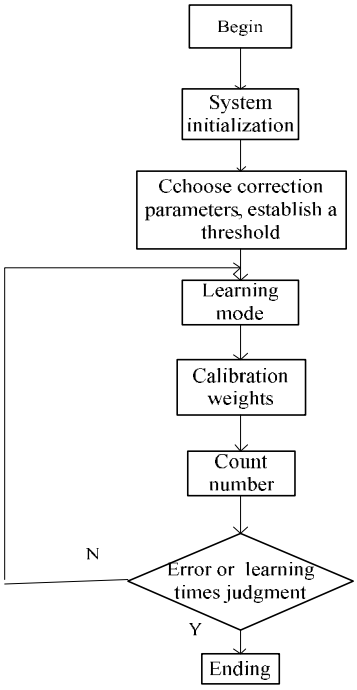


Figure 5. Flowchart of wavelet neural networks algorithm

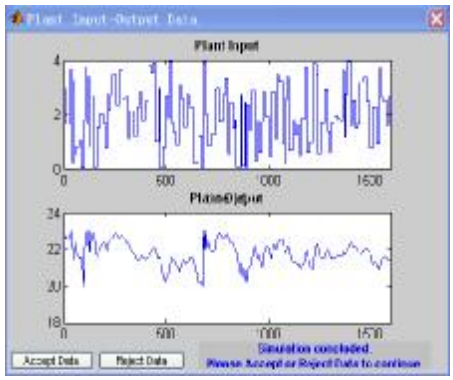
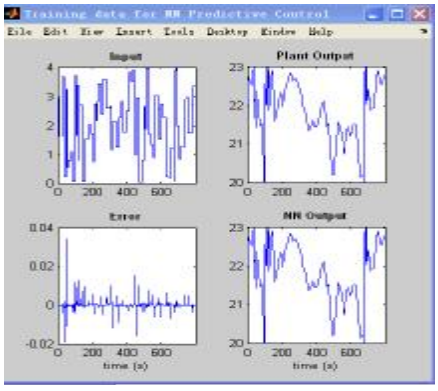
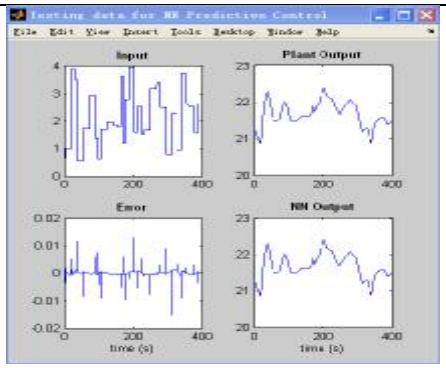


Figure 6. The random samples for training



(a) Training results



(b) Verification results

Figure 7. Output results

6. Conclusion

This system makes use of computing and reasoning capabilities of digital signal processor, designs the liquor identification system with the core of DSP. Wavelet neural networks are used for identification, in which the neurons number of input layer of neural network is the number of sensors in the gas sensor array. The number of neurons in the output layer is equal to the main sample parameters we want to identify. Thresholds and weights in hidden layer neural networks is general respectively represented by translation and scale parameters of the wavelet function, and wavelet function is used to represent the entire excitation function of hidden layer nodes in neural network. Through artificial recognition system consisting of gas sensor array and wavelet neural network can simulate biological olfaction, identify the main component of liquor, and give the quality evaluation or category of the liquor.

7. Acknowledgment

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