Sound-Quality predict for medium Cooling Fan Noise Based on Bp Neural Network Model

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ABSTRACT: *The self-learning capability of this prophecy method is so strong that each association weight could generate itself via network learning with a more objective and accurate predicted result. Base on the complexity and non-linear description of vehicle cooling fan sound quality evaluation, the problem about the submission of BP neural network in sound quality prediction is discussed. Combining the basic principles and models with examples the complete implementation process is presented. Then BP neural network assessment method is compared with the existing prediction methods, and the conclusion shows that in interior vehicle subjective and objective noise evaluation, the prediction effect of the former method is much better. To a large extent the method could be used to improve the decision-making accuracy, which is of great importance to the evaluation, analysis and control of fan noise nowadays.*

Keywords: **fan; sound quality; BP neural network; predict model**

I. INTRODUCTION:

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the biological nervous systems, such as the human brain's information processing mechanism. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. An NN is configured for

A specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of NNs as well.

- Neural networks are a new method of programming computers.
- They are exceptionally good at performing pattern recognition and other tasks that are very difficult to program using conventional techniques.
- Programs that employ neural nets are also capable of learning on their own and adapting to changing conditions.

Many products and applications employ or include fans, for example Information Technology (IT) devices and products, household appliances, air-conditioning systems and automotive applications.

Low-noise design is a key purchase requirement in all of these fields, where often the main noise source is a fan. Forgiven constraints, such as fan dimensions and cooling performance, it is not possible by technical means to achieve an arbitrary low-noise design.

The effective characterization of fan noise is challenge in acoustic and sound quality measurement. In general, the product sound quality does not depend only on the emitted noise level or frequency-weighted level like A-weighted level or loudness. Tonal components, howling sounds and modulated signals are often the cause of customer complaints.

Loudness has been introduced as a more hearing related parameter than the A-weighted level in the last decades. Several methods exist in international standards for measuring the loudness of stationary signals (ISO 532 B and DIN 45631). DIN 45631 will be extended with respect to loudness of time-varying signals (DIN 45631/A1, draft version published in January 2008).

This is an important step, because in practice we almost always have to deal with time-varying signals.

Besides time-varying loudness, other psychoacoustic parameters like sharpness and roughness can be used for sound quality evaluation. Sharpness considers the amount of high frequency components of a noise (DIN 45692, draft version published in April 2007), and roughness evaluates modulation characteristics. In addition, a metric combining modulation spectral analysis with loudness calculation has been introduced.

For a long time, researchers have been trying to explore the establishment of accurate objective quality parameters to describe people's subjective sense of sound quality evaluation model. Because of the randomness of human subjective evaluation and the existence of some non-linearity between objective parameters, the existing linear regression model of sound quality cannot map the complex nonlinear relationship between subjective and objective evaluation. To the desired level. Artificial neural network is a kind of forecasting method with good application effect, and it is widely used in automobile industry. Neural network is a adaptive nonlinear dynamic system composed of a large number of simple neurons and has many advantages compared to other methods.

This paper starts with the subjective evaluation experiment and the psychoacoustic parameters metrics. Then a BP neural network is applied to predict the radiator fan sound quality.

II. SUBJECTIVE EVALUATION EXPERIMENT:

In the human brain, a typical neuron collects signals from others through a host of fine structures called *dendrites*. The neuron sends out spikes of electrical activity through a long, thin stand known as an *axon*, which splits into thousands of branches. In the training mode, the neuron can be trained to fire (or not), for particular input patterns.

In the using mode, when a taught input pattern is detected at the input, its associated output becomes the current output. If the input pattern does not belong in the taught list of input patterns, the firing rule is used to determine whether to fire or not.

The firing rule is an important concept in neural networks and accounts for their high flexibility. A firing rule determines how one calculates whether a neuron should fire for any input pattern. It relates to all the input patterns, not only the ones on which the node was trained on previously.

At the end of each branch, a structure called a *synapse* converts the activity from the axon into electrical effects that inhibit or excite activity in the connected neurons Pair wise comparison method is a more commonly used subjective evaluation method, which makes it easy for the evaluation subject to obtain the relative comparison result between the evaluation samples. However, when the number of samples is evaluated, the amount of evaluation effort required by the paired comparison method in the general sense will become very large. In this paper, an improved pair wise comparison method, which is a group comparison method, which is suitable for more evaluation samples, is put forward and applied to the actual subjective evaluation experiment. Group comparison method can greatly reduce the workload of subjective evaluation, and make the evaluation experiment more practical and get more stable evaluation results.

2.1 Sample collection and processing:

Artificial Neural Networks (ANN) are currently a 'hot' research area in medicine and it is believed that they will receive extensive application to biomedical systems in the next few years.

At the moment, the research is mostly on modeling parts of the human body and recognizing diseases from various scans (e.g. cardiograms, CAT scans, ultrasonic scans, etc.).

Neural networks are ideal in recognizing diseases using scans since there is no need to provide a specific algorithm on how to identify the disease.

Neural networks learn by example so the details of how to recognize the disease are not needed.

What is needed is a set of examples that are representative of all the variations of the disease.

The quantity of examples is not as important as the 'quality'. The examples need to be selected very carefully if the system is to perform reliably and efficiently.

Neural Networks are used experimentally to model the human cardiovascular system.

Diagnosis can be achieved by building a model of the cardiovascular system of an individual and comparing it with the real time physiological measurements taken from the patient.

If this routine is carried out regularly, potential harmful medical conditions can be detected at an early stage and thus make the process of combating the disease much easier

The evaluation sample is a sample of the in-vehicle noise samples recorded using the simulation head. The sample samples the noise samples of the front and rear seats of the car at different fan speeds. A total of 34 samples, each sample length of 5s.Many studies have shown that loudness differences have a significant effect on the evaluation results, and their correlations are about 90%. Therefore, the loudness of the evaluation samples is equalized to obtain the correct evaluation results of the evaluated parameters.

In this experiment, the grouping method is used. The method is to participate in the evaluation of 34 sound samples (according to l-34 on its series) To select one of the sound samples as a reference to the (anchor) sample, that is, each group contains reference sound samples. In the case of grouping the samples, the uniform distribution of the evaluation characteristics of each set of samples will result in a better consistency of the evaluation results between the groups.

2.2 The numerical results of the evaluation:

After the evaluation result of the evaluation subject is obtained, it is digitized. In this experiment, it is assumed that the comparison of the amount of the sample before the sample is greater than the subsequent sample, its assignment is 1; otherwise, the assignment is -1; that the two are equal when the assignment is 0.The evaluation of the poor performance of the data were removed, because A, B, C three groups of samples and evaluation is relatively independent, so the results of the main body removed also maintained its relative independence, each other is not necessarily linked.

2.3 Evaluation results:

After the scores of each group are analyzed, the results of each group need to be combined to obtain the sorting results of all the samples. The results of each group can be combined based on the reference samples designed in the evaluation experiment.

Table 1 Subjective and objective evaluation results of cooling fan noise

Sample number	Loudness	Sharpness	Roughness	Fluctuation Strength	results
1	14.6789	2.2873	0.1498	1.0703	11.25
2	16.0532	2.2802	0.1558	1.1389	31.54
3	17.1067	2.3077	0.15	1.1268	30.95
4	19.6523	2.3065	0.1647	1.1096	25.83
5	20.7133	2.3081	0.1628	1.0834	22.46
6	18.1014	2.2991	0.1584	1.0815	21.08
7	15.2848	2.2983	0.1605	1.1056	17.71
8	12.4518	2.2422	0.1276	1.0833	13.04
9	9.87	2.2177	0.1185	1.097	8.33
10	17.1994	2.2654	0.1479	1.1487	3.91
11	8.5849	2.1854	0.108	1.0863	1.91
12	9.29824	2.181	0.1146	1.1414	1.16
13	11.6437	2.2317	0.1368	1.1077	18.87
14	13.1256	2.2274	0.1373	1.051	13.75
15	13.7708	2.2444	0.14	1.0643	10.75
16	14.5246	2.2622	0.1413	1.1101	3.29
17	16.3905	2.2469	0.1537	1.1261	3.62
18	18.5851	2.2158	0.1499	1.0731	6.25
19	19.8767	2.2343	0.1757	1.1209	13.04
20	21.0267	2.2157	0.1747	1.0714	24.66
21	22.9601	2.126	0.192	1.1165	27.7
22	8.2883	2.0241	0.1151	1.0749	32.83
23	9.5909	1.9831	0.1262	1.0745	30.7
24	11.1065	1.957	0.1294	1.0858	28.33
25	12.4215	1.9629	0.1279	1.0831	26.87
26	14.3233	1.9503	0.1454	1.1183	22.62
27	15.3147	1.9444	0.1609	1.0915	23.91
28	16.0041	1.9841	0.1561	1.0206	17.25
29	16.631	2.0039	0.1621	1.1196	20.04
30	17.2932	2.0199	0.1627	1.119	15.75
31	18.7892	2.0001	0.1694	1.1118	10.45
32	19.0838	2.0265	0.1651	1.0981	11.25
33	20.6017	2.0316	0.1791	1.1098	6.04
34	21.5704	2.058	0.1713	1.0806	2.92

III. BP NEURAL NETWORK MODEL:

Feedback networks can have signals traveling in both directions by introducing loops in the network.

A Neural Network can be successfully used in the C.A.I.S. project, given that we have access to enough training data.

Since we need it to be highly accurate, we need to carefully gather contextual variables that closely relate to diagnosing heart murmur and its various grades.

Feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point.

They remain at the equilibrium point until the input changes and a new equilibrium needs to be found.

Feedback architectures are also referred to as interactive or recurrent, although the latter term is often used to denote feedback connections in single-layer organizations.

BP network is a multi-layer feed forward network with single hidden layer trained by back propagation algorithm. It is a mature and widely used artificial neural network. It is a kind of multi-layer forward feedback neural network with error back propagation .In theory, a three-tier BP network can approach any nonlinear function.

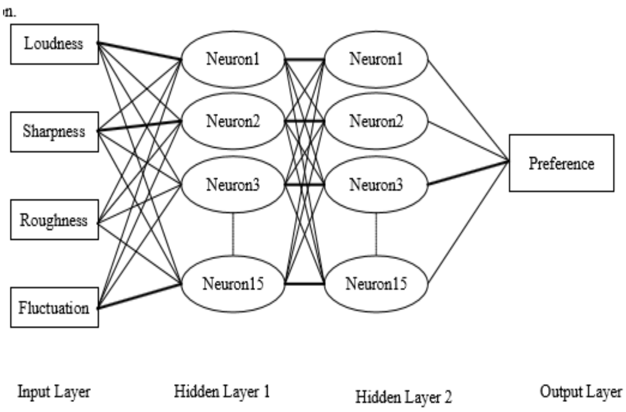

Fig.1 Network structure

The topology of the BP neural network is 4-15-15-1, and the structure of the network model.The individual relations between the input variables and the output variables are not developed by engineering judgment so that the model tends to be a black box or input/output table without analytical basis. The sample size has to be large. Requires lot of trial and error so training can be time consuming.

A total of 24 data from 1 to 24 in Table 1 were selected as training samples, and data of 25 to 34 were selected as test samples. The use of software MatlabR2007 neural network toolbox (Neural Network Toolbox) newff function to create BP training network; use trained as a training function, the function is studied by the gradient descent method, and the learning rate is adaptive.

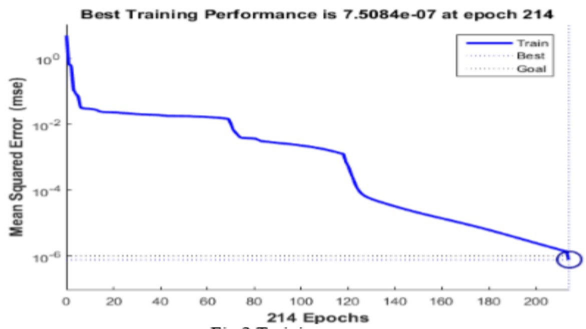

Fig.2 Training error curve

It can be seen from Fig.2 that the established BP neural network prediction model shows good prediction accuracy and fast convergence speed (after 214 training, the network error is required).

IV. CONCLUSIONS:

Based on the BP neural network, the acoustic quality prediction of the vehicle noise can be considered as a quantitative factor, which can be a quantitative factor or a qualitative or uncertain factor, which can solve the nonlinear problem in the acoustic quality prediction. The BP neural network prediction model, which is established in this paper, not only provides some guidance for the prediction of the noise quality in the vehicle, but also proves the feasibility of the model of noise prediction in the vehicle noise.

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