'92 韓國自動制御學術會議論文集 1992. 10. 19~21

ADEX 개발에 관한 연구

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A Study on the Development of ADEX

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ABSTRACT

Diagnostic prototype expert system was developed by analyzing the measured acoustical data of automobile. For the utilities of this system, 1/3 octave filter(band-pass filter) and A/D converter were used for data acquisition and then information was analyzed using signal processing technique and pattern recognition by Hamming network algorithm. In order to raise the reliability of the diagnostic results, fuzzy inference technique was applied and, the results were displayed as graphical method to help the novice in diagnostic field. The validation of this diagnostic system was checked through experiments and it showed an acceptable performance for diagnostic process.

1. Introduction

There has been a strong request for computer system in production line because of high speed and automation of equipment. And, the necessity of monitoring system has been increased in the diagnosis of installation. These tendency is more and more elevating in the side of shortage of expertise in the diagnostic field, prevention of industrial accident and settling of being incapability of expert due to the variety of production.[1]

Especially, automobile is a very complicate system which is composed of thousands of components, and it is one of the most important transportation device in modern society. Also, it has been developed in the face of performance and structure with the progress of the living environment. Besides, many expert mechanics and accumulated diagnostic techniques are required due to the increased demand and automobile variation, but the skillful mechanics and the diagnostic techniques are incapable of satisfying these demands.[2][3]

In this study, therefore, expert system for diagnosis of automobile is developed by measuring acoustic signal to supply and support the relative incapability of mechanics owing to the development of automobile.

In addition, Fuzzy inference technique is applied to raise the reliability of decision making, and pattern recognition technique by Hamming network is adopted to extend the knowledge base. The validity of the developed diagnostic algorithm and the efficiency of the expert system are verified through experiments using automobiles.

2. Development of software

2.1 Simple diagnostic technique

In the simple diagnosis software, statistical method was used for tendency analysis and management of customer. Unexpected increase of RMS value or kurtosis level represents the possibility of fault for automobile and by analyzing these diagnostic index, the proper time for troubleshooting can be predicted. These index can be calculated simply in a short duration because it does not require specific signal processing technique, but it may not detect the signal which represents the characteristics about fault position and elements. Fig.1 shows an example of tendency analysis graph using RMS value.

2.2 Precision diagnostic technique

In the case of fault diagnosis by analyzing the data detected from sensor, much time and memory are required in the signal analysis and processing. Therefore, efficient algorithm which is capable of detecting distinct characteristics of received signal is required and for settling this problem, concept of pattern recognition is introduced.[4]

General pattern classification and recognition have been applied at the field of acoustics or vision. In this system, algorithm for fast pattern recognition and database for storage of classified pattern are developed. Fig.2 shows the schematic diagram of pattern recognition for precision diagnosis. In the figure, automobile offers an data for preprocessor. The data are
detected by sensor and then transformed to the frequency region by RMS-to-DC circuit and 1/3 octave filter. After finishing this process, center frequency and feature vector are compared with the training pattern by classifier.

In this system, 1/3 octave band data were classified using modified hamming network and fuzzy inference technique was applied to deal with ambiguous information received by driver and many operating variables.[5],[6]

2.3 Heuristic diagnosis technique

Heuristic diagnosis technique was included to make up for troubleshooting which could not be diagnosed by acoustic data. This part is constructed using OPS83 as development tool.

2.4 User interface

As the many other expert system, information used by expert and analytic results are often inaccurate and ambiguous. For that reason, this system puts some degree of belief in the question at the user. Also, for the convenience of user, contents of process are displayed as the Korean alphabet and fault position and elements are displayed as graphical method. And some keys which used frequently are indicated on the keyboard to help the novice to the computer. Fig.3 shows an flow chart for diagnostic process.

3. Development of hardware

3.1 Data acquisition board

In the expert system by measuring of sound data, 1/3 octave data were used instead of time data for fast decision by each frequency. Data acquisition board was consist of Multiplexer, Bandpass filter, RMS to DC and A/D converter. Fig.4 shows an block diagram of data acquisition board and function for each components is as follow. [7],[8]

(1) 1/3 octave filter

As referred previously, octave data were used instead of time data received directly through microphone to simplify and raise the efficiency of the system. For this, 1/3 octave filter was constructed using Micro-
processor Programmable Universal Active Filter.

(2) RMS to DC

Practically, measured signals through microphone which passed octave filter are cut-off time data according to each band. To represent time data by level of each band, RMS value of each band should be calculated and therefore RMS to DC circuit is needed. This circuit calculates RMS value of input signal and offers an output as DC voltage.

(3) A/D converter

It is necessary for the system to convert analog RMS voltage to digital signal. In this study, A/D converter which fits in with the aim of the system was constructed.

3.2 X-Y table

Recently, in the experimental analysis and fault diagnosis, many kind of sensors are used and much data are needed to get more detail information. In addition, more and more measuring time, accuracy of data and man power have been needed. To overcome the referred problems, measuring X-Y table was developed. Fig. 5 shows an appearance of X-Y table. [9]

4. Configuration of the system

Fig.6 represents the inference process of developed expert system. The left side of flow chart represents the measuring process of acoustic data and right side represents the heuristic inference process.

If the system is initialized, expert system requests some specification and symptom of the automobile to be diagnosed and then samples the acoustic data by using 4 microphones. After measuring the 32 points of automobile, some feature patterns are generated by hamming network algorithm and inference process is activated through input information and rules using fuzzy technique. [10]

5. Experiment

5.1 Method and apparatus for experiment

In the experiment, the automobile engine part was divided into 32 points as shown in Fig.7 and sampled the acoustic data of normal state. For the revival of fault state, artificial faults for some kind of components were generated as Table 1.[11]

5.2 Results and consideration for experiment

The diagnostic results are represented in Table 2 and it could be known that the proposed Neuro - Fuzzy technique was superior to the conventional diagnostic method.

While wrong decision was made for the fault CASE II and it might be thought as the vicinity of the each ignition plugs and decreased sound level. Furthermore, in the case of fault CASE VI, it was impossible to find the fault with the conventional method because the coolant temperature sensor does not affect to the overall sound level at all.

As a future study, It is necessary that more case study and field test are required for better decision making.

6. Results

Automobile diagnostic expert system by measuring sound data was developed and Neuro-Fuzzy Technique was proposed to raise the reliability of the results. Also, data acquisition system and automatic measuring system were developed for efficient data processing.

From the experimental results, it was certified that the proposed Neuro-Fuzzy Technique was superior to the conventional diagnostic method and developed system showed an about 83 % diagnostic success for the given case.

On the other hand, as the microphones are easily affected by external disturbance, counter-plan is required for the exterior noise to improve the reliability of diagnostic results.

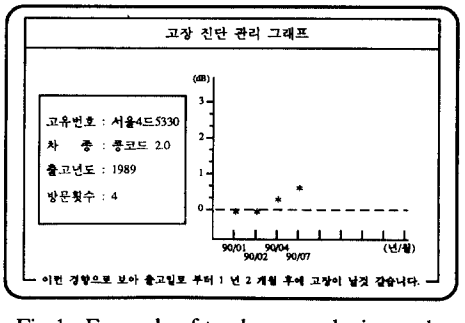

Fig.1 Example of tendency analysis graph

REFERENCE

1. R. A. Collacott, " Mechanical Fault Diagnosis and Conditioning Monitoring ", Champman & Hall, Ltd., 1977
2. J. E. Oh, B. W. Choi, " Expert System for machinery Fault Diagnosis ", J. of KSAE, Vol.10, No.1, 1988, pp.6 - pp.12
3. M. Tomikashi, N. Kishi, H. Kanegae and A. Hino, " Application of an Expert System to Engine Trouble-shooting ", SAE paper, No.870910, 1988, pp.1440 - pp.1446
4. Laszl Monostori, " Learning Procedures in Machine Tool Monitoring ", Computers in Industry, Vol.7, 1986
5. J. Shin, " Development of Automobile Diagnostic Expert System by Fuzzy Inference", Master's Thesis, Hanyang Univ., 1990
6. K. Hirota, " Fuzzy Inference and Fuzzy Control ",JSME, Vol.93, No.856, (1990) pp.24 - pp.30
7. " Data Conversion Products Databook ", Analog Devices
8. " Maxim Integrated Products Guide ", Maxim
9. " Motion Control Application Manual ", SGS
10. " Development of On - line Diagnostic Expert System by Noise and Vibration, Research Report, Hanyang Univ., 1991
11. J. E. Oh, H.Park, W.I.Lee, J.H.Cho, " A Study on the Identification of the Sound Source for 4 Cylinder Gasoline Engine Using Sound Intensity Method ", J.of KSAE, Vol.11, No.1, 1989

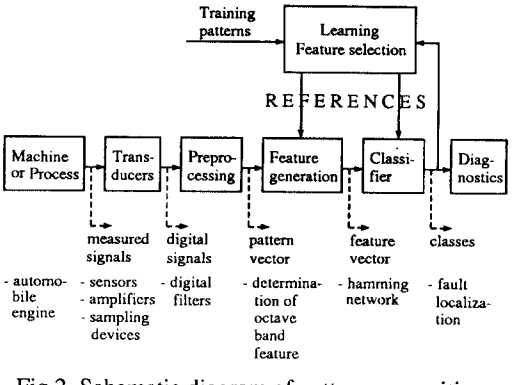

Fig.2 Schematic diagram of pattern recognition

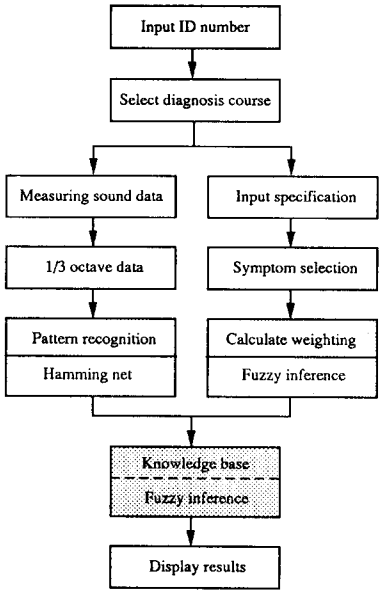

Fig. 3 Flow chart for diagnostic process

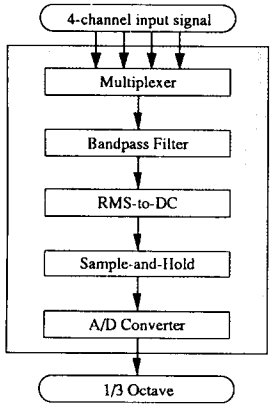

Fig.4 Block diagram of data acquisition board

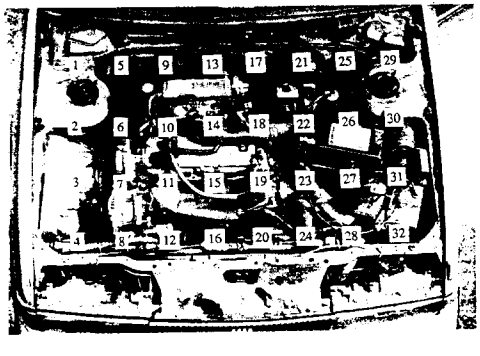

Fig.7 Measuring points of automobile engine part

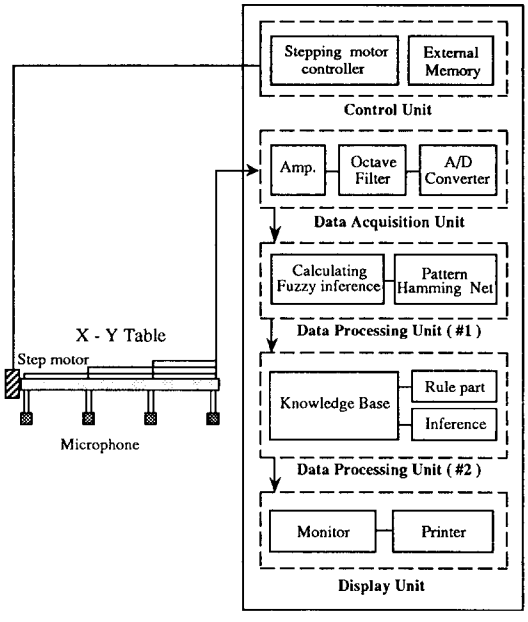

Fig.6 Schematic diagram of inference process

Table 1 Fault types and contents

TYPE	Contents of fault
F1	Increasing of RPM
F2	Ignition plug #1 fault
F3	Ignition plug #2 fault
F4	Ignition plug #3 fault
F5	Ignition plug #4 fault
F6	Coolant temp. sensor fault

Table 2 Diagnostic results according to course and fault types

Course / TYPE	Simple diagnosis	Precision diagnosis	Neuro-fuzzy technique
F1	Normal	Normal	Normal
F2	Fault	I.P. #4 fault	I.P. #4 fault
F3	Normal	I.P. #2 fault	I.P. #2 fault
F4	Fault	Distributor fault	I.P. #3 fault
F5	Normal	I.P. #4 fault	I.P. #4 fault
F6	Normal	Normal	Coolant temp. sensor fault
Diagnostic ratio	50 %	50 %	83 %