Research on Fault Self-Diagnosis of Automobile Electronic Control System Based on Data Flow Analysis

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Abstract

Electronic control systems are widely used in modern automobiles, which greatly improves the power, safety, fuel economy and emission of automobiles, and at the same time, greatly improves the driving comfort of automobiles. However, it also makes the system more complex, and the fault diagnosis of maintenance personnel sometimes becomes extremely difficult. The development and application of automobile fault self-diagnosis system provides convenience for automobile drivers and maintenance personnel to find and eliminate faults in time. At present, most of the new automobile diagnostic equipments provide data stream reading function. Through the dynamic monitoring of electric signals in automobile running, the dynamic data are arranged and compared, so as to determine the causes and positions of faults. Using the dynamic data flow function of the fault diagnosis instrument, the dynamic data of the input and output signals of various sensors and actuators in the automobile electronic control system can be read out. This paper introduces the method of fault diagnosis of automobile electronic control system by using data stream, and explains the important role of data stream analysis in fault diagnosis of electronically controlled automobile.

Keywords*: Data flow, Electronically controlled cars, Fault diagnosis*

Ⅰ. Introduction

The application of automotive electronic control system not only improves the vehicle power performance, but also improves the fuel economy and vehicle emission, but also makes the vehicle fault diagnosis complex [1]. The development and application of automobile fault self diagnosis system provides convenience for automobile drivers and maintenance personnel to find and eliminate faults in time during automobile operation [2]. With the continuous improvement of automobile technology, the electronic control systems with different functions in modern automobile are increasing. Automotive electronic control systems are generally equipped with fault self diagnosis system. The self diagnosis system determines whether the sensor works normally and outputs fault codes by monitoring each circuit or software of the electronic control system to determine whether the electrical signal of the sensor is within the specified range [3]. In addition to the functions of code reading and code clearing of microcomputer fault self diagnosis system in electronically controlled vehicles, the microcomputer fault detector also has the function of dynamic test [4]. When the simple fault code can not find the fault, it is particularly important to detect and analyze the data flow. The ability to analyze data flow has become the yardstick of the level of automotive electronic control maintenance personnel [5]. Using the dynamic data flow function of the fault diagnosis instrument, the dynamic data of the input and output signals of various sensors and actuators in the automotive electronic control system can be read out. By analyzing these data, it is easier to judge the type and location of the fault.

Electronic control systems are widely used in modern vehicles, which has greatly improved the power, safety, fuel economy and emission of vehicles, and greatly improved the driving comfort of vehicles [6]. However, it also makes the system more complex, and sometimes the fault diagnosis of maintenance personnel becomes extremely difficult. The dynamic data flow detected by the fault self diagnosis system can be displayed automatically, which brings unexpected help to the fault diagnosis of electronically controlled vehicles [7]. However, at present, many maintenance personnel only rely on fault code to judge fault, and do not make full use of data flow function. At

present, most of the new automotive diagnostic equipment provide data stream reading function. Through the dynamic monitoring of electric signal during vehicle operation, the dynamic data are arranged and compared to determine the cause and location of fault. Data flow function has unique advantages in diagnosing soft faults of electronic control system [8]. At present, many maintenance personnel only rely on fault codes to judge faults, and do not make full use of data flow function. Using data flow to diagnose the fault of electronically controlled vehicles is of great significance to improve the fault diagnosis accuracy of electronically controlled vehicles. This paper aims to study the influence of dynamic data flow analysis technology on automobile fault diagnosis. Analyzing the data flow can effectively make up for the deficiency of fault code diagnosis. Through comprehensive analysis and judgment of the vehicle, the fault cause can be determined accurately and quickly.

Ⅱ. Causes of Soft Faults in Electronic Control System

The work of electronically controlled fuel injection engine is mainly to control the oil supply under various working conditions through the engine electronic control system, and the oil supply must match the engine. This matching relationship must be the relationship between the condition of the electronic control system and the actual condition of the engine. The actual working condition is unique to the engine, and the electronic control system needs many parameters to reflect and determine this unique working condition. When the electronically controlled automobile runs normally, the voltage values of the input and output signals of the microcomputer control system have a certain change range. When the voltage value of a certain circuit signal exceeds the specified range or cannot be recognized when it is sent to the microcomputer, and this phenomenon can be maintained for a period of time, the microcomputer judges that this part of the signal circuit is faulty, and stores the fault in the memory in the form of code [9]. The parameters obtained by the engine electronic control system are transmitted by various sensors in the form of electrical signals, and the electrical unit signals of various sensors have an artificially specified range. When the electrical signals of a certain circuit exceed the specified range or send signals that cannot be recognized by the electronic control unit, this phenomenon will not disappear for a period of time.

The self-diagnosis system of the electronic control unit judges that this part of the signal circuit has a fault, and stores the fault in the random access memory inside the system in the form of a fault code. If the working characteristics of the sensor change, such as sensitivity decrease, measurement error increase or response speed slow, the input signal will be distorted. Generally, the self-diagnosis system can only monitor the circuit signal of the electric control system, and can only monitor the range of the signal, but can not monitor the change of the sensor characteristics [10]. The linear throttle position sensor should output a voltage signal proportional to the throttle opening, and the control system can judge the throttle opening, that is, the load, according to its input voltage signal, so as to determine the fuel injection quantity and other controls. The control system transmits the real-time data parameters transmitted by the data communication line in the diagnostic socket to the computer diagnostic instrument in a serial manner. When the diagnostic instrument receives these data, it can translate them into responding numbers or characters according to the communication protocol, which is beneficial for automobile maintenance personnel to analyze automobile faults according to the data.

Ⅲ. Fault Code and Data Flow Function Analysis

The so-called data stream refers to the dynamic data of input and output signals of various sensors and actuators of electronically controlled vehicles that can be read by the fault diagnosis instrument. When the electronically controlled automobile runs normally, the voltage values of the input and output signals of the microcomputer control system have a certain change range. When the voltage value of a circuit signal exceeds the specified range or the signal can not be recognized by the microcomputer, the microcomputer judges that this part of the circuit is faulty and stores the fault in its internal random access memory in the form of code. Generally, the fault self-diagnosis system of electronically controlled vehicles has the function of driving record, which can record the relevant data during the driving process. Through the computer fault detector, the actual instantaneous values of input and output signals of various sensors and actuators can be displayed on the display screen in the form of data table, which is the data flow function [11]. Data flow refers to transmitting the real-time data parameters of the

control computer to the diagnostic instrument in a serial way through the data communication line of the control system in the diagnostic socket. In the data stream, it includes the information of fault codes, the real-time operation parameters of the control computer, and the mutual control instructions between the control computer and the diagnostic instrument. According to the display mode of automobile fault diagnosis instrument, automobile data flow is divided into numerical parameters and state parameters. Numerical parameters refer to the unit parameters that change within a certain range, and are often used to express the working voltage, pressure, time, temperature, speed, etc. of each component in the electronic control system. State parameters usually represent the working state of switches or solenoid valves in electronic control systems. Figure 1 shows the structure of intelligent fault diagnosis system based on polyphase support vector machine.

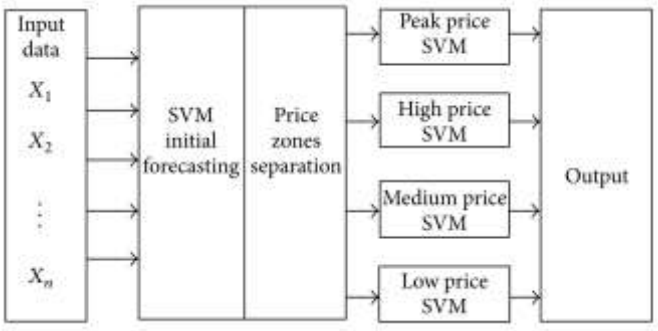

Fig.1 Intelligent Fault Diagnosis System Structure

Generally, the self-diagnosis system can only monitor the circuit signals of the electronic control system, and can only monitor the range of signals, but cannot monitor the changes of sensor characteristics. If the sensitivity of the sensor decreases for some reason, the self-diagnosis system has no fault code output, although the engine does show fault. At this time, with the help of data flow function, analyze and judge according to the engine fault phenomenon, so as to find and eliminate the fault. When the soft fault occurs in the electronically controlled engine, the actual instantaneous data of the engine measured by the data flow function of the fault detector can be compared with the normal value, and the data beyond the normal range and with deviation can be determined. Using the data flow function, the fault type and fault location can be accurately judged.

Ⅳ. Fault Diagnosis of Automotive Electronic Control System Based on Data Flow Analysis

The instantaneous data values of the input and output signals of various sensors and actuators in automobile operation can be displayed on the display screen in the form of data stream through the microcomputer fault analyzer. In this way, it can be judged whether the microcomputer control system works normally according to the changes of various data of the control system during the automobile working process. Through the analysis of the acquired data stream, we can know the working state information of various sensors and actuators of the automobile electronic control system in real time, master the running status of the automobile, and judge whether the automobile electronic control systems work normally. By analyzing the change time of the acquired data stream values, we can see whether the working time limit exceeds the normal range. Time limit refers to the number of times that should occur in a certain unit time, or the state that should be reached. When the throttle is slowly opened from idle position to full open position, the intake air quantity and injection time increase uniformly with the throttle opening. When the accelerator pedal is pressed down quickly, the data value of air intake is still normal, but the data value of throttle opening changes abnormally.

When there is no fault code or the indication of fault code is wrong, read the dynamic data stream of the electronic control system through the fault diagnosis instrument, and accurately diagnose the cause and position of the fault by numerical analysis or correlation analysis of the relevant parameters in the data stream. When the fault comes from inside, the neural network module on each component can get the diagnosis result quickly and find the faulty component quickly. Figure 2 shows the framework of fault diagnosis system.

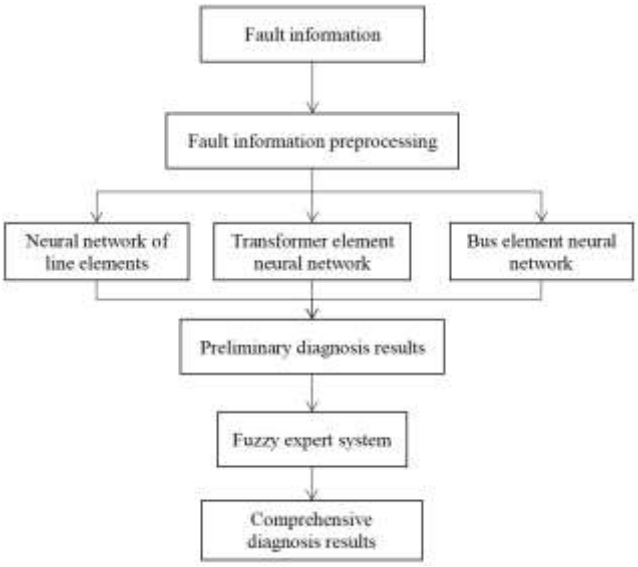

Fig.2 The Framework of the Fault Diagnosis System

After cleaning the throttle body, the angle of the engine with good performance can quickly adaptively reach the normal range even if the basic setting is not made. If everything else is normal, the mixture should become thinner when there is a large amount of intake air, but the result is that the mixture is too rich, so it is reasonable to think that there is a deviation between the intake air signal and the actual situation, resulting in corresponding changes in other data. The size and occurrence time of automobile data flow values reflect the performance and actual working state of automobile engine or automobile electronic control system, and there may be causal or correlation between the data. Therefore, mastering relevant data flow analysis methods is very effective for diagnosing the fault nature and fault location of electronic control system. In automobile fault judgment, the time analysis method is often used to judge whether the oxygen sensor signal is faulty. Because the signal of oxygen sensor requires signal voltage and voltage change, it can be accurately judged whether it fails or not through the change frequency of signal voltage. The frame structure of fault diagnosis system for electronically controlled automobile engine is shown in Figure 3.

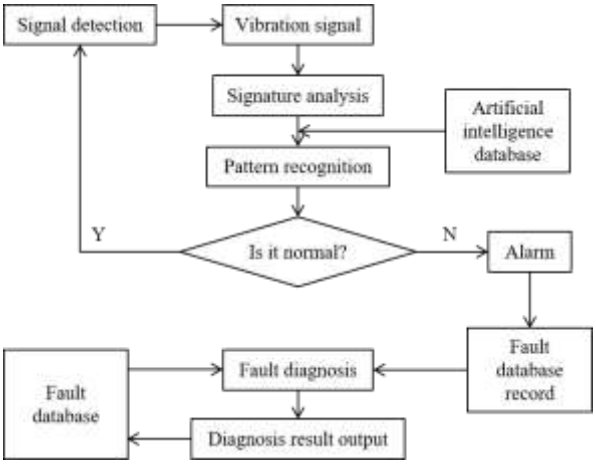

Fig.3 Frame Structure of Engine Fault Diagnosis System

When repairing some vehicle types, it is impossible to correctly judge whether a component is good or bad because there are no relevant detailed maintenance technical data and detailed standard data. In this case, it is usually possible to compare the data flow of the same system with that of the same vehicle type, and determine whether the faulty vehicle components are faulty according to the comparison results. Generally, the self-diagnosis system can only monitor the circuit signal and signal range of the electronic control system, but cannot monitor the change of sensor characteristics. The intelligent platform for fault diagnosis based on data flow analysis is shown in Figure 4.

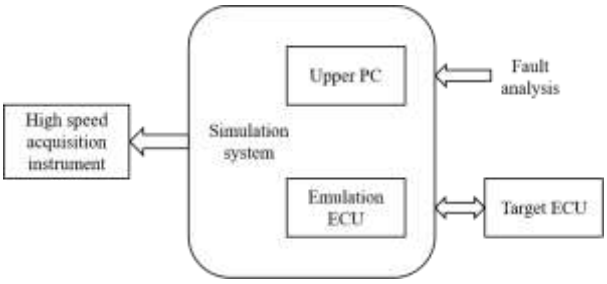

Fig.4 Intelligent Fault Diagnosis Platform

Simulated faults of various sensors, such as abnormal operation and serious deviation, cannot be detected by fault code function [13]. You cannot completely rely on this function when diagnosing faults. If the sensitivity of the sensor decreases for some reason, although the engine does have fault performance, the self-diagnosis system has no fault code output. At this time, the data flow function should be used to analyze and judge the engine fault phenomenon, so as to find and eliminate the fault. When the change frequency of signal voltage does not conform to the standard number within the specified time, it proves that it has a fault. If it is less than the standard value, it means that the response of oxygen sensor is slow. The law and range of numerical changes of the acquired data stream are analyzed, and whether the measured object is normal or not is judged by analyzing and comparing the measured values with the standard values of normal conditions. In some cases, the fault code may not be reflected, but the data flow function can be used to accurately judge the type and location of the fault. Therefore, the data flow function should be fully utilized and developed to improve the efficiency of fault diagnosis for electronically controlled vehicles.

Ⅴ. Conclusions

With the wide application of electronic technology in automobiles, there are more and more electronic devices in automobiles, and the maintenance work of automobiles becomes more specialized and more complicated. In the fault diagnosis of electronically controlled vehicles, the data flow function should be actively used while using the fault code function. Using the data flow function, the fault location can be found accurately, the loss caused by blind disassembly can be avoided, and the accuracy of fault diagnosis can be improved. If there is no fault code or the indication of fault code is wrong, the data flow can be read from the diagnostic interface of the automotive electronic control system by a diagnostic instrument, or the relevant data can be detected from the input and output terminals of the electronic controller by a multimeter and an oscilloscope, and the data flow analysis can be carried out according to the numerical value of the detected data, the correlation or causal relationship between the data, etc., so as to accurately diagnose the faults of the automotive electronic control system. It is necessary to master the analysis method of data flow, find out the cut-in point, grasp the main contradiction, and make a comprehensive analysis to make an accurate judgment. With the continuous improvement of automobile technology, the function and method of data flow function in fault diagnosis of electronically controlled automobile also need continuous research and improvement.

References

[1] Zhang Xiaolu, Yang Yujia. Application of data flow analysis in the diagnosis of automobile engine electronic control system problems. Internal combustion engine and accessories, vol. 322, no. 22, pp. 161-162, 2020.
[2] Xu Shaoyan. Experimental research on fault diagnosis of automobile engine electronic control system based on waveform and data flow. Automation and Instrumentation, vol. 241, no. 11, pp. 47-49+53, 2019.
[3] Zhao Yin. Analysis of the method of using “data flow” to diagnose electronically controlled engines in automobile maintenance. Technological Innovation and Application, vol. 155, no. 7, pp. 102-102, 2016.
[4] Mingguangxing. Application of data stream and waveform combination analysis in automobile fault diagnosis. Times Agricultural Machinery, vol. 46, no. 1, pp. 39-40, 2019.
[5] Mo Rongzhen. Research on Intelligent Detection Method of Electronic Control Vehicle Fault Based on Data Stream. New Generation Information Technology, vol. 2, no. 21, pp. 63-67, 2019.

[6] Xu Guangming. Automobile fault diagnosis technology based on fault code and data stream. Gansu Science and Technology, vol. 34, no. 18, pp. 77-78+140, 2018.
[7] Weis S, Garbade A, Fechner B, et al. Architectural Support for Fault Tolerance in a Teradevice Dataflow System. International Journal of Parallel Programming, vol. 44, no. 2, pp. 208-232, 2016.
[8] Park Zhenhua. Automotive electric power steering system warning. Farmer's staff, vol. 607, no. 2, pp. 225-225, 2019.
[9] Zeng Zhaoping. Application of Electronically Controlled Vehicle Data Stream in Failure Analysis. Management and Technology of Small and Medium-sized Enterprises, vol. 500, no. 4, pp. 174-175, 2017.
[10] Nagarajan R, Dhanasekaran R. Fault-Tolerant Wireless Communication System for Process Control in Wind Power Stations. Journal of Scientific & Industrial Research, vol. 75, no. 1, pp. 51-55, 2016.
[11] Yu Hongyan, Lin Xubin. Diagnosis and analysis of common faults in automobile fuel system. Automotive Engineer, vol. 282, no. 10, pp. 58-60, 2020.
[12] Zhou Ze. The role of data flow analysis in the fault diagnosis of electronically controlled engines. Internal combustion engines and accessories, vol. 321, no. 21, pp. 140-141, 2020.
[13] Li Zhaopeng, Zu Bingjie. Application and research of data flow analysis in fault diagnosis of electronically controlled engines. Auto Maintenance, vol. 4, no. 256, pp. 33-36, 2017.