INTELLIGENT FAULT MONITORING SYSTEM OF NEW ENERGY TRACTOR ENGINE FOR BIG DATA

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面向大数据新能源拖拉机发动机智能故障监测系统

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ABSTRACT

Tractor engine has complex working environment and many parts. In the process of use, with the increase of service mileage and working hours, parts will wear to a certain extent, resulting in some engine failures. Using modern fault diagnosis technology to know the working performance of tractor engine in time, and to judge whether each component is in or will be in any fault state, is of great importance and practical significance for the research of fault diagnosis technology theory and diagnosis system of tractor engine. Taking the engine of new energy tractor as the research object, the principle and monitoring method of engine intelligent fault diagnosis are introduced. Then, based on big data and neural network technology, the engine intelligent fault monitoring system of new energy tractor for big data is designed. The fault diagnosis system of tractor engine based on artificial intelligence and big data technology realizes the functions of database and signal analysis, which improves the real-time and accuracy of the system.

摘要

拖拉机发动机工作环境复杂，零部件多。在使用过程中，随着使用里程和工作时间的增加，零件会有一定程度的磨损，导致一些发动机故障。利用现代故障诊断技术及时了解拖拉机发动机的工作性能，判断各部件是否处于或将处于任何故障状态，对拖拉机发动机故障诊断技术理论和诊断系统的研究具有重要的现实意义。以新能源拖拉机发动机为研究对象，介绍了发动机智能故障诊断的原理和监测方法。然后，基于大数据和神经网络技术，设计了新能源拖拉机发动机大数据智能故障监测系统。基于人工智能和大数据技术的拖拉机发动机故障诊断系统实现了数据库和信号分析功能，提高了系统的实时性和准确性。

INTRODUCTION

In recent years, with the encouragement of national purchase subsidy policy, there are more and more users of agricultural tractors, which greatly promotes the rapid development of rural economy *(Jafari M. J. et al., 2020)*. Tractor engine has complex working environment and many components. In the process of use, with the increase of mileage and working hours, the components will wear to a certain extent, resulting in some engine failures *(Chen Y. M. et al., 2021)*. Tractor engine is a complex system, and its failure rate accounts for more than 90% of the total vehicle failure rate, which is the most prone component of tractor. Tractor failures are various, and the causes of failures are also complicated. A fault may show multiple signs, and one sign may reflect multiple faults *(Dong J. H. et al., 2018; Wang Yingbo et al., 2021)*. In order to avoid serious accidents, the use of modern fault diagnosis technology to timely understand the working performance of tractor engine, judge whether the components are in or about to be in what fault state, the research of tractor engine fault diagnosis technology theory and diagnosis system has a very important and practical significance *(Jhih Y. C. et al., 2021; Qiuju X. et al., 2021; Rulli F. et al., 2021)*. Agricultural tractors provide great convenience for farmers, reduce labour intensity and production costs *(Wei W. et al., 2021)*. In the agricultural production and transportation work, agricultural tractors will have a variety of faults. As tractor operators, it is very important to understand and master the causes of common faults and maintenance methods *(Yu L. C. et al., 2021)*. It is particularly important to adopt effective strategies for fault diagnosis of tractor engine to remind the driver of correct use and timely maintenance *(Cheng R. et al., 2018)*.

When the tractor breaks down, observe the fault performance, adopt specific fault detection methods according to different fault performance, determine the cause of the fault, and finally determine the troubleshooting method *(Gultyaeva E., Shaydayuk E., Gannibal P., 2021)*.

At present, the engine fault diagnosis system in our country is still lack of a universal platform integrating multiple parameter acquisition, analysis and processing, diagnosis and reasoning. At the same time, when analysing the nonlinear relationship between fault phenomenon and fault cause, the existing fault diagnosis theory cannot be simply applied to the fault diagnosis system *(Martínez-Moreno F. et al., 2021)*. In order to achieve the purpose of fault diagnosis of tractor engine without disassembly and improve the diagnosis efficiency, an artificial intelligence fault detection method based on neural network is proposed and a tractor engine vibration signal acquisition system is constructed *(Gross G. et al., 2018)*. Taking the new energy tractor engine as the research object, this paper introduces the engine intelligent fault diagnosis principle and monitoring method, and then designs an intelligent fault monitoring system for new energy tractor engine based on big data and neural network technology. When analysing the cause of failure, we should be good at thinking, observe the failure phenomenon, and analyse it in sections according to the relationship between various parts *(Jensen R., 2021)*. We should also follow the principle of simplicity to complexity, from the outside to the inside. We should first analyse the simple and superficial reasons, then consider the complex and internal reasons, first find the probable and common reasons, and then check the unlikely parts to avoid unnecessary disassembly *(Nouiri M. et al., 2018)*.

Agricultural tractors bring great convenience to farmers, reduce labour intensity and reduce production costs. However, it is inevitable that agricultural tractors will fail during operation, which seriously affects the storage and transportation. Based on this, based on the analysis of the common faults of agricultural tractors, this paper puts forward the detection and elimination methods of tractor faults. For a certain fault, there may be many reasons, but because tractor is the unity of many parts working in coordination, the organic connection between them determines that there are certain regularity in various fault reasons. Therefore, according to the specific situation and use experience of tractors, the causes of faults can be found out through scientific analysis and judgment. Using artificial intelligence can improve the analysis process and get a fault diagnosis model that can solve practical problems, thus effectively improving the accuracy and efficiency of fault diagnosis. The method in this paper can effectively diagnose the engine faults of new energy tractors, with high diagnostic accuracy, and can provide reference for engine fault diagnosis and maintenance personnel. Tractor engine fault diagnosis system based on artificial intelligence and big data technology comprehensively uses signal acquisition technology, signal processing technology, database technology, neural network technology and artificial intelligence expert system, realizes the processing function of database and powerful signal analysis, and improves the real-time diagnosis and diagnosis accuracy of the system.

In agricultural production and transportation, agricultural tractors will have various faults. As tractor operators, it is very important to understand and master the causes of common faults and maintenance methods. Literature thinks that to check the faults of tractors, we should first observe the fault phenomena, determine the main causes of the faults through analysis and judgment, and then eliminate them. Literature points out that modern fault real-time detection is a comprehensive technology, which can analyse the faults of machines by signal processing and data analysis according to the fault characteristics and vibration laws of machines. Literature points out that a fault may show multiple signs, and one sign may reflect multiple faults, which brings some difficulties to fault analysis. Literature uses big data and neural network algorithms to design a new energy tractor engine intelligent fault monitoring system. The main tasks of engine fault detection are: use the various feature indicators collected by the sensor to determine whether the machine is working in a normal state; classify the fault characteristics to accurately determine the faulty parts and provide a theoretical basis for rapid maintenance; use data Technologies such as analysis, probability theory and big data can predict engine failures and realize the health management of machinery and equipment. Literature uses field test methods to verify the rapid diagnosis system of tractor faults. The test results show that the use of artificial intelligence diagnosis method can not only effectively improve the accuracy of the system, but also the response of the diagnosis system is faster, and the stability of normal work can still be maintained in harsh on-site environments such as exposure, vibration, and dust.

MATERIALS AND METHODS

Principle of fault diagnosis

There are many types of faults in agricultural tractors, which generally include five aspects:

1) Abnormal appearance. The exhaust emits black smoke, white smoke or blue smoke, the tractor leaks oil, air and water, the front wheel swings while driving, and the lights flicker. 2) Abnormal sound. Abnormal sound, knocking sound, air blasting sound, hoarseness of horns, etc. 3) Abnormal temperature. Overheating

of engine, overhigh temperature of cooling water, overhigh oil temperature of gearbox or rear axle, overheating of brake, etc. 4) Abnormal consumption. Excessive consumption of fuel oil, engine oil and cooling water, abnormal increase or rapid decrease of oil level in oil pan, etc. 5) Abnormal function. Difficulties in starting, difficulty in shifting or shifting gears, steering and braking failure, etc.

With the rapid development of mobile Internet technology, artificial intelligence, big data technology stand in the development of tuyere, more and more big data application services emerge. For such a complex tractor system, a small part problem may affect the operation of the whole machine. As the core of the whole system, the engine is easy to be damaged and led to serious mechanical failure. Through the observation of the tractor's appearance, if there is any abnormality, such as the tractor inclines on the flat road, the tire has abnormal wear, scratches, and parts are lost, the operator should be alert. No matter what part of the component, no matter what degree of failure occurs, it will lead to the change of the whole system function, and this change will be directly reflected in the change of parameters. When you feel that the temperature is too high during driving, or when you stop halfway for inspection, if you touch the temperature of various parts of the vehicle abnormally, such as the brake drum, tire, rear axle housing, transmission housing, etc., the temperature makes your hands unbearable, which indicates that the tractor is faulty. The clearance of each part of tractor has its standard value. If the clearance is too large or too small, it indicates that there is a fault. All kinds of oil consumption of tractors have a standard range. If the oil consumption increases obviously, the tractor has hidden faults. Because of the huge tractor system, the parameter information in the running process will be very complex, so in fault diagnosis, we should first extract useful fault features and remove useless parameters. Because the fault cannot be directly judged according to the extracted characteristic parameters, it is necessary to further analyse the parameters and extract the fault symptom information. With the above foundation, fault types can be identified and classified. The fault diagnosis process is shown in Figure 1.

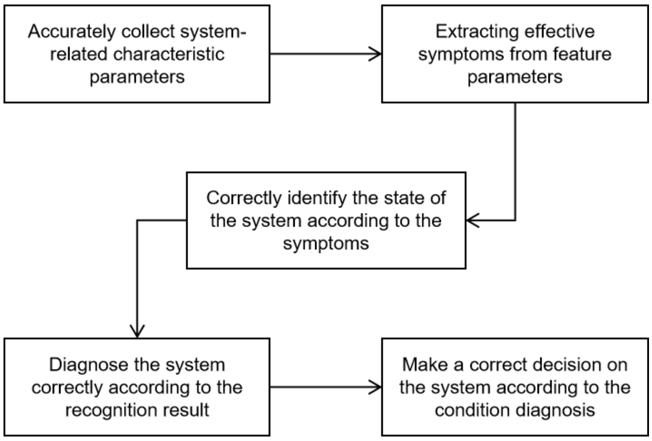

Fig. 1 - Schematic diagram of fault diagnosis process

In order to improve the accuracy of tractor engine fault diagnosis, based on the classification of big data, this paper uses neural network to analyse and judge it. The process of fault diagnosis is complicated, and the most important thing is to diagnose the fault state of the system according to the fault symptom.

Most of modern agricultural tractors use electronically controlled multi-point fuel injection engines, and engine failures, especially cylinder failure, are generally caused by oil or fire failure of one cylinder of the engine. In engine fault detection, the fault of engine can be judged by analysing the characteristics of vibration signals. For tractors, during their operation, the parameters such as heat and vibration will change continuously. Sensors are used to collect these pieces of information, including vibration frequency, displacement of machinery and equipment, instantaneous engine speed, acceleration, temperature, voltage and current, etc. If the tractor has faults, the fault information can be extracted from these parameters. Signal processing mainly includes the use of Fourier, wavelet and other methods to amplify, denoise, transform and other processing. In engine fault detection, due to the influence of noise background in test signal, data redundancy will be generated. The speed and accuracy of engine fault diagnosis can be effectively improved by using artificial intelligence database algorithm. The design framework is shown in Figure 2.

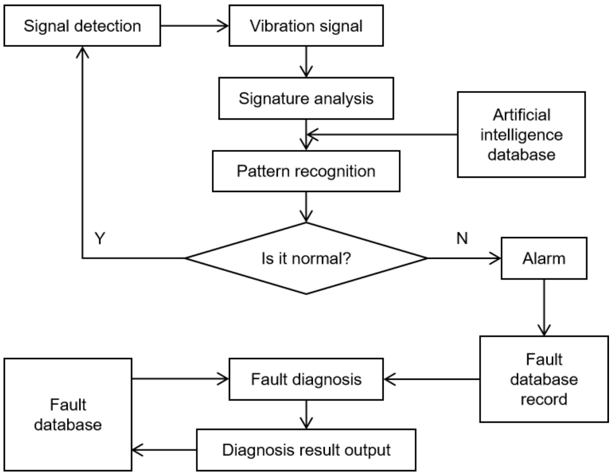

Fig. 2 - The framework of the engine fault diagnosis system

The trained neural network model is used to detect the special diagnosis of known faults, and the known faults and the detected faults are compared to judge whether the model is accurate or not. When the engine is found to have faults, if the engine has faults, the fault experience database of artificial intelligence database can be used to identify the types of faults.

Engine fault diagnosis framework is mainly divided into signal detection, signal recognition, feature analysis, artificial intelligence database and fault database. Among them, signal collection and analysis is the main part of fault analysis system, and the efficiency of pattern recognition can be improved by using artificial intelligence database. When the machine is in normal operation, it is necessary to predict and judge the state of the machine in a certain time in the future through a series of parameters. In the process of fault identification and classification, according to the collected fault symptoms, various identification algorithms and models are adopted to carry out accurate fault diagnosis. The common faults of fault diagnosis system can be analysed by virtual simulation, and the experience database of diagnosis system can be established by using the results of simulation analysis, at the time of diagnosis. When there is a fault signal, the signal characteristics and fault information are compared quickly to get the signal diagnosis results. Figure 3 shows the structure of artificial intelligence virtual platform for fault diagnosis.

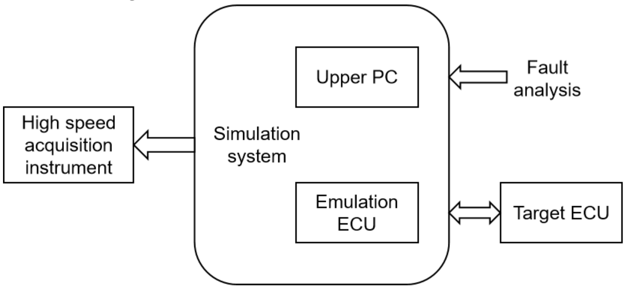

Fig. 3 - Fault diagnosis artificial intelligence virtual platform structure

The main signals collected in tractor engine fault diagnosis are speed and vibration signals. After these data are processed, the subroutine of algorithm can be used to judge the fault type.

Detection method of tractor fault

Sensory identification method mainly refers to judging the fault location of tractor through sensory organs without using other measuring tools and instruments. In order to achieve this, we need the appraisers to accumulate rich experience. The appraiser mainly judges the colour, water and oil of tractor exhaust by looking at it to see if there is water leakage, gas and oil; Through ear listening, it is mainly to judge the sound after the tractor when it is started, and check whether the sound of the chassis is abnormal; Judging the temperature of tractor body by hand touch, whether the body runs flexibly; Judging whether there is burnt smell or abnormal smoke exhaust smell during tractor operation by sniffing.

The comparative method is to check the same parts, that is, to replace them again, in order to compare the changes of parts before and after checking to judge whether the replaced parts are in normal condition. If it is suspected that the fuel injector, oil pressure gauge and other components are not working properly, they can be replaced with good technical status for comparison to determine whether the components are normal. If there is a problem with the tractor injector components, the adjustment method should be used to compare the technical status of the operation to determine whether the components are operating normally.

The method of test and proof is to use the working method of changing a certain position or observe the change of the fault in the working state, and judge the fault position directly. For example, the diesel engine cannot be started normally. It is suspected that the cylinder sleeve and piston have worked for a long time, which leads to serious wear and abnormal compression. The cylinder and piston need to be checked to see if the wear is not working properly due to long-term operation. To judge whether this is the case, a small amount of engine oil can be injected into the cylinder, and the compression performance can be checked after several revolutions. If it is determined that this is the reason, a small amount of engine oil can be injected into the cylinder to check whether the compression performance is good after running several times.

Intelligent fault diagnosis method

Intelligent algorithm based on confidence weight and artificial neural network is the most commonly used artificial intelligence algorithm at present, but there is little research on tractor fault diagnosis. It is a new attempt to use artificial intelligence algorithm in engine fault diagnosis. In order to find out the faults, necessary inspection means and methods should be provided. The state of tractor is related to environmental temperature, pressure, machine vibration frequency, voltage value, current value and other parameters, and this relationship is very complex, so it is necessary to use neural network for fault diagnosis of tractor uncertainty. Through observation, understand the main phenomenon of the fault, but also in-depth and detailed analysis of these phenomena, in order to determine the location and cause of the fault. After using big data to construct fault features, neural network can be used to identify and judge them. The diagnosis architecture of tractor transmitter based on big data is shown in Figure 4.

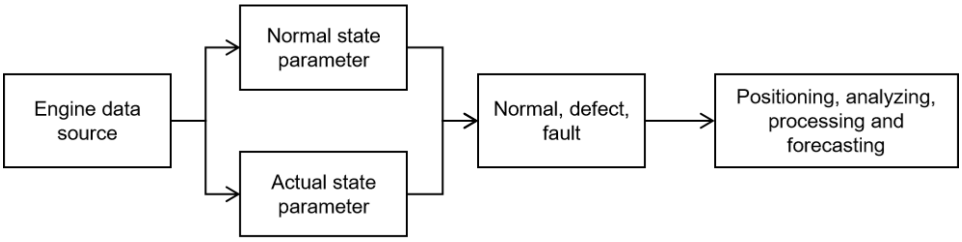

Fig. 4 - Tractor transmitter diagnosis architecture based on big data

Neural network is a mathematical model established by researchers to simulate human brain thinking and analysing problems. It uses the methods of gradient descent and weight updating to obtain the minimum error function. Using neural network subnet, tractor engine faults can be measured from different aspects, and local information fusion can be completed. Using information fusion decision neural network, the diagnosis results of subnet can be output. The fault parameters of tractor engine mainly include fuel supply time, fuel injection pressure, sealing of plunger pair and outlet valve, which are also included in the vibration signal of engine. After repeated learning and training, a set of weights is generated to call the test samples, so as to predict the characteristics of the target object. The structure of neural network model is shown in Figure 5.

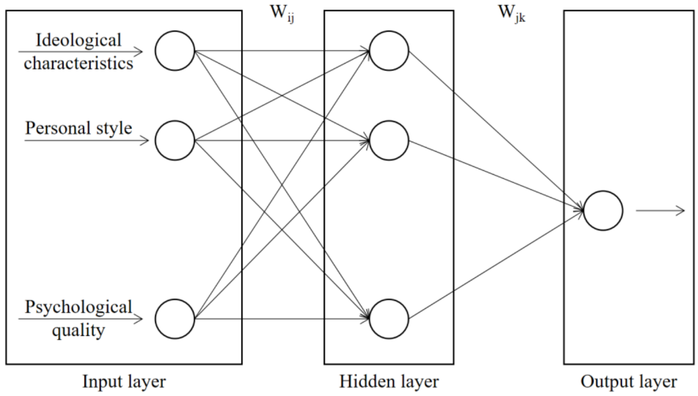

Fig. 5 - Comprehensive quality evaluation model

A three-layer BP network can be used to complete any n-dimensional to m-dimensional mapping. The number of neurons in the hidden layer $s=\sqrt{n+m}+a$, where n and m are the number of nodes in the input and output layers, respectively. The activation function of the hidden layer neuron is selected as the hyperbolic tangent function, and the function form is:

$$f(x)=\frac{e^{x}-e^{-x}}{e^{x}+e^{-x}} \tag{1}$$

The activation function of the output layer uses the Sigmoid activation function, and the form of the function is:

$$f(x)=\frac{1}{1+e^{-x}} \tag{2}$$

The induced local domain of a certain neuron j in the hidden layer is:

$$v_j(p)=\sum_{i=1}^{n} w_{ij}x_i-\theta_j \tag{3}$$

The induced local domain of a certain neuron k in the output layer is:

$$v_k(p)=\sum_{j=1}^{s} w_{jk}v_j(p)-\theta_k \tag{4}$$

In which n and s are the number of neurons in the input layer and the hidden layer respectively. In engine fault diagnosis, multisensor can be used as integrated neural network. In actual fault diagnosis, information fusion includes local fusion and global fusion, so neural network can also be in series and parallel. In order to find out the main reference that affects the performance, the neural network learning method of artificial intelligence and nonlinear mapping can be used to establish the model of engine parameters and performance evaluation. Each neuron can receive the signal from the upper layer, and after processing, it can output the result to the next layer through a related function. Therefore, a neuron can be regarded as a mathematical function with certain analysis, and a neural network is composed of numerous such networks. The system uses signal acquisition technology, signal processing technology, neural network technology and artificial intelligence expert system to realize the rapid and accurate judgment of engine fault.

RESULTS

Tractor working environment is complex, and noise is the main factor affecting signal fault diagnosis. Therefore, tractor engine fault diagnosis system firstly classifies the original training samples by using dynamic clustering artificial intelligence method, and obtains different groups. Then, the classified samples are trained in the subnet of neural network, and the corresponding weights and thresholds are obtained to form the empirical knowledge base of engine fault diagnosis. Figure 6 shows the fault detection process of tractor engine based on artificial intelligence and big data.

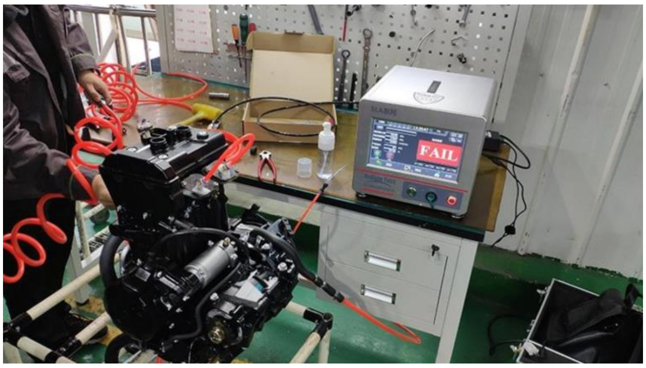

Fig. 6 - Failure detection of tractor engine

The decision algorithm of the confidence weight database is adopted for the judgment of the engine fault type. The basic principle is to assume that the artificial neural network forms a fault vector $G=[G_{1i}, G_{2i,...}, G_{mi}]$. Its confidence weight vector for engine failure is $Z=[Z_{1i}, Z_{2i,...}, Z_{mi}]$., then the parallel combination of subnets is $N_n=[NN_1, NN_{2,...}, NN_m]$., thus forming the fault matrix G and the confidence weight matrix z, and the confidence matrix is assigned to each subnet, namely:

$$G=\begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1m} \\ g_{21} & g_{22} & \cdots & g_{2m} \\ \cdots \\ g_{n1} & g_{n2} & \cdots & g_{nm} \end{bmatrix} \tag{5}$$

$$z=\begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & g_{2m} \\ \cdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \tag{6}$$

The fusion output is:

$$Y = G \cdot R \tag{7}$$

Therefore, the probability of occurrence of the i-th fault is:

$$g_i = g_{i1}z_{1i} \hat{+} g_{i2}z_{2i} \hat{+} \ldots \hat{+} g_{in}z_{ni} \tag{8}$$

For the decision fusion of the two sub-networks, the fusion result is:

$$g_i = g_{i1}z_{1i} \hat{+} g_{i2}z_{2i} \tag{9}$$

Since $g_{i1<1}, z_{i1<1}, g_{i1>} g_{max} = g_{i1} z_{1i}$, so we can deduce:

$$g_{i1} > g_{\max} = \max\{g_{i1}z_{1i}, g_{i2}z_{2i}, \ldots, g_{in}z_{ni}\} \tag{10}$$

The final output result can be expressed as:

$$Y = \max\{g_i\} \tag{11}$$

Or any fusion result g_i that is larger than a certain threshold may fail, so the fault detection of tractor engine can be realized by using this principle.

The neural network of tractor engine fault is trained by gradient method. After 3000 iterations of training, the actual calculated network error will be obtained. The sample training is shown in Table 2.

Table 1

Training results of neural network samples

Fault	**Output node**				
	1	2	3	4	5
Blocked oil path	-0.015	0.184	-0.005	-0. 028	-0.113
Fuel injector failure	1.036	0.255	0.041	0.017	0.252
Tubing rupture	-0.121	0.788	0.005	0.019	0.211
The flywheel is stuck	-0.033	0.122	0.354	0.011	0.125
Air pump channeling oil	0.028	-0.355	0.003	1.051	-0.552
Piston wear	-0.019	0.327	O.251	-0.004	0.666

The field test is to verify the tractor in the real working environment, test the performance of the tractor engine fault diagnosis system, test the overall performance and reliability of the system, and finally realize the practicability and accuracy of the tractor engine fault diagnosis system. As shown in Figure 7, in the field test, the light will have a certain impact on the LCD display of the engine fault diagnosis system, resulting in the display is not clear, so the time period with weak light in the morning and evening is selected.

Fig. 7 - Schematic diagram of field acceptance experiment

In order to verify the reliability and stability of the intelligent fault monitoring system for new energy tractor engines facing big data, 10 new energy tractor engines with faults were diagnosed and analysed. A fault signal collected from new energy tractor engine is shown in Figure 8.

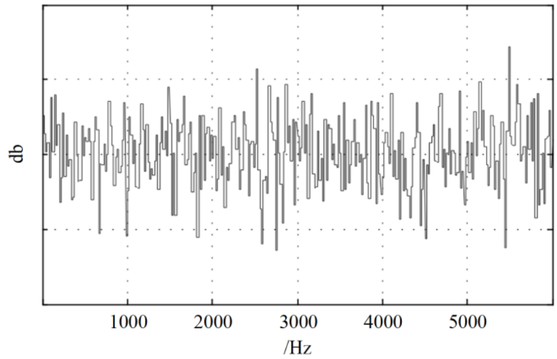

Fig. 8 - The original data of the fault signal

In order to overcome the influence of noise on the experimental results, the artificial intelligence filtering method is used to filter the experimental signals. In the aspect of engine fault signal edge extraction, the wavelet transform has the characteristic of adjustable time-frequency window to approximate any detail part of the signal, and the edge signal and noise are gradually separated by multi-scale. First, the signal is decomposed by two-dimensional wavelet:

$$f(x,y)=f_0(x,y)=f_J(x,y)+\sum_{i=1}^{J} g_j(x,y) \quad (12)$$

f_J is the projection of $f(x,y)$ on space V_J^2 , and:

$$g_j(x,y)=\sum_{k,m}\left[d_{j,k,m}^1\varphi_{j,k}(x)\psi_{j,m}(y)+d_{j,k,m}^2\varphi_{j,k}(x)\psi_{j,m}(y)+d_{j,k,m}^3\varphi_{j,k}(x)\psi_{j,m}(y)\right] \quad (13)$$

$j=1,\ldots J$ is the details in three directions.

Then establish the correlation coefficient $\omega_{j,k,m}^1$ and $d_{j,k,m}^1, d_{j,k,m}^2, d_{j,k,m}^3$ for dynamic comparison, select the three-direction wavelet coefficients to filter out the noise, and then perform edge extraction. After signal processing, the signal shown in Figure 9 is obtained.

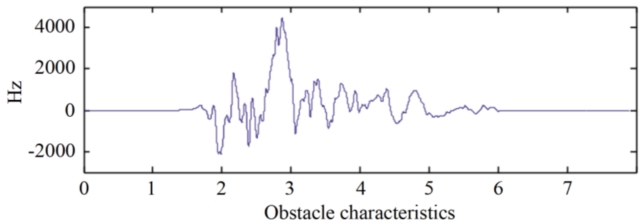

Fig. 9 - Data after fault signal processing

After using neural network algorithm for fault diagnosis, the fault diagnosis results shown in Table 2 are obtained.

Table 2

Fault diagnosis results

Fault	Diagnostic results	Actual results	Accuracy (%)
Blocked oil path	2	2	100
Fuel injector failure	7	5	100
Tubing rupture	3	2	100
The flywheel is stuck	3	3	100
Air pump channeling oil	5	6	100
Piston wear	3	2	100

It can be seen from the table that the intelligent fault monitoring system for new energy tractor engine facing big data can accurately diagnose faults, and the diagnosis results are consistent with the actual results, which can provide reference for engine fault diagnosis and maintenance personnel. Wear and oil leakage occurs at the joint of the convex head at both ends of tractor high-pressure oil pipe, fuel injector and oil outlet valve. A round copper skin can be cut from the waste gas cylinder pad, and a small hole can be pierced in the middle for grinding and sliding, so that the urgent need can be solved by placing it between convex pits. In this experiment, artificial intelligence method was used to process the acquisition results, and the curve of diagnosis results at high resolution was obtained. The test results show that the panel of the engine fault monitoring system can display the result curve of tractor engine fault diagnosis in real time, which verifies the feasibility and correctness of the fault diagnosis monitoring algorithm. Using artificial intelligence diagnosis method can not only effectively improve the accuracy of the system, but also make the diagnosis system respond more quickly. In order to solve the problem that the engine oil pump can't pump oil at the first start of the locomotive after overhaul, the oil filter or oil outlet pipe should be removed, and then the oil injector should be used to fill the oil from the oil outlet hole of the locomotive body. The oil filter or oil pipe leading to the oil indicator should be installed immediately, and the oil will pump up after starting. From the whole experiment, it is found that the tractor engine fault diagnosis system can achieve stable working state in the whole working cycle, and can still maintain normal working stability in the harsh field environment such as exposure, vibration and dust.

CONCLUSIONS

Tractors are widely used. In agricultural production, tractors and farm tools can complete farmland operations such as ploughing, raking, sowing, intertillage and harvesting. In addition, tractors can be used for farmland capital construction such as ditching, bulldozing and levelling, and can also be used for agricultural transportation, as well as fixed operations such as pumping threshing and processing of agricultural and sideline products. In agricultural production, increasing the number of agricultural tractors and improving their quality, and strengthening the management and maintenance of tractors during operation are conducive to the further development of agricultural mechanization in China.

In order to overcome the technical difficulties of tractor engine fault detection under strong noise background and improve the accuracy and detection efficiency of engine fault diagnosis, an artificial intelligence fault detection method based on neural network is proposed, and a tractor engine vibration signal acquisition and fault analysis and processing system is constructed. Taking the engine of new energy tractor as the research object, the principle and monitoring method of engine intelligent fault diagnosis are introduced. Then, based on big data and neural network technology, the engine intelligent fault monitoring system of new energy tractor for big data is designed. Using artificial intelligence diagnosis method can not only effectively improve the accuracy of the system, but also the response of the diagnosis system is faster and the adaptive ability to the environment is stronger. The system can effectively diagnose the engine fault of new energy tractor, and the diagnosis accuracy is high, which can provide reference for engine fault diagnosis and maintenance personnel. The increase of tractor quantity, the improvement of tractor quality and the reasonable use, maintenance and management are of great significance to the realization of Agricultural Mechanization in China.

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