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Research Article

Intelligent Vehicle Engine Dynamic Test System Based on Internet of Things

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In the context of technological modernization in the field of automotive engine testing, the development of an intelligent automotive engine testing system based on IQ has become an important trend in the future. This paper mainly studies the development of engine test software platform, the technical control of test process conditions, and the intelligent conversion of important components such as temporary fuel flow meters. By comparing the traditional bench test system and the dynamic test system based on the Internet of Things, the efficiency of data information transmission, information security, perception ability, and response speed between them are compared, and the intelligent dynamic engine detection based on the Internet of Things is found. The system is more secure and more efficient in information transmission, with a 12% increase in perception performance and a 48% increase in system response time. This also fully shows that the intelligent dynamic engine detection system based on the Internet of Things will be more suitable for current equipment and can also be detected more accurately, which can realize effective supervision of the running status of the test prototype and remote online feedback of the analysis results, and solve the engine test process. It solves the problem of efficient, reliable, and safe transmission and transmission of data and information between all levels and layers, and improves the ability of rapid perception and response in the process of engine testing.

1. Introduction

Automotive engine testing technology is an important part of the automotive manufacturing process and one of the most complex parts testing technologies. There are many technologies for automobile testing, including voltage, current, resistance testing, internal environment testing, and connector testing. In recent years, integrated network technology has gradually entered people's field of vision with its fast information transmission speed and flexible management methods. Shared networks are an essential part of next-generation IT. IoT connects sensors, controllers, machines, people, and things in new ways through intelligent detection, identification, general information, and other communicating sensor technologies. It uses the local network or the Internet to create a network of people and things, things, and computing, and also creates remote control and intelligent control. With the growing maturity of network sensor technology, Google's development of an intelligent engine test system is based on an important trend and technological modernization background for future automotive engine testing.

The engine dynamic detection system needs to conduct experiments through the engine bench and evaluate the performance, economy, power effect, reliability, etc., of the engine through the experimental data. The engine bench experiment is also the most basic test platform and also needs to test oil, coolant, windshield washer dose, radiator, clutch, brake pump, etc. Because of the engine interior, the situation is changeable and complex, there are many experimental items, and there are many related parameters. The performance requirements for the engine bench will be relatively high, high accuracy and high-frequency acquisition are required, and the test bench needs to be adjusted in the control system.

In this paper, through the steps in the engine test, the development of the engine machine detection system is established, the technical state management in the test and the fuel consumption meter in the operation are the focus, and the research is carried out to establish a more efficient and convenient system. Various dynamic parameters inside the engine can be collected accurately and quickly, and various attribute information of the engine can be extracted from the database and analyzed, such as hydraulic pressure, cold temperature, ignition time, tire pressure, cylinder operating parameters, and fuel consumption to further improve the level of engine performance testing in China and lay a solid foundation for the development of engine products. In the comparison of the two systems, the performance perception of the system has been improved by 12%, and the response time has also been greatly improved.

2. Related Work

As human beings enter the era of intelligence, the use of artificial intelligence is gradually increasing smartphones, TVs, monitoring, etc., as well as the use of safety, and the increase in traffic accidents in daily life has caused people to be concerned about the safety of cars and lives. The development of intelligent driver assistance systems is becoming an important part of the structure of future intelligent transportation systems, with the goal of reducing the number of vehicles, traffic accidents, and their subsequent fatalities. The parameters derived from this intelligent system are the safety and comfort of the passengers. In this context, Moussaid and Toumanari propose intelligent braking system (IBS) by improving anti-lock braking system (ABS) technology. It can protect people's life safety and reduce the incidence of accidents. The simulation idea adopts the switching action of IBS and ABS mechanism to simulate the actual traffic situation [1]. Kishore et al. propose a compact wideband mmWave antenna for intelligent transportation (ITS) applications. The antenna uses coplanar waveguide feeding technology to achieve bandwidth. The proposed antenna operates at the resonant frequency of 79 GHz with a large bandwidth of 78.2 GHz. The measured gain of the antenna is 17.5 dBi. The proposed antenna is well suited for short-range radar (SRR) applications and technologies [2]. Andreev et al. proposed the application of intelligent engineering concepts to cyber-physical production systems (CPPS). Engineering to optimize the production process chain is becoming an important competitive factor. In this context, industrial companies are faced with the problem of producing customized and efficient products. Through the application of smart factory CPPS, the problem of improving economic efficiency can be ensured. Smart factories aim to plan CPPS to ensure that products are produced according to individual requirements at target costs [3]. However, this is rarely used in intelligent vehicles, especially in the engine dynamic test, and there is almost no introduction.

The development of the Internet of Things represents the development direction of the informatization of the entire society. As far as the communication industry is concerned, the long-term development goal is to achieve seamless connection and communication between people. The essence of the Internet of Things is industry informatization. The driving force for governments to vigorously promote the development of the Internet of Things is to find new economic growth points and create jobs. In this context, operators have become important promoters of the Internet of Things worldwide. Operators will gain huge benefits from the development of the Internet of Things and at the same time lead the entire communication industry to develop in a more in-depth direction. In the future, the in-depth development of the Internet of Things in more industries needs to be driven by innovative models. The current technology is developing rapidly, and the use of dynamic test systems has gradually increased. In order to accurately analyze the penetrating overload signal, Liu F proposed a dynamic test system with low power consumption and high load. The system can withstand an overload signal of 2×10 g. In order to achieve the characteristics of high sampling rate, low power consumption, and shock resistance, the system uses a silicon crystal oscillator as the main oscillator and a low-power CMOS chip. When the system starts working, the processor goes into deep sleep mode and starts powering the peripheral circuits when it enters transmit mode. When the missile launches a signal, the hysteresis trigger circuit will generate a trigger signal, thereby starting the acquisition system for data acquisition. Experiments show that this scheme can prolong the life cycle of the missile and accurately collect the overload signal of the air gun [4]. Inter-regional oscillations are most detrimental to the synchronization integrity of interconnected power systems. This damage comes from their broad spectrum and participant generators. Intrinsic damping associated with inter-regional oscillations, leaving potential for widespread outages, Fayez et al. explored the effect of a strategic dynamic braking intervention based on interval model fuzzy logic on a dual braking model to eliminate the danger of power oscillations between the negatively damped regions of the two Kundur regions, and they used in a test system MATLAB/Simulink environment. By analyzing the effects of the four perturbations on performance, the unstable nature of the system response is clearly detected. The system oscillatory behavior is stabilized in an appropriate manner. The performed nonlinear time simulation results highlight the great potential of the proposed scheme in mitigating inter-regional power oscillations [5]. In order to improve the dynamic accuracy of five-axis machine tools, Song et al. proposed an evaluation method based on the specimen and comprehensive evaluation (CE) system. Compare the frustum and S specimen in ISO 10791-7 to show their ability to reflect dynamic accuracy and build kinematics and dynamic simulation models to influence the effect of various dynamic factors on the S specimen. The relationship between dynamic factors and S specimens is applied to the construction of CE system. The data and dynamic accuracy of the system can reach the standard value through construction, and the accuracy can be affected by adjusting the offset of the machine tool. Finally, it is concluded that the dynamic accuracy of the five-axis machine tool can be improved by adjusting

[6]. The deep rock mass is a massive hierarchical structure, which plays an important role in the nonlinear dynamic behavior of rock. Jiang H developed a test system to study the dynamic properties of deep rock masses. The test system is mainly composed of a loading device and a measuring system. In the loading device, the vibration exciter is used as the power source, and various forms of dynamic and static loads such as horizontal static load, horizontal impact, and vertical impact are applied to the structural system composed of rock blocks. The test results show that the test system has reasonable design, convenient operation, and high measurement accuracy; it can be used to study the nonlinear rock mechanics phenomenon of massive rock mass [7]. The dynamic test system plays a huge role in various fields, and its application in intelligent vehicle engines is also in urgent need of development. There are many kinds of vehicle engine testing systems, such as emission testing and fuel consumption testing. The testing system is a system fully controlled by computer integration. Different data analysis is performed on different experimental projects in order to derive more detailed studies, finding out their differences, and control them by computer.

3. Development and Management of Test Systems

3.1. Requirements for Dynamic Test Conditions. The engine dynamic simulation test shall include dynamic process and vehicle simulation. A dynamic process or execution state is a function of time. In vehicle simulation, an engine test bench should be used to simulate the operation of the vehicle and wheels, not the engine mathematical model. In other words, apart from the real engine, the rest of the power transmission system is virtual. Compared with the vehicle axonometric conditions and the actual vehicle road test conditions, the vehicle simulation test conditions have unique characteristics and advantages. The vehicle simulation test has more real data and is suitable for the scene. The test environment has both the vehicle axonometric environment and the road environment. The traditional bench testing system mainly tests the instrument. The test is relatively simple, the function of the instrument is relatively single, and it is easy to have compatibility problems with other running equipment. The incompatibility between the instrument and the instrument will easily lead to low test performance of the engine bench and weak expansion, make major changes, or rebuild [8]. From the perspective of detection accuracy, the traditional test system is recorded by personnel, and the existing errors will be too large, resulting in inaccurate data and affecting experimental judgment. Naturally, the accuracy will not be too high, and the adaptability of its own system is too poor, not to a high degree. The current advanced intelligent equipment can meet the requirements of the experiment, but the equipment price is too high, resulting in less application in the detection system. At present, the engine performance test in the research and development is mainly to test the electric power. Products are usually tested with eddy current sensors in the factory inspection, but there are also a small number of manufacturers that use water eddy current tests. The dynamometer is the basic unit of the engine test bench, and its main technical parameters are shown in Table 1. There are still quite a lot of domestic tester manufacturers, but not many have high precision and meet the requirements. The market urgently needs high-intelligence and high-precision engine performance testing equipment. With the rapid development of the times, the requirements for engine electronic control technology are getting higher and higher, the sensors also need to keep up with the needs of the times and be updated or upgraded, the data storage, sorting, and accuracy of the electronic control technology are quite strict, and the sensors also need to be more precise. At present, most of China's sensing equipment comes from foreign companies. Because they do not have independent intellectual property rights, they cannot design high-demand sensors. Especially in terms of intelligence, the data obtained are basically a blank sheet of paper. With the progress of the current market, some companies that produce sensors have appeared in the market. The sensors produced are generally used in relatively poor environments, such as high temperature, high pressure, and other environments, and these sensors mainly detect engine speed, internal air pressure, temperature, instrument panel data, etc. The equipment still does not meet the requirements, the performance, accuracy, product quality, and reliability are relatively low, and the technology in these areas needs to be improved urgently.

As a complete emission testing system, the system measures computer engine parameters for simultaneous production and documentation. After the test is complete, the data can be edited and the test report published. The data module is a standard excel that can be used to download map analysis. The results of the package test and the results of continuous measurements (each exhaust speed, torque, power, exhaust temperature, vehicle speed, concentration, and flow) shall be provided. Continuous analysis of raw exhaust gas, continuous analysis of diluted exhaust gas, and general analysis can be performed. It can compensate for the time delay caused by the pipeline and control the catalytic conversion efficiency. The system software supports standard test cycles [9] (e.g., mock type I test cycle table and standard static test 13 as specified in the standard appendix) and defined user test cycles [10]. Software for simulating and evaluating relevant emission control standards includes equipment for validating test procedures, equipment for detecting emissions, and equipment for fully automatic monitoring and detection. Test reports can be created in predefined or user-defined formats. The control, data acquisition, and processing software used by the system must work on Windows 98. The testing process is fully automatic under computer control and can perform automatic testing (including automatic CO control and full flow particle sampling system), automatic calibration, automatic cleaning, automatic leakage control, automatic linearization control, automatic test status control, etc. [11].

Table 1: Comparison of main technical parameters of various dynamometers.

Dynamometer type	Hydraulic dynamometer	Eddy current dynamometer	AC power dynamometer	DC power dynamometer
Manufacturer	Hangzhou Keyi	South peak	Schenk	Schenk
Series model	WE	CW	DYNAS2	GS
Nominal power (kw)	110	100	120	120
Nominal torque (N.m)	380	320	270	390
Rated speed (rpm)	5500	6400	9600	8100
Torque measurement accuracy	±0.3FS	±0.3FS	±0.3FS	±0.2FS
Response characteristics	0–100% (0.4 s)	0–100% (0.3 s)	0–100% (0.5 s) 24000 rpm (s)	0–100% (0.4 s) 6440 rpm (s)
Moment of inertia ($n.m^2$)	0.38	0.25	0.32	1.02
Brake (drive bidirectional function)	Only brake function	Only brake function	Brake (drive bidirectional function backward drag control)	Brake (drive bidirectional function backward drag control)

3.2. Development of the Test System. Any product needs to undergo a number of tests before entering the market, and the engine is no exception. The engine needs to undergo durability testing, calibration testing, high-intensity temperature difference shock testing, engine emission testing, etc., to verify whether it meets the entry requirements and market demand [12]. In the process of engine research and development, it also needs to spend a sum of money. The direction of consumption is mainly in the testing equipment and verification services, and the cost accounts for nearly half of the total capital, so as to achieve high-precision, high-efficiency, and high-intelligence detection of engine performance indicators. It is very important to reduce product production time and reduce cost. The high-precision, high-efficiency, and high-intelligence detection engine can reduce the cost of enterprise expenses, reduce the running time of the instrument, improve the detection efficiency, and improve the system. According to the requirements of the test system, the test system is developed on the basis of dynamic theoretical data and actual operation data. The test system needs to have test process, console, data storage, parameter formulation, and other related data, so as to realize the control of these basic modules. The system can also create new modules by itself, edit the modules, and integrate them according to the same data, so as to realize the parameter cycle [13]. Doing so can ensure data stability within the module and increase system stability. All the designs of the system are designed in order from small to large. In the design, the versatility of various parameters is realized, which meets the dynamic testing requirements in the system design, and the shared program is implanted, so that the main application programs can be shared. The software platform is mainly composed of computer, card board, main control software, interface layer, and actual running software. Different software deals with different system problems. The main control software can manipulate the test and display the resulting data, as shown in Figure 1. The interface layer is mainly to form a connection between the main control software and the actual running software, and realize the intercommunication of data through the Dll interface [14].

3.3. Technical Status Management during Testing. At present, there are still many problems in engine testing, such as the validity of test data, the accuracy of data collection, and the problem of system management [15]. Traditional engine system testing has been unable to meet the current research and development needs of high-tech products, the traditional engine system test data error is large, the calculation is not accurate, and the data transmission is prone to problems. In this paper, the state of the engine during testing is managed and the entire system is planned according to a new model to ensure that the data of the engine during testing are as accurate as possible. According to the data parameters under management, the model can output information data stably, and this technology mainly combines the Internet, computer, and database to build models, so as to ensure high-precision sensing and implement remote control under multi-layer distribution [16]. In this way, it is possible to more accurately understand the data in the engine during the test, basic data such as fuel consumption, temperature, engine internal pressure, and coolant temperature. Transmit the data through the sensor, and transmit the data to the control system. Through the display function, the user can intuitively see the various data in the engine test. The environment, images, and other information can also be fed back through the remote server to achieve efficient transmission of information during the test. And the data are accurate and reliable, which solves the problem of low reliability in traditional detection systems and realizes fast perception and response [17]. The device data model is shown in Figure 2.

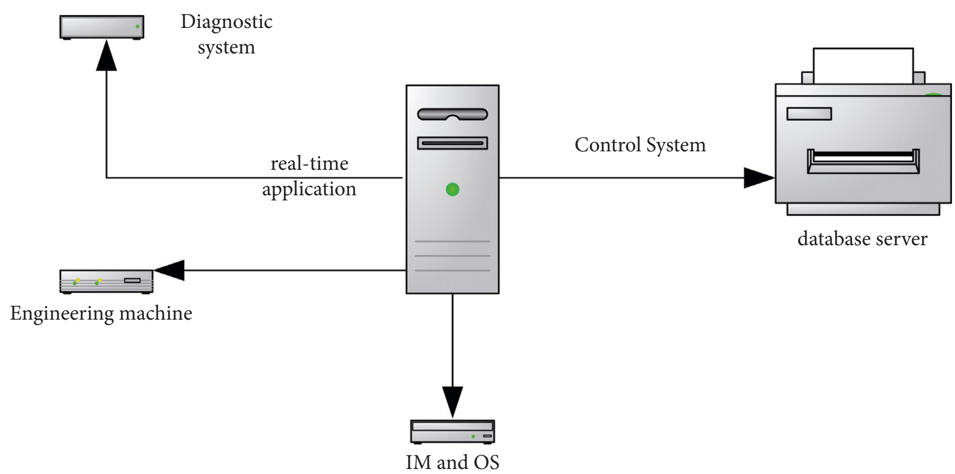

Figure 1: Development principle of test system platform.

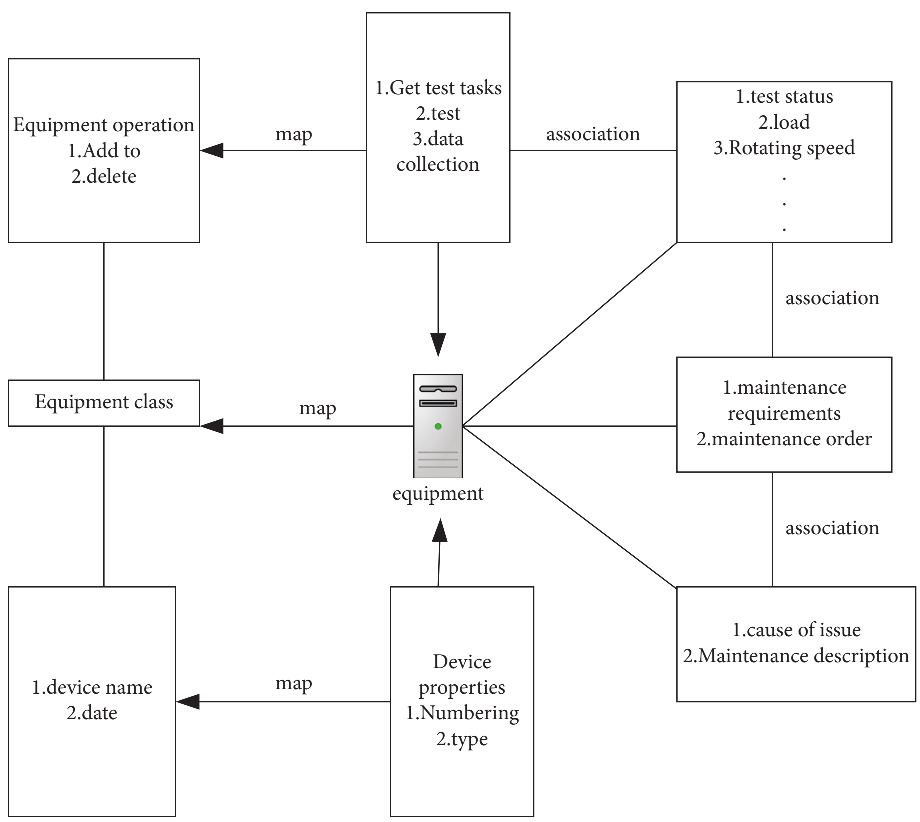

Figure 2: Device data model diagram.

Among them, the data acquisition system of the engine test bench is shown in Figure 3. The data acquisition system includes the instruments required for the test, the host computer, and the mobile terminal [18]. In the real-time test, the equipment to be tested is connected to the computer through the network, so that the computer can integrate various data. These instruments to be tested are: sensors, analyzers, fuel consumption meters, etc. [19]. Integrating these devices can avoid gaps in information collection and conflicts caused by manufacturers' mismatches in device information [20]. Sort out all the information of the equipment that has not collected data, and then analyze the collected information through the dynamic data software through the computer after the test, and extract the required file information from the analysis. After the information is processed, it is transmitted to the background through the database terminal for file organization and processing, and finally a web database is formed. In this way, users can also access the database through mobile phones or smart devices and can access or extract information only by request. Of course, IP is also required, and the access to the address, through the operation of the mobile phone, transmits the

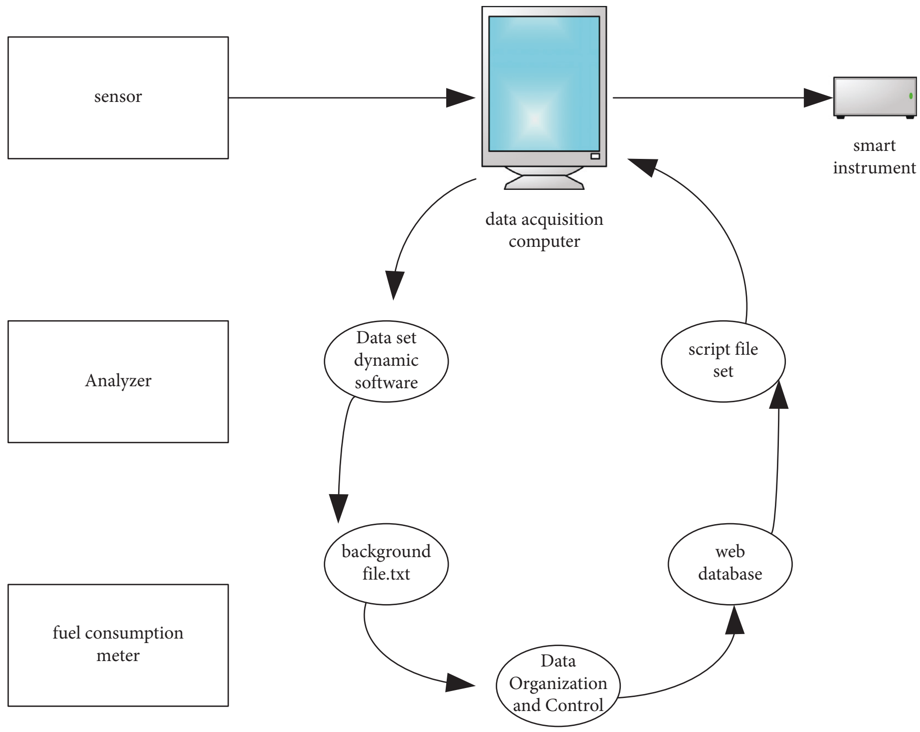

Figure 3: The data acquisition system of the engine test bench.

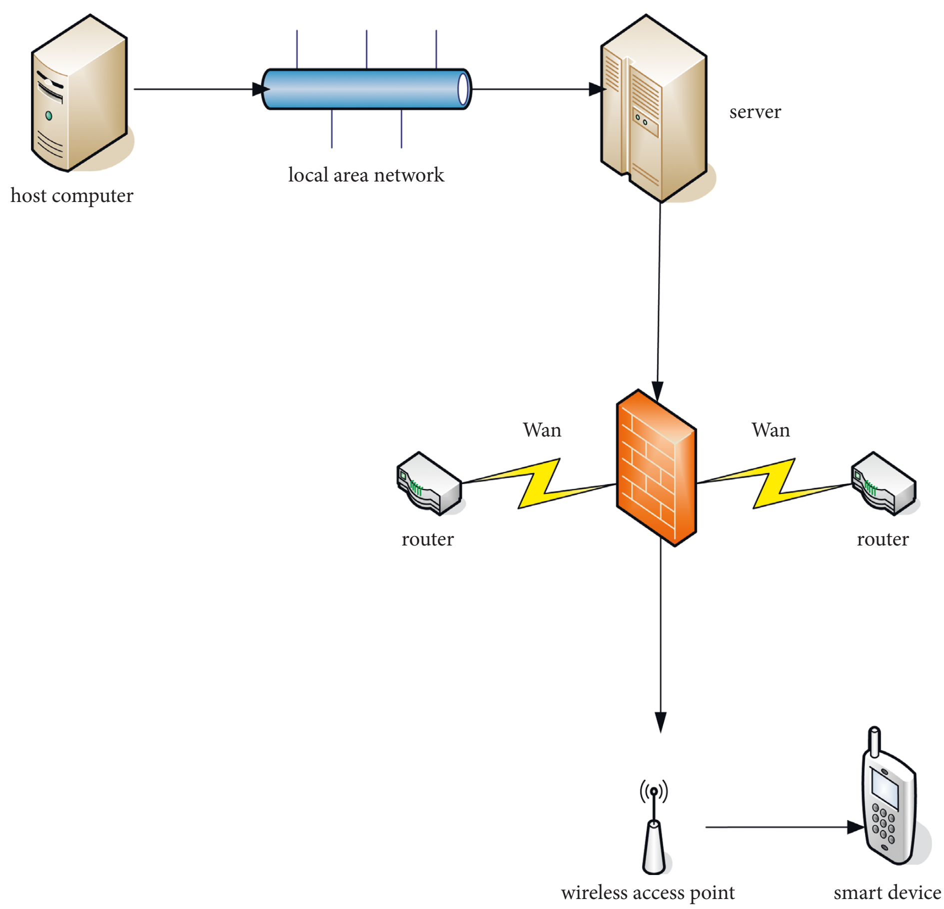

Figure 4: Transport network architecture.

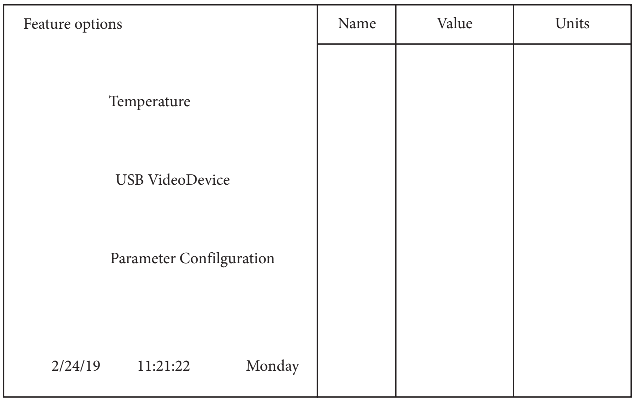

FIGURE 5: Mobile phone demo.

acquired information to the smart device, performs remote control and supervision, and makes timely suggestions for the information [21]. Figure 4 shows the framework of network transmission. Setting a firewall in the local area network can prevent infection by external viruses or network viruses. Figure 5 shows a demonstration diagram of the mobile terminal, which can be used for function selection or data selection.

3.4. Research and Development of Key Components of the Test System. The necessary condition for daily engine operation is fuel. As the test data of the engine, fuel consumption is also an important factor to consider in product development and design [22]. His role is mainly to measure the fuel consumption, the fuel consumption ratio of the vehicle running per unit time. The fuel consumption meter is also important reference data. The main disadvantage of the traditional fuel computer is that it cannot correctly calculate the fuel consumption, the response speed is relatively slow, there is no telephone function, and the level of intelligence is relatively low. This paper analyzes the theoretical basis of the network, tests the functional requirements based on the motor workbench, mainly studies the database storage technology and fuzzy theory algorithm based on artificial neural network, and develops the serial network technology. The two are combined at the same time to build a relatively good fuzzy neural network model. The artificial neural network has the characteristics of storage and learning. The test results are compared and analyzed through the model to meet the efficient and accurate measurement and transportation of fuel consumption [23]. The developed fuel consumption meter includes flow meter, variable frequency impeller pump, electromagnetic proportional valve, exchanger, automatic exhaust valve, temperature and pressure sensor, etc. Only with the help of artificial neural networks can we better utilize the expertise of experts to express the knowledge of the rules, but the number of hidden nodes affects the network noise. Since fuzzy conclusions cannot learn artificial neural units, fuzzy neural networks evaluate the accuracy of test data according to their merits. Figure 6 shows the neural network modeling process.

First initialize the neural network, formulate corresponding parameters according to the training environment, and then normalize it according to the weight function to obtain the normalized training data, which can be

$$y = \left(y_{\max} - y_{\min}\right) \times \frac{\left(x - x_{\mathrm{map}}\right)}{\left(x_{\max} - x_{\min}\right)} + y_{\min}. \tag{1}$$

Afterward, the obtained training data are evaluated for its accuracy. The evaluation is divided into five grades, 1–5 grades, respectively. The input parameters are determined by the learning algorithm. The parameters to be learned are the connection weight p_{ij}^{l}, which are

$$p_{ij}^{l}\,(j = 1, 2, 3 \ldots l = 1, 2, 3..i = 1, 2, 3, \ldots). \tag{2}$$

Calculate the error cost function E with the weight c_{ij} and the width μ_{ij} of the correlation function, and the calculation can be obtained:

$$E = \frac{1}{2} \sum_{i=1}^{r} \left(t_i - y_i\right)^2, \tag{3}$$

t_i represents the expected output, y_i represents the actual output, and the following formula is the learning algorithm of the parameter p_{ij}^{l}:

$$\frac{\partial E/\partial p_{ij}^{l} = \partial E/\partial y_1 \partial y_1/\partial y_{1j} \partial y_{1j}/\partial p_{ij}^{l} = -(t_l - y_l)\partial_j x_i}{p_{ij}^{l}(k+l) = p_{ij}^{l}(k) - \beta \partial E/\partial p_{ij}^{l} = p_{ij}^{l}(k) + \beta\left(t_l - y_l\right) a_j x_i}. \tag{4}$$

The fuzzy neural network structure is shown in Figure 7.

4. Analysis of Engine Dynamic Test System

In this paper, in order to better detect the dynamic system, in the case of meeting the needs of the engine and the integrated vehicle, the analysis is carried out to ensure that the constants are the same. In this paper, two vehicle companies are investigated, and one uses a traditional bench. The test system: the other one is an intelligent engine dynamic test system based on the Internet of Things, which records and processes the test data. The physical quantities that the dynamic test system needs to study include the in-cylinder pressure, the pressure of the intake and exhaust systems, the fuel flow rate, the standard voltage signal, and the elevation of the injector needle valve. 16BIT adopts special technology to input necessary parameters and needs to be connected online. All software is connected to the Internet, and dynamic data changes can be realized. The test system is equipped with a charge amplifier to ensure detection accuracy. When it exceeds 98pc Fs and when the error is controlled within 3% and the detection system requires multiple data sampling, the above data are saved and can be used at any time. There needs to be a pressure detector in the system to understand the pressure in the cylinder to prevent cylinder explosion. The system needs to indicate the effective pressure, the maximum pressure, and the position, record the mean value and deviation, measure it through the system function calculation formula, and calculate the output result. In this paper, the traditional bench test system and the

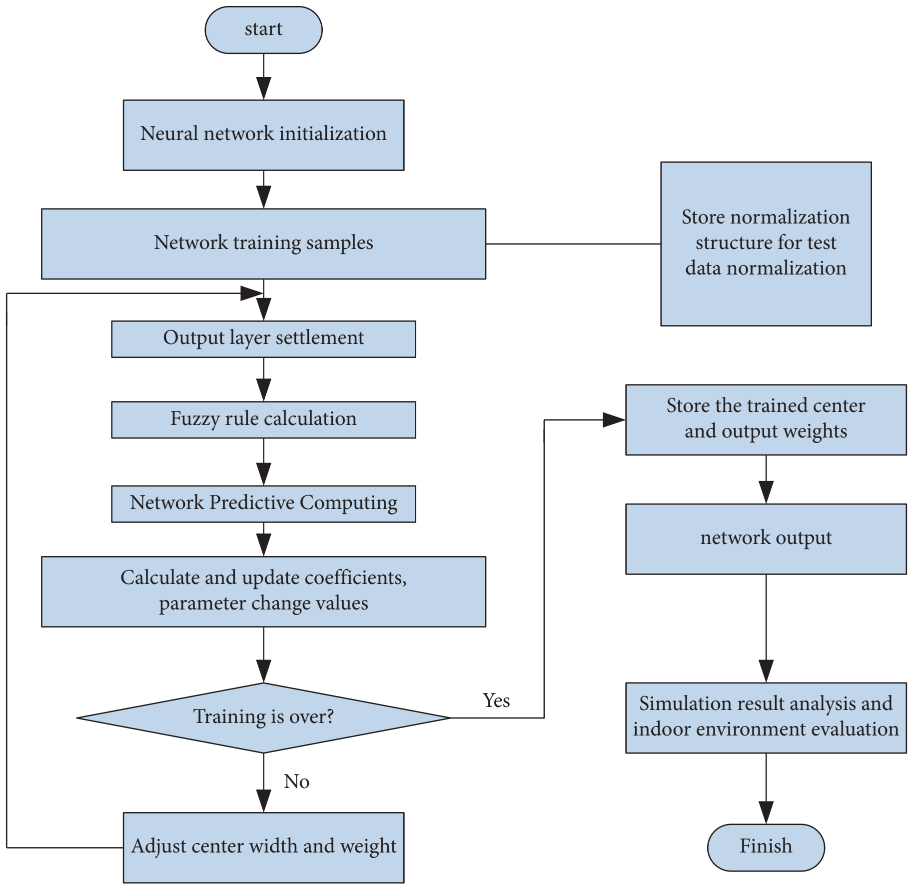

Figure 6: Neural network modeling steps.

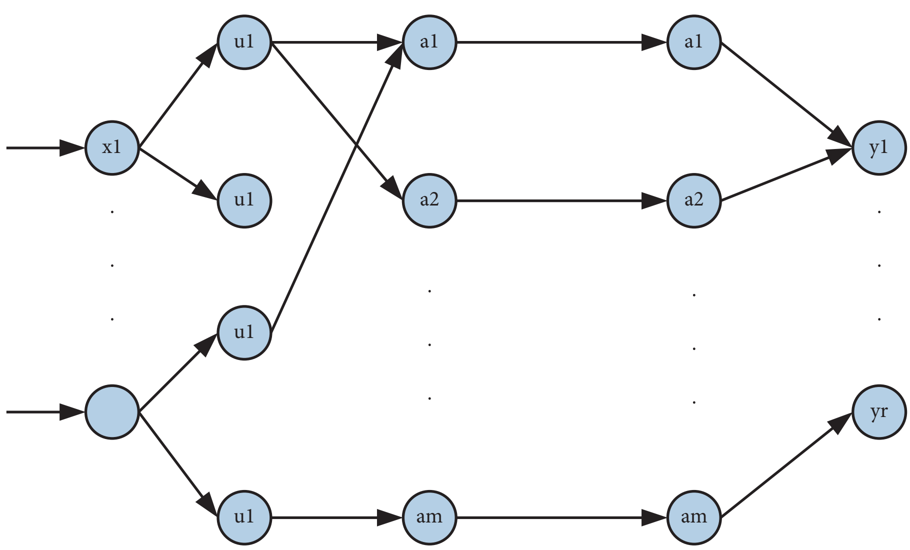

Figure 7: Fuzzy neural network structure.

dynamic test system based on the Internet of Things are compared, and the efficiency of data information transmission, information security, perception ability, and response speed between them are compared to illustrate the difference between the two differences. Figure 8 shows the comparison of data information transmission efficiency between the two companies.

Through the comparison chart, it is found that through the comparison of three sets of experimental data, the traditional test system can only reach about 75% in data information efficiency, while the data information efficiency of the intelligent dynamic test system can reach 95% or even higher. It shows that the intelligent dynamic test system is more efficient in information and data processing in engine testing.

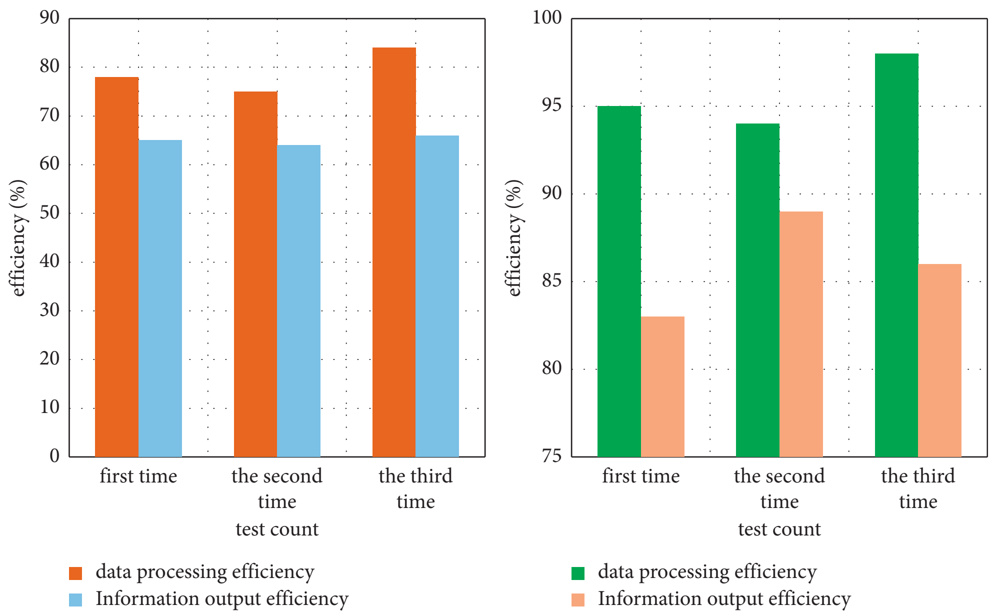

Figure 8: Comparison of data information transfer efficiency.

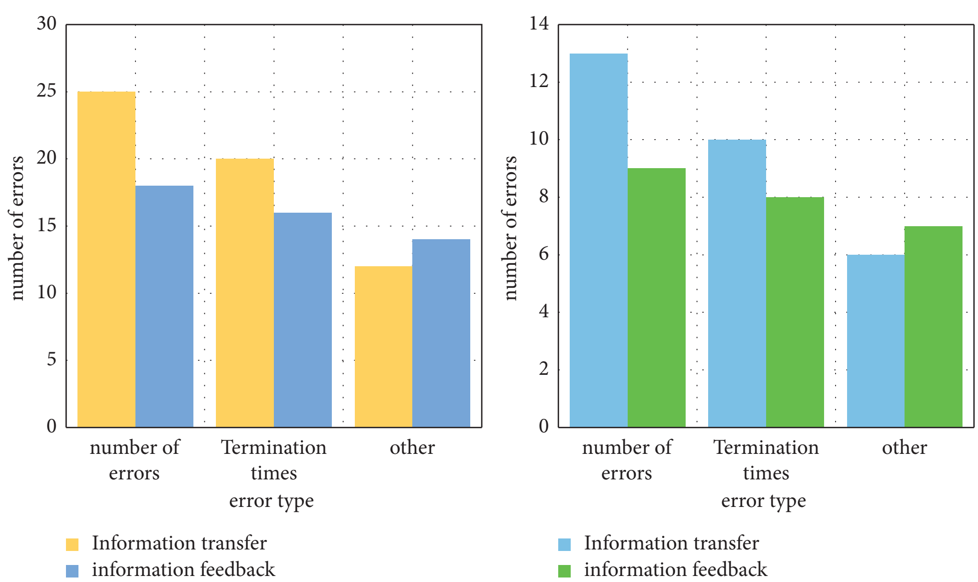

Figure 9: Comparison of system error times.

There are also differences in the information security between the two systems. The article analyzes and compares the system error data of the two companies within one month. The traditional test system is prone to system transmission errors in the process of information feedback and transmission, which leads to the inability of information to continue to be transmitted to the next step and reduces the security of information transmission. The security of the system is judged by the number of errors in the system. The more the errors, the lower the information security. Figure 9 shows the comparison between the two in information security.

From the number of errors of the two systems, it can be seen that the number of errors in the traditional test system is nearly twice that of the intelligent dynamic test system, and the security is greatly reduced, which also shows that the intelligent engine detection system based on the Internet of Things is more reliable in terms of security.

When the test system perceives the middle of the engine text, it judges the internal conditions of the engine through the perception of the system. The accuracy of the system perception also determines the pros and cons of the system. The comparison between the two systems in the text is shown in Figure 10.

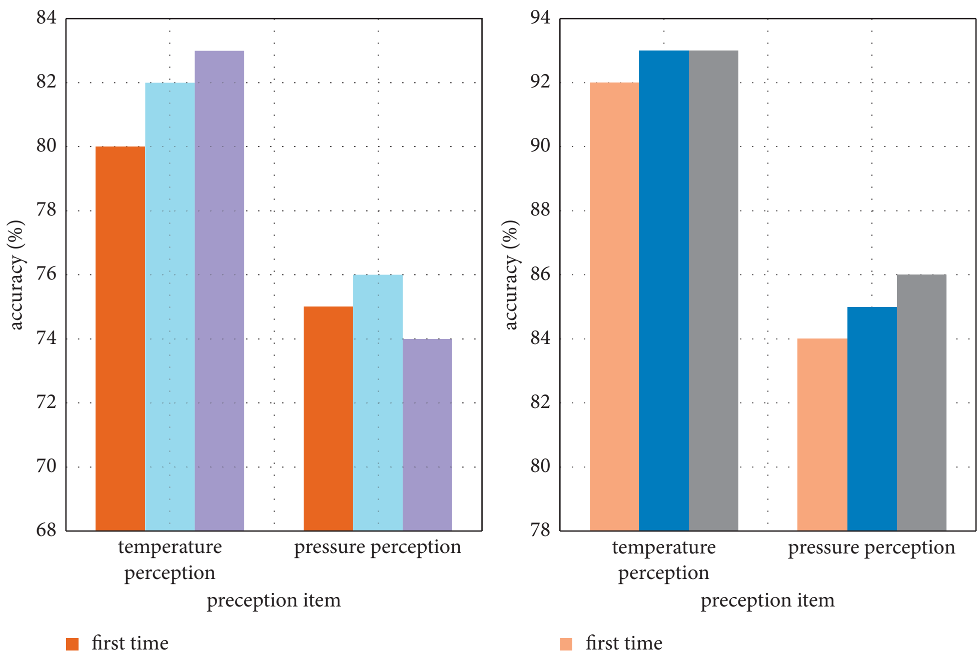

Figure 10: Perceived accuracy comparison.

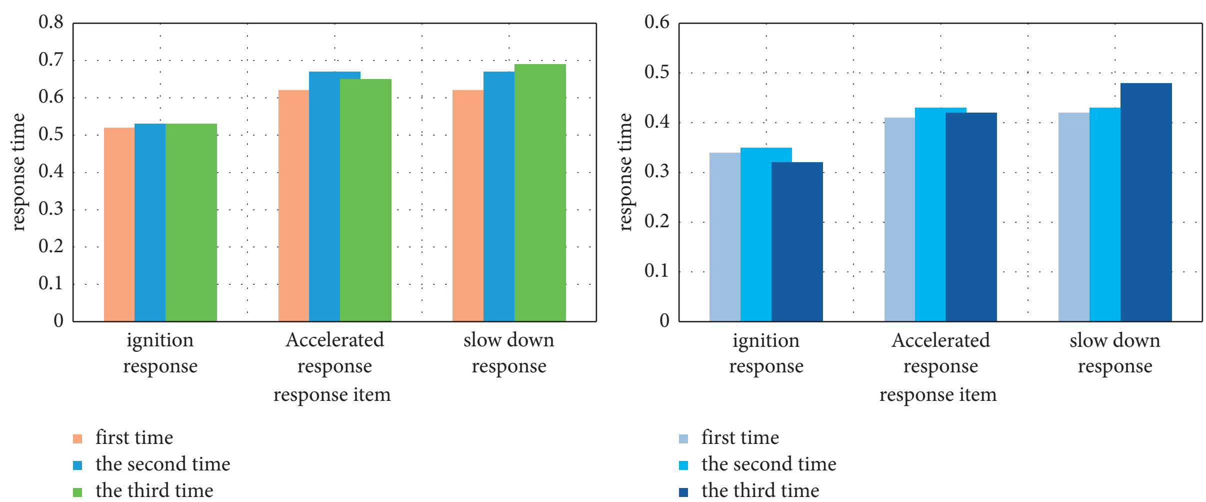

Figure 11: Response time comparison.

By comparing the sensing accuracy of the two systems, it can be found that the intelligent dynamic test system based on the Internet of Things has improved the sensing accuracy by about 12% compared with the traditional detection system. If there is a high situation, it needs to be dealt with in time. If there is an error in perception or inaccuracy, it will easily lead to danger, which also shows that perception is very important to the system. It also fully shows that the intelligent dynamic detection system based on the Internet of Things is more secure and more sensitive.

The response speed of the system also determines the pros and cons of the system. The faster the response speed, the faster the system can respond after the driver's command, such as acceleration, deceleration, and engine ignition. It will be more smooth to use and enjoy for the driver. As shown in Figure 11, the response time of the two systems is compared.

From the response time of the two systems, it can be seen that the response time of the traditional system is about 0.65 s, the response time of the intelligent dynamic test system is about 0.35, and the response time is increased by 48%, which greatly shows the superiority of the intelligent dynamic test system. It also shows that the model established by the Internet of Things is more suitable in the field of vehicle engine testing. It can also solve the problems in the test more effectively.

5. Conclusion

This paper mainly uses the Internet of Things thinking to analyze and compare the traditional engine testing system, explain the engine testing requirements, simulate the testing of the vehicle on the traditional bench, and obtain the experimental data. By judging the data, it is found that the performance of the traditional engine testing system is relatively low and not suitable for current equipment. The dynamic detection system based on the Internet of Things is introduced. Through the comparison between the two in the efficiency of information transmission, information security, system perception, and system response time, the intelligent dynamic engine detection system based on the Internet of Things is found. It is higher in terms of safety and information transmission efficiency. The perception performance is improved by 12%, and the system response time is improved by 48%. It also fully shows that the intelligent dynamic engine detection system based on the Internet of Things will be more satisfactory. The current equipment can also be tested more accurately. Through the research and development of the system, the cost of new products can be reduced. The principle of research and development is explained, and the state management in the system is explained, etc., and analyzes it by establishing a fuzzy neural network. The analysis of the internal situation of the engine is not enough in this paper, the number of variables in the two systems is not enough, and there may be errors in data processing. In the future, more companies will adopt intelligent dynamic engine test systems to save cost, enhance engine performance, and ensure driver safety.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no potential conflicts of interest in this study.

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