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Research and Design of the Tobacco Machinery Equipment Remote Fault Diagnosis System Platform

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Abstract

Because of the machine equipment fault has the fuzzy characteristics, based on the ZJ19E monitoring system, proposed one kind based on the Internet of things technology and fuzzy neural network intelligent fault diagnosis of remote control system scheme, established the fault diagnosis model based on fuzzy neural network, realizes the remote diagnosis of the machine equipment fault, improves the traditional control methods greatly improved productivity and automation, and improves the high rate of fault diagnosis of the machine equipment, makes the ZJ19E monitoring system remotable and intelligentialize.

Keywords*: monitoring system; fuzzy neural network; intelligent diagnosis*

1. Introduction

The traditional way of ZJ19E surveillance system uses Single form to test and control the operational equipments, mainly collects statistics to prepare it for operation, set up different functions such as fault alarm and parameter control. However, if maintenance of the surveillance system were to only be based on the fault alarm, productivity will be greatly lowered. To accurately determine the place where the fault lies, analyses the cause behind the fault and timely resolve the fault, a new surveillance system is really needed. With the creation of the Internet, "computing clouds" and other new communication techniques in the same series, the change of the ZJ19E surveillance system to the new remote fault diagnostic system has been given high regard by many in the technological field. The remote diagnostic system's diagnosis can link the user, the production team and experts in the diagnostic system all together. With the Internet helping to exchange information over long distances efficiently, when the remote diagnostic system is ready, it will be able to quickly find the source of the fault and alert the workers at the site and share the information with experts in the remote surveillance centre and the production team, hence diagnosing the fault more efficiently and greatly increase productivity. This diagnostic system's output coefficient and automated feature also greatly improved the traditional way of surveillance [1-2].

2. The Overall Structure of the System

A smart remote fault surveillance system [3] can set up a fault detector at the surveillance centre, set up an important monitoring point on the cigarette roller, using the sensor at the monitoring point to receive on site information. The overall structure of the system is as shown in Figure 1:

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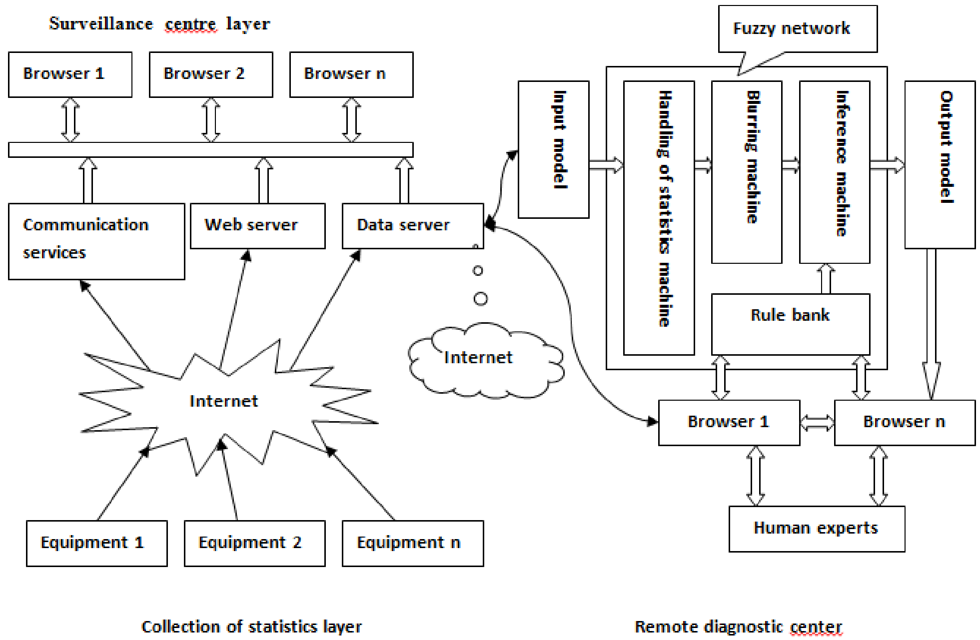

Figure 1. The Overall Structure of the Smart Remote Fault Surveillance System

From Figure 1, it is shown that the smart remote fault surveillance system basically consists of the collection of information layer, the on-site layer, the surveillance centre layer, and the smart diagnostic centre.

The collection of information layer: includes the collection of statistics for communication and faulty messages, and the handling of these statistics etcetera. The collection of statistics mainly includes the vibration, temperature, pressure and the communication condition of the monitoring point of the surveillance system, the condition of the transmitter, the reporting condition, and the condition of the import and export port etcetera. This layer also handles the signals received. These signals are then transmitted to the surveillance centre layer as basic statistics.

The surveillance system layer is mainly made up of different kinds of service equipments, including equipments used for communication, collation of statistics and equipments used to surf the web etcetera. The collection of information layer will send the signals collected to the equipments used for communication to be presented by the surveillance centre. Using these operational statistics to do an on-site analysis, the condition of the surveillance system can be determined, whether it is functioning normally or if there is an underlying fault in the system. If there are any abnormalities, it can then use the data collected to do a simple diagnosis. If the fault cannot be solved, the remote diagnosis system will then be activated to provide an effective solution. A database server is used to keep all the data collected, so that they can be retrieved and referred through the web server when needed.

The remote diagnostic centre is an important part of the system. It mainly includes a model for the entering and deleting of data, fuzzy neural network (pre-processing of information, a rule base, a blurring machine, an inference machine) browser etcetera. The remote diagnosis centre connects to the surveillance centre through the internet. The surveillance centre then transmits the fault messages to the remote diagnostic centre through the internet. The remote diagnostic centre will then base on the on-site condition of the equipment to do a fault analysis and diagnosis. It provides a platform for a wide range of internal diagnosis information that can be shared, allowing the collaboration of many diagnostic methods, the handling of the data of different fault messages, increasing the amount of information stored in the database of each system so that its diagnostic capability will be able to improve continuously.

3. The Realization of a Remote Diagnosis System

When the equipment or the surveillance centre is faulty, the surveillance centre will send out a help message and blur the data of the equipment condition that has gone through pre-processing to send it to the inference machine so that these information can combine with the experts' knowledge in the database of the inference machine to assist in the diagnosis of the fault.

When the local surveillance centre cannot solve the fault, it will then seek help from other surveillance centers overseas and connect with the remote diagnostic centre. The remote diagnostic centre will then base on the on-site data of the equipment and the fault analysis given by the expert system so that the experts in this field can infer and feedback the result to the surveillance centre to continue with the maintenance. When there is a fault in the surveillance centre, the remote surveillance can then be activated. The web service target addresses can also be converted from the surveillance centre to the remote diagnostic centre so that the plan of the remote diagnostic centre replacing the surveillance centre in its surveillance duty can be realized [4-5].

4. The Operation Theory of the Remote Diagnosis System

The workers at the scene uses a central surveillance browser that makes use of a URL to collate all the addresses of the resources needed to link to the diagnostic centre so that the information of the faulty equipment at the scene to be made perfect before sending to the browser in the diagnostic centre, starting up the fault diagnostic server, deducing and solving the error through the fuzzy neural network, proceeding with the fault diagnosis.

At the same time, the workers at the scene and the experts at the remote diagnostic centre can discuss the condition of the equipment through a video. Lastly, workers at the remote diagnostic centre can discuss the result and combine the result with the analysis by the diagnostic server to come up with the final outcome and send it to the web server production HTML page. This way the workers at the scene can download and view the final diagnosis outcome.

5. Fuzzy Neural Network

The on-site surveillance and fault diagnosis on the soldering iron is done through feedback after looking through the statistics and after extensive experiments and analysis, making sure the signal of the frequency, temperature of the soldering iron, and the pressure of the iron pressing on its tracks through the monitoring points.

5.1. The Confirmation of the Subordinate Function

Subordinate function U(x) is the linking logic in the [0-1] area, satisfying $0 \leq U(x) \leq 1$, using a series of rules to blur the information collected. The blurring logic rule uses blurring logic deduction, using the blurring logic theory to show accurately the extent of the fault, increasing the accuracy of the fault diagnosis.

Based on experience and knowledge, the function of the grade of abnormal temperature has been set up. Like shown in formula (1), x1 is the temperature of the soldering iron (℃).

$$U(x1) = \begin{cases} 0, x1 < 85 \\ 0.06x1 - 5.1, 85 \leq x1 < 90 \\ 0.04x1 - 3.3, 90 \leq x1 < 100 \\ 1, x1 \geq 85 \end{cases} \quad (1)$$

The function of the grade of the pressure the soldering iron places on the tracks, like shown in formula (2), x2 is the pressure on the tracks (Pa).

$$U(x2) = \begin{cases} 1, x2 \leq 0.01 \\ -25x2 + 1.25, 0.01 < x2 < 0.03 \\ 0, 0.03 \leq x2 < 0.1 \\ 1, x2 \geq 0.1 \end{cases} \quad (2)$$

The function of the grade of the fault of the soldering iron's frequency, like shown in formula (3), x3 is frequency (Hz).

$$U(x3) = \begin{cases} 1, x3 < 600 \\ 0.008x3 + 4, 600 \leq x3 < 800 \\ 0, 800 \leq x3 < 1000 \\ 0.01x3 - 7, 1000 \leq x3 < 1200 \\ 1, x3 \geq 1200 \end{cases} \quad (3)$$

5.2. The Establishment of a Fuzzy Neural Network

Fuzzy neural network [6] basically contains four layers, namely, an immediate input layer, a blurred layer, a hidden layer and an export layer.

The immediate input layer is the first. Due to the pressure caused by the soldering iron on its tracks, abnormal temperature of the soldering iron, abnormal frequency, etcetera, the total probability of a fault happening is X={x1, x2, x3}, when the amount of elements in the set up of the fuzzy neural network is n-3;

The blurred layer is the second. It blurs the data entered into the system by the input layer according to the fuzzy sets present;

The hidden layer is the third, when the input value is blurred to form the output value, the formula for the in the hidden layer is shown in (4) elements:

$$H = \sqrt{n + m} + l, l \in (0,1) \quad (4)$$

There are nine elements in the set-up of the hidden layer.

The output layer is the fourth, its set up consists of three elements, the total probability of a fault happening is Y= {y1, y2, y3}; the fuzzy neural network is as shown in Figure 2.

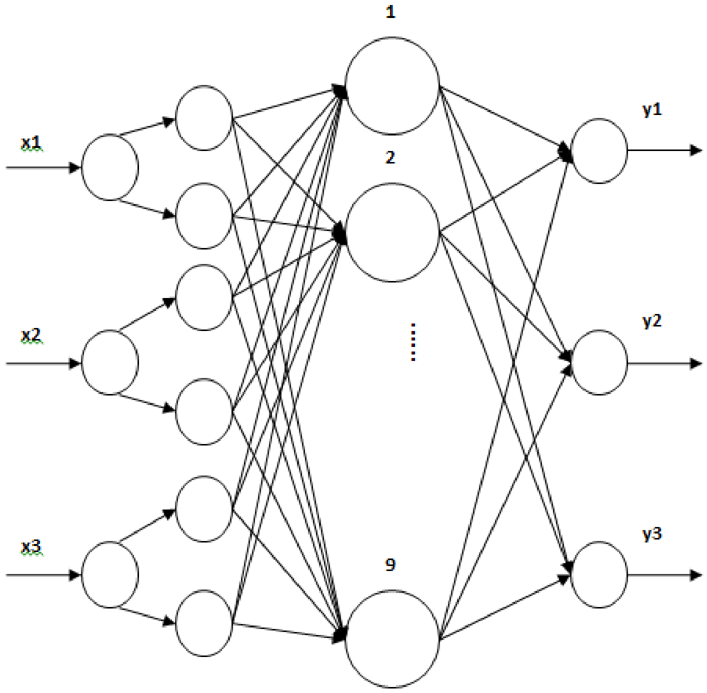

Figure 2. The Model of the Fuzzy Neural Network

Before using the remote diagnostic system on the soldering iron, we need to understand the fuzzy neural network well and we need to have some substantial data so that it will help in our research later. ε rule of learning is used in the understanding of the fuzzy neural network. It represents the difference in the expected and the actual output of the fuzzy neural network, the changing of the power value ε rule of learning is done by iterative computations changing the power value t_{ij}, until ε error reaches the smallest. Function (5) represents the formula for the change of t_{ij} , θ represents the speed of learning.

$$\Delta t_{ij=\theta\beta y_j} \quad (5)$$

5.3. The Testing Process of the Fuzzy Neural Network

This essay basically does research based on faulty soldering iron track. This fault can be caused by three ways.

During the process of collecting statistics, the soldering iron's operational condition was categorised into three categories, namely the abnormal temperature of the iron, pressure caused by the iron on the tracks and faults in the frequency. The soldering iron's operational condition was tested in different surrounding conditions such as different temperature, pressure and frequency. 4 experiments were conducted in the different surrounding conditions and the average values are shown in Table 1.

Table 1. In the Different Surrounding Conditions and the Average Values

Fault	Temperature of the iron(℃)	Pressure(Pa)	Frequency(Hz)
Abnormal temperature of the soldering iron	100	0.01	0.072
Pressure caused by the iron on the tracks	120	0.025	0.08359
Faults in the frequency	90	0.009	0.2571
Faults in the tracks	90	0.01	0.278

Testing process

During the testing process, faults that may happen in a soldering iron such as its abnormal temperature, the excessive pressure it is exerting on the tracks and its abnormal frequency are shown in Table 2.

Table 2. The Phenomenon of a Fault Present in the Soldering Iron

Working condition	Internet output	Type of operational condition
1	Y1	Abnormal temperature of the soldering iron
2	Y2	The soldering iron causes pressure on the tracks
3	Y3	Fault is present in the frequency of the soldering iron

Directed at the BP improvement calculation method [7] used in training the internet, the speed of learning θ is 0.5, the momentum β is 0.85, the expected error, was 0.5%. 50 samples are collected under each working condition, and after pre-processing them, they are entered into the internet to proceed with the web training. The working condition and the expected output of the fuzzy neural network in each working condition are as shown in Table 3.

Table 3. The Model's Expected Output

Working condition	Y1	Y2	Y3
1	1	0	0
2	0	1	0
3	0	0	1

Using these 50 sets of samples to train the internet, and next make use of Matlab to enter verification samples into the trained models for the calculation of simulation to occur to prove the accuracy of using the fuzzy neural network [8]. After using the results as a comparison with the fuzzy neural networks expected output, it proves that the output value after using the fuzzy neural network tallies with the actual output and also explains that after training the internet, the model can diagnose the fault more accurately.

5.4. The Method of Compression of Statistics

To accurately record the equipment's operational condition at crucial points, monitoring points can be added. However, with more monitoring points, more statistics will be collected. We have to take into account whether we can successfully transfer the statistics through the Internet which has a fixed amount of space. Hence, to ensure that the statistics can be transferred from the collection of statistics layer to the surveillance centre successfully, the method of compression of statistics can be used so that it will take up less space on the internet [9].

The method of compression of statistics is used in this essay to allow the statistics in the whole surveillance system to be compressed to just the statistics at the crucial points. For example, if the total amount of statistics is n1, the amount of statistics after compression is n2, the compression factor is expressed as ζ, while the method of compression as k, by setting up adequate amounts of compression factors ζ and method of compression M to reduce the space taken up in the Internet, the specific expression is: $n2 = ζ \times (k \times n1)$.

The different methods of compression are listed below

1) Method of taking the average value, using the average value in a controlled area to compress the statistics.

2) Method of using the biggest and smallest value, compare the biggest and smallest value in a controlled area to be used as the signal for the compression of data.

6. Conclusion

Using the Internet to change the traditional surveillance system can help to realise the vision of achieving more with the use of internet, test the operating condition of the soldering iron, collate the information recorded at the monitoring point and when a fault arises, maintenance workers can diagnose and resolve the fault wherever they are, reducing the time needed for maintenance and unneeded losses, accurately diagnosing the fault efficiently, achieving a smart production and greatly increased the productivity of the equipment. The theory of the fuzzy neural network can also be used to deduce the operational condition of the soldering iron and the cause of the fault, and to provide the model of the fuzzy neural network so that it can combine with the experimental process of the fuzzy neural network for discussion. Combining technologies of the Internet with the fuzzy neural network, the surveillance system plays an important role in greatly increasing the level of protection, reducing the frequency of the system breaking down and it is also very practical. Hence, it is worth a more in depth research and more should know about it.

References

[1] J. Li, Z. Yuan, H. Tian and A. Liang, "Design of remote fault diagnosis system for medium and small-sized enterprises", Procedia Engineering, **(2011)**, pp. 48-52.

[2] J. Y. Son, J. H. Lee, J. Y. Kim, J. H. Park, and Y. H. Lee, "Rafd: resource-aware fault diagnosis system for home environment with smart devices", IEEE Transactions on Consumer Electronics, vol. 58, no. 4, **(2012)**, pp. 1185-1193.

[3] H. Sun, "Intelligent Remote Monitoring and Fault Diagnosis of Engineering Machinery System Design", Applied Mechanics & Materials, **(2014)**, pp. 496-500.

[4] P. F. Sun and Y. He, "Study on Remote Distributed Fault Diagnosis System in Modern Agricultural Machinery. Advanced Research on Automation Communication Architectonics & Materials **(2011)**, 225-226.

[5] Y. Li and Z. Cai, "Gravity-based heuristic for set covering problems and its application in fault diagnosis", Systems Engineering & Electronics Journal, vol. 23, no. 3, **(2012)**, pp. 391-398.

[6] Y. Wang and L. Najjar, "Factor Neural Network Theory and Its Applications", International Journal of Information Technology & Decision Making, vol. 14, no. 2, **(2015)**.

[7] Q. Li, D. L. Sun, L. Zhang, and X. Q. Wang, "Fault Diagnosis of Some Equipment Based on BP Neural Network", Applied Mechanics & Materials **(2014)**, pp. 644-650:1193-1196.

[8] S. V. Degtyarev, O. V. Shatalova, A. F. Rybochkin, and A. A. Kuzmin, "Simulation of bioimpedance analysis in matlab", Biomedical Engineering, vol. 47, no. 4, **(2013)**, pp. 202-204.

[9] Y. Liang and Y. Li, "An Efficient and Robust Data Compression Algorithm in Wireless Sensor Networks", Communications Letters IEEE, vol. 18, no. 3, **(2014)**, pp. 439-442.

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