Fault Diagnosis Method of Road Traffic Communication Network Based on SVM

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Abstract—The development of road traffic communication technology makes communication means more diverse. With the increase of the complexity of urban road traffic communication network, the fault diagnosis of road traffic communication network has been paid more and more attention. The alarm data in the communication network is the manifestation of network failure. Network operation and maintenance personnel can understand the current network operation status according to the alarm information displayed in the system, and then analyze, locate and handle the fault. Therefore, the identification of alarm information is very important for the timely treatment of network failure. In this paper, based on the existing communication network theory and network equipment alarm information, this paper proposes a method using SVM, which can effectively solve the fault identification of network communication input anomaly.

1. INTRODUCTION
The development of road traffic communication technology makes communication means more diverse. With the increase of the complexity of urban road traffic communication network, the fault diagnosis of road traffic communication network has been paid more and more attention[1]. The alarm data of communication network of road traffic system reflects that in the process of communication network operation, due to some faults and other abnormal conditions, the communication network fails, which is the performance of communication network failure during operation. However, due to the complexity of manual operation and multi-source fault, it is difficult to accurately judge the alarm manually. Communication network fault detection and diagnosis can filter, merge and transform the alarm data in advance, so that the alarm data arriving at the network manager is processed. In this way, network managers can quickly judge and locate the fault source with the help of communication network fault detection and diagnosis system[2]. Therefore, as the core technology of communication network management, fault diagnosis technology has gradually become a hot research issue.

Rapid and accurate fault diagnosis of road traffic communication network is related to the robustness of road traffic communication network. Xin-miao Wang[3] introduced the existing detection methods, and further proposed an improved genetic neural network model network fault detection method, which improved the learning ability of complex situation. Da-qing Jiang[4] proposed a new semi-supervised automatic spectral clustering algorithm based on the combination of paired constraint information propagation and automatic clustering number determination in view of the lack of prior knowledge and the need to determine the clustering number in advance of most spectral clustering algorithms in network fault detection. The clustering performance is improved and the accuracy is
improved. Wen Yang[5], aiming at the problem of fault detection of energy network with tree topology and based on the energy hierarchical balance relationship, provided the detection conditions for sensor faults and equipment faults. The result obtained has the advantage that sensor faults and equipment faults can be analyzed simultaneously. Yu-yan Sun[6] proposed a fault diagnosis and location method of intelligent communication network based on deep learning. Based on the redundancy monitoring of communication network fault state, the fault characteristic information based on different monitoring nodes is analyzed, and the representation mode of communication network fault characteristic information is proposed. The fault diagnosis model of communication network based on deep confidence network is established and the real-time fault analysis and processing flow is given.

To sum up, due to the complex network topology and massive alert data of road traffic, multiple abnormal information sources can be generated in a short time, and many types of classifiers are difficult to handle and have poor effects. The Support Vector Machine (SVM) belongs to supervised learning and is a two-class classification model. Its basic model is the linear classifier with the largest interval defined in the feature space[7]. The Support Vector Machine includes kernel method, which can be used for nonlinear classification and becomes a nonlinear classifier. The learning strategy of support vector machines is interval maximization, which can be transformed into a convex quadratic programming problem[8]. This paper designs a road traffic communication network fault diagnosis system based on support vector machine, which can more accurately identify the source of network fault and thus guarantee the road traffic operation efficiency.

2. OVERVIEW OF SUPPORT VECTOR MACHINES
Support vector machine (SVM) is a new technology in data mining and a new tool to solve machine learning problems by means of optimization methods. It was first proposed by V.V. Apnik et al. In recent years, its theoretical research and algorithm implementation have become increasingly mature, and it has become a powerful tool in the field of classifiers.

The basic idea of support vector machine is to find a hyperplane, so that it can separate the two kinds of data points correctly as much as possible, and at the same time make the two kinds of data points farthest from the classification plane, namely the separation hyperplane with the largest geometric interval. For linearly separable data sets, there are an infinite number of such hyperplanes (perceptrons), but the separated hyperplanes with the greatest geometric spacing are unique. As is shown in Figure 1.
3. DESIGN OF FAULT DIAGNOSIS METHOD

Support vector machine (SVM) is a supervised learning mechanism, which can effectively distinguish fault types and locate faults through the system, so that the road traffic communication system can be maintained in real time and effectively. Fault diagnosis establishes a fault type model through the alarm data of abnormal detection, identifies the fault at the same time, and finally locates the fault source through the location of data source and fault type.

3.1. Fault classification

With the application and function enhancement of road traffic communication technology, the system fault is constantly updated and evolved, especially the road traffic communication network is becoming more and more complex and the communication nodes are increasing, which will lead to the increase of fault probability. In addition, the road traffic communication environment is becoming more and more complex, so the real-time and reliability issues are becoming more and more important. Road traffic communication failures can be roughly divided into communication link failure, single thread deadlock failure, hard disk failure, router failure, database failure, power failure, sensor failure and controller failure.

Communication link failure: the physical channel failure between two nodes in the network leads to data transmission failure. The common communication link failures include serial port failure, Ethernet interface failure and asynchronous communication port failure.

Single thread deadlock failure: it refers to the phenomenon that a single process (thread) is waiting for resources in the execution process. If there is no external processing, the process will enter the infinite waiting state, which seriously affects the normal operation of the system. It is mainly caused by the lack of system resources, improper sequence of process (thread) advancement and improper resource allocation.

Hard disk failure: it is generally divided into hardware failure and software failure. The hardware failure caused by software is relatively complex, which is mainly caused by the system software and application software loaded in the hard disk.

Router failure: the probability of hardware problems in routers is relatively low. The common router failures include system failure to power up normally, parts damage, poor heat dissipation or incompatible equipment.

Database failure: it is generally divided into internal transaction failure, system failure, media failure and computer virus failure. Transaction internal failures can be divided into expected and unexpected, and most of them are unexpected. The expected transaction internal failure refers to the transaction
3.2. Fault modeling

The establishment of fault model is the core technology of this fault diagnosis. The method of support vector machine is used to process the abnormal detection alarm data of road traffic communication.

The training set is established according to the historical data of abnormal detection and alarm:

$$Q = \{(x_1, t_1), (x_2, t_2), \ldots, (x_m, t_m)\}$$  \hspace{1cm} (1)

Where \(x_i\) denotes the feature vectors, \(x_i \in \mathbb{R}^n, t_i \in \{0, 1\} (i = 1, 2, \ldots, m)\). Select kernel function \(K(x, y)\) and parameter \(C\):

$$\min \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} t_i t_j \mu_i \mu_j K(x_i, x_j) - \sum_{j=1}^{m} u_j$$  \hspace{1cm} (2)

s.t \( \sum_{i=1}^{m} t_i \mu_i = 0 \) \hspace{1cm} (3)

The optimal solution: \( \mu^* = (\mu_1^*, \ldots, \mu_m^* )^T \).

Select \( \mu^* \) a positive component of \(0 < \mu_m^* < C\), The threshold was calculated:

$$\beta^* = t_j - \sum_{i=1}^{m} t_i \mu_i^* K(x_i - x_j)$$  \hspace{1cm} (4)

The fault model is constructed:

$$f(x) = \text{sgn} \left( \sum_{i=1}^{m} \mu_i^* t_i K(x, x_i) + \beta^* \right)$$  \hspace{1cm} (5)

The specific fault identification process is as follows:
4. EXPERIMENT AND RESULT ANALYSIS

In this paper, the existing road traffic communication network operation process collected network alarm data sets, and the network fault categories are divided into communication link failure, single thread deadlock failure, hard disk failure, router failure, database failure, power failure, sensor failure, controller failure, etc. Then, the road traffic communication fault diagnosis model based on support vector machine proposed in this paper is used for verification experiment, and the alarm data is identified to accurately identify the fault type.

4.1. Sample pretreatment

A sample is a collection of fault alarm data. Since normalization can retain the original semantic characteristics, all fault alarm data in a sample are normalized, and the new vector generated contains the original independent fault alarm information. Through the above method, the samples are processed into the input vectors that can be accepted by SVM, and the input vectors are input into the SVM model to train and optimize the fault model. The training set and test set are normalized and mapped as follows:

$$\alpha = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$  (6)

Where $\alpha \in \mathbb{R}^n$, $x_{\min} = \min(x)$; $x_{\max} = \max(x)$.

4.2. Analysis of experimental results

After dividing the sample set, 80% training samples and 20% test samples are randomly allocated. The training sample set is used to train the SVM model, and the test sample is used to test the trained model.

**TABLE 1. FAULT SOURCE ACCURACY TABLE**

| Fault category           | Accuracy Rate |
|--------------------------|---------------|
| Communication link failure| 0.96          |
| Single thread deadlock failure | 0.93          |
| Hard disk failure        | 0.95          |
| Router failure           | 0.93          |
| Database failure         | 0.96          |
5. CONCLUSION
In this paper, support vector machine method is used to solve the problem of road traffic communication fault recognition. The experiment shows that the fault recognition accuracy is high. However, because the running space consumption of SVM is mainly to store training samples and kernel matrix, when the number of samples is large, the storage and calculation of matrix will consume a lot of machine memory and operation time, so the speed of processing large-scale samples is slow, this problem still needs further research and improvement.

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|-----------------|-----|
| Power failure   | 0.96|
| Sensor failure  | 0.92|
| Controller failure | 0.93|