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Multi-Dimensional and Multi-Scale Modeling of Traffic State in Jiangxi Expressway based on Vehicle Network

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Abstract

In order to improve the big data analysis and traffic data management ability of the Jiangxi high-speed traffic condition monitoring platform, a multi-dimensional multi-scale analysis model of Jiangxi high-speed traffic condition characteristics based on vehicle networking and traffic big data information fusion is proposed. On the basis of building a good knowledge base, model base, and method base, the model base feature analysis and dynamic detection method are used to effectively mine big data of the Jiangxi high-speed traffic status monitoring platform. Combined with information fusion theory, the multi-dimensional model of the Jiangxi high-speed traffic status monitoring platform based on text information, location information, picture, audio, video, and other Jiangxi high-speed traffic status data can be realized. The test results show that big data mining in the platform with this method has better clustering and achieves high multi-dimensional multi-scale fusion of high-speed traffic condition characteristics in Jiangxi. The efficiency of data scheduling and access are improved effectively, enhancing the multi-dimensional multi-scale analysis and resource scheduling ability of Jiangxi high-speed traffic condition characteristics.

Keywords: car networking; Jiangxi high-speed traffic; state characteristics; multi-dimensional multi-scale; big data

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1. Introduction

The establishment of software systems in big data environments depends on effective metadata management, dependency and data modeling, application modeling, knowledge modeling, and a friendly and unified development environment. The analysis and processing ability of software systems in big data environments depends on the knowledge base, model base, and method base, which can be accessed, searched, and maintained effectively. Compared with the traditional sense of "data", the connotation of "big data" is expanding; it is a general name given to all valuable information such as numbers, text, sounds, images, and videos [1]. Its characteristics can be summarized as 4V, that is, the new traffic data acquisition method of volume (marine), velocity (high speed), variety (diversity), and veracity (), which makes many ideas possible. These data play an important role in promoting the further development of traffic research. At the same time, big data has been regarded as a technical weapon to relieve traffic pressure. The application of big data is helpful to understand travel laws and causes of urban traffic congestion, realize the harmony between traffic and life, improve the livability of the city, and provide a comprehensive decision based on data and evidence for the accurate management of the government. The rise of big data has had a profound impact on traffic development, bringing about great changes in traffic data collection, application and management, and traffic planning. This research focuses on establishing an effective knowledge base with consistency and completeness, creating a model base with a structure that is easy to copy and maintain, and facing different types of big data to provide an effective method base [2]. Quanzhou traffic big data is used to test and evaluate the knowledge base, model base, and algorithm base to determine whether they can meet the requirements of data processing ability, timeliness, and so on. The big data analysis application platform can be further developed to provide a unified application development environment for big data with "computability" and realize the practical application of the knowledge base, model base, and algorithm base under different types of big data. This paper studies and solves how to

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create an effective knowledge base with consistency and completeness, how to create a model base that is easy to copy and maintain, and how to carry out in-depth research and design in the face of different types of big data to provide an effective method base [3].

With the development of big data's information processing technology, big data integrated information processing and dispatching technology is used to carry out urban traffic information management and realize the integration and analysis of urban traffic big data, which is of strategic significance to the development of intelligent cities in China. Traffic big data is characterized by various types, heterogeneity, large space-time scale leapfrogging, dynamic variability, high randomness, localization, and limited life cycle, so it is necessary to carry out big data information fusion and optimal dispatching design in the Jiangxi high-speed traffic condition monitoring platform to improve the efficiency of traffic data management to meet the intelligent needs of urban traffic, such as high timeliness and knowledge traction. It is important to study the construction model of the Jiangxi high-speed traffic condition monitoring platform based on big data in order to optimize traffic scheduling and improving intelligent traffic construction [4].

In the large data environment, the large data mining of the high-speed traffic state monitoring platform of Jiangxi is based on data modeling, application modeling, and knowledge modeling. The invention relates to a large data information fusion method for a high-speed traffic state monitoring platform in Jiangxi, which mainly comprises the following steps: the method adopts optimized spectrum feature extraction technology to carry out the extraction and fuzzy clustering processing of the large data of the high-speed traffic state monitoring platform in Jiangxi, the rule knowledge items of the large data set are extracted, and the data optimization and fusion scheduling are realized. A large data fusion scheduling technique for the Jiangxi high-speed traffic state monitoring platform based on fuzzy directional clustering was proposed in [5]. By using the fuzzy neural network learning method, the association rules data mining and information fusion processing of the high-speed traffic state monitoring platform of Jiangxi were carried out, and the large data of the high-speed traffic state monitoring platform was accurately fused and dispatched based on the fuzzy information fusion method. However, the calculation cost of the method is large, and the time of mining was not good. A large data fusion scheduling algorithm for the Jiangxi high-speed traffic state monitoring platform based on rough set vector quantization coding and neural network classification was proposed in [6], and a characteristic distribution model of large data in the high-speed traffic state monitoring platform of Jiangxi was constructed. The BP neural network was used for data classification, and the information fusion and adaptive scheduling of the large data of the high-speed traffic state monitoring platform in Jiangxi were realized in the characteristic subspace. However, the method had poor performance in anti-interference capability.

In order to solve the above problems, a multi-dimensional and multi-scale analysis model of Jiangxi high-speed traffic state characteristics based on vehicle networking and traffic big data information fusion is proposed in this paper. Firstly, the storage structure of Jiangxi high-speed traffic condition monitoring platform big data is analyzed. On the basis of clustering the information of Jiangxi high-speed traffic state information, the model base feature analysis and dynamic detection method are used to mine the Jiangxi high-speed traffic condition monitoring platform big data effectively, and big data information fusion processing is carried out. The ability of big data monitoring and resource information scheduling in the platform is improved. Based on data information fusion, a multi-dimensional and multi-scale algorithm with high real-time traffic state characteristics is established, the vehicle network scheduling model facing different model big data is quickly formed, and the multi-dimensional and multi-scale modeling of Jiangxi high-speed traffic state characteristics based on vehicle networking is realized. The intelligent information management ability of the Jiangxi high-speed traffic condition monitoring platform is improved. Finally, the simulation results demonstrate the superior performance of this method in improving the mining and information fusion scheduling of big data in this platform.

2. Distribution Structure Model and Feature Extraction of Big Data

2.1. Characteristic Distribution Model of Big Data in Jiangxi Expressway Traffic Condition Monitoring Platform

In order to realize optimization and fusion scheduling of large data in the high-speed traffic state monitoring platform of Jiangxi, a distributed data structure model of large data under the traffic data test environment is first constructed. A four-tuple $G = (V, E, W, C)$ is used to represent the fuzzy distributed junction storage center of large data in the high-speed traffic state monitoring platform of Jiangxi, and it is a space embedding dimension of large data interaction. The high-dimensional feature space reconstruction of large data in the high-speed traffic state monitoring platform is carried out by adopting a plurality of non-linear component joint statistical method, and the information fusion and feature extraction of the large data are carried out in combination with the fuzzy clustering method. The overall structure model of the data fusion scheduling in the high-speed traffic state monitoring platform of Jiangxi is shown in Figure 1.

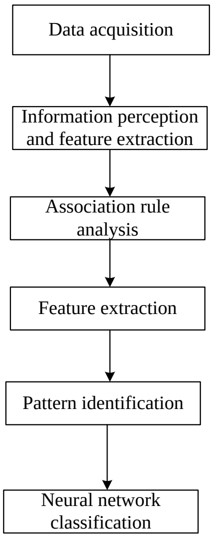

Figure 1. Implementation principle of large data fusion scheduling in the high-speed traffic condition monitoring platform of Jiangxi

In the Jiangxi high-speed traffic condition monitoring platform, traffic information is affected by multiple factors in the process of big data fusion and scheduling, which leads to a greater interference intensity of data mining and information fusion.

$$x_n = x(t_0 + n\Delta t) = h[\boldsymbol{z}(t_0 + n\Delta t)] + \omega_n \tag{1}$$

Where $h(\cdot)$ is the big data distributed time series in the Jiangxi high-speed traffic condition monitoring platform, which is represented as a function of the multi-dimensional data structure model. ω_n is big data's association rule characteristic quantity in the Jiangxi high-speed traffic condition monitoring platform [7]. The distribution function description of big data's distribution structure model in the Jiangxi high-speed traffic condition monitoring platform is as follows:

$$X_p(u) = \begin{cases} p\sqrt{\dfrac{1 - j\cot\alpha}{2\pi}}\, \mathrm{e}^{j\frac{u^2}{2}\cot a} \displaystyle\int_{-\infty}^{+\infty} x(t)\, \mathrm{e}^{j\frac{t^2}{2}\cot\alpha - jtu\csc\alpha}\, \mathrm{d}t, & \alpha \neq n\pi \\ x(u), & \alpha = 2n\pi \\ x(-u), & \alpha = (2n \pm 1)\pi \end{cases} \tag{2}$$

Where p is the order of big data storage structure in the distributed Jiangxi high-speed traffic condition monitoring platform, and α is the time window width of statistical information sampling. A big data sampling information flow model of the Jiangxi high-speed traffic condition monitoring platform is constructed, and combined with the time series analysis method, the statistical analysis of the Jiangxi high-speed traffic condition monitoring platform big data is carried out. It is a set of non-stationary random linear combination sequences, which can be used to analyze the characteristics and information fusion scheduling of the Jiangxi high-speed traffic condition monitoring platform big data [8].

A differential equation is constructed to express the information flow model of the large data of the high-speed traffic state monitoring platform of Jiangxi. In the state space, the evolution of $\boldsymbol{x}_{\mathbf{n}} \to \boldsymbol{x}_{\mathbf{n}+1}$ reflects the information fusion scheduling evolution model $\boldsymbol{z}_{\mathbf{n}} \to \boldsymbol{z}_{\mathbf{n+1}}$ or $\boldsymbol{z}(t) \to \boldsymbol{z}(t+1)$ of the large data time series of the high-speed traffic state monitoring platform of the unknown Jiangxi. The evolution process can realize the information fusion scheduling process of the large data. For the large data time series $\{x(t_0 + i\Delta t)\}$, $i = 0,1,\cdots,N-1$ measured by the early statistics, the phase space reconstruction track of the platform is expressed as follows:

$$X = [s_1, s_2, \cdots s_K]_{\mathbf{n}} = (x_n, x_{n-\tau}, \cdots, x_{n-(m-1)\tau}) \tag{3}$$

Where $K = N - (m-1)\tau$ represents the orthogonal feature vector of the big data time series of the Jiangxi high-speed traffic condition monitoring platform. τ is the time delay in sampling big data of the platform. Fourier transformation is conducted for the big data information flow of the platform to obtain $x(k)$. Under gray model training, the frequency domain characteristic component of the big data of the Jiangxi high-speed traffic condition monitoring platform is as follows:

$$A(t) = mt + \sqrt{am}B^{H}(t) \tag{4}$$

Where a is the inter-domain variance coefficient of big data, and $B^{H}(t)$ represents the information fusion scheduling correlation function. The characteristic distribution model of big data in the Jiangxi high-speed traffic condition monitoring platform is constructed. Combined with big data mining technology, the information scheduling and data mining processing carried out [9].

2.2. Feature Analysis and Dynamic Detection of Model Library

Based on the information clustering processing of the Jiangxi high-speed traffic state characteristic information, the big data of the platform is effectively mined by using the model library feature analysis and dynamic detection method. Through autocorrelation feature matching, the feature map of the Jiangxi high-speed traffic state monitoring platform big data is obtained as $\{x_n\}_{n=1}^{N}$.

$$\mathbf{x_n} = (x_n, x_{n-\tau}, \cdots, x_{n-(m-1)\tau}) \tag{5}$$

With the construction of the information flow model and the phase space reconstruction of the Jiangxi high-speed traffic condition monitoring platform big data, the mapping relationship between the big data information flow model and the nonlinear feature extraction of the Jiangxi high-speed traffic condition monitoring platform is established. In order to remove the dimension of the original data, the grey distribution model of the Jiangxi high-speed traffic condition monitoring platform big data is obtained by using the feature matching method of association rules.

$$\frac{\mathrm{d}\mathbf{z}(t)}{\mathrm{d}t} = F(\boldsymbol{z}) \tag{6}$$

In the m-dimensional phase space, the information fusion and adaptive special decomposition of the traffic data are carried out, and the expression $s_i = (x_i, x_{i+\tau}, \cdots, x_{i+(m-1)\tau})^{\mathrm{T}}$ of the output traffic data feature sequence is obtained as a set of scalar sampling sequences. The trajectory of the vector characteristic time series of the Jiangxi high-speed traffic condition monitoring platform big data in high-dimensional phase space is $\{x(t_0 + i\Delta t)\}$, $i = 0,1,\cdots,N-1$. The information fusion scheduling is carried out by using the grey model. The association rule function $C(\tau)$ of big data in the Jiangxi high-speed traffic condition monitoring platform is defined as follows:

$$C(\tau) = \lim_{T\to\infty}\frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} x(t)x(t+\tau)\mathrm{d}\tau \tag{7}$$

Where τ is the time delay of the Jiangxi high-speed traffic condition monitoring platform big data in reconstructing phase space, which represents the correlation degree of big data change in the platform. Combined with the information fusion theory, the text information, position information, pictures, audio, videos, and other Jiangxi high-speed traffic state data are pattern recognition and information fusion. The optimal dispatching of big data in the Jiangxi high-speed traffic condition monitoring platform is realized. The storage of big data in the traffic platform consumes a large amount of storage, and real-time data processing is also required. Combined with big data's information fusion processing, the adaptive scheduling ability of big data in the Jiangxi high-speed traffic condition monitoring platform is improved [10].

3. Large-Scale Data Information Fusion and Scheduling Optimization of High-Speed Traffic State Monitoring Platform in Jiangxi

3.1. Data Information Fusion of Jiangxi Expressway Traffic Condition Monitoring Platform

On the basis of effective mining of the Jiangxi high-speed traffic condition monitoring platform big data by using the model base feature analysis and dynamic detection method, big data information fusion and scheduling optimization of the through-processing platform are carried out. For the big data sample data set of K Jiangxi high-speed traffic condition monitoring platforms in the input learning machine, $\{x_i, y_i\}$ and $i = 1, 2, \cdots, k$, in which k represents the sampling number of Jiangxi high-speed traffic condition monitoring platform big data time series. After normalizing the collected data, a Jiangxi high-speed traffic condition monitoring platform is loaded into the high-dimensional phase space $\{x_i\}_{i=1}^{N}$ through an intelligent learning system. The autoregression process of big data's non-stationary random linear combination sequence of the Jiangxi high-speed traffic condition monitoring platform big data is constructed in the high-dimensional phase space. The expression is as follows:

$$f(x) = \omega^{\mathrm{T}} (\phi)_X + b \tag{8}$$

Where ω represents the large data information fusion scheduling error vector matrix of the high-speed traffic state monitoring platform of Jiangxi, and b is the deviation vector of the large data information fusion scheduling of the high-speed traffic state monitoring platform of Jiangxi [11]. The method comprises the following steps: the large historical data of the high-speed traffic state monitoring platform of Jiangxi is selected as an initial characteristic quantity of the information fusion scheduling model, and self-adaptive correction is carried out on the error term of the large data information fusion scheduling of the high-speed traffic state monitoring platform in Jiangxi. The discriminant function of obtaining the information fusion correction is as follows:

$$L_\xi = \begin{cases} |f(x) - y| - \xi, & |f(x) - y| \geq \xi \\ 0, & |f(x) - y| < \xi \end{cases} \tag{9}$$

The reconstructed Jiangxi high-speed traffic state monitoring platform is represented by any point in the large data time sequence phase space of the high-speed traffic state monitoring platform of Jiangxi as $\boldsymbol{X}_n$, the nearest neighbor point in the high-dimensional gray model of the high-speed traffic state monitoring platform is denoted as $\boldsymbol{X}_{\eta(n)}$, and the training function of the m-dimensional gray model is established. The optimization model for obtaining the large data information fusion scheduling of the high-speed traffic state monitoring platform of Jiangxi is as follows:

$$\min_{\omega, h, \zeta_l, \zeta_l^*} = \frac{1}{2} \omega^{\mathrm{T}} \omega + c \sum_{i=1}^{l} (\zeta_l + \zeta_l^*) \tag{10}$$

Based on the information fusion theory, this paper realizes the pattern recognition and information fusion of the text information, position information, pictures, audio, videos, and other Jiangxi high-speed traffic state data in the high-speed traffic state monitoring platform of Jiangxi and improves the intelligent information management ability of the platform [12-14].

3.2. Big Data Fusion Scheduling Model

On the basis of data information fusion, a high-speed traffic state characteristic multi-dimensional multi-scale algorithm of the Jiangxi high-speed traffic state is established. By using the statistical regression analysis method, a nonlinear time series model of large data in the high-speed traffic state monitoring platform of Jiangxi is constructed, and a linear combination model is obtained as follows:

$$x_k = \sum_{n=0}^{N/2-1} 2(a_n \cos\frac{2\pi kn}{N} - b_n \sin\frac{2\pi kn}{N}), \quad k = 0, 1, \cdots, N-1 \tag{11}$$

Where a_n represents the amplitude of the large data linear programming model, and with m large data nodes $A_1, A_2, \cdots, A_n$, the linear programming problem of large data fusion scheduling in the Jiangxi high-speed traffic condition monitoring platform is expressed as follows:

$$\min(f) = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij} \tag{12}$$

$$\begin{cases} \sum_{j=1}^{m} X_{ij} = a_i, \ i = 1, 2, \cdots, m \\ \sum_{i=1}^{m} X_{ij} = b_i, \ j = 1, 2, \cdots, n \\ X_{ij} \geq 0, \ i = 1, 2, \cdots, m, \ j = 1, 2, \cdots, n \end{cases} \tag{13}$$

Assuming that the number of big data distribution nodes in the Jiangxi high-speed traffic condition monitoring platform is $n, N_1, \cdots, N_n$, the learning algorithm of the fuzzy convolution neural network is used to obtain the adaptive learning weighting coefficient of big data classification.

$$\alpha_{desira}^{i} = \alpha_1 \cdot \frac{Density_i}{\sum_i Density_i} + \alpha_2 \frac{AP_i}{AP_{init}} \tag{14}$$

The statistical quantitative set of the data is $(u,v) \in E$ for $B \subset V$, and $A \cap B = \varphi$ realizes the data scheduling and information fusion processing in the Jiangxi high-speed traffic condition monitoring platform according to the above processing.

4. Simulation Experiment and Result Analysis

In order to test the performance of this method in realizing big data fusion and adaptive scheduling of the traffic platform, a simulation experiment is carried out [15-16]. The software platform of the experiment is designed by Matlab 7. The data sampling time of the Jiangxi high-speed traffic condition monitoring platform is 1200s, the size of the data sample is 1,024, the size of the training sample is 100, and the number of simulation iterations of Y *HW* = 0.21. The big data information fusion, which is the detection threshold of association rules, is 100. The sampling period of large data fusion dispatching in the Jiangxi high-speed traffic condition monitoring platform is 120s. According to the above simulation environment and parameter setting, the data scheduling and information fusion processing of the Jiangxi high-speed traffic condition monitoring platform are carried out, and the original sampling data is shown in Figure 2.

The data sampling result of the high-speed traffic state monitoring platform of the Jiangxi high-speed traffic condition in Figure 2 is the test data set. The information fusion and the self-adaptive scheduling are carried out, and the obtained information fusion output result is shown in Figure 3.

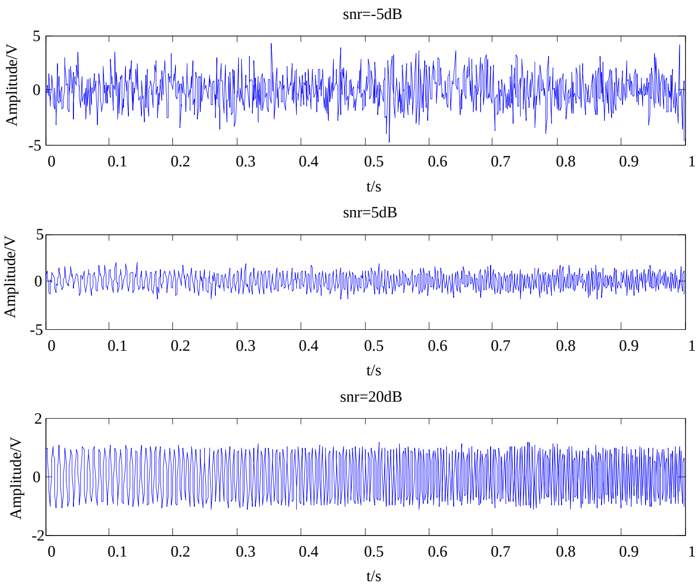

Figure 2. Data sampling results of Jiangxi high-speed traffic condition monitoring platform

Figure 3 shows that using big data to mine the Jiangxi high-speed traffic condition monitoring platform can achieve good clustering and high degree of information fusion. The accuracy of data scheduling of the Jiangxi high-speed traffic condition monitoring platform is tested by different methods. The comparison results are shown in Figure 4. The analysis in Figure 4 shows that this model can effectively realize the adaptive scheduling of the Jiangxi high-speed traffic condition monitoring platform, and the accuracy is high. The adaptive performance is better [17-18].

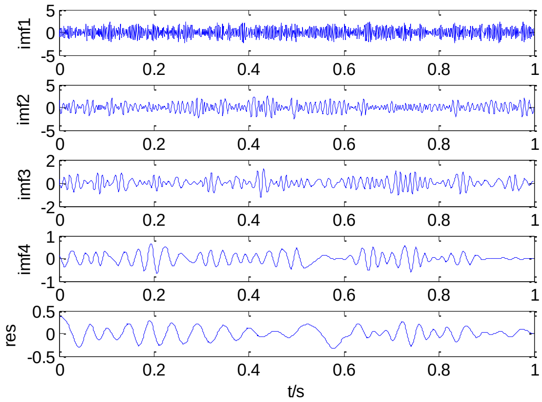

Figure 3. Information fusion processing results of Jiangxi high-speed traffic state monitoring platform

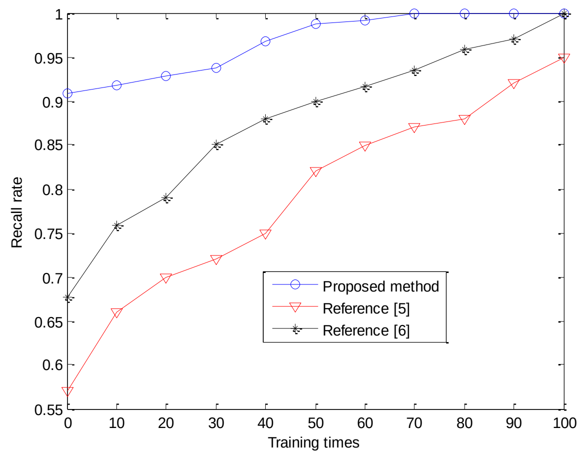

Figure 4. Performance comparison

The accuracy of Jiangxi high-speed traffic condition monitoring and dispatching is tested by different methods. The comparative results are shown in Table 1. The analysis in Table 1 shows that the accuracy of Jiangxi high-speed traffic condition monitoring using this method is higher.

Table 1. Comparison of accuracy of Jiangxi expressway traffic condition monitoring

Iterations	Proposed method	Reference [4]	Reference [5]
100	0.921	0.845	0.910
200	0.935	0.856	0.923
300	0.985	0.890	0.934
400	0.992	0.911	0.945

5. Conclusions

In the high-speed traffic state monitoring platform of Jiangxi, the information fusion and optimization of the large data must be carried out, and the efficiency of the traffic data management of the high-speed traffic state monitoring platform of Jiangxi is improved. The requirements of urban traffic intelligence, such as high timeliness and knowledge traction, are met. This paper presents a multi-dimensional multi-scale analysis model of the high-speed traffic state of Jiangxi, which is based on the information fusion of vehicle networking and traffic data. According to the establishment of a good knowledge base, model base, and method base, information clustering processing is carried out on the high-speed traffic state characteristic information of Jiangxi, and a model base characteristic analysis and a dynamic detection method are adopted to carry out the effective mining of the large data of the high-speed traffic state monitoring platform. Based on the information fusion theory, the pattern recognition and information fusion of the high-speed traffic state data of the Jiangxi high-speed traffic state monitoring platform are carried out. The large data monitoring and resource information scheduling capability of the high-speed traffic state monitoring platform are thereby improved, and the high-speed traffic state characteristic multi-dimensional multi-scale algorithm of the Jiangxi high-speed traffic state is established. The intelligent information management capability of the high-speed traffic state monitoring platform of Jiangxi is also improved. In this paper, the data processing of the high-speed traffic state monitoring platform of Jiangxi is better, the scheduling accuracy is high, and the demand of intelligent traffic information management is satisfied.

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