# Optimization of Urban Mass Transit System Based on Support Vector Machine and Ant Colony Algorithm

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**Abstract.** Due to the rapid growth of economy, the acceleration of urbanization, the rapid expansion of city scale and the rapid increase of urban population, the existing urban transportation can no longer meet the requirements of urban growth. The immature urban mass transit (UMT) system is the root of traffic congestion, so it is urgent to build an efficient and intelligent UMT system to solve the city transportation congestion problem. Based on the research of SVM (Support Vector Machines) algorithm and CAD theory, this article puts forward a traffic stream forecasting model according to the characteristics of UMT, thus providing support for the optimization of UMT system. The algorithm model is applied to the optimization of UMT system. This method optimizes the training parameters in SVM through GA to get the optimized SVM prediction model. Compared with traditional ant colony algorithm (ACA), this model has better fitting degree and higher accuracy with real data, and is suitable for UMT system optimization. In order to provide theoretical guidance and decision support for UMT related work.

**Keywords:** Support Vector Machine Algorithm; CAD; Genetic Algorithm; UMT; Optimize
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## 1 INTRODUCTION

Due to the continuous improvement of people's living and economic level, the traffic stream is increasing. The density of traffic of the existing urban road network can't match the rapid growth of automobile trips, which leads to frequent traffic jams in cities and the traffic jam problem is becoming more and more serious. The intelligent rail transit system can improve the transportation efficiency of trains and reduce the congestion time of trains at stations and road sections by optimizing the train diagram and scheduling scheme. For example, by monitoring traffic flow and passenger demand in real-time, dynamically adjusting train schedules and stops to reduce congestion and waiting time. Intelligent rail transit system can reduce traffic congestion by optimizing route planning. For example, by analyzing historical and real-time traffic data, the intelligent rail transit system can adjust the route direction to avoid congested sections and periods, so as to reduce congestion and travel time of passengers. Intelligent rail transit system can optimize traffic flow through intelligent signal control. Through the linkage with the traffic lights, the intelligent rail transit system can adjust the timing of the lights in real time according to the traffic flow, so as to reduce the waiting time of vehicles at the intersection and improve the traffic efficiency of the road. The intelligent rail transit system can encourage passengers to use public transport by sharing traffic modes. The system can improve the transparency of transportation routes through passenger information sharing. For example, by monitoring traffic flow in real time and providing real-time passenger information, passengers can understand the arrival time, frequency, congestion situation, and other information of trains, so that they can better plan their travel routes and times and reduce congestion on urban roads. To sum up, the intelligent rail transit system can solve the problem of urban traffic congestion by improving transportation efficiency, optimizing route planning, intelligent signal control, sharing traffic modes and passenger information sharing. These methods can effectively reduce urban road congestion, reduce environmental pollution, and improve the efficiency and convenience of urban transportation system.

At present, in order to reduce the cost of urban Railway track operation and the problem of passenger distribution, it is necessary to constantly improve the model strategy of rail transit services. Therefore, it is necessary to allocate the developed operator cost model in a mixed mode for medium and short distances. Feng et al. [1] conducted an analysis of the commercial optimization problem of integer mixed programming models. It constructed practical cases for heuristic exploration, proving the effectiveness of the proposed nonlinear technology model. Traffic jam seriously affects people's normal life and work, and the current city transportation is facing severe challenges. Foda et al. [2] constructed a model for greenhouse gas emissions from electric travel. It constructs a spatial mapping model for the energy consumption timing algorithm of electric buses that can be scheduled. Considering that the energy consumption of each trip of the vehicle simulator of the public transport network is constant, it simply analyzes the construction of the basic algorithm of the Surrogate model. The operation efficiency of mass transit will have a great impact on the city transportation environment, citizens' travel situation and the whole social benefit. The issue of energy consumption is becoming increasingly prominent in the rapid development of urbanization. Gao and Yang [3] conducted an analysis of the operational cost and service utilization of network urbanization in the development of rail transit. Through the daily operation and energy maintenance of rail transit, it has constructed a network rail transit speed profile optimization system for renewable energy. The formation of the final planning scheme of the track line is mainly determined by the planners' preference for the weights of various planning objectives and the constraints. Because the initial investment of mass transit is huge, the main goal in mass transit line planning is to make the initial investment of mass transit as small as possible, while taking into account other goals. Golbabaei et al. [4] conducted an analysis of driving technology in intelligent and sustainable cities. Some researchers believe that autonomous vehicles are the key to the development of urban rail transit. This study aims to investigate and analyze environmental achievements in the context of intelligent transportation. Through the analysis of the transportation sustainability results of renewable energy, it integrates the expected liquidity effects of urban transportation policies. Nowadays, UMT system generally adopts high-speed and high-density operation mode, so it must rely on advanced mass transit technology for management and control. The purpose of mass transit scheduling optimization is to determine the optimal or nearly optimal operating departure schedule, so that the mass transit system can achieve the highest operating efficiency and service level.

In recent years, China's urban rail transit has been in a period of rapid rise, with multiple large-scale urban rail transit infrastructure projects such as subways and light rail being completed one after another. Public transportation plays a very important role in reducing urban traffic pressure and improving urban transportation capacity. UMT route planning is a complex decision-making process with multiple objectives, constraints, uncertainties, unmeasurable factors, large capital expenditures, and long-term implications. As the basis of intelligent transportation structure, accurate prediction of traffic flow is an important basis for achieving scientific and standardized Transportation planning, traffic guidance and traffic control. However, due to the randomness, complexity, and uncertainty of traffic flow, it is difficult to establish a suitable mathematical model. Therefore, artificial intelligence methods are increasingly being valued in traffic flow prediction. Among them, SVM not only shows superiority in the case of linear separability, but also shows many advantages in nonlinear and high-dimensional pattern recognition. Based on the research of SVM classification algorithm, this article combines SVM algorithm with CAD to explore the optimization of UMT system. The main work and innovation focus on the following aspects:

① Based on the analysis of the current research status of traffic stream forecasting, this article points out the limitations of traditional models. Aiming at the shortcomings of SVM algorithm, GA (Genetic Algorithm) is used to optimize the parameters of SVM, and the phase space of the original data of AC traffic is reconstructed by chaos theory, and the traffic stream prediction model is established.

② According to the characteristics of mass transit system, the whole algorithm is designed to find all the optimal or suboptimal solutions that meet the constraints within a limited quantity of algorithm steps. Moreover, an example is tested and verified by simulation. The results show that the model and algorithm can meet the needs of UMT system optimization and automatic operation adjustment.

The structure of this article is as follows:

Section 1: Introduction. Mainly introduces the relevant background of the research and the significance of the topic selection; Summarize the research status and development trend of UMT system; Explain the research content and structure of this article. Section 2: Summary and research of relevant literature. Section 3: Analyze the relevant theoretical basis of the research, introduce the relevant theoretical basis of SVM, and explain the concepts and principles. Based on the above, the optimization of UMT system is analyzed by combining SVM algorithm with CAD. Section 4: Research on the improvement of the algorithm; And carry on the experimental analysis. Section 5: Summarize the existing research work.

## 2 RELATED WORK

The mobility of urban rail transit has received widespread interest from cities and countries. Huang et al. [5] constructed an integrated mode control program for railway service stations through urban simulation analysis of rail transit. This model divides the geographical features of different regions and predicts the system features of the fully automated shared fleet in that region. Khodaparastan et al. [6] conducted a computer-aided energy consumption analysis of tram rail transit. By capturing and controlling regenerative energy, it analyzed the construction of energy and voltage capture braking for variable power stations on electric vehicles. This method recycles and reuses a portion of the wasted energy in urban rail transit. The current construction of urban rail transit is moving towards the goal of intelligence and intelligence. Optimizing the intelligent level of urban rail transit has become the key to this work. Liu et al. [7] conducted a performance analysis of computer planning algorithms for urban rail transit. A detailed derivation of the solution model for nonlinear gradient information under transformation and the implementation steps of the algorithm are provided. The study conducted simulation on three different slope urban railways. The results indicate that this method has advantages in the accuracy of rail transit. Urban rail transit is the core service medium of large cities. Liu et al. [8] proposed a CAD intelligent track control system based on deep learning models to address the chaotic situation of interval control in some urban rail transit systems. The system can conduct deep mining and collision comparison of passenger traffic through facial recognition and iris recognition, and intelligently determine solutions. Luan et al. [9] conducted a value measurement analysis of the multi-indicator system for urban rail transit. Through the information entropy analysis of the model matrix, a flexible data-driven networked Decision model is constructed. By adjusting the priority of the model program, the reliability of the proposed framework was constructed.

Lv et al. [10] conducted energy consumption optimization for the rapid growth of urban rail transit pressure. It constructs a mixed responsibility pressure model under unconstrained conditions. By optimizing and integrating the nonlinear conditions of the target, the solution process for improving commercial rail efficiency has been simplified. In the process of optimizing the alternative target of system operating costs, it constructed a data validation model for rail transit. The results indicate that the proposed model has significant application value in energy conservation of the energy consumption system. Mo et al. [11] has made great efforts to improve the path selection parameter model analysis of urban rail transit system. By inferring the information difference data under the framework construction, a nonlinear constrained dynamic traffic load model for urban rail systems was constructed. This model proposes that when passengers follow predefined behavior patterns in urban rail transit, the solution of the original problem depends on the difference between the exported and observed information. Szalai et al. [12] printed printed materials for Railway track tool strategy. It analyzed the organizational model printing results of traditional materials for production tools. Through model stamping of different Railway track part materials, it analyzes the optimization and infrastructure application of 3D printing rapid prototyping deep drawing tools for automobile and railway sheet testing. Taboada and Han [13] conducted a data network analysis on the input and output of sustainable rail transit models. By tracking the carbon dioxide footprint of stations and passengers of open source urban rail transit, it builds the sustainable development efficiency of frequency and link occupancy under the proposed indicators. Through experimental verification and analysis of the proposed method data, its efficiency evaluation of transportation routes has been greatly improved. Tian et al. [14] developed and applied urban driving strategies for trams. The development technology of its research comes from advanced tram track optimization technology. The relevant drivers and railway operating systems have evaluated the system energy consumption of circuit trajectories for potential solutions. In order to develop an enhanced algorithm for optimal speed trajectory energy utilization, optimization testing of value control was conducted. Wang et al. [15] conducted accelerated fatigue experimental analysis of urban rail tram simulation. When the acceleration fatigue switch device of the urban tram malfunctioned, the prediction model analysis of the fatigue experiment was carried out by applying experimental data analysis, simulation testing, and fault data fitting. It provides data assurance analysis for temperature factors.

Wei et al. [16] constructed an optimization model for the vertical linear link between concentrated station stations. By constructing objective functions for the operating costs and energy consumption costs of station nodes, it analyzes the widespread search applications of continuous space. Analysis of strategy points considering site optimization. It proposes a dynamic adaptive complex constraint condition processing process. This satisfies complex constraints on the optimization of the actual situation of the interconnection link. The safe use of urban rail transit cannot be separated from the strategic guarantee of network security. Xu and Li [17] conducted a theoretical analysis of fast node parameter reference for rail transit. It explores the safe operation strategies for the system robustness of urban rail transit. The results show that in the process of constructing the traffic system from cluster point to network, the robustness and topological parameters of computers are improved. Xu et al. [18] conducted an optimization analysis of evacuation measures based on the theoretical framework of orbital freedom in public spaces. It builds the theory by simulating and optimizing the Emergency evacuation strategy of the station. Currently, many cities have simulated the consequences of high-risk congestion in rail transit. In the process of carrying out the evacuation strategy of frame traffic, it constructed a simulation operation optimization mode of Emergency evacuation. The results indicate that the removal of the metal barrier at the station can effectively ensure the effectiveness of evacuation. Zhang et al. [19] conducted traffic demand maintenance for railway calculation cycle costs. Considering the energy, the user's recurrent expenditure cost, it developed the profiling analysis demand of Railway track, and optimized the regenerative braking energy for the simulation model construction of train energy conservation. On this basis, it conducted a joint optimization of the calculation cost and sensitivity of train operation. The effectiveness of this method was verified during the analysis of the impact of railway lines on transportation. At present, the Internet of Things of intelligent transportation system controlled by CAD has strong and efficient control capability. The CAD Internet of Things plays an important role in the virtual system simulation of urban rail transit. Zhu et al. [20] analyzed the depth sensor of Physical system of rail transit. Through this method, it can quickly carry out the expected evolution of intelligent transportation system and result analysis.

Based on the research of SVM algorithm and CAD theory, this article puts forward a traffic stream prediction model according to the characteristics of UMT, thus providing support for the optimization of UMT system. The simulation results show that the model has better fitting degree and higher accuracy than the traditional ACA, and is suitable for UMT system optimization.

## 3 OPTIMIZATION OF UMT SYSTEM

### 3.1 SVM Algorithm and CAD Technology

SVM (Support Vector Machine) is a common Supervised learning algorithm, which can be used for classification, regression, anomaly detection and other tasks. CAD (Computer Aided Design) technology is a software tool used for designing and simulating complex systems. The introduction of SVM algorithm and CAD technology into urban rail transit can improve the safety, reliability and efficiency of the transportation system. Using SVM algorithm for anomaly detection of tracks can timely detect defects and faults in the tracks and avoid accidents. For example, SVM algorithm can be used to classify the image or sound data of the track to detect possible problems such as cracks, deformation, wear, etc. The use of SVM algorithm to achieve intelligent train operation control can improve the efficiency and safety of train operation. For example, SVM algorithm can be used to analyze and predict various factors during train operation, such as traffic flow, weather, terrain, etc., in order to achieve more intelligent and accurate speed control and path planning. CAD technology can be used to design and optimize stations and routes. For example, CAD technology can be used to design and simulate the layout of stations, transfer channels, Skyway, etc. to achieve a more convenient and safe passenger experience. Using SVM algorithm and CAD technology, traffic flow can be predicted and scheduled to improve the efficiency and reliability of the traffic system. For example, SVM algorithm can be used to predict traffic flow, and then CAD technology can be used to optimize traffic signals to achieve more efficient and smooth traffic flow. In a word, the introduction of SVM algorithm and CAD technology into urban rail transit can greatly improve the intelligent level of the transportation system and improve the safety and efficiency of the transportation system. However, it should be noted that in practical applications, factors such as data availability and quality, algorithm complexity and scalability, technology feasibility and cost need to be considered.

Identification and prediction of UMT is the basis and prerequisite for building UMT system. On this basis, the identification and prediction of UMT condition are further studied. In order to solve the shortage of traditional traffic stream forecasting model, some scholars introduced various intelligent algorithms into traffic stream forecasting modeling, and neural network and SVM appeared. Among them, the neural network algorithm based on artificial intelligence has high recognition accuracy, but it is easy to converge locally. Given a sample data set:

$$\{(x_i, y_i)\}_{i=1}^{N} \tag{1}$$

Where $x_i \in R$ is the input vector, $y_i \in R$ is the output vector, and $N$ is the quantity of training samples. The goal is to find a function $f(x)$, which can better approximate all sample points. The nonlinear processing ability of SVM mainly comes from kernel function, and with the help of kernel function, nonlinear classifiers in input space can be constructed. The nonlinear SVM is shown in Figure 1.

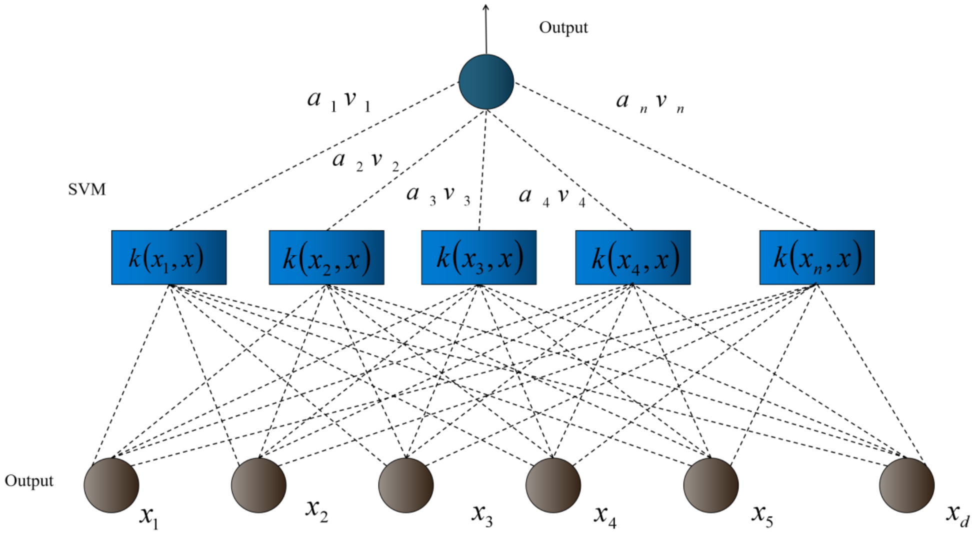


**Figure 1:** Nonlinear SVM.

With the introduction of kernel function, the inner product operation in high-dimensional space can be realized by the function in input space, which avoids the dimension disaster. Commonly used kernel functions include radial basis function, polynomial kernel function, etc. Since radial basis function has only one variable to be determined, compared with other kernel functions, radial basis function is used to construct the SVM regression model in this article. The specific formula is as follows:

$$k(x_i, x_j) = [\varphi(x_i) \bullet \varphi(x_j)] \tag{2}$$

The estimation function of the support vector regression machine is expressed as:

$$f(x) = [\omega^T \bullet \varphi(x)] + b \tag{3}$$

Where $\omega$ is the weight vector, $b$ is the threshold, and $[\bullet]$ stands for inner product operation. For any $\Phi(x) \neq 0$ and $\int \Phi^2(x) dx < \infty$, the following equation holds:

$$\int\int K(X, X')\Phi(x)\Phi(x')dxdx' > 0 \tag{4}$$

In the evolutionary algorithm, the optimal solution set of a multi-objective optimization problem is composed of different individuals in multiple afternoon populations, and the quantity of individuals who "participate" in this optimal solution set is different, so we are more willing to "participate" in the construction of the optimal solution set, which means that the sub-population with more solutions can be better developed, that is, it can leave more of its own "genes". In the process of traffic stream modeling and forecasting based on SVM, the first step is to determine the optimal SVM parameters, which is the key technology to improve the accuracy of traffic stream forecasting. The key parameters are mainly penalty coefficient $C$ and kernel function parameter $\sigma$ .when the value of $C$ is small, the sample punishment beyond the insensitive zone in the sample data is also small, and at the same time, the training accuracy is reduced, the system promotion ability is worse, and the phenomenon of "lack of learning" appears; When the value of $C$ is too large, it is easy to "over-learn". When the $\sigma$ value is small, it is easy to appear "under-learning" phenomenon, and when the $\sigma$ value is large, it is easy to appear "over-learning" phenomenon.

### 3.2 Traffic Stream Forecasting Modeling Based on SVM Algorithm

The traffic flow prediction modeling based on SVM algorithm first requires collecting traffic flow data. Such as the number of vehicles, speed, road conditions, etc. These data can be obtained from traffic monitoring systems, sensors, GPS, and other channels. After the data is collected, preprocessing is required, including Data cleansing, missing value filling, feature extraction, etc. Select features related to traffic flow from the preprocessed data as input. These features can include historical traffic flow data, weather conditions, time periods, road conditions, etc. Divide the data into training and testing sets. The training set is used to train the model, and the test set is used to verify the predictive performance of the model. The model uses SVM algorithm to train the training set and establish a prediction model. SVM algorithm is a Supervised learning algorithm, which can learn the nonlinear relationship between input and output through training samples, thus realizing the prediction of new data. Optimize the model to improve prediction accuracy and generalization ability. Optimization can be achieved by adjusting the parameters of the SVM algorithm, selecting different kernel functions, and adding features. Evaluate the trained model using a test set and calculate indicators such as prediction error, accuracy, and recall rate. If the performance of the model is not ideal, Feature selection, model parameter adjustment and other operations need to be carried out again. Apply the trained model to actual traffic flow prediction. By monitoring real-time traffic flow data, predict future traffic flow, provide decision-making support for traffic management departments, and achieve traffic optimization and scheduling. It should be noted that traffic flow prediction is a complex problem that involves multiple factors and dynamic changes. In order to improve prediction accuracy and reliability, it is necessary to select appropriate features and algorithms, and fully preprocess and analyze the data. At the same time, it is also necessary to provide a reasonable explanation and application of the predicted results based on the actual situation.

In the process of traffic stream modeling based on SVM, the quality of parameters directly determines the prediction effect of traffic stream. If the parameters are determined irrationally, the prediction error of traffic stream will be large, otherwise the prediction accuracy of traffic stream will be high. In view of the implicit parallelism and powerful global search ability of GA, this article proposes a method of traffic stream prediction based on GA-optimized SVM, and uses GA to determine the training parameters in SVM. The algorithm borrows the selection mechanism of biological evolution in nature and solves the problem through genetic mechanism such as selection, crossover and mutation. Genetic coding is the basic step of GA, which transforms the problem to be solved into a form that GA can handle. Binary coding method is the most commonly used genetic coding method, which expresses the solution parameters in the form of 0 and 1 codes and connects them to form a "chromosome". Binary coding can solve most of the problems to be solved. Figure 2 shows the GA iterative optimization process.

Set the GA population size as 25 and the quantity of iterations as 250. This shows that the SVM parameter population evolves continuously in the process of optimization until the training conditions are met and the optimal parameters $C$ and $\sigma$ are obtained. Let the length of the mass transit section be $L$ and the travel time of the section be the road weight, then the road weight function of the section is:

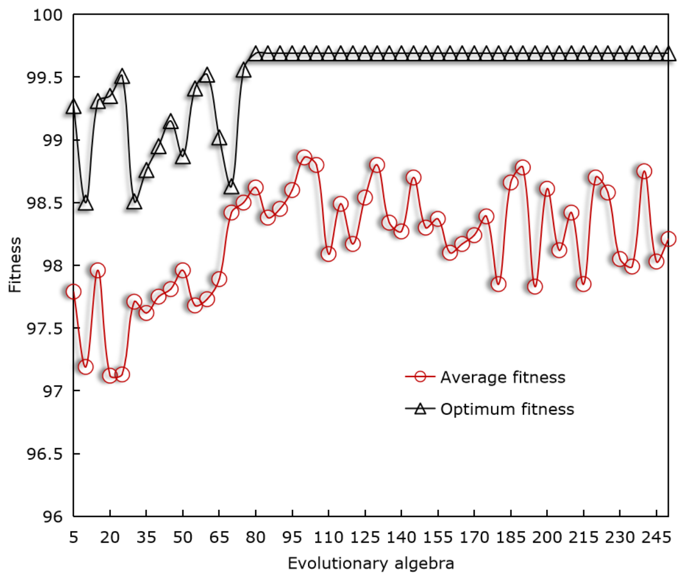


**Figure 2:** Fitness curve of genetic parameters.

$$T = \frac{L}{V(Q)} \tag{5}$$

Where: $Q$ is the density of traffic, and $V(Q)$ is the average driving speed of the corresponding section when the density of traffic is $Q$. $T$ is the time required to pass through the section $L$ when the density of traffic is $Q$. According to the changing law of traffic stream, traffic stream has temporal correlation and spatial correlation, that is, the factors affecting traffic stream in a certain section include: traffic stream in the first few periods of the section; Traffic stream of several adjacent sections of this section. The delay time and embedding dimension of traffic stream are estimated by autocorrelation method and false neighbor method, and the phase space of the processed traffic stream data is reconstructed according to chaos theory to establish the time series of traffic stream modeling. The feasible region constraint can be based on the possible connection relationship of the track line and the possible quantity of stations, and ensure the feasibility of the line and stations within this range. Other constraints can be dealt with by penalty function, and the constraints outside the feasible region can be punished by penalty function.

When forecasting short-term traffic stream of road network, there are some problems such as vehicles leaving, driving and changing routes in far-away sections, and the correlation between sections is low. If it is taken into account, the prediction accuracy of the model will be affected. Therefore, the road section with the strongest correlation with the studied road section is selected to improve the prediction accuracy. The correlation coefficient between random variables in probability theory is used to judge the correlation between the traffic stream of the studied section and other sections. The relationship among traffic stream $Q$, driving speed $V$ and traffic stream density $K$ is as follows:

$$Q = V * K \tag{6}$$

Under normal traffic conditions, the relationship between speed and density can be expressed by the following formula:

$$K = K_m - \frac{K_m}{V_m} V \quad (7)$$

Where $V_m$ is the smooth speed and $K_m$ is the blocking density. Through the above formula, we can deduce:

$$Q = K_m V - \frac{K_m}{V_m} V^2 \quad (8)$$

When the flow $Q$ meets the condition of the following formula (9), it can be concluded that the relationship between the speed $V$ and the flow $Q$ is shown in formula (10):

$$0 \le Q \le \frac{K_m V_m}{4} \quad (9)$$

$$V = \frac{V_m}{2} \pm \frac{1}{2}\sqrt{V_m^2 - \frac{4V_m}{K_m} Q} \quad (10)$$

The training samples of training traffic stream are input to SVM for training, parameters $C$ and $\sigma$ are determined by GA, and the optimal parameters are finally obtained through continuous evolution. Firstly, it is necessary to prepare a training dataset for training the SVM model. The training dataset should include input features and corresponding output labels. For traffic flow prediction problems, input features can include historical traffic flow data, time periods, road conditions, etc., while output labels can be predicted traffic flow values for a future period of time. Next, use genetic algorithm to optimize the parameters of SVM. Genetic algorithm is an optimization algorithm based on Natural selection and genetic mechanism, which can be used to search the optimal solution. In genetic algorithms, a fitness function needs to be defined as an evaluation indicator to evaluate the fitness of each individual. For traffic flow prediction problems, the prediction error can be used as a fitness function to find the optimal combination of SVM parameters. Input the training dataset into the SVM model for training. During the SVM model training process, it is necessary to select appropriate hyperparameters such as kernel functions and regularization parameters, as well as optimize the model through cross validation and other methods. Evaluate the trained SVM model using a test dataset, calculate indicators such as prediction error, accuracy, and recall to evaluate the predictive performance of the model. In the process of genetic algorithm optimization, the parameters of SVM can be gradually optimized through continuous evolution. At each iteration, a new generation of population is generated based on the current optimal solution, and new individuals are generated using operations such as crossover and mutation. By continuously iterating, gradually approaching the optimal solution. After multiple iterations, the optimal parameter combination was finally determined. The optimal parameters should enable the SVM model to achieve optimal predictive performance on the test dataset. Apply the trained SVM model to actual traffic flow prediction. By monitoring traffic flow data in real-time and utilizing the SVM model with optimal parameters to predict future traffic flow, it provides decision-making support for traffic management departments and achieves traffic optimization and scheduling.

It should be noted that in the process of SVM model training and genetic algorithm optimization, it is necessary to fully preprocess and analyze the data, select appropriate features and algorithms to capture the changes in traffic flow, improve prediction accuracy and reliability. At the same time, it is also necessary to provide a reasonable explanation and application of the predicted results based on the actual situation.

Through the role of cooperative operator, the population climbs to search for the possible better solution near the current optimal solution and two sub-populations independently searching in different decision spaces and introducing each other's excellent genes, so as to expand the search area of the algorithm. The selection operation is to keep good individuals for the next generation of iterations. The genes in the two chromosomes were randomly exchanged by single-point crossover method, and the crossover rate was 0.6; Variation refers to the exchange of gene codes "0" and "1" in chromosomes. It is judged whether the convergence condition is satisfied. If it is satisfied, go directly to the next step, otherwise, use selection, crossover and mutation operations to process the current generation population and generate the next generation population. The mutation operation generates new individuals according to the uniform mutation method of mutation probability, and finally obtains the optimized model parameters. Considering that the solution space of the model is large, but the constraints are simple, GA adopts the real number coding method. It can directly perform genetic operation on the phenotype of the solution, reducing the possibility of invalid crossover.

## 4 APPLICATION EXAMPLE

GA Optimized Support Vector Machine (GA-SVM) is a prediction method that combines genetic algorithm (GA) and support vector machine (SVM). By utilizing the optimization ability of GA, the parameters of SVM can be optimized, thereby improving the prediction effect of traffic flow.

The following is an analysis of the potential predictive effect of GA-SVM on traffic flow:

Parameter optimization: GA-SVM optimizes the parameters of SVM through genetic algorithms to find the optimal parameter combination. Compared to traditional trial and error methods, GA can quickly find better parameter combinations, thereby improving the prediction accuracy of the model.

Nonlinear modeling: SVM has powerful nonlinear modeling capabilities, which can transform nonlinear problems into linear problems through kernel functions. The prediction of traffic flow is often a nonlinear problem, so SVM can better capture the changes in traffic flow.

Small sample learning: Traffic flow data is usually limited, and GA-SVM can use a small number of samples for learning, thus maintaining high prediction accuracy even in small data volumes.

Robustness: Traffic flow prediction is influenced by various factors, such as weather, time, road conditions, etc. GA-SVM has strong robustness and can maintain stable prediction performance in different scenarios.

Prediction accuracy: By utilizing GA optimized SVM models, it is possible to more accurately predict the trend of traffic flow changes. Compared to traditional methods such as linear regression, GA-SVM performs better in terms of prediction accuracy and stability.

GA-SVM has many advantages in traffic flow prediction, such as parameter optimization, nonlinear modeling, small sample learning, robustness, and prediction accuracy. By using GA-SVM to predict the traffic flow, the efficiency and reliability of the traffic system can be improved, providing decision support for the traffic management department.

In order to analyze the traffic stream prediction effect of GA-optimized SVM, this section carries out simulation tests. The traffic stream data of an intersection every hour is selected as the simulation object, and a total of 200 traffic stream data are obtained. 150 traffic stream data are selected as the training set of SVM to test its fitting ability, and the remaining 50 traffic stream data are used as the verification set of SVM to test its performance. Because the monitoring equipment is easily disturbed by the external environment, the obtained data may be polluted by noise. Therefore, this article uses wavelet denoising method to denoise the sample set. The traffic stream data takes 5min minutes as a statistical interval. Selecting training samples with the same dimension for time series and space series, and taking the dimension of input vector as 5 to construct a training sample set; And use GA to optimize SVM parameters. The calculation parameters of GA are: crossover rate and mutation rate are 0.6 and 0.01 respectively, and the population number is 20. The optimized SVM parameters are obtained: $\sigma$ is 0.481 and $C$ is 10.08. In MATLAB environment, GA toolbox and LIBSVM toolbox are used to optimize the parameters of prediction model.

Two sets of data are selected for simulation tests according to different traffic stream data characteristics. The specific test results are shown in Figure 3.

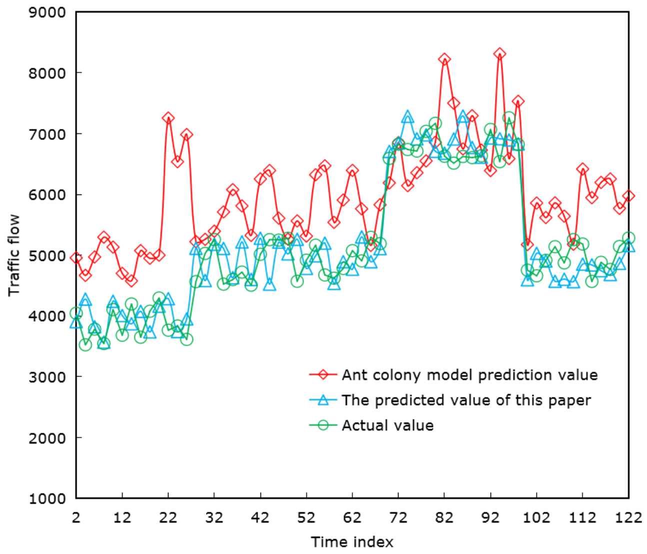


**Figure 3:** The prediction result of the 26th data item.

Taking the first 15 data items as the training set, the 16th and 17th data are predicted, and the specific test results are shown in Figure 4.

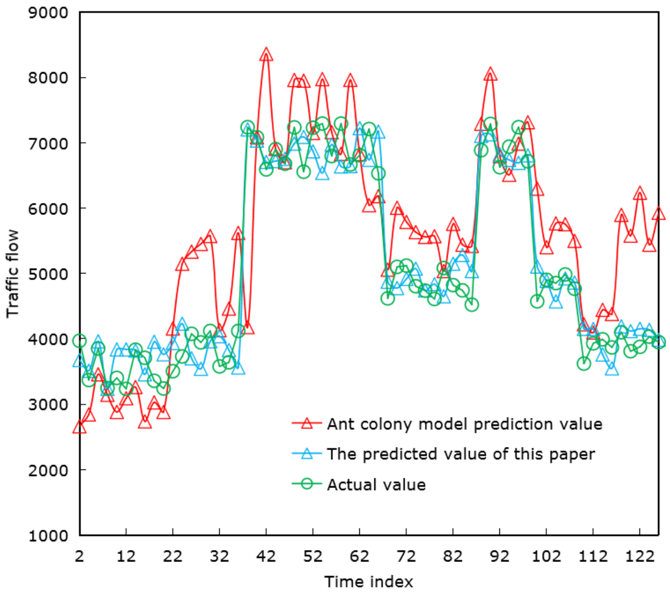


**Figure 4:** The prediction results of the 16th and 17th data items.

SVM forecasting model can get better results than ACA, and can better reflect the real situation of traffic stream. It shows that the improved SVM algorithm can effectively predict the density of traffic and thus the road weight under the condition of small samples.

In the process of GA optimization, if the initialized chromosome itself is close to the feasible solution, the probability of reaching the feasible solution will be greatly increased through crossover and mutation. Therefore, a pattern classification method is designed in this article, which makes the results of historical solution be used as the initial value when the optimization algorithm is initialized to speed up the convergence. GA has the advantages of strong global optimization and is not easy to fall into local extremum. Optimizing some important parameters in SVM through GA can improve the prediction accuracy of SVM model. The evolution curve of the algorithm is shown in Figure 5.

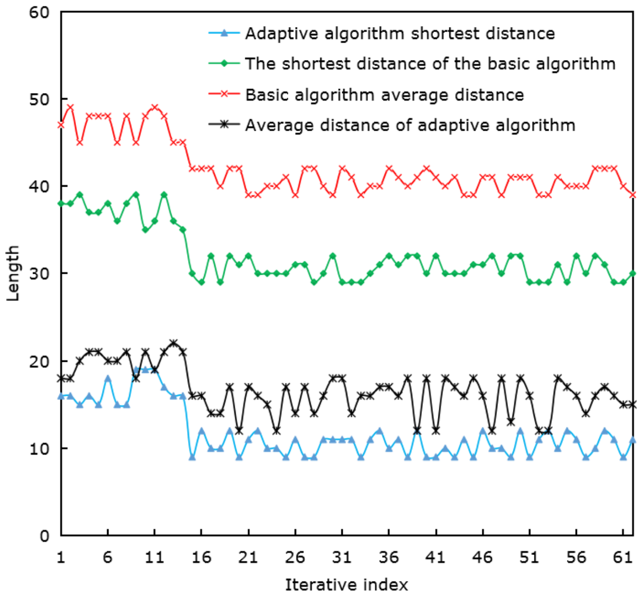


**Figure 5:** Evolutionary curve of algorithm.

Figure 5 shows that the optimal route obtained using improved SVM is better than the route obtained using basic ACA.

Perform repetitive optimization and stop running when the maximum number of repetitions is reached. On this basis, this article proposes a new optimization strategy that takes the individual with the highest fitness as the optimization objective. Determine the maximum iteration number through many tests. In this section, several examples will be selected to test this algorithm, and the error test is shown in Figure 6.

When the program continues iterative optimization, the total fitness value of the algorithm is the largest after the 80th iteration. This shows that the algorithm has the best multi-objective overall optimization performance and the best overall control effect. The parameters can be searched globally and quickly within the initialization range by using GA. The simulation results in Figure 6 above show that the error of the improved algorithm is about 1.2, and its result is better than the traditional SVM algorithm and the basic ACA. Figure 7 shows the evolutionary comparison of the basic ACA, the traditional SVM algorithm and the improved SVM algorithm in this article.

Overall, this method has better fitting ability and higher accuracy than traditional methods. The results indicate that the model can accurately predict short-term traffic stream and has good predictive performance, providing reference for UMT planning.

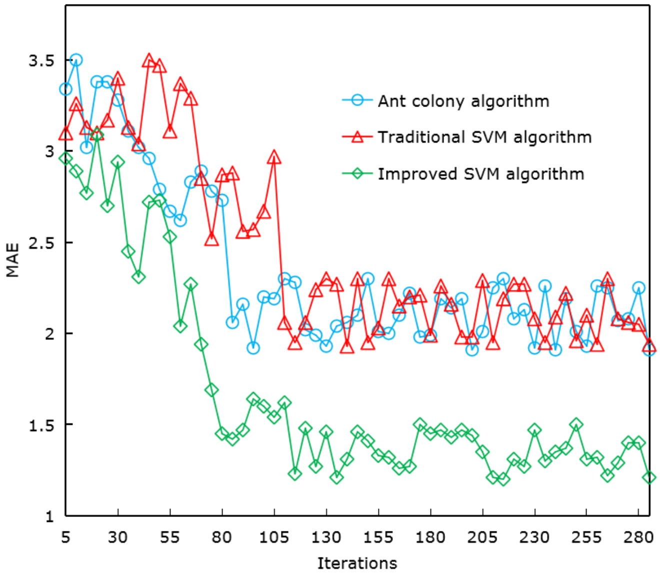


**Figure 6:** Algorithm error.

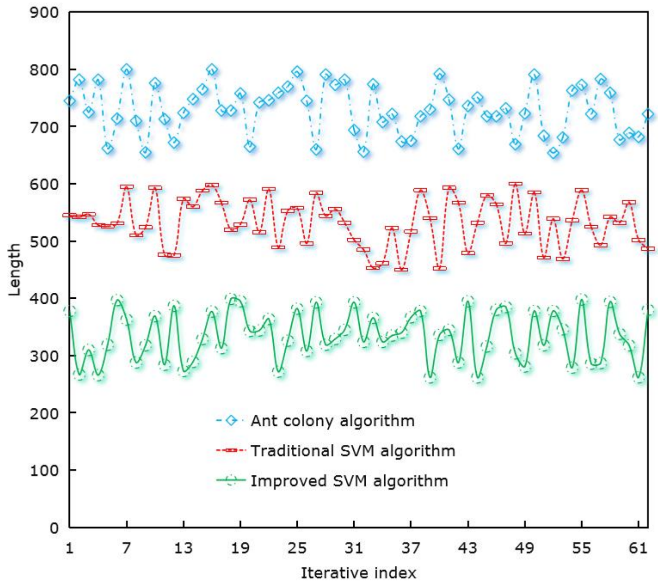


**Figure 7:** Algorithm evolution comparison diagram.

Intelligent traffic management and UMT systems require real-time collection of data such as traffic flow, vehicle location, speed, and signal strength. These data can be obtained through various sensors, GPS, mobile networks, and other means, and transmitted in real-time through data transmission networks. Intelligent traffic management and UMT systems need to process and analyze the collected data to obtain information such as traffic flow and vehicle driving status. This can be achieved through various algorithms and data processing techniques, such as machine learning, image processing, signal processing, etc. Intelligent traffic management and UMT systems can optimize the operational efficiency of traffic flow by controlling traffic signals. By monitoring traffic flow data in real-time, the timing of signal lights can be dynamically adjusted to reduce congestion and improve vehicle traffic efficiency. Intelligent traffic management and UMT systems can monitor and warn traffic conditions in real-time to avoid traffic accidents and congestion. It can monitor and analyze the vehicle speed, position, driving track and other information, timely find potential risk factors, and remind drivers to pay attention to safety through early warning information. Intelligent traffic management and UMT systems can improve user satisfaction and loyalty by optimizing user management and services. For example, personalized navigation services, real-time traffic information, parking space reservations, and other services can be provided to provide users with a convenient and comfortable travel experience. To sum up, intelligent traffic management and UMT system optimization need to start with data acquisition and transmission, data processing and analysis, traffic signal control, real-time monitoring and early warning, user management and service optimization to achieve intelligent management and optimization of the traffic system. By using advanced algorithms and technologies, the efficiency and reliability of the transportation system can be improved, traffic accidents and congestion can be reduced, and the travel experience of users can be improved.

## 5 CONCLUSIONS

Identification and prediction of UMT is the basis and prerequisite for building UMT system. On this basis, the identification and prediction of UMT condition are further studied. However, due to the complexity and variability of traffic stream, it is difficult to model it reasonably; Parameter selection support vector machine prediction model for parameter selection of conventional SVM. On this basis, the improved SVM model is GA. On this basis, UMT is optimized. The optimization model established in this article and the solution method adopted are reasonable and can meet the needs of automatic adjustment of train normal operation. In addition, this model obtains better SVM parameters, which can track the changing trend of traffic stream more effectively. Compared with traditional ACA, it has better fitting degree with real data. It improves the prediction accuracy of traffic stream and can be applied to practical intelligent traffic management and UMT system optimization.

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## REFERENCES

[1] Feng, T.; Tao, S.; Li, Z.: Optimal Operation Scheme with Short-Turn, Express, and Local Services in an Urban Rail Transit Line, Journal of Advanced Transportation, 2020(1), 2020, 1-19. https://doi.org/10.1155/2020/5830593

[2] Foda, A.; Mohamed, M.; Bakr, M.: Dynamic surrogate trip-level energy model for electric bus transit system optimization, Transportation Research Record, 2677(1), 2023, 513-528. https://doi.org/10.1177/03611981221100242

[3] Gao, Z.; Yang, L.: Energy-saving operation approaches for urban rail transit systems, Frontiers of Engineering Management, 6(2), 2019, 139-151. https://doi.org/10.1007/s42524-019-0030-7
[4] Golbabaei, F.; Yigitcanlar, T.; Bunker, J.: The role of shared autonomous vehicle systems in delivering smart urban mobility: A systematic review of the literature, International Journal of Sustainable Transportation, 15(10), 2021, 731-748. https://doi.org/10.1080/15568318.2020.1798571
[5] Huang, Y.; Kockelman, K.-M.; Garikapati, V.; Zhu, L.; Young, S.: Use of shared automated vehicles for first-mile last-mile service: Micro-simulation of rail-transit connections in Austin, Texas, Transportation Research Record, 2675(2), 2021, 135-149. https://doi.org/10.1177/0361198120962491
[6] Khodaparastan, M.; Mohamed, A.-A.; Brandauer, W.: Recuperation of regenerative braking energy in electric rail transit systems, IEEE Transactions on Intelligent Transportation Systems, 20(8), 2019, 2831-2847. https://doi.org/10.1109/TITS.2018.2886809
[7] Liu, P.; Zhou, L.; Chen, X.; Piao, C.; Zhou, X.: Gauss pseudospectral - based velocity optimization for rail transit trains with running and computation delays, Optimal Control Applications and Methods, 44(3), 2023, 1588-1601. https://doi.org/10.1002/oca.2797
[8] Liu, Y.; Shah, M.-A.; Pljonkin, A.; Ikbal, M.-A.; Shabaz, M.: Design and Research on the intelligent System of Urban Rail Transit Project based on BIM+ GIS, Scalable Computing: Practice and Experience, 22(2), 2021, 117-126. https://doi.org/10.3233/JIFS-189307
[9] Luan, X.; Cheng, L.; Song, Y.; Sun, C.: Performance evaluation and alternative optimization model of light rail transit network projects: A real case perspective, Canadian Journal of Civil Engineering, 46(9), 2019, 836-846. https://doi.org/10.1139/cjce-2018-0505
[10] Lv, H.; Zhang, Y.; Huang, K.: An Energy-Efficient Timetable Optimization Approach in a Bi-Direction Urban Rail Transit Line: A Mixed-Integer Linear Programming Model, Energies, 12(14), 2019, 2686. https://doi.org/10.3390/en12142686
[11] Mo, B.; Ma, Z.; Koutsopoulos, H.-N.; Zhao, J.: Ex post path choice estimation for urban rail systems using smart card data: An aggregated time-space hypernetwork approach, Transportation Science, 57(2), 2023, 313-335. https://doi.org/10.1287/trsc.2022.1177
[12] Szalai, S.; Herold, B.; Kurhan, D.; Németh, A.; Sysyn, M.; Fischer, S.: Optimization of 3D printed rapid prototype deep drawing tools for automotive and railway sheet material testing, Infrastructures, 8(3), 2023, 43. https://doi.org/10.3390/infrastructures8030043
[13] Taboada, G.-L.; Han, L.: Exploratory Data Analysis and Data Envelopment Analysis of Urban Rail Transit, Electronics, 9(8), 2020, 1270. https://doi.org/10.3390/electronics9081270
[14] Tian, Z.; Zhao, N.; Hillmansen, S.; Roberts, C.; Dowens, T.; Kerr, C.: SmartDrive: Traction energy optimization and applications in rail systems, IEEE Transactions on Intelligent Transportation Systems, 20(7), 2019, 2764-2773. https://doi.org/10.1109/TITS.2019.2897279
[15] Wang, L.; Liu, S.; Qiu, R.; Xu, C.: Fault prediction model of high-power switching device in urban railway traction converter with bi-directional fatigue data and weighted LSM, Applied Sciences, 9(3), 2019, 444. https://doi.org/10.3390/app9030444
[16] Wei, L.; Qiu, X.; Pu, H.; Schonfeld, P.; Zhen, S.; Zhou, Y.; Xu, Z.: Concurrent Optimization of Subway Vertical Alignments and Station Elevations with Improved Particle Swarm Optimization Algorithm, IEEE Transactions on Intelligent Transportation Systems, 23(12), 2022, 24929-24940. https://doi.org/10.1109/TITS.2022.3195754
[17] Xu, H.; Li, Y.: Robustness analysis of urban rail transit network, International Journal of Performability Engineering, 15(10), 2019, 2762. https://doi.org/10.23940/ijpe.19.10.p23.27622771
[18] Xu, H.; Tian, C.; Li, Y.: Emergency Evacuation Simulation and Optimization for a Complex Rail Transit Station: A Perspective of Promoting Transportation Safety, Journal of Advanced Transportation, 2020(4), 2020, 1-12. https://doi.org/10.1155/2020/8791503

[19] Zhang, H.; Pu, H.; Schonfeld, P.; Song, T.; Li, W.; Hu, J.: Railway alignment optimization considering lifecycle costs, IEEE Intelligent Transportation Systems Magazine, 14(5), 2021, 22-40. https://doi.org/10.1109/MITS.2021.3071032
[20] Zhu, F.; Lv, Y.; Chen, Y.; Wang, X.; Xiong, G.; Wang, F.-Y.: Parallel transportation systems: Toward IoT-enabled smart urban traffic control and management, IEEE Transactions on Intelligent Transportation Systems, 21(10), 2019, 4063-4071. https://doi.org/10.1109/TITS.2019.2934991