Research on Integration of Video Vehicle Data Statistics and Model Parameter Correction

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Abstract

The integration of vehicle statistics and model calibration can fundamentally improve the accuracy of simulation for two times, and then achieve the full automation of microscopic traffic simulation, which is of great significance to scientific assistance of traffic management and control decision.In this paper, the YOLO depth learning algorithm used in vehicle detection, the KCF (Kernerlized Correlation Filter) algorithm used in vehicle tracking, the genetic algorithm used in VISSIM parameter correction, and the virtual detection line method used in vehicle statistics are introduceddetailedly.This paper puts forward the idea of integration, that is, using COM interface to integrate the technology of intelligent vehicle statistics, the technology of model parameter correction and traffic simulation, which provides the research foundation for realizing the fully automated traffic simulation that meets the accuracy requirements.

Keywords

Vehicle traffic statistics; vehicle detection; vehicle target tracking; model parametercorrection; integration.

1. Introduction

The technology of intelligent vehicle statistics can enhance the accuracy of data acquisition and statistics. The combination of Intelligent vehicle statistics technology and model parameter correction can improve the accuracy of microscopic traffic simulation model twice, and then realize the automation of model simulation, which is conducive to the effective completion of traffic status analysis. Some research on UAV aerial photography, video target detection, vehicle recognition and positioning, model calibration and so on have been done. However, the research results have not been applied to actual traffic simulation, and the complete integration results have not been found. Based on the above analysis, the idea of integration is put forward in this paper, and it is introduced detailedly that the video vehicle data acquisition and transmission based on UAV, YOLO deep learning algorithm for vehicle detection, KCF (Kernerly Correlation Filter) algorithm for vehicle tracking, genetic algorithm for VISSIM parameter correction, virtual detection line method for vehicle statistics and COM interface integration technology.and the research framework, algorithm flow chart and working schematic diagram are given out . The research framework of this paper is shown in Figure 1.

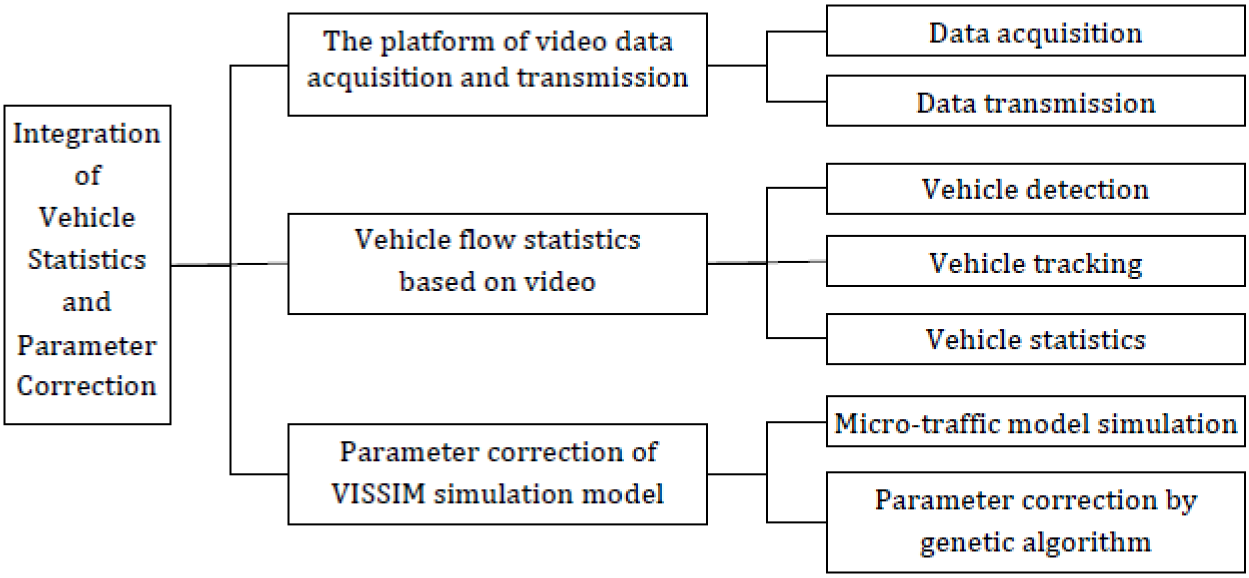

Fig 1. Framework of integrated research

2. Video Data Acquisition and Transmission Based on UAV

Using UAV to collect video data can effectively save human resources and time resources for data acquisition, which is flexible and less risky. The main components of UAV platform are remote control, power system, GPS, camera and battery with image transmission [1]. Its two main functions are to complete the task of collecting vehicle data in a specified period of time on a given road and transmit the collected video to the ground monitoring terminal in real time, so as to provide data support for vehicle detection and tracking in the future.

Camera and SIM7100C GSM (4G transmission module) can be installed on UAV platform, so as to establish a stable mobile network data transmission channel [2], which can realize the long-distance transmission of data collected by UAV to the ground end. At the same time, the ground monitoring equipment can also use the 4G module to send specific instructions to the UAV to realize the long-distance operation of the UAV. Ground-end equipment is equipped with IP to receive UAV information. Video streaming data is acquired and analyzed by data transmission protocol (HTTP protocol) to complete timely return and real-time monitoring of video data.

3. Vehicle Flow Statistics Based on Video

3.1. Vehicle Detection

A method of vehicle recognition in video data using YOLO deep learning algorithm is introduced in this paper. As a new End-to-End detection algorithm, YOLO algorithm blurs the difference between CG, FE and CV in the whole detection process. It does not need to extract the region candidate box in advance, and simplifies the whole process of target detection, then can accomplish the detection task quickly. The implementation steps of YOLO [3,4] are as follows:

① Each image is divided into a $s \times s$ grid. Each grid first is determined whether the center of a target falls into its interior. If the center of a target falls into the grid, the grid is responsible for predicting the target.

② In each grid, the reliability of B target boxes and the target boxes are predicted. Among them, the credibility reflects the confidence of the target frame in detecting objects. The calculation formula is as follows: formula is as follows:

$$Pr(Object) \times IOU \quad (1)$$

$$IOU = \frac{area(BB_{dt} \cap BB_{gt})}{area(BB_{dt} \cup BB_{gt})} \quad (2)$$

Pr (Object) is the probability that the boundary box contains the target object; BBgt is a reference standard box based on training labels; BBdt is the target box; area (.) represents area.

Each target box contains five parameters: (x, y, w, h) and Confidence, where (x, y) represents the position of the center of the target box relative to its parent grid, i.e., the coordinates of its center point, (w, h) represents the width and height of the target box. At the same time, each grid also predicts C class probabilities, namely Pr(Classi | Object). The probability value represents the probability that the target center of the class i falls into the grid. The number of categories targeted by C is independent of B. Each target box contains four-dimensional coordinate information and one-dimensional target credibility, then the data output from each grid is $5 \times B + C$ dimension. Therefore, a total of $s \times s(5 \times B + C)$ dimension tensors are output in the output layer $s \times s$ grids.

③ Predict the probability of C target categories in each grid.

④ In the test phase, the probability value and reliability of the target category are multiplied to calculate the confidence of the specific category of each target box. The formula is as follows:

$$Pr(Class_i \mid Object) \times Pr(Object) \times IOU_{pred}^{truth} = Pr(Class_i) \times IOU_{pred}^{truth} \quad (3)$$

⑤ YOLO uses Sum-Squared error as loss function. The form of loss function is as follows:

$$\begin{aligned}&\lambda_{coord}\sum_{i=0}^{S^2}\sum_{j=0}^{B} I_{ij}^{obj}[(x_i-\hat{x}_i)^2+(y_i-\hat{y}_i)^2]+\lambda_{coord}\sum_{i=0}^{S^2}\sum_{j=0}^{B} I_{ij}^{obj}[(\sqrt{\omega_i}-\sqrt{\hat{\omega}_i})^2+(\sqrt{h_i}-\sqrt{\hat{h}_i})^2]+\\&\sum_{i=0}^{S^2}\sum_{j=0}^{B} I_{ij}^{obj}(C_i-\hat{C}_i)^2+\lambda_{noobj}\sum_{i=0}^{S^2}\sum_{j=0}^{B} I_{ij}^{noobj}(C_i-\hat{C}_i)^2+\sum_{i=0}^{S^2} I_{i}^{obj}\sum_{c\in classes}(\sqrt{\omega_i}-\sqrt{\hat{\omega}_i})^2+(\sqrt{h_i}-\sqrt{\hat{h}_i})^2]\end{aligned} \quad (4)$$

λ_{coord} denotes the weight of the positioning error, λ_{noobj} denotes the weight of the confidence error of the mesh that does not contain the center of the object, Ii denotes whether or not the center of the object falls into the mesh i, and if so, Ii=1, and vice versa, Ii=0. Iij means to determine whether the jth detection boundary box in grid i is responsible for the object, if so, Iij=1, and vice versa, Iij=0.

The flow chart of YOLO vehicle detection presented in this paper is shown in Fig. 2. Firstly, each frame of video data is captured, then the vehicle samples in the image are marked, and some samples are selected as training data sets and the other part as testing data sets. The Darknet framework training model is deeply learned by using YOLO. Then, the trained model is applied to video data to complete vehicle detection and save the test results for the preparation of follow-up vehicle tracking.

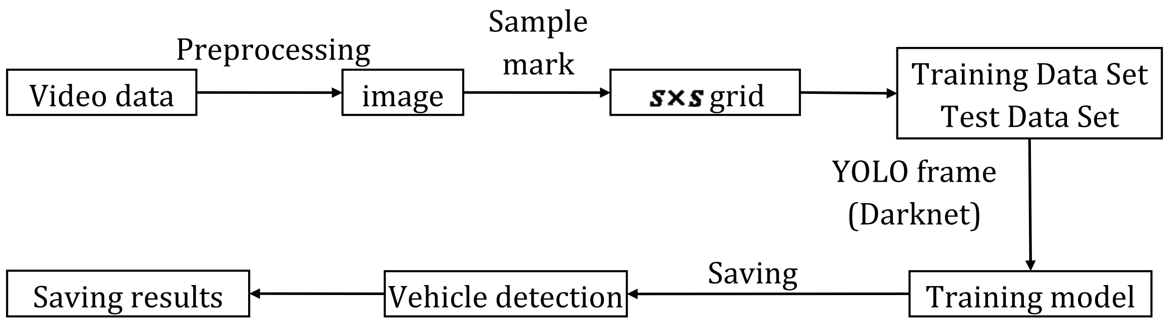

Fig 2. Flow chart of YOLO vehicle detection

3.2. Vehicle Tracking

On the basis of target detection, the state of moving target is estimated continuously, that is, target tracking. There are two main types of moving object tracking methods: matching-based moving object tracking and real-time detection-based moving object tracking. Among them, TLD, Struck and KCF algorithms are based on real-time detection. Compared with TLD and Stroke algorithm, KCF algorithm has faster speed, better real-time performance and higher accuracy.

Cyclic migration is used in KCF algorithm to generate a large number of samples and extract directional gradient histogram (HOG) features. All samples are used to train ridge regression classifier. In the case of large number of samples, the similarity between the current frame image and the tracking target is calculated by using the Gaussian kernel function. The target region with the greatest similarity is selected as the location of the tracking target in the new frame image [5]. Meanwhile, two-dimensional fast Fourier transform (FFT2D) is used to map the time domain to the frequency domain, which reduces the computational complexity in sample training and target detection. Finally, in the process of fast target detection, the two-dimensional inverse fast Fourier transform (IFFT2D) is used to map the frequency domain to the time domain to get the optimal location of the target in the next image. KCF algorithm can be summarized as training, detection and update.

3.3. Traffic Flow Statistics

Common methods of traffic flow statistics include target matching, area marking, virtual coil and virtual detection line. The method of using virtual detection line is introduced to complete vehicle statistics in this paper. The core idea is to set up a virtual detection line with appropriate length and position on the lane, only process the image on the detection line, transform the two-dimensional image signal into one-dimensional time signal similar to the ring electromagnetic induction coil, and then judge whether there is a vehicle passing through the virtual detection line by the changing characteristics(6). The virtual detection line method can be used for real-time vehicle statistics and calculation is very convenient.

4. Parameter Correction of Micro-simulation Model

4.1. Brief Analysis of Micro-simulation Software

VISSIM simulation software is a commercial simulation software developed by PTV company in Germany. It is a micro, time-driven, multi-purpose simulation modeling tool based on driving behavior. It is used to establish micro-simulation traffic model to reproduce traffic status and analyze traffic operation under different traffic conditions. It is widely used in the analysis of urban roads and expressways. However, the software is developed by Germany, and many default parameters are not suitable for China's urban road conditions. Therefore, it is important to use intelligent algorithm to calibrate the parameters of the simulation model in order to realize the localization of VISSIM simulation. The application of genetic algorithm in VISSIM simulation parameter correction is introduced in this paper.

4.2. Genetic Algorithm

Genetic algorithm is a random search and optimization algorithm based on natural selection and heredity. There are three basic operations: selection, crossover and variation. The principle of survival of the fittest is used in genetic algorithm to select good individuals from the initial population, so that these individuals can enter the next generation with a larger probability. The new generation of individuals can be obtained by exchanging information through crossover operation, i. e. exchanging parts of the individuals with crossover probability, which is called the number string of chromosomes. An opportunity for the generation of new individuals is provided by variation operation. It refers to changing the value of a string in a number string with a very low probability of variation for a randomly selected individual. The flow chart of genetic algorithm is shown in Fig. 3.

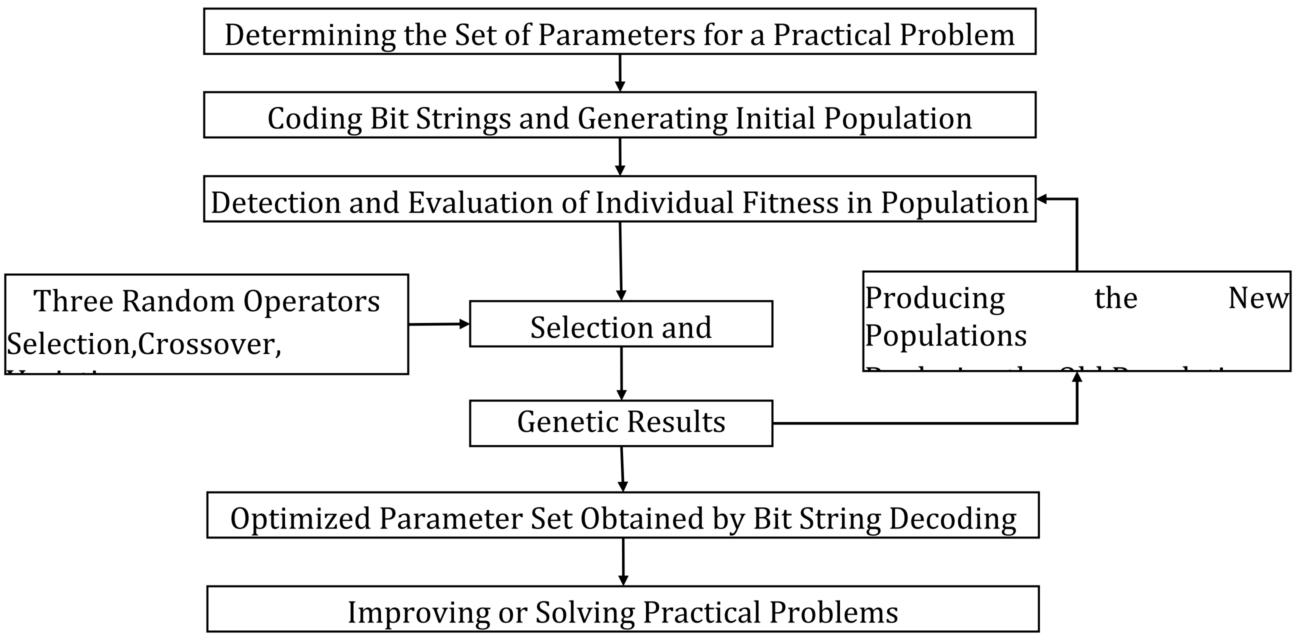

Fig 3. Flow chart of genetic algorithm

5. Integrated Analysis

The COM interface of VISSIM software opens various related objects in its simulation model to user applications, including the attributes and methods of the objects. The COM interface of VISSIM is easily used to read the attribute values of the simulation model road network objects, change the relevant parameters of the simulation model, and control the simulation process by self-adaptation and induction(7). YOLO algorithm, KCF algorithm, genetic algorithm and other complex intelligent algorithms can be implemented by python. By using Python to call COM interface module of VISSIM software, the integration of vehicle statistics, parameter correction and simulation model can be realized.

The main control program integration diagram of COM interface technology presented in this paper is shown in Figure 4. Firstly, the background picture is imported into the VISSIM simulation software. On this basis, the road network model of intersection is established. Traffic flow composition, path assignment, signal light set, data detector and travel time detector are added and saved as *.inp file. At the same time, Python is used to complete the video vehicle statistics and the vehicle input in VISSIM through COM interface, so as to realize the traffic simulation of designated intersection. The output data of VISSIM software can be acquired by python in real time, and the default parameters of VISSIM according to the data can be processed by using genetic algorithm, so as to realize the function of parameter correction.

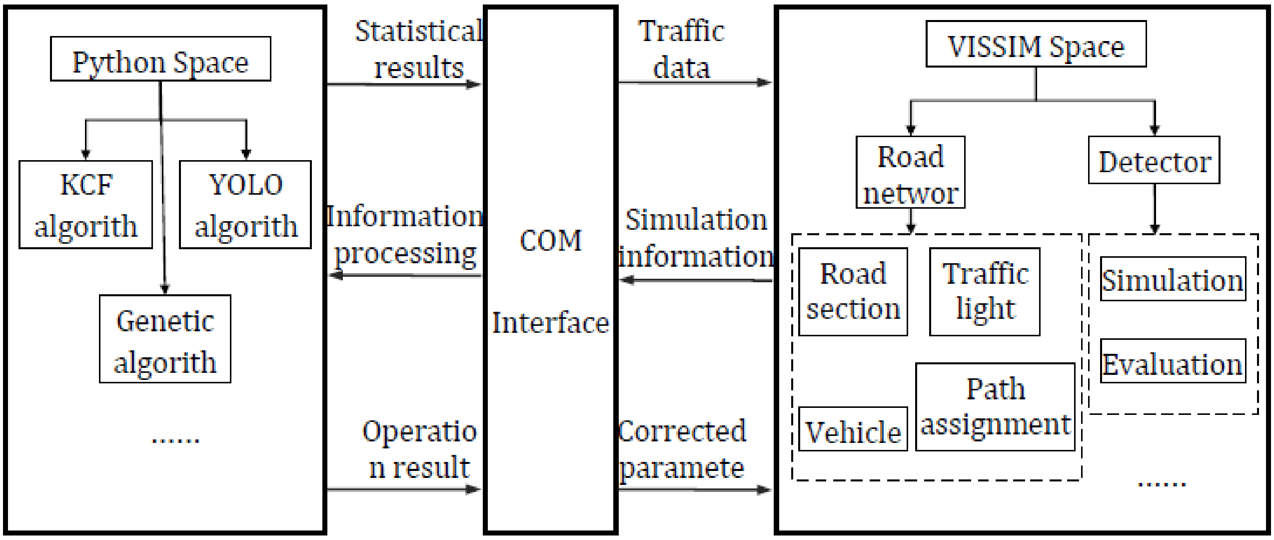

Fig 4. Integration diagram

6. Conclusion

In this paper, the idea of integration of vehicle statistics, parameter correction and traffic simulation is put forward, and the research framework is given. The video data acquisition, vehicle flow statistics and VISSIM parameter correction in the framework are introduced theoretically and algorithms are studied. YOLO algorithm, KCF algorithm, virtual detection line method and genetic algorithm are applied to vehicle detection and vehicle tracking respectively. In the research of vehicle statistics and VISSIM parameter correction, the flow charts of each algorithm are given. Finally, the integration of vehicle statistics and model calibration with VISSIM model is completed by COM interface technology, which lays a research foundation for accurate and fully automated micro-traffic simulation, and is of great significance to traffic control, traffic control scheme design and improvement of current traffic problems.

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