The Bus Control System Based on Intelligent Security Design

Jialin Yang\textsuperscript{1a}, Tiebin Wu\textsuperscript{1b*}, Jiaxing Chen\textsuperscript{1c}, Mengna Ji\textsuperscript{1d}, Xia Cai\textsuperscript{1e}

\textsuperscript{1}College of Energy and Electromechanical Engineering, Hunan University of Humanities, Science and Technology, Loudi 417000, China
\textsuperscript{a}1598999184@qq.com, \textsuperscript{b}wutiebin81@163.com, \textsuperscript{c}1206083380@qq.com, \textsuperscript{d}jiran1015@163.com, \textsuperscript{e}31531084@qq.com

*Correspondence author: wutiebin

Abstract—Due to traffic congestion and the changeable internal and external driving environment, it is difficult for bus drivers to respond quickly to the surrounding environment in an emergency, resulting in traffic accidents. This paper designs an intelligent and efficient active security system. The security monitoring system includes abnormal emotion processing system and trajectory offset processing system. The two systems are applied to image acquisition unit, image processing unit, vehicle trajectory determination unit, data storage unit and data transmission unit. The trajectory offset processing system and abnormal emotion processing system are used to analyze and process the data of various sensors, upload the data to the platform, and realize multi department cooperative processing.

1. Introduction
In terms of security, the existing bus has not yet had a complete system scheme to deal with the problem of driving trajectory and the driver's own control. Scholars at home and abroad have systematically expounded and experimented on various parts of the system, but for the functions required by the current bus system market, there is no cross sharing and integration of resources. Among them, V2X lidar technology monitors all traffic participants on the road in real time, provides decision-making data for users connected to the Internet Network in this design, effectively responds to instantaneous changing road conditions, and realizes vehicle road coordination network \cite{1}. However, this technology can not take into account the tracking ability and the stability of public transportation in the tracking process. In the emotional analysis and detection part, such as tied factor analysis (TFA) \cite{2}, 3D deformable model (3dmm) \cite{3}, eigen light field (ELF) \cite{4}, illumination cone model (ICM) \cite{5}, etc., they all have limitations. Therefore, this paper constructs a set of intelligent security public transport system with complete performance.

2. Overall Design
The security intelligent public transport system is mainly composed of mechanical part and control circuit part. As shown in Figure 1, the main equipment is the cab camera, which aims to collect facial expressions with high accuracy; There are internal and external environment cameras, and the upload system part is used to form relevant images, obtain data and analyze them later.

The control circuit part is mainly composed of emotion analysis system and trajectory analysis system. The emotion analysis system includes image acquisition unit, image processing unit and image analysis unit. The image processing unit is used to read the key frame of vehicle image data, and the image analysis unit compares, analyzes and judges the key frame through the algorithm. The trajectory
analysis system includes a vehicle positioning unit, a vehicle trajectory acquisition and analysis unit, and uses the data storage unit to upload the key frames and analysis and determination results to the cloud server.

![Fig1. Schematic diagram of bus structure](image)

### 3. Core Module Design

Aiming at the problem of lack of track and emotion detection, by studying the relevant vehicle models, a set of bus control system which can realize track offset processing and abnormal emotion processing is designed.

#### 3.1 Vehicle Data Trajectory Extraction

The track data is the data that needs to be combined with time and space orientation. The vehicle track should be able to clearly reflect the historical position information data of vehicle motion. The vehicle trajectory can be regarded as the set of spatiotemporal mapping vectors corresponding to the vehicle trajectory at different times T, the time t is taken as an independent variable, the function model is established, the existing data is used for training, and the model information is continuously improved, so that the spatial trajectory position coordinates of the vehicle trajectory at each time can be determined.

Set \( t; \) Is the motion track of the vehicle in the plane space, and \( X \) and \( y \) are the surface plane coordinates respectively, then \( t = (x, y, t) \) is the track coordinate information of the vehicle at time \( t \). So far, there have been many and in-depth research work on the detection of trajectory data anomalies in many industries. However, the characteristics of vehicle trajectory data, i.e. anomaly detection, need to consider many factors, such as the sparsity of data, the uncertainty of location and time sequence caused by large data scale, the real-time problem caused by fast data update, and the imbalance of distribution are all the influence categories that need to be considered in anomaly detection.

![Fig2. Frequency domain analysis of vehicle trajectory](image)

#### 3.1.1 Vehicle Trajectory Positioning Uncertainty

The accuracy of vehicle trajectory positioning is limited by positioning technology, and the problems of calculation accuracy, signal fluctuation error and data loss will affect the positioning of the data collected by vehicle trajectory in plane space. Moreover, the asynchronous or different time and frequency of trajectory data acquisition will cause the uncertainty of positioning data timing, resulting in the inconsistency of space-time position of vehicle trajectory data. The uncertainty caused by this...
inconsistency problem will cause large errors in the position coordinates of the collected trajectory data, and then affect the accuracy of vehicle trajectory detection.

![Fig3. Schematic diagram of intelligent vehicle trajectory tracking](image)

In order to obtain high-precision vehicle trajectory positioning information, the visual perception positioning connected to the camera can be added on the basis of the original positioning satellite, and the big data analysis can be carried out on the pictures of the bus in the fixed running track, so as to correct or make up for the errors caused by the satellite in positioning. Multi mode cooperative vehicle positioning achieves the effect of accurately collecting positioning information.

![Fig4. Based on Beidou Positioning flow chart](image)

China's Beidou satellite navigation system can provide high-precision and reliable positioning, navigation and timing services, with the service characteristics of the combination of navigation and communication. The analysis of trajectory anomaly data can be solved efficiently by Beidou.

### 3.1.2 Vehicle Trajectory Data Sparsity

Vehicle trajectory data can reflect the real situation of vehicle motion, and this kind of motion trajectory is often presented in a periodic law. With the increase of the amount of data, the trajectory distribution will show the phenomenon of uneven distribution. For example, when the road section with frequent traffic congestion is not congested, the vehicle trajectory will show the characteristics of sparsity with the reduction of traffic flow.

Bus is a kind of public transportation, which has a relatively fixed driving cycle. On the premise of obtaining a large number of vehicle tracks, the driving track can be divided into multiple sections, among which the sections with rugged lanes, large traffic flow and more dangerous sections can be used as key sections. The relatively stable trajectory distribution can be obtained by monitoring whether the vehicle reaches another key interval from one key interval in a relative time.

### 3.1.3 Real Time Performance of Vehicle Trajectory Data

The position data information of vehicle trajectory will increase with the growth of time and movement, which reflects that the vehicle trajectory data is real-time. With the growth of time, the amount of data
is increasing. The problem is that there is no suitable equipment to store the vehicle trajectory in real time and effectively. Due to the bottleneck of positioning technology, it is difficult to detect the abnormal behavior characteristics of fast moving trajectory, so it is necessary to find a reasonable and effective trajectory anomaly detection method.

The solution is to iterate the obtained information in the vehicle system. Take one cycle of vehicle driving as an iteration. Before that, relevant information will be transmitted to the Internet as a database. Automatically delete the information left by the vehicle to ensure the effectiveness of the database. Automatically delete the information left by the vehicle to ensure the capacity. In this way, the vehicle track information can be recorded circularly, and there is enough storage space in the system.

Through the extraction of vehicle data trajectory, the relevant positioning of trajectory and the sparsity and real-time of trajectory data are controlled, which effectively solves the problem of taking into account the tracking ability and the stability of public transportation in the tracking process.

3.2 Vehicle Trajectory Analysis

(1) Filter the track data outside a certain range. When calculating the track similarity, it is necessary to intercept and filter the initial track. If this operation is not carried out, the similarity of track data will be calculated directly for the distance between vehicle track points, which will lead to large errors.

(2) Store the vehicle track into the data warehouse according to the time sequence characteristics. If the number of vehicle track data points is greatly missing in the data warehouse, it needs to be deleted, and the track data with no more than 50 vehicle track points shall be filtered out.

(3) Due to the uneven distribution of vehicle track points and different generation time of track points, the vehicle track timing needs to be rearranged. As shown in Fig. 7, the camera is used to form an imaging plane to obtain the acquisition of external data information. Through mapping, the deviation caused by relevant pitch angle and offset angle is considered, and finally the vehicle trajectory analysis within the allowable error range is generated.
After analyzing the vehicle trajectory, if the data is abnormal or the deviation is too large, the abnormal vehicle trajectory will be reported through the alarm and reminder device near the bus driver. At the same time, through the analysis of the driver's own state, it can determine whether the driver itself is abnormal. When the driver is also abnormal, it will give an alarm reminder. If the reminder is still abnormal for three times, and the vehicle is in danger, it will start the vehicle emergency braking and parking treatment.

![Fig7. Schematic diagram of trajectory deviation processing](image)

If the bus is equipped with the system designed in this paper, when the trajectory deviates, the system will take emergency braking to transmit the emotion detection, deviation direction, deviation distance, road condition information and other data information to the information processing center for preliminary data analysis, then send the data information to the Ministry of public security and the bus company. The Ministry of public security and the bus company will cooperate to deal with and summarize the accident.

3.3 Emotion Detection and Analysis
The detection method is characterized in that its neural network includes a multi task convolution network, and the face image is detected and extracted from the overall image by multi task cascade.

![Fig8. Face information from the perspective of network](image)

When the neural network outputs multiple face key point position information, the multiple face key point position information is used to correct the tilt angle of the face image. The key points of multiple
faces include left eye and right eye. The coordinates of the left eye are \((X_1, Y_1)\) and the coordinates of the right eye are \((X_2, Y_2)\); The face image is rotated \(\alpha\) for tilt angle correction, wherein \(\alpha\) satisfies: 
\[
\alpha = \arctan \left( \frac{y_2-y_1}{x_2-x_1} \right) \tag{6}
\]

The method of inputting the acquired face image into the emotion recognition network includes: inputting the relevant characteristics of the whole face image or refined parts as an input object. An emotion recognition network training module for testing and alternately updating face image samples in fatigue driving state, emotional excitement state and normal state to form an emotion recognition network; The overall image acquisition module is used to collect the overall image of the driver and identify whether the driver is in a fatigue state or emotional state.

Through the 3D deformable model face recognition algorithm, the degree of tolerance for pose changes is increased, and the related facial emotions can be analyzed more efficiently and quickly. Compared with the existing buses, this is the first time to analyze the interior of the cab.

Figure 9 reflects the relevant steps of abnormal emotion processing. In this system, the driver's expression will be continuously monitored, captured and analyzed. If an abnormality is detected, three reminders will be taken. If there is corresponding improvement and return to normal, the vehicle will continue to drive; On the contrary, if there is no corresponding improvement, emergency braking shall be adopted to ensure road safety.

4. Conclusion
This design constructs a security intelligent public transportation system integrating the analysis of vehicle trajectory data characteristics, trajectory exception processing, vehicle internal environment monitoring, driver emotional state detection and analysis, which plays a positive role in improving the safety of public transportation operation.

![Diagram](image)

**Fig9. Schematic diagram of abnormal emotion processing**

**Acknowledgement**
This work was supported by the Hunan Province Innovation and entrepreneurship training program for college students, and by the Projects of Education Department of Hunan Province (20C1022 ).

**References**
[1] Binbin Jing, Kai Lu, Xiaowen Yan, Huan Wu, Jianmin Xu. Green wave coordinated control method of dual cycle trunk road based on speed guidance under vehicle road coordination [J]. Journal of South China University of Technology (NATURAL SCIENCE EDITION), 2016, issue 8
[2] PRINCE S J, WARRELL J, ELDER J, et al. Tied factor analysis for face recognition across large pose differences [J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2008, 30(6): 970-984.

[3] BLANZ V, VETTER T. Face recognition based on fitting a 3D morphable model [J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2003, 25(9): 1063-1074.

[4] GROSS R, MATTHEWS I, BAKER S. Appearance-based face recognition and light-fields [J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2004, 26(4): 449-465.

[5] GEORGHIADES A S, BELHUMEUR P N, KRIEGMAN D J. From few to many: Illumination cone models for face recognition under variable lighting and pose [J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2001, 23(6): 643-660.

[6] Haibo Chen. Driver's emotional state detection method, system and process: China, CN201910064138.0 [P]. January 23, 2019.