TCAS：Train Collision Avoidance System

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Abstract: With the development of rail transit technology, the autonomous recognition and operation environment of the train becomes the development direction and research focus of the current rail transit. Due to the complex operation environment of the train, the traditional control technology requires the ground equipment to conduct the train operation, and the train does not have the ability to independently identify the surrounding environment. When the subway signal system failure cases, train driver manual, because manual operation working condition is not stable, the ability to recognize different from person to person, curve, ramp, bad lighting circuit stadia environmental restrictions, etc., require the system to assist drivers in front of the train distance judgment and prompt, collision, side impact or human error can be avoided through a red-light signal.

This project according to this requirement, based on the car communication and active identification technology has been developed based on the Train car communication track early warning and protection System (TCAS: Train Collision Avoidance System)[1], for equipment not installed on-board ATC or signal System failure cases, use of TCAS System identification in front of the Train, the visual perception environment to get the data, radar and other equipment, through the intelligent algorithm realization of vehicle ahead and signal detection, the safety of the Train running environment protection. Alarm by default tracking distance. Realize the driving control with intelligent train as the leading, strengthen the system safety protection level.

Introduction

At present, as the main force of urban transportation, urban rail transit plays a more and more

important role in solving road congestion and traffic accidents.Urban rail transit system can effectively alleviate the large city population density, traffic flow, road congestion, frequent traffic accidents and many other problems.However, due to the complexity of the train running environment, the traditional train control technology requires the ground equipment to command the train running, and the train does not have the ability to independently identify the surrounding environment. When the subway signal system failure, the train driver turns to manual driving. Because of the unstable working condition of the manual operation, the ability of recognition varies from person to person, such as the ability to identify the corners, ramps, poor lighting, line of sight affected by environmental restrictions.It is necessary to assist the driver in judging and prompting the distance of the train ahead, to avoid the rear end and side punching or through a red-light signal caused by human errors.

For the above, we can see that the current urgent need a system to assist the driver to identify different circumstances around the train. When the signal system failure (when a signal system fault occurs on a single train or multi trains) leads to a central dispatcher cannot quickly handle the operation of the train and the driver manual driving safety and efficiency cannot be guaranteed. The system provides the train speed and position as well as line ahead, to assist the driver driving safety.

In summary, this design is devoted to the study of train operation environment perception, line map construction and multi-source information fusion technology. Considering the actual situation of the scene, give an optimal design of environmental awareness structure to improve the target detection accuracy and reliability of the system, and to improve the automation level of urban rail transit system.To eliminate the adverse effects of accidents caused by human uncertainty to the safety and efficiency of urban rail vehicles. Reduce operating costs and promote the development of city rail transit in china.

The present situation of research and development at home and abroad

(1) Environmental perception based on binocular vision [2]

Binocular vision uses two cameras in different directions or a camera via moving or optical technique to virtual two cameras to shoot the same target. Finally calculate the parallax of the target point position in the world coordinate system.

(2) Research based on deep learning environment perception [3]

Apply deep learning to the driverless environment perception and driving decision, can break through the key problem of driverless [4]. At the same time, self-driving is also the best application

scenario for deep learning. Compared with the traditional pattern recognition algorithm, the deep learning algorithm has the characteristics of higher accuracy and stronger adaptability to the environment. It can easily cope with complex driving situations and provide the driving scheme for execution,undermany training of vehicle traveling data. Deep learning algorithm can improve the safety of driving. Deep learning has the potential to complete the final 5% of the pilotless drive.

(3) Track area target recognition of urban rail train

It is an important step to autonomous driving to detect and identify obstacles and pedestrians and react quickly. At present, a lot of recognition techniques can identify the target in the track area and contribute to the development of this field.

(4) Environment perception based on fusion of vision and radar [5]

Information fusion refers to the coordination and merger of multiple sensors in time or space according to certain rules, or the coordination and merge of single sensor's multiple characteristics, so asto achieve certain characteristics of the environment description.At present, many methods such as image grayscale, bilateral filtering, edge detection and image segmentation [6] are used in the recognition of lane at home and abroad.In vehicle recognition, road sign recognition and pedestrian detection, it mainly focuses on detection method based on machine learning. Then extracts features of detection objects and train classification models to achieve accurate detection.

In order to improve the environmental awareness of intelligent vehicle, need to use camera with a variety of sensor combination. And use computer technology to make a comprehensive analysis of multi-sensor information obtained by time to get the consistency of the description and interpretation of the measured object, to complete the task of decision-making and estimation.The performance of the system is more superior than that of the components.

The main content of the design

This design is based on laser radar and long and short focus cameras to range and identify the obstacles ahead of the train.

System function

This design is aimed at vehicles which do not have ATC equipment or the failure of signal system.

Using TCAS system identify the front train. Visual environment and radar equipment are used to perceive the environment andacquire data. Using intelligent algorithmdetect the front vehicle and the signal, andprotect the running train.

System implementation process

The main equipment of this design are two cameras, a laser radar and a TCAS host. Cameras are used for getting images, then using GPU to identify obstacles by using deep learning technology. Laser radar is used for velocity measurement, distance measurement and positioning.Finally, the TCAS host fuse the information of these sensors to get the information of current train speed, signal color, turnout status and distance between front obstacles and vehicles ahead to help the driver.

According to the application scene of the system,we tested the function and stability of the system in line 6, Shanghai, for straight track, bend and slopes.During the test, the cameras, the laser radar and the TCAS host were installed at both ends of the train.

In view of the function of the collision avoidance system in this design, a detailed technical introduction is made here:

(1) Signal lamps and turnouts affectvehicle identification.

In this project, with the assist of laser, cameras are used to capture images by using deep learning techniques to identify obstacles, and signal lights and turnouts.When the laser part finds the signal machine or the turnout position according to the current location on the map, it will send these information to visual part.After this, visual part using deep learning technique gets the signal light color and turnout. The data is then sent to the TCAS host.

The vehicle identification function which affects the vehicle is mainly completed by the visual use of deep learning technology.

(2) Fusion of laser and visual data and alarm

The TCAS host combines the laser and visual data with sensor fusion logic andgets a more accurate information about the distance between the front obstacle and the turnout state of the signal etc.When the TCAS host gets the signal for a red light, there will be avoice alarm to stop. When the TCAS host gets the front obstacle distance less than 150m, the voice alarm is started. As the obstacle gets closer and closer, the level of the alarm is getting higher and higher.When the TCAS

host detects trains and turnouts, the image alarm appears, and the voice alarm for the turnout speed limit is given.

Conclusion

The design is toachievean auxiliary collision avoidance function on straight lane, bend lane, turnout and slope etc. When running on a straight lane, the detect range is not less than 300m range. When running on abendlane,the detect range is not less than 70m.When running on aslopelane,the detect range is not less than 100m.And the ranging error is less than 10%. The accuracy of recognition of signal light color, train and turnout was 98%.It also ensures the accurate positioning and speed measurement of the train, and the positioning error is not more than 5m.

Technological innovation point[8]

The key technological innovations of this design include:

(1) High performance vehicle computing technology

Build a customized platform, embedded stable customization system, equipped with high-performance processor, reasonably allocate functions of GPU and CPU, to build efficient learning network, to show the high efficiency and high real-time of vehicle computing system.

(2) Recognition technology based on deeplearning [7]

Deep learning is a neural network toimitate the human brain for analysis and learning. Through deep learning, it is possible to avoid the tedious and one-sided features of the artificial selection.According to the characteristics of the fixed lane of rail transit, the image and point cloud data can be used to optimize the recognition effect through machine training, learning and identifying by automatic selection of machines.

(3) Multi-sensor fusion technology

Mapping image 2D coordinates and radar 3D coordinates to the unified electronic map coordinate system, through custom development multi-sensor fusion logic algorithm based oneach sensor characteristics, focus on efficient and accurate decision-making. It can effectively compensate for the inaccuracy of data acquisition by a single sensor in a specific environment.

(4) Construction technology of lane electronic map

Electronic map as an increasingly mature and effective form of map product,by building an electronic map of the subway line for the system,can assist the systemto improvethe rate and accuracy ofpath judgment and related obstacle identification.

(5) High-accuracy vehicle engineering implementation technology

Using professional surveying and mapping equipment,based on the characteristics of the subway vehicle do some high accuracy measurements of the target installation vehicle.According to the measurement results, formulate the corresponding vehicle inside and outside equipment installation plan. According to the requirements, the installation, adjustment and corresponding calibration work will be completed so as to make full preparation for the high precision operation of the system.

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