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Highway Secondary Accident Warning System Based on Video Detection

Jingqiu Liu*

College of Transport & Communications, Shanghai Maritime University, Shanghai 200135, China.

Abstract

After an accident on the expressway, the driver places a warning triangle to warn the follow-up traffic flow.This method has a high risk factor and the early warning effect is not obvious,in order to provide efficient and continuous early warning of secondary accidents on expressways,this paper proposes a highway secondary accident early warning system based on video detection, which includes an accident detection device and an accident early warning device.In areas with a high incidence of secondary accidents on expressways, when the accident detection device detects an accident, it will immediately turn on the spike light alarm at the first accident site.According to the established vehicle driving state discrimination model, if the subsequent traffic is in a dangerous collision state, the voice alarm will be activated;At the same time, the upstream area of the accident uses variable information boards to carry out hierarchical alarms according to the level of an accident.The early warning system studied in this paper makes up for the shortcomings of existing early warning methods,realize the active discovery of accidents and rapid and accurate early warning,further realize the intelligence and automation of accident early warning, and effectively avoid the occurrence of secondary accidents.

Keywords

Expressway; Warning System; Secondary Accident; Video Detection; Multi-Level Warning.

1. Introduction

After nearly 30 years of rapid development, the total mileage of highways in my country has exceeded 140,000 kilometers. While expressways in our country bring convenience to people's travel, there are frequent accidents on expressways, and the number of "second accidents" caused by this has also increased.According to incomplete statistics, the number of secondary accidents on the Suiman Expressway increased year by year from 2012 to 2016. During the five-year period, the total number of secondary accidents reached 940, accounting for 57.3% of the total traffic accidents, and the death toll caused by the secondary accidents accounted for the total traffic accidents accounted for 54.2% of deaths, the injured accounted for 67.3% of the total traffic accidents, and property losses accounted for 71% of the total traffic accident losses[1].For the second traffic accidents with heavy casualties, severe economic losses, and bad social impact, how to make effective early warning becomes extremely important. The traditional early warning method places a warning triangle 150 meters behind the accident vehicle,during the placement process, people are in danger of being hit by an incoming vehicle,it cannot be placed in the event of a major accident, and the warning signs are easily overlooked,especially at night, the early warning effect cannot be achieved. In view of this, many scholars at home and abroad have conducted a lot of research from different aspects of accident early warning.Miu Hejiang [2] proposed the method of accident impact time and scope based on the theory of traffic flow fluctuation, and established the accident impact time model.

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Li Chanjuan [3] constructed early warning indicators and warning limits for secondary accidents, and explained the way and content of early warning information. Liu Jun [4] and others designed an alarm device carried by on-site staff or traffic police, which can give two-way alarms to speeding vehicles and accident handlers. Xie Wenbo[5] et al. designed an accident lane two-way early warning system composed of an early warning vehicle and a remote control device based on the PP-PA theory. Zhao Xiaolei [6] designed a management and control system for traffic safety early warning on long downhill sections to achieve vehicle speed control and accident early warning.Yang Changhua [7] designed an intelligent guidance early warning system that uses red and yellow lights to actively induce vehicles and avoid collisions when the distance is too close. Wang Fei [8] proposed a multi-level safety warning model based on the safety distance of vehicle braking, and designed a "person-vehicle-road" safety warning composed of early warning units (roadside equipment, wearable equipment) and vehicle-mounted terminals. system. American scholar Muhammad Sameer Sheikh [9] et al. proposed an automatic detection technology for traffic incidents based on the vehicle and road communication conditions. Ali Jalali [10] et al. used vehicle-mounted detection units to analyze the time series of traffic density and speed based on GPS detection data to detect the location of traffic incidents.

It can be seen that the early warning of secondary accidents on expressways is developing in the direction of intelligent detection and positioning and two-way early warning. Based on the analysis of the above references and the current situation of early warning of secondary accidents on expressways in my country, it is concluded that the following three questions.

(1) An accident information collection problem

For the collection of accident information at this stage, on the one hand, the accident personnel or other personnel approaching the accident scene will make a telephone call;On the other hand, it was found randomly by traffic managers during daily patrols.The collection of accident information is passive and delayed.At the same time, the traffic control department could not take effective actions in time due to problems such as underreporting of accident information and inaccurate positioning due to the unclear statements of the police.

(2) Issue of early warning information

Constrained by insufficient road infrastructure,at this stage, the issuance of early warning information mainly relies on traffic police sirens or shouts to give early warning to upstream vehicles. It is difficult to combine factors such as accident level, impact range and duration, traffic flow, weather visibility and other factors to issue large-scale early warning information.Although some expressways are equipped with variable information boards or lane indicators,however, due to the limited number and lack of system, it is difficult to induce the follow-up traffic flow in time.It is easy to cause large-scale traffic congestion and increase the risk of secondary accidents.

(3) It is difficult to promote the early warning system

Vehicle-mounted early warning equipment is used for accident early warning. Vehicles are extremely dependent on equipment. Considering the cost of equipment, vehicle-mounted early warning equipment cannot be widely installed in a short period of time. This also means that in the event of a traffic accident, vehicles without the equipment are not installed. It will not be possible to obtain accident information in time, and there is a greater security risk.

The above problems are the problems that need to be solved in the early warning process of the secondary accident on the expressway.In order to effectively solve the above problems and meet the need for early warning of secondary accidents on expressways in the new era,this article starts from the perspective of rapid early warning and graded early warning of secondary accidents.A set of early warning systems for highway secondary accidents based on video detection has been constructed. In order to verify the practicability of the system, the

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equipment required by the system was first installed on the highway with high incidence of accidents, mainly including highway diversion areas, long downhill sections, long-line sections, road turning sections, etc. The following describes the system components of the early warning system and the early warning workflow.

2. Warning System Composition

Figure 1 shows the structure diagram of the early warning system. The highway secondary accident early warning system based on video detection mainly includes accident detection devices and accident alarm devices. It is used for the early warning of secondary accidents on highway accidents. The functions are as follows.

(1) The accident detection device mainly includes front-end detection module, information transmission module and central processing control module

The front-end detection module includes a host, a video vehicle detector,the front-end detection module uses virtual coil trigger technology to capture and record all vehicles in areas with high accidents. The host computer controls the video vehicle detector to monitor the high-incident road sections, and sends the monitoring information to the central processing control module through the information transmission module; The video vehicle detector includes an outfield camera that acquires a video image of the vehicle.

The information transmission module can use different transmission methods such as optical fiber transmission, wireless transmission and broadband transmission.It transmits the video recorded by the field camera and captured information (time, location, vehicle speed, license plate, etc.) to the central processing control module in time, which is the lifeline connecting the front end and the back end.

The back-end central processing control module completes the processing of the video and pictures transmitted by the data transmission system through the background management software,and analyze the relevant vehicle data information (vehicle speed information), determine whether the vehicle is a faulty vehicle,and record storage and write to the database. At the same time, it is connected with other systems in the public security network.It is convenient to carry out alarm and rescue quickly and realize resource sharing.

(2) The accident alarm devices mainly include voice alarms, light-emitting spikes and variable information boards

Multiple voice alarms are installed on the wave guardrail of the shoulder of the road with an interval of 30 meters and coded to locate the vehicle.The voice alarm is equipped with a controller, a communication receiver, a speaker and a battery pack, which can communicate with the central processing control module, and can send out a specific alarm voice according to communication instructions. At the same time, after the scene of the accident is confirmed by the back-end manager, the manager can use the voice alarm to make a remote warning.

The luminous road studs are installed on the lanes at an interval of 5 meters, and are connected to the central processing control module. They can display two different warning colors of red and yellow according to the communication instructions. After an accident occurs, it can achieve a secondary stepped type to the rear vehicle. Call the police.

Multiple variable information boards are installed in turn upstream of areas with high incidence of highway accidents to provide drivers with road geometry information, road section traffic status information, and traffic service information synthesized by text, numbers, images, etc., to induce subsequent vehicles to drive safely.

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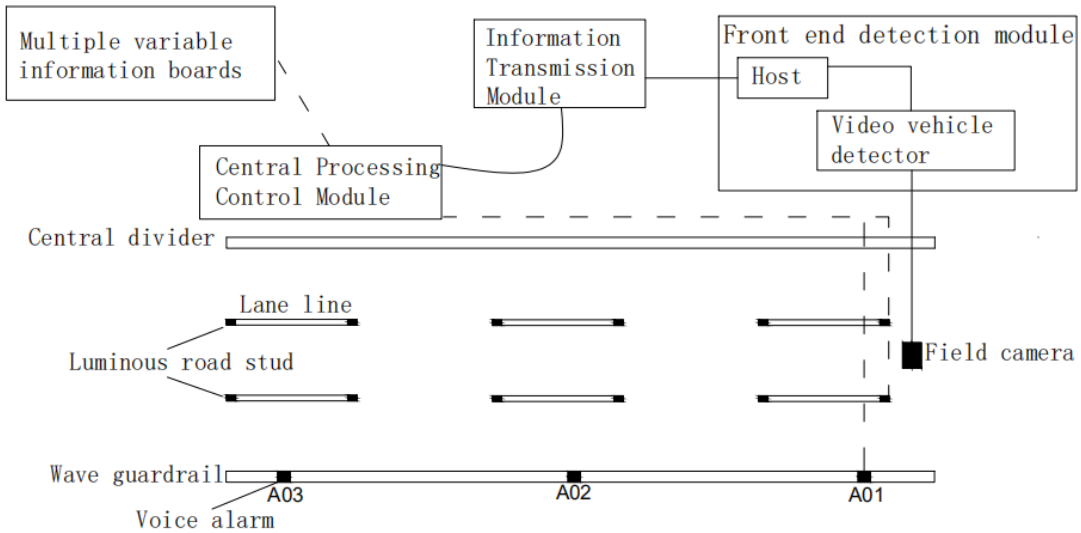

Figure 1:Structure diagram of early warning system

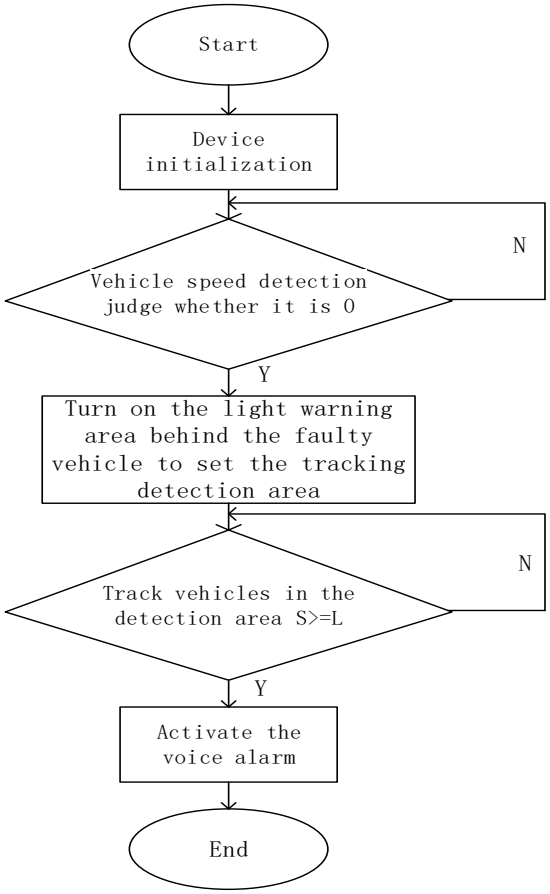

Figure 2: Early warning flow chart of accident scene

3. Warning System Workflow

The on-site work flow chart of the early warning system is shown in Figure 2. The specific working process of the early warning system will be described below.

(1) Obtain video images

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First, each functional device is initialized, and the field camera in the video vehicle detector monitors the road sections with high accidents in real time, and obtains the video images of the road sections with high accidents.

(2) Identification of faulty vehicles

The host sends the monitored video image to the central processing control module through the information transmission module. The central processing control module uses the virtual coil trigger technology to extract the vehicle speed in the acquired video image, and judges whether the vehicle is malfunctioning according to whether the detected vehicle speed is 0 .

(3) Luminous road stud warning

If the speed of a vehicle is detected to be 0, the central processing control module determines that the vehicle is a faulty vehicle, and locates the faulty vehicle through an encoded voice alarm. The central processing control module wirelessly controls the luminous road stud to be in the lane where the faulty vehicle is located. At the rear, turn on the red flashing stud at 0-150 meters, and turn on the yellow flashing stud at 150-300 meters.

(4) Set up vehicle tracking detection area

Select the 300-meter area of the lane where the faulty vehicle is located in the video image and set it as the vehicle tracking detection area, set the vehicle tracking detection area as the area of interest, and set two virtual coils at a certain distance inside it, using the muffler point and cross ratio The calibration algorithm of the invariance theorem realizes the coordinate transformation between the region of interest in the original image and the top view, obtains the correspondence between plane coordinates and three-dimensional coordinates, creates a top view of the research lane, and all subsequent processing is performed on the top view map; Perform background update, image binarization, and patch analysis on the video image to obtain the patch cluster area, and then perform positioning and tracking analysis on the rear vehicles in the vehicle tracking monitoring area; extract driving in according to the results of positioning and tracking analysis The speed of the vehicle in the detection zone. At the same time, real-time distance detection is performed on the vehicles in the detection area, and the distance L between the detected vehicle and the accident vehicle is obtained.

(5) Establish a vehicle driving discriminant model

The central processing control module makes real-time driving status judgments for vehicles in the detection area. Extract the vehicle speed v of the vehicle entering the detection area and the distance L from the faulty vehicle. According to the vehicle's maximum design deceleration a and the driver's reaction time t, a corresponding vehicle driving state discrimination model is established. If S<L-x, the vehicle is in a safer driving state; if S L-x, the vehicle is in a collision driving state. Among them, L is the distance between the front of the detected vehicle and the accident vehicle; x is the length of the accident vehicle; S is the limit safe distance required for a normal driver to brake and decelerate to stop immediately after discovering a faulty vehicle. The expression is:

$$\mathrm{S}=\mathrm{S}_1+\mathrm{S}_2+\mathrm{S}_3=\mathrm{V}\left(t_1+\tau_4\right)+\frac{V\tau_5}{2}+\frac{V^2}{2a_{\max}}-\frac{a_{\max}\tau^2{}_5}{24} \tag{1}$$

Among them, t_1 is the driver's reaction time, τ_4 the vehicle braking force start time, τ_5 is the acceleration increase time, V is the vehicle's initial speed, a_{max} is the vehicle's maximum braking deceleration, S_1 is the vehicle travel distance within the driver's reaction time; S_2 is The distance traveled by the vehicle during the braking coordination phase; S_3 is the distance traveled by the vehicle while the braking force remains unchanged.

(6) Voice alarm warning

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When the vehicle is found to be in a collision driving state, the central processing control module communicates and controls the voice alarm to issue a warning voice until the vehicle changes lanes.

(7) Variable information board warning

At the same time early warning of the accident scene, according to the severity level of the accident, in the upstream area of the accident location, the variable information board can be used to display the accident location, the occupation of the lane, the expected duration of the accident, the recommended speed, the detour path, etc. Information, the accident information is accurately transmitted to the driver in the form of text and graphics, to ensure that the driver has enough time to prepare and adjust.

According to the occupation of the lane by an accident, an accident is divided into 5 levels, which are safe, safer, normal, dangerous, and dangerous, as shown in Table 1.

Table 1:Grade of an accident

occupied lane	0	shoulder	1	2	3
Accident level	safety	relatively safe	general	relatively dangerous	danger

According to the level of an accident, the variable information board is used to issue early warning information as follows.

1) Safety level, no accidents, no warning required;

2) Relatively safe level, it only occupies the shoulder of the road, and the subsequent traffic flow is basically unaffected. The road can pass normally, and prompt messages such as attention to accidents and appropriate slowdown are issued;

3) General level, occupies 1 lane, traffic is affected to a certain extent, release selective guidance information, follow-up traffic slows down and promptly induce to other lanes without traffic accidents to avoid lengthening the queue of vehicles;

4) Relatively dangerous level, occupying two lanes, issuing mandatory information to induce subsequent traffic to the remaining lanes in time; mandatory speed limit; high-speed entrance restriction, regular release;

5) Danger level, occupy three lanes, close the accident section, and close the high-speed entrance in the same direction; vehicles on the way are forced to leave the high-speed on the nearest exit ramp.

4. Features of Warning System

The early-stage early warning system was installed on a highway with a high incidence of accidents, using video detection and automatic alarm methods to overcome the shortcomings of traditional three-legged warning signs. The early warning system has the following characteristics.

(1)Efficient early warning

When a vehicle has an accident, the system quickly detects and locates the location of the accident,Clarify the lane where the accident is located and use the stepped continuous alarm in the form of lights, voices, icons, etc. for the first time in the subsequent traffic flow,Minimize the interference to other irrelevant vehicles and improve the early warning efficiency of accidents.

(2)Classified early warning

Turn on the spike light alarm after the accident, and turn on the voice alarm when the subsequent traffic is detected in danger of collision.At the same time, early warning information such as compulsory, inducement, suggestion and reminder will be issued from near to far in different areas upstream of the accident, so that the early warning is classified.

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5. Conclusion

Aiming at the shortcomings of the existing prevention methods for secondary accidents on expressways, this paper proposes a warning system for secondary accidents on expressways based on video detection.Through the installation of system devices in areas with high incidence of accidents, rapid early warning of the first scene of the accident is realized, and variable information boards are used to provide graded early warning to the upstream area of the accident.The early warning system effectively guarantees the safety of on-site personnel,Realize the classification and continuous early warning of the secondary accident early warning information, and achieve the timeliness of early warning.The research results of this article provide research ideas for the subsequent study of secondary accidents on expressways.At the same time, the next step needs to focus on solving theoretical and technical issues.

(1)Clarify the division of the accident-affected zone and the early warning content of each zone, and how to network with the public security system and the medical care system in the accident rescue system, so that the accident can be quickly issued and rescued.

(2)When using variable information boards and on-board early warning equipment to release early warning information, it is necessary to clarify the level and content of early warning information release according to the accident level, impact time, impact range, weather conditions, etc., to achieve accurate vehicle safety management.

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