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A Study on Intelligent Railway Level Crossing System for Accident Prevention

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Abstract

Accidents at level crossing have large portion on train accidents, and causes economical loss by train delay and operational interruption. Various safety equipments are employed to reduce the accident at level crossing, but existing warning device, and crossing barrier are simple train-oriented protection equipments. In this paper, intelligent railway level crossing system is proposed to prevent and reduce accidents. For train driver's prompt action, image of level crossing and obstacle warning message are continuously provided to train driver through wireless communication in level crossing control zone. Obstacle warning messages, which are extracted by computer vision processing of captured image at level crossing, are recognized by train driver through message color, flickering and warning sound. It helps train driver to decide how to take an action. Meanwhile, for vehicle driver's attention, location and speed of approaching train are given to roadside equipments. We identified the effect of proposed system through test installation at Sea train and Airport level crossing of Yeong-dong line.

Keywords : *Intelligent level crossing, Obstacle detection, Image processing, Onboard monitoring*

1. Introduction

Recently, The collision accident with train and automobile at the level crossing comprises more than 90% of all level crossing accidents and has tendency to be caused by personal mistakes more than other railway accidents [1].

The level crossing safety equipment usually informs vehicle drivers and pedestrian that train is approaching.

Most existing crossing control equipments just block for approaching trains and existing obstacle detectors can't control effectively due to drawbacks about detection range and what to detect. In technical point of view, an intelligent level crossing control system which prevent accidents and improve safety hasn't been actively studied than developed countries although better information delivery systems are developed by improvement of communication and control technologies [2-4].

In this paper, we present intelligent level crossing system to complement the above disadvantages of existing system and make persons (train or vehicle drivers, pedestrians, and etc.) more secure. The intelligent level crossing system has been designed and developed, based on case study of existing accidents at level crossing. We installed the developed system at Airport level crossing of Yong-dong line and henceforth have been verifying its performance.

2. Intelligent Level Crossing System

The number of vehicles on the road continues to rise dramatically. This has led to heavy traffic congestion which is blamed for a growing number of car accidents. Particularly serious accidents can occur because of violations of level crossing regulations.

Many researchers have proposed schemes to prevent level crossing accidents. However, more intelligent technology is required to prevent accidents at level crossings. Fig. 1 shows architecture that employs an intelligent system at level crossings. Hereafter, we refer to this architec-

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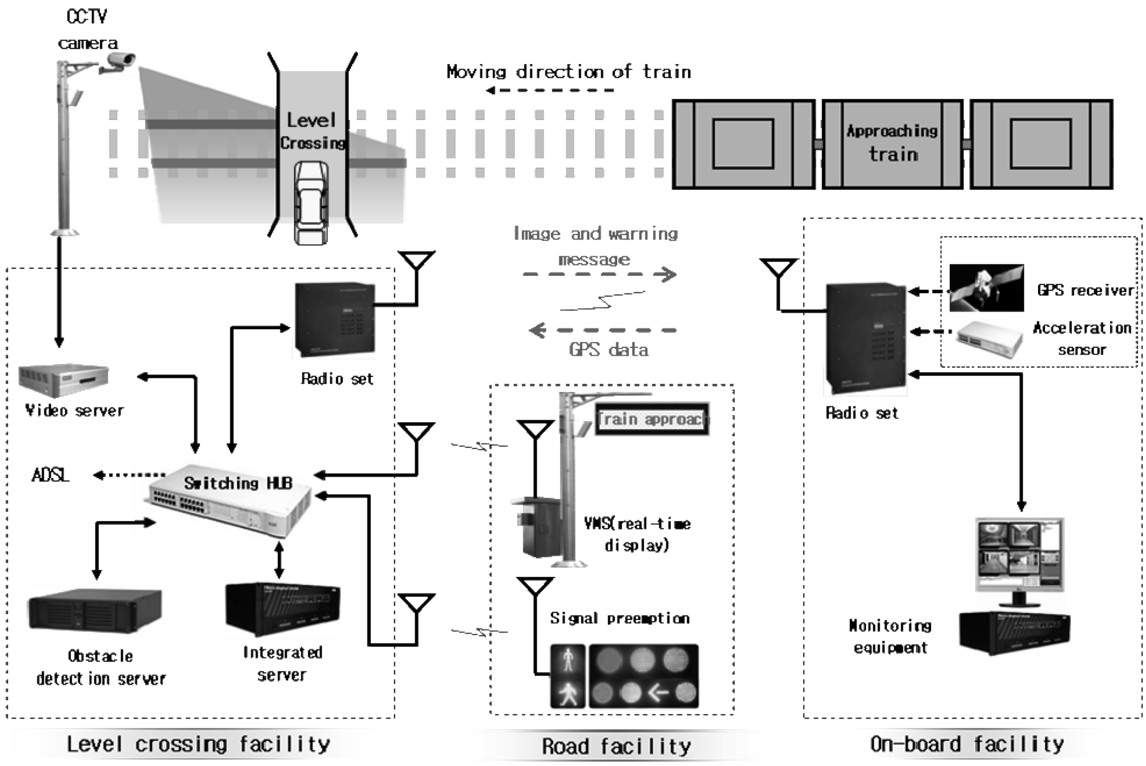


Fig. 1 Architecture of the intelligent level crossing system

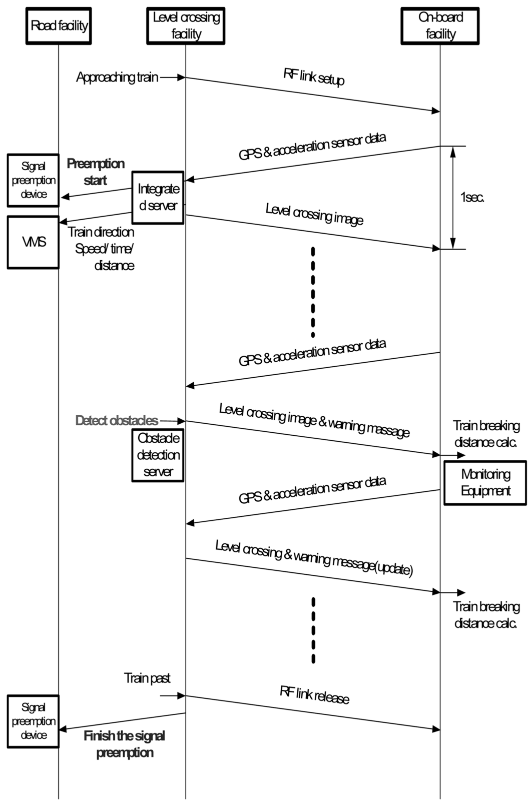


Fig. 2 Data flow of the intelligent level crossing system

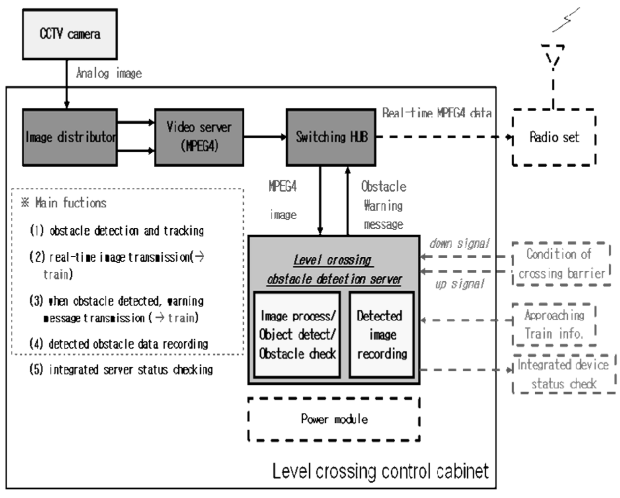


Fig. 3 Data flow of obstacle detection equipment

ture as the intelligent level crossing system [5,6].

The intelligent level crossing system provides warning information to train and roadside traffic adjacent to a level crossing, using a wireless two-way communication link, for the purpose of preventing accidents and reducing damage. Level crossing events (like warning messages) and video information about obstacles trapped on the crossing gate (vehicles and pedestrians, etc.) are transmitted to a train from the level crossing, and information related to the train (direction, velocity, estimated time of arrival) is sent to the level crossing.

The video information transmitted from the level crossing is displayed on the monitoring equipment of the train cab so that the train driver can stop the train before approaching the level crossing if necessary.

The integrated server estimates the time of arrival using information from the train and provides this arrival time to roadside display units and to the road traffic signal control equipment of the intersection adjacent to the level crossing. This information makes drivers and pedestrian informed of the approaching train, and encourages them to clear the level crossing quickly (Fig. 2).

The main components and functions of the intelligent level crossing system are as follows.

Fig. 4 Detection area setting on ga-dong level crossing

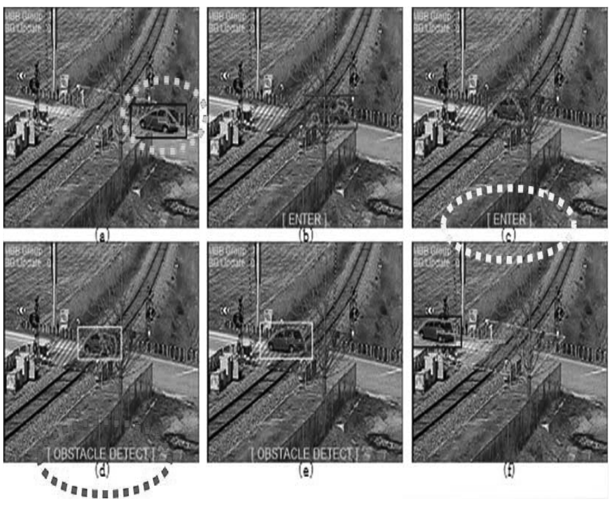


Fig. 5 Image process of obstacle detection test

2.1 Obstacle Detection Server using Image Processing

This diagnoses the condition of crossing gates, detects any trapped obstacles, and tracks the movements of obstacles in real time [2].

Obstacle detection server detects obstacle at level crossing area through image process and it determines whether obstacle exists by checking entry of object, dwell time at level crossing area (Fig. 3).

The result of obstacle detection test at Ga-dong level crossing of Kyung-buk line (Fig. 5).

2.2 Monitoring Equipment

This subsystem is installed in the cab of the train. Warning messages and real-time video of any obstacles are provided to help the train driver notice obstacles and stop the train before the level crossing. If the train driver fails to react appropriately, this system is designed to immediately deploy the emergency brake (Fig. 6).

2.3 VMS(Variable Message Signs)

An LED visual display device is installed between the level crossing and the adjacent road intersection to apprise vehicle drivers of accidents at the level crossing, and to provide information about approaching trains such as train moving direction, and estimated time for arrival. The VMS

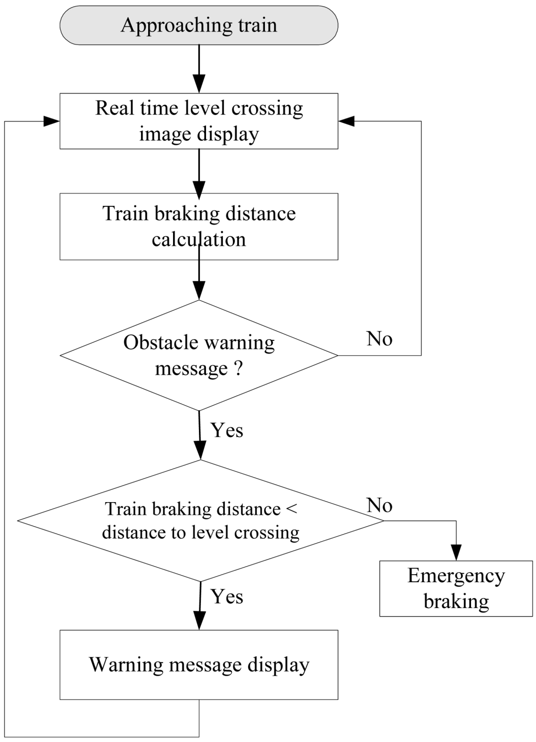


Fig. 6 On-board monitoring process

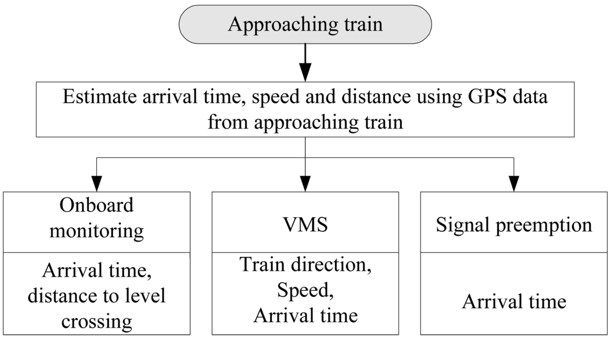


Fig. 7 Integrated server process

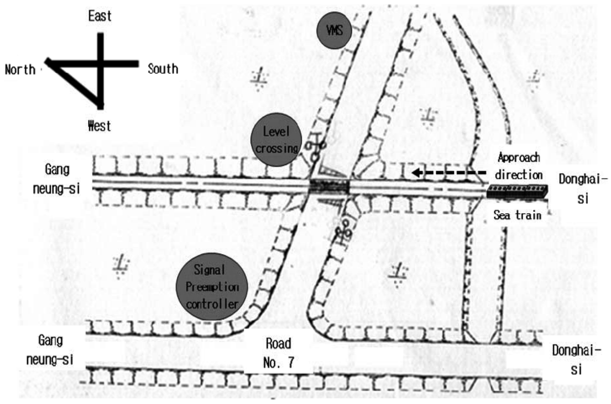


Fig. 8 Site of level crossing for test installation

indicates the presence of vehicles on the level crossing and the approach of trains in real time to vehicle drivers for the purpose of reducing accidents on the level crossing.

2.4 Preemption Signal Control Unit

In urban areas, long lines of vehicles on road intersections adjacent to level crossings can occupy level crossing and cause accidents. If a level crossing is near a road intersection, the vehicles leaving the level crossing for the road intersection shall be given priority for the traffic signal. In other words, when a train is approaching, it is necessary to stop vehicles attempting to enter the level crossing and to allow vehicles already on the level crossing to quickly exit the level crossing. In this way, accidents can be prevented.

2.5 Integrated Server

The integrated server estimates the time of arrival for the approaching train; information regarding time of arrival is then used by the real-time display system and the road traffic signal control unit (Fig. 7).

3. Installation of Intelligent Level Crossing System

The developed intelligent level crossing system was installed in driver's cabin of Sea train and Airport level crossing of Yong-dong line. Henceforth, we have been verifying its performance by equipment functional and environmental test and drawing the optimization method.

Installed equipments are obstacle detection server using image processing, wireless transceiver, monitoring system on sea train, VMS(variable message signs), road traffic signal control unit, and integrated server.

Pole, control cabinet and UPS (non-interruption electric source) were installed on the level crossing site where integration server, CCTV camera and obstacle detection system were set up. Location of pole is about 2.5 m away from rail and 2 m away from existing control cabinet. The piping excavation was executed in order to supply the power from the railway transformer and Pole / UPS base work were executed in order to install UPS. Arm structure of 1.5 m length was attached to Pole in order to install the antenna of wireless transceiver.

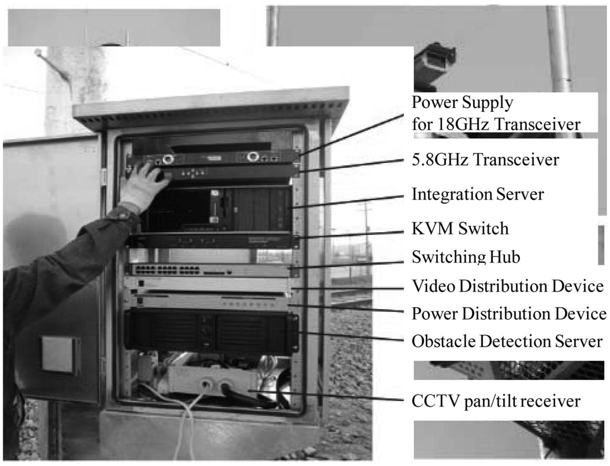


Fig. 9 CCTV camera of level crossing site

Integration sever, obstacle detection server, power supply of 18 GHz wireless transceiver, 5 GHz wireless transceiver, KVM switch, communication switch, video distribution device, power distribution device, and CCTV pan/tilt receiver were installed inside control cabinet. CCTV camera which provides images with obstacle detection server was installed on the top of pole(Fig. 9).

The UTP cable and the other cables reaching to top of pole were clearly installed inside pole in advance. Cabling work was performed after work schedule had been agreed with the person in charge of Gang-won headquarters, Korea Railroad Corporation. Control cabinet was connected with incoming line through hole under cabinet. It was locked and attached with warning sign to restrict outsider access.

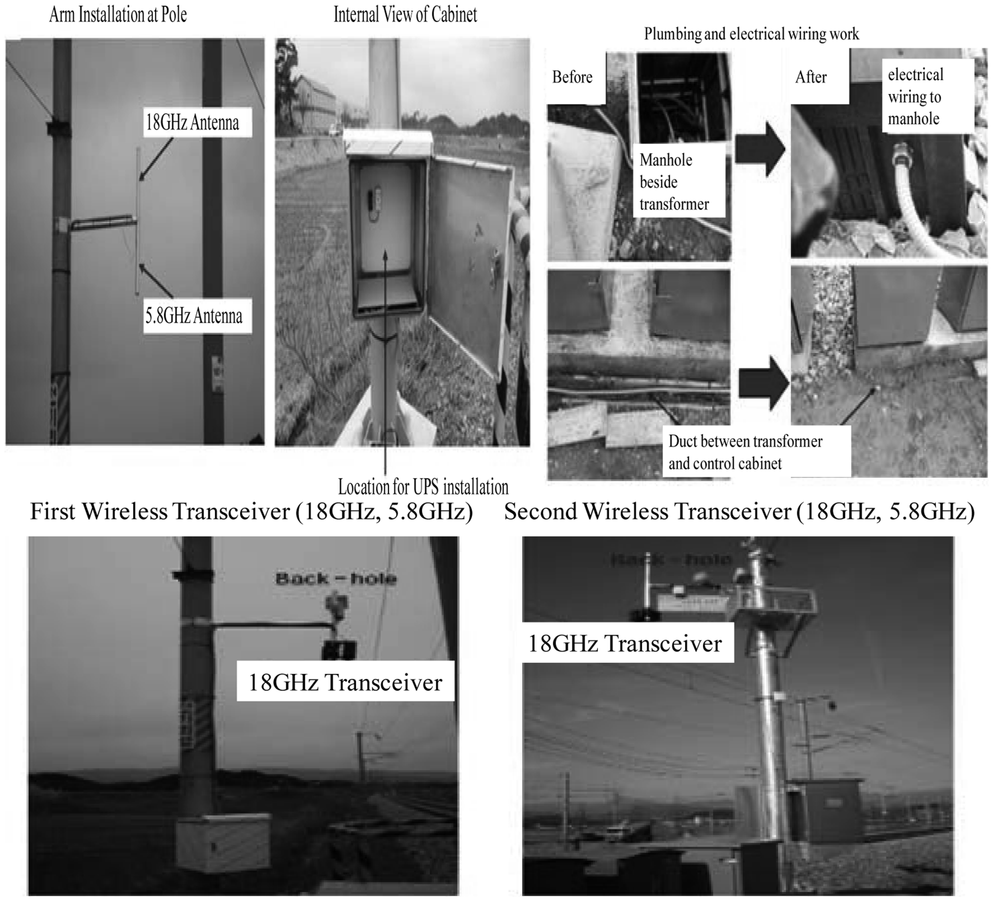


Fig. 10 Bidirectional wireless transceiver

Wayside RF transceiver allows wireless two-way communication between the train and the level crossing. Warning messages and visual information are continuously transmitted from the level crossing to the train, and the location and velocity of the train are sent to the integrated server. The wireless transceiver should be designed while taking into account the maximum velocity of the train at the level crossing (150 km/h), the level crossing warning time (30 sec), the wireless transmission distance (over 1,250 m) and a redundancy structure for high availability.

As shown in Fig. 10, the bidirectional wireless transceivers were installed in 2 places to make wireless communications possible within 2 km coverage in front of level crossing. The second wireless transceiver was installed on the top of pole located in level crossing as shown in Fig. The first wireless transceiver was installed at about 1.2 km site in direction to Dong-hai City from level crossing. For the first wireless transceiver, Arm mounting, control cabinet mounting, and electric wiring were also performed at existing pole.

High resolution GPS, 18 GHz vehicle wireless transceiver, and monitoring equipment were installed at driver's cabin of sea train which directs toward Gang-neung from Dong-hai, as shown in Fig. 11. Power supply of AC 220 V was provided from train electrical system.

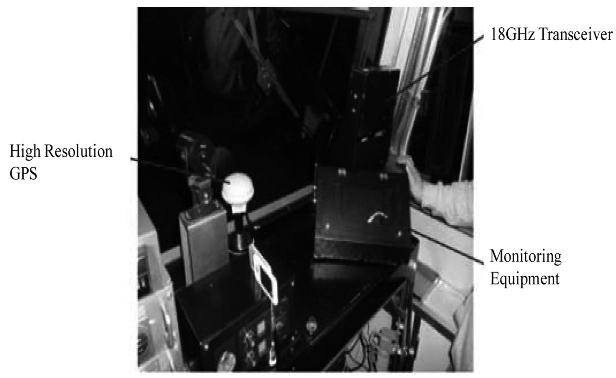


Fig. 11 On-board monitoring equipment of sea train

VMS(Variable Message Signs) equipment was installed at 200 m away from level crossing toward 18th combat flight airport. It helps vehicle drivers notice the situation of level crossing. Pole base foundation work (excavation, first class lightning grounding, 2nd class grounding of control cabinet, steel reinforcement, concrete placing, refilling, and etc.), pole installation work, and display panel installation, drawing of electric power, etc. were done.

The developed road traffic control unit (standard traffic signal controller (STLC-S2) 1 SET (S)) was certified by Korea Road traffic Authority. VMS system and road traffic control unit were installed with the assistance of the Transportation department, Gang-neung City Hall. The use of 18 GHz wireless transceiver was permitted by Gang-neung radio management office.

4. Test Operation

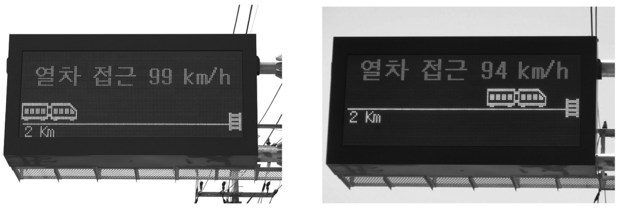
We have tested the installed system for 35 days from 5/25/2010 to 6/30/2010. The train equipped with the intelligent system passed the level crossing near airport 3 times a day and totally about 90 times during test.

Image of crossing as shown Fig. 12 was displayed to driver at train cabin. For the test period, the situation that obstacle is trapped in crossing after crossing barrier is lowered did not happen. Intentionally, we made the vehicle

(a) Before crossing barrier was lowered

(b) After crossing barrier was lowered

Fig. 12 On-board monitoring program



(a) 2km far from crossing (b) near from crossing

Fig. 13 Operation of VMS when train approaches

trapped in crossing and identified that warning signs, num. 2 and 3 of Fig. 12 (b) were turn to red color correctly. In Fig. 12, the image of num. 1 is displayed automatically when train approaches 2 km far from crossing. Driver can cancel automatic braking by pushing num. 5 button when automatic braking is initiated due to obstacle detection.

The VMS worked correctly during test period as shown Fig. 13. It indicated the approach of trains in real time to vehicle drivers of adjacent road intersection.

Generally, in a railway, the test operation is required for more than one year in order to verify function and performance (including environmental performance) of the developed system. In first phase, test operation has been performed by the end of June, 2010. The following test items will be performed in next phase.

- Collection and analysis of field test data.
- Developed system : stability test during four seasons.
- Communication reliability between train and ground.
- Obstacle detection : determine the degree of precision.
- Surveys: SP (Stated Preference) / RP (Revealed Preference) investigation.
- Various considerations using simulation tool.
- Maintenance plans : field visit inspection once a week.

5. Conclusion

We described test installation of the developed intelligent level crossing system which was studied by the support of the development project of damage reduction technology at level crossing. Interoperation between VMS system, wireless transceiver, road traffic signal control unit, and obstacle detection system should be checked continuously to confirm its stability. We will continuously collect the test results at test installation site and correct the developed system.

We expect that the developed intelligent level crossing system will improve the overall level crossing control technology and reduce the accident drastically. The developed wireless transceiver can be applied to train-ground communication for control command transmission, etc.

and the image processing and train tracking algorithm are also expected to be used for train detection and control.

This study could improve the existing prevention system of level crossing where many accidents occur. In case the accident occurs, the cause of accidents can be found through this study. It will be useful to clarify who is responsible for accidents. Afterward, in case the early warning system (EWS: Early Warning System) is planned to install, it can be used for the early warning system.

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