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Development of Safety Equipment using Laser Radar Sensor for Railway Platform

Jong-Gyu Hwang*, You-Ho Kim[1], Hyun-Jeong Jo, Kwon-Hee Choi[2] and Tae-Kuk Ko[1]

Train Control & Telecommunication Research Division, Korea Railroad Research Institute, Uiwang-si 437-757, Korea
[1]Department of Electrical & Electronic Engineering, Yonsei University, Seoul 120-749, Korea
[2]Korea Railway Technology Corporation, Seoul 151-801, Korea

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Abstract : Many casualties are being occurred due to many misses the railway platform, and the accident occurrence is being increased. Recently in Korea, efforts to prevent casualties fundamentally are being made by installing and operating the PSD(Passenger Screen Door) as to prevent these casualties of passengers. However, in case of the PSD system, although it can solve the problem of public casualties at platform fundamentally, it is impossible to install it at whole railway platforms. This paper proposes the safety equipment using LaserRadar sensor for the prevention against casualties of passengers at platform. The safety equipment using novel sensor is the safety equipment making an approaching train stopped if the falling object is a person by detecting the obstacle at platform, and it has the merit possible to apply it to platform since it may detect accurately under ambient environmental elements such as the snow, rain and yellow dust, etc. also. We manufactured a prototype of the safety equipment to reduce public casualties at platform by using LaserRadar sensor and carried out its performance test, and the result is presented in this paper.

Key words: railway platform, laserradar sensor, railway casualty accident

1. Introduction

Many developments have been accomplished in the operation of Korean railway, and currently, KTX-II high-speed railways and light rail projects of each city and provincial government are being promoted on a full-scale basis. Various train control technologies are applied in accordance with railway projects being constructed newly, and it is the actual situation where the necessity for safety of passengers and operational personnel and for more certain safety device is being more strengthened along with much interest in the technical development. Thus, it is an actual situation required desperately that the research of safety equipment for new technologies being developed and applied currently, or of safety device for the equipment being used currently.

Although railway accidents are in the slightly diminishing trend every year, but still accidents are not reduced in the human behavioral aspect. Based on the year of 2008, 231 cases (casualties 201 cases) of accidents were occurred in general railways, which were increased by 5% compared with those of previous year , and 164 cases of accidents were occurred in the metropolitan rapid transit, which were decreased by 16% compared with those of previous year. By the cause of railway accident, although accidents due to the fault of railway facilities are in a downward trend, accidents by the public persons are not diminishing. In case of the train accident, 32% of the accidents were occurred according to human factors also such as the falling down of passengers at the platform, etc. or careless action of workers, etc. Especially, the safety issue of subway platform is reaching a serious level to the extent that total casualties of 412 persons had been occurred until past 2002 ~ end of 2006 due to the accidents according to direct contacts of passenger with train such as the suicide, trespassing, contact with train, etc [1][2]. The type of public casualties includes largely the falling into track, suicide and careless action, etc., and the safety measures being applied currently to these accident types are arranged together, and the main

*Corresponding author: jghwang@krri.re.kr

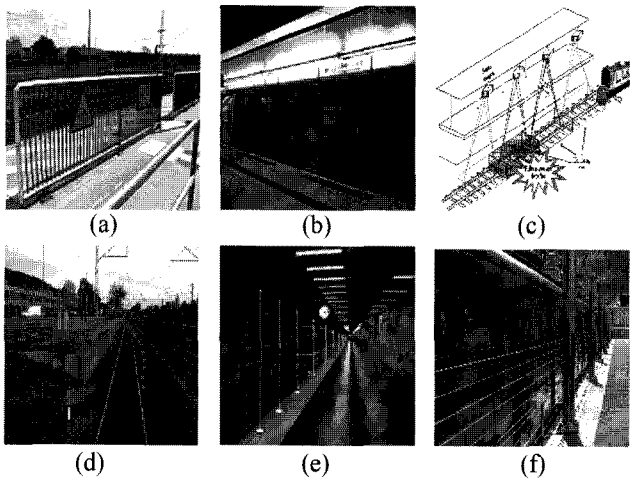

Fig. 1. Method of prevention against falling from platform and the detection of obstacles. (a) Platform safety fence (b) Screen door (c) Detection of track obstacles using stereo cameras (d) Detection of platform track obstacles using laser radar sensors (e) Detection of falling obstacles at the edge of platform (f) Loop-type screen door.

examples of these accidents are shown in Fig. 1.

Recently in Korea, efforts to prevent casualties fundamentally are being made by installing and operating the PSD with underground station building as its center to prevent these casualties of passengers. However, in case of the PSD system, although it can solve the problem of public casualties at platform fundamentally, it is impossible to install it at whole station buildings because its cost is very high, and in case of the ground station building of general railway whose operation speed is higher, installation of PSD is impossible due to the characteristics of railway system. Therefore, substantial station buildings do not install the PSD yet, and the accidents where passengers are falling into the railway track in accordance with careless actions or missteps of passengers are still occurred frequently in these station buildings.

To solve this problem, although a method by which other passengers present at the platform push this button to stop the approaching train when passengers fall into the track is being operated in Korea by installing auxiliary safety equipment such as the passenger emergency stop button at the station building, but this has the problem that the emergency stop button must be handled by the passenger also. In addition, the method detecting the falling into track automatically by installing several CCTVs at the platform is under study [2]-[4]. This equipment has the problem that there is a dead zone of CCTV existed, and especially in case of the ground station building, it does not recognize the falling person accurately in accordance with the environmental factors around the station building such as the snow, rain, yellow dust and etc.

To solve these problems, this paper proposed the safety equipment to reduce public casualties at platform by using LaserRadar sensors possible to detect falling persons accurately anywhere at the ground and underground station buildings irrespective of the environmental factors [5]-[7]. The safety equipment using LaserRadar sensors is the safety equipment making an approaching train stopped if the falling object is a person by detecting the obstacle at platform through, and it can solve problems kept by other safety equipment which have been studied precedently as mentioned previously. Currently, the manufacturing of prototype for this proposed safety equipment was completed, and the performance test to detect obstacles is being carried out, and the algorithm to judge the detection of falling object into the track through this performance test is being supplemented. This paper presents the structure and function, development of the prototype, and the result of performance test of proposed safety equipment

2. Comparative Analysis on the Detection Sensor

Issue of the public casualties at platform is the one occupying many parts of the railway accidents not only in Korea but also in foreign countries, and many efforts to prevent or reduce it are being proceeded. In case of Korea, although PSD systems are being installed in the underground section of metropolitan rapid transit to protect against public casualties at platform fundamentally, but they are not installed at whole station buildings due to the cost problem. Station building where the PSD is not installed operates the safety equipment which makes an approaching train stopped by making other passenger handle this button, if any passenger falls into the track, by installing an emergency stop button at the middle of platform. Since this emergency stop button is connected with the track circuit for platform section, it has the mechanism that, if the button is pressed, the corresponding track circuit will be short-circuited and the signal prohibiting entry to the platform will be transmitted by ATC (Automatic Train Control) system to the on-board, and simultaneously, the "RED" signal which means the prohibition to entry will be displayed at the trackside signal and the train will be stopped by these signals from the ground. Since this safety equipment using the emergency stop button can transmit the stop

signal to an approaching train entering into the platform only if passengers push it manually, and the button can be randomly pushed by careless action even in the case where a passenger did not fall into the tract, it has the problem such as the occurrence of obstacle in the train operation, etc.

Fig. 1 is the one showing various safety equipments to reduce public casualties at platform being applied or developed at home and abroad. (a) and (b) are those showing the platform safety fence and PSD system being applied in Korea, (c) is the one showing the safety equipment to detect falls using multiple stereo cameras being developed in Korea. (e) is the equipment to detect falls at the edge of platform using infrared sensors, and although it is being applied partially in the overseas, many applications are not available since it is impossible to be applied if the platform is located in the curved section and it has the demerit impossible to distinguish falling objects such as the person from paper, etc. In case of (f), it is the loop-type PSD developed in Korea to substitute it for an expensive PSD system, but it is not deployed since it has a problem such that there is no advertisement attaching side, etc. (d) is the equipment proposed in this study, and it is the equipment detecting falls using the LaserRadar.

Like this, various safety equipments are being applied to prevent public casualties at platform, and in addition, many studies are being accomplished to solve these problems even until the present time. Although the ultimate solution to this problem is the installation of PSD system, studies on safety equipment stopping a train by detecting the fall of passenger automatically by using sensors as the method to substitute it realistically are actively accomplished both at home and abroad due to the problems such as the cost, etc. Especially in case of the ground platform, it has the demerit also possible to add an extra weight on stifling of passengers by blocking the surrounding scenery. In addition, if the train fails to stop at the fixed location of platform, a certain problem in opening and closing screen doors may be occurred, and it is necessary to prepare the method to deal with it for the case where any human body or object is jammed at the gap between the screen door and train. It is urgent to build the safety equipment at platform by using LaserRadar sensors under this environment

3. Comparative Analysis on the Fall Detection

As explained in the previous section, although the PSD system is the only safety equipment possible to prevent public casualties at platform fundamentally, it is impossible to install it at every station building due to various realistic problems. Therefore, the safety equipment through detection of falling into track using various sensors must be applied to station buildings for metropolitan rapid transit and general railway where PSD systems can not be installed. Like this, various sensors can be applicable to the detection of passenger's falling into track, and the development for safety equipment using the sensor partially is under progress.

Generally, sensors such as the infrared sensor, radar sensor, ultrasonic sensor, CCD or IR camera, etc. are used as the method to identify trespassers and obstacles located at the platform track. But, these sensors have problems that they respond to the external environment such as the electric field, magnetic field and light, etc. sensitively. That is, there are problems such that the infrared sensor has an inferior distance performance, and the reliability of radar sensor is inferior due to its

Table 1. Comparison of obstacle detection sensor

Kind	Feature	Problem
Infrared sensor	Frequently used for detecting human body.	Impossible to detect when there is no change in the motion of object. And it is difficult to apply it to precise parts since its detection distance and motion speed, etc. are not constant.
Ultrasonic sensor	Distance is limited.	Error in measurement of distance occurs due to the changed velocity of sound if difference in temperature is big.
Camera sensor	Possible to detect 3D area. Possible to recognize states of screen door alone.	Impossible to detect in the condition of dark surroundings.(lighting required)
LaserRadar sensor	Possible to detect 3D area. Excellent capability to detect obstacles even in any installation environment (heavy snow, rain, sunlight and night). Simple and easy to install, operate and maintain.	

sensitivity to the external environment, while its distance performance is superior, and the ultrasonic sensor has an inferior distance performance and distance resolution. Since measurement data are different due to the distortion of measured data caused by this, the selection of obstacle detection sensor is very important. Table below shows the features of obstacle detection sensor. Although an image sensor has demerits that it cannot detect obstacles in the condition of dark surroundings, it is the current trend to use it frequently since it can detect three-dimensional areas. Table 1 shows sensors being applied to the detection of passenger's fall or to be applicable and main features. Since each sensor has unique characteristics respectively as shown in the Table, there are problems in applying it for the detection of passenger's fall with only one sensor.

4. Safety Equipment using Laserradar

Generally, sensors such as the infrared sensor, radar sensor, ultrasonic sensor, CCD or IR camera, etc. are used as the identifying method of safety equipment for obstacles. But, these sensors have problems that they respond to the external environment such as the electric field, magnetic field and light, etc. sensitively. That is, there are problems such that the infrared sensor has an inferior distance performance, and the reliability of radar sensor is inferior due to its sensitivity to the external environment, while its distance performance is superior, and the ultrasonic sensor has an inferior distance performance and distance resolution. Since measurement data are different due to the distortion of measured data caused by this, the selection of obstacle detection sensor is very important. In addition, although various sensors should be used complexly to detect passenger's fall from the platform analyzed in previous section, it was analyzed that the LaserRadar sensor is the only sensor being operated well in all of the climate conditions as the safety equipment for platform track of railways. Thus, this paper developed the safety equipment using LaserRadar sensors.

LaserRadar device is utilized for grasping real-time location of the target, obstacle detection, etc. in various fields such as the military, traffic safety, and security fields, etc. all over the world. Recently, the necessity for study on the method detecting objects using laser radar is raised in the railway safety field also as a part of prevention measures against safety accident at platform in accordance with the obstacle detection device at level crossing, tunnel, bridge and rapid transit. Method to detect obstacles using the LaserRadar is to emit laser

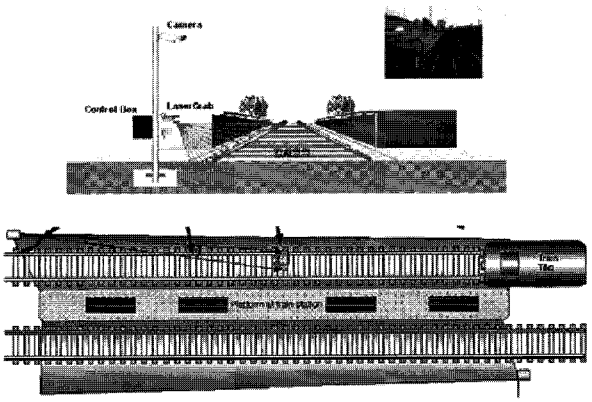

Fig. 2. Schematic view of the developed safety equipment.

pulses to the target, and to recognize the location and shape of the object in three dimensions by analyzing reflected laser values. It can grasp the movement and direction of obstacle also by tracking the change in data values through continuous laser pulse feedback. In case of the safety equipment detecting the passenger's fall at platform, the installation cost can be reduced relatively since the detection area of 1 set of the equipment is wide, and there is no restriction according to the place, and the maintenance is relatively easier in comparison with other devices. Moreover, it is its feature that it displays the performance effectively even in the bad weather such as the rain and snow.

Fig. 2 is the figure showing a system detecting the obstacle at platform track by using the LaserRadar sensor. As shown in the Figure, it is the safety equipment which makes the train entering into the platform stopped by detecting the fall of passenger into the track by installing a LaserRadar sensor at each side of the platform respectively. LaserRadar sensor is installed at the upper end of 10 cm from the track, and judges by SW whether a detected object is a person or not by detecting the fallen object through laser scanninr, and its structure is made to transmit a stop signal to the train by a wireless or wayside signal if it is judged to be a person. In addition, we made the camera which was attached at the upper end of pole where the sensor part was installed recorded whenever any event detecting an object falling into the track is occurred, and made it utilized as data for maintenance and accident handling. In case of the sensor used in this paper, since it is able to detect any object with a soccer ball size which is located about more than 400 m apart also, it can detect whole areas by installing one sensor part at each side of platform respectively, and it has the feature

Table 2. Specification for manufacture of prototype

Item	Spec.
Detectable distance	1-400 m
Limit of distance resolution	±10 cm
Detection speed	1000 Hz
Alarm time	below 1sec
Alarm output	Relay
Beam dia.	25 cm
Obstacle size	Min. 20×30 cm
Item	Spec,
Laser wavelength	905 nm
Laser safety level	1st level
Laser model	Pulsed laser diode
Temperature	-10-+50°C
Humidity	0-100%
Pilot size	450×300×150 mm
Pilot weight	7 kg

possible to detect falling objects sufficiently in case of the platform in the curved part also. The prototype of safety equipment using this LaserRadar sensor was manufactured in this study, and main specifications of manufactured prototype are same as those in table 2.

Fig. 3 is the one showing the picture of prototype for safety equipment manufactured through this study to reduce casualties at platform. The lens part at top part of the prototype is the transmitting/ receiving part of LaserRadar sensor, and the bottom part is consisted of the control part including its motor to adjust scanning angle of emitting laser, and the part judging the detection of final passenger by processing scanned data into the image was implemented by the SW of computer connected to this prototype.

The first test place was carried out at the lakes and roads and the test was interfaced through notebook to collect and analyze detected data, and the analysis on detected data was performed through dedicated viewer developed to suit for the LaserRadar. It is necessary to conduct further studies on analysis and application software through analyzed data of this applied software so that they can be suitable for the platform environment of railways. The result of second test and its analyzed content are supposed to be reflected in the final report of competent year. In the test to validate performance of the developed prototype, it has a maximum 600 m of measurement range, and the accuracy is approximately ±10 cm (at single shot), scanning speed is over 1000 Hz, and the rotation angle is about 90°. To analyze detected images, we used notebooks where the dedicated applied software was loaded, and made it possible to output detected images in various forms in accordance with the selection of option of the applied software.

Figure 4 is the picture showing the prototype installed at the site for performance test of it and the picture expressed by overlapping the screen sensing with that prototype and the picture of same region taken at the satellite, and it scanned various places of slightly elevated region of the pier located at the opposite side of measuring point. Yellow marks show the data scanned by the laser. As seen in the result, it can be seen that

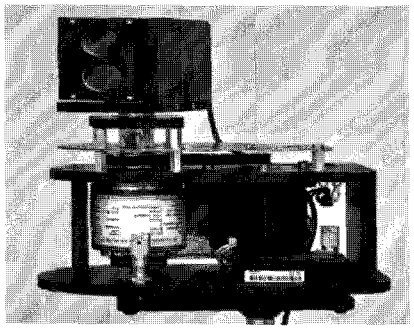

Fig. 3. Prototype of LaserRadar sensor.

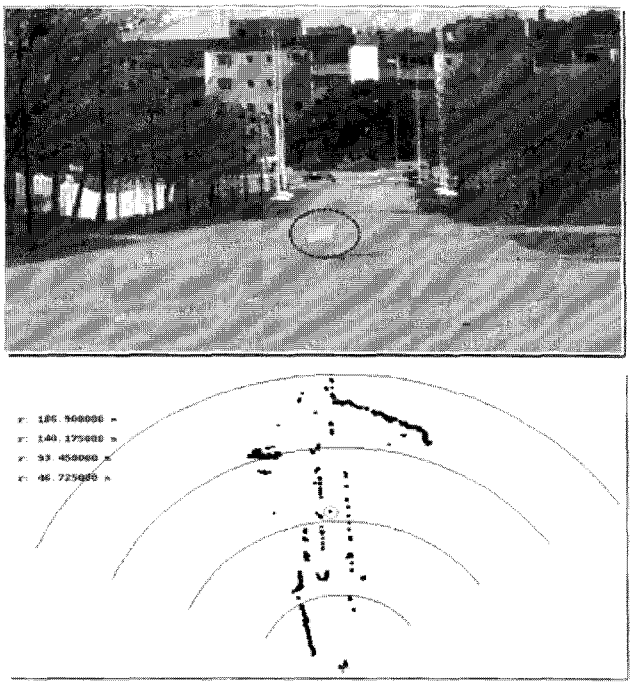

Fig. 4. Performance validation test and its result using the prototype.

the poles for streetlight located on the left bridge were scanned. In case of the expressed color of scanned information, the indicated color can be adjustable through the selection of option in accordance with the dedicated program.

Currently, the basic performance of this prototype was verified by carrying out the test in a foreign country, and to utilize it for the safety equipment to reduce public casualties at platform actually, it is necessary to conduct subsequent studies such as the adjustment of parameters for applied program, etc. which can distinguish whether any person was fallen or not through accumulation of data via scanning of corresponding region through actual model installation. That is, to utilize the developed prototype as the actual safety equipment, many scanned data for actual application targets are necessary and the classification of detected object can be accomplished through them.

5. Conclusion

Since many public casualties are occurred at the platform of railways, many efforts to reduce them are under progress. This paper proposes the safety equipment using LaserRadar sensors to prevent casualties of passengers at the platform. The safety equipment using LaserRadar sensors has more merits than other methods in the aspects of ambient operational environment or cost in comparison with other sensors, and it can be utilized as the safety equipment for various parts of railway such as the level crossing as well as the platform, etc. Currently, this paper carried out the performance test after manufacturing a prototype, and is working on the tuning of SW parameters. If this safety equipment using the novel sensor is applied to the railway sites, it is anticipated that it will become an epoch-making measure to the reduction of accidents involving human lives which occupy many parts of railway accidents.

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