# Image Processing Based Obstacle Detection with Laser Measurement in Railways

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**Abstract**

**Intelligent transport and transportation systems are becoming indispensable systems of today. Continuous new investments and work are being carried out to ensure safety in all transport ways and to reduce accident rates. In this study, a simulation is designed to increase the safety of railways. Most of the railway accidents are caused by the obstacles on the rails. These obstacles means, trees, rocks and consists of similar structures. In this application, the railway has been developed on the detection of any obstacles on the rails, the introduction of the emergency system, and the transmission of information to the movement center. The camera and the laser distance meter installed on the train are used to scan the image with the image processing method, and the results are verified and the obstacle is detected. Emergency braking system, warning system is inserted into the circuit to prevent the obstacle from crashing. In addition to this, the main computer status message is sent to the movement center with the help of the created network. As a result, accident rates will be reduced, and intelligent train systems will be further developed.**
**Keywords—Railway, train, image processing, laser meter, obstacle detection, rail mask.**

## 1. Introduction

Intelligent vehicles at the indispensable point of transport and transport of intelligent cities are at a point where security should be improved. At this point, railway vehicles are becoming more widely used in transportation and transportation. This transportation method, which can be made with relatively low freight and human transportation, seems to be important in the future. Intelligent transportation systems, and the focus of this study are shown in Fig. 1.

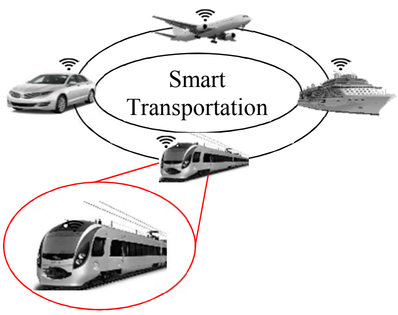


**Fig. 1.** To focus on rail systems in intelligent transport systems.

### 1.1. Motivation

Transportation on railways is carried out via rail. For this reason, railway lines should be laid in the areas where this transportation is desired. This transport has some risks like other types of transportation. Among the greatest risks can be obstacles that can be placed on the rails. Especially, in the passageways and similar passageways, the cars cause obstacles on the rails because of the accidents. In addition to this, stone rolls and tree falls can be counted among these obstacles. Because of this obstacle, there are many accidents, and as a result both life and material losses are experienced. If such an obstacle is detected and an emergency warning and safety system is established, such risks will be reduced. The accident on the railway and the obstacle on the rail are given in Fig. 2.

**Fig. 2.** Accident and obstacles in railways [20, 21].

### 1.2. Problem Statement

This study aims to determine the obstacles on the railway line and to reduce the accidents by introducing emergency warning system. Some of the issues that need to be resolved in order to accomplish this are listed below:

- Initially, images and other data should be taken from the railway.
- The railway line should not be detected from the images.
- It should be determined whether it is obstructed on the detected line.
- Obstacle detection should be done by image processing method and from data received from other devices.
- After two separate determinations made, the correctness of the barrier should be confirmed by comparison.
- As a result of the confirmation of the obstacle, the train emergency service is required to take the patrol.
- It is necessary to make a report to the movement center with the established communication network.

## 1.3. Proposed Approach

Data will be taken from the camera, the position sensor, and the laser metering device placed on the train. Immediate detection of the railway will be done from the images taken with the camera. For this detection, image masking will be used as image processing methods. The determined railway line will be compared with the previously determined reference railway line mask and it will be tried to determine whether there is an obstacle on the line. Three types of masks were selected as the rail structure. These masks are scanned over the image to determine if the rails on the view are obstructed if there is no rail. The direction of the data from the laser meter will be determined a second time whether there are any obstacles on the way. If the two results obtained are the result of the obstacle, it will be confirmed that the obstacle is present. The braking system, which is constructed as an emergency system, will be commissioned as a result of this verification. Thus, the train will be stopped without hitting obstacles. At the same time, information will be sent to the center of movement via the established network and will be sent along with the status of renunciation. As a result, according to the size of the obstacle, the aid team will be dispatched from the center of movement and the train will be made available for the shortest possible time.

## 1.4. Related Work

There are many studies on failures in railways. There are many underground works such as rail profile analysis, train failures, catenary system failures. Jamshidi et al., were proposed a method of image processing to detect rail malfunctions on railways. In this method, they used deep convolution neural network (DCNN) [1]. Karakose et al., proposed a method of fixing the rails, and the rails on the presence of defects [2]. Razvan et al., proposed a method upon detection of imperfections in rails [3]. Aydin et al., were developed an application on the detection of faults in the pantograph and catenary systems on railways [4]. Gibert et al., proposed a method for the detection and classification of rail failures and used DCNN in this method [5]. Ai et al., were proposed a method of ensuring communication on high-speed railways [6]. Karaduman et al., Proposed a method using image processing and fine grain classifier upon extraction of rail profile and detection of rail faults [7]. Wei et al., suggest a method for detecting failures in the suspension systems of vehicles on railways [8]. Efanov et al., were implemented an application on determining the lifetime of the catenary system by measuring the vibrations in the catenary system on the high-speed train line [9]. Ma et al., proposed a modular predictive control and modular multilevel converter based railway traction power conditioner (RTPC) for railways [10]. Yaman et al., were developed a method for finding rail faults [11]. Zhang et al., were proposed a railway crack detection method based on empirical mode decomposition (EMD) adaptive noise cancellation [12]. Toliyat et al., suggest a method for detection of failures in the rail by wavelet transform [13]. Bruce et al., by measurements in the determination of failure in long-rail circuit in short-term memory (LSTM) it is proposed to use recurrent neural network (RNN) [14]. Lei et al., Proposed a method by which the delay is estimated using a probabilistic communication in high-speed train [15]. Matei et al., Have proposed a hybrid method on the identification of railway switches. With this study, along with experimental training data, these properties are used to build a statistical database that is used to classify the behavior of the system based on observations [16]. Henao et al., Proposed a method of estimating electromagnetic torque with the control of vibrations without using any sensor [17]. Lamb et al., were proposed a method for the failure of railway bridges and the safety of the whole railway network during floods and erosions. Risk situations have been identified in light of past experiences and current technologies [18]. Krummenacher et al., proposed an approach to detecting turntable wheels by classifying the pictures with a Support Vector Machine (SVM), as well as CNN, upon detection of failures on railway train wheels [19].

In this study, a method has been proposed to determine the obstacles on the railway, which cause a large part of train accidents, to put the emergency warning and braking system into operation and to minimize possible accidents. This method reports the position of the obstacle detected by sending information on the movement center in the same time zone.

## 1.5. Outline of the Paper

In the next section, the theoretical knowledge of the proposed approach is given. It has been determined how the system will be created and how parameters will be laid out. In the third section, the results obtained from the simulation are given. In the last part, the results of this study and suggestions that can be added to future studies have been made.

# 2. System Theory

In order to reduce the number of accidents on the railway, it is necessary to determine the obstacles that may occur anywhere on the rails, and to stop the emergency system of the train. This study is carried out a simulation application for this system. The general structure of the system is given in Fig. 3.

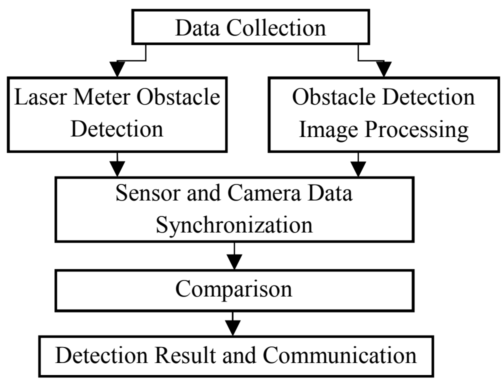


**Fig. 3.** System diagram.

Firstly, the obstacle is detected from the images taken from the camera mounted on the train. In order to make this determination, images taken from the camera are scanned with predefined railway masks. If these masks match the rails, the rails are detected. When the rails are detected, it is decided that no obstacle is encountered. Parallel to this process, the trainer mounted laser meter is also checked for any obstacles on the railway. It is observed whether there is any obstacle in the range of 50-70 m in the control performed. The system for realizing these operations is shown in Fig. 4.

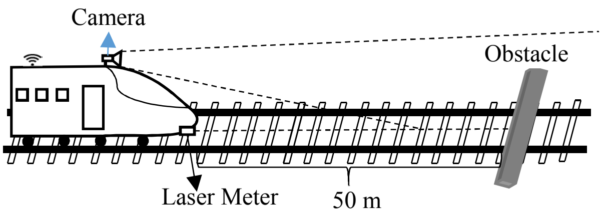


**Fig. 4.** Data collection system on railway.

The mask types used to scan images are shown in Fig. 5. These masks are scanned in the corresponding portions of the obtained images. This scan looks at whether there is a match. The first conclusion is that there is an obstacle according to the result of this pairing.

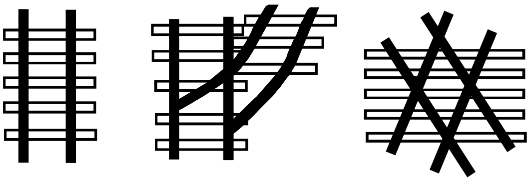

**Fig. 5.** Railway type for mask.

Obtained camera images are taken at a distance of 50 m and compared with the mask and the similarity rate is checked. If the similarity rate in any region is greater than 90%, the rail is fixed, if it is small, the rail can not be detected and there is a possibility of obstruction here. This process is shown in Fig. 6. It will be decided by looking at the laser meter result.

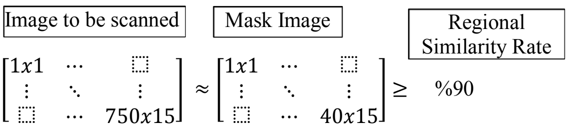


**Fig. 6.** Determination of the similarity rate with the masking of the railway image.

The data obtained using laser meters, and the resulting condition of these data are given in Equation 1.

$$\mathcal{L} = \begin{cases} \text{No Obstacle}, & d > 70 \\ \text{Possible Obstacle}, & 50 \le d \le 70 \end{cases} \quad (1)$$

where $\mathcal{L}$ denotes Laser Meter obstacle detection result, and $d$ is represent measurment between train and obstacle.

The results obtained from the camera images and the laser meter data are compared for confirmation. If the result of both systems is true, there is an obstacle. If one is true and the other is false, there is a chance that it is blocking. If there is a false end in either, no obstacle is present on the railway.

**Table 1.** Compression image result with laser meter result.

| **Image Processing Result** | **Laser Meter Result** | **Overall Results** |
|---|---|---|
| False | False | No obstacle |
| False | True | Possible Obstacle |
| True | False | Possible Obstacle |
| True | True | Obstacle |

Application can continue to look at the next image and laser result. The results of this comparison are given in Table 1.

## 3. Simulation Results

The starting point is taken as 50 meters from the forehead image, and the end point of the view is identified as 1 meter wide. The previously determined mask of 1 meter width is scanned over this image to see if it matches. If there is a match of 90%, this region is considered as a rail, and compared to the laser meter result. If the two results are the same and the obstacle is not detected, the system takes a new image and performs the same operations again. This process continues until the moment when the trip begins at the end.

40x15 Straight Rail Mask

40x15 Railway Switch Mask

40x15 Railway Cross Switch Mask

**Fig. 7.** Railway type for mask.

Numerical data for masks and masks are given in Fig. 7. An exemplary representation for the receiving image, the area to be scanned, the mask, and the resulting similarity result is shown in Fig 8.


(a) (b) (c) (d)

**Fig. 8.** (a) Railway image, (b) Scanned Section, (c) Masks, (d) Similarity results.

According to the results obtained scanned image is checked whether or not the fastening rail. Fig. 9 shows the result obtained by scanning a mask with a mask for rail detection.

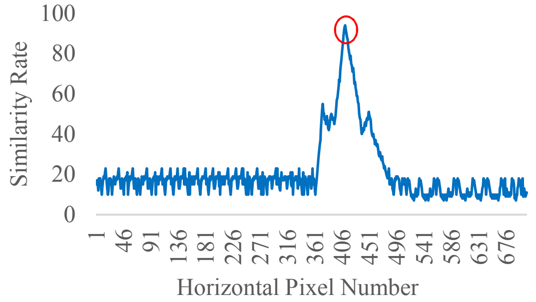


**Fig. 9.** Result graphic for the section scanned with the mask.

The similarity ratio calculated for 100 images used for the application is shown in Fig. 10. As can be seen in Fig. 10, it was determined that rail was fixed for 90 and above, and that there was no obstacle in the railway. For values less than 90 it is not incompatible with the possibility that obstacle on the railway is observed.

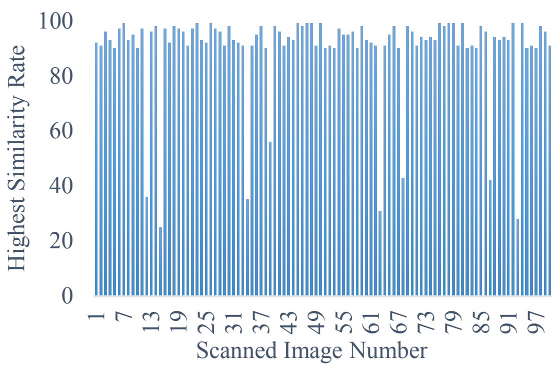


**Fig. 10.** Result graphic for railway images.

## 4. Conclusions

Railways are a mode of transport that is desired to be widespread and improved. Smart cities will evolve along with these systems as they evolve. Among the things that need to be done during the development are providing security and reducing the loss of life and property. The aim of this study is to determine the obstacles on the rails causing accidents in the railways and to set up emergency warning system. For this purpose, image processing and laser meter are used to detect the obstacle. In the study, 92.50% correct detection was obtained in scanning the scene and detecting the rails and the obstacle. In addition, if the real system is included in the real system outside the simulation on the laser meter, the success rate will be increased even more. Thus, the rates of accidents on railways will be reduced. In the future, a system that is constantly evolving and recognizing the type of obstacles will be developed to provide more effective security.

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