

RTRI Develops Automated Visual Inspection System for Vehicle Underbody

The Railway Technical Research Institute (RTRI) has developed an automated visual inspection system that captures images of the underbody of passing railway vehicles and diagnoses any external abnormalities.

1. Effects and features of the system

- Using a device for capturing images of vehicle exteriors, abnormalities in vehicle underbody equipment can be diagnosed from images captured outdoors, with a false positive rate of less than 1%.
- The imaging device consists of a line scan camera, high-luminance line lights, a laser Doppler velocimeter, a vehicle detection sensor, and other components (Figure 1), and it can capture and store high-resolution images of the underbody of passing vehicles outdoors, regardless of the time of day or weather conditions.
- This system utilizes Artificial Intelligence (AI) in its diagnostic algorithm and employs a learning method developed to be robust against external disturbances such as sunlight and wetting by rain at the inspection points.
- The vehicle identification numbers required for diagnostic processing and for managing inspection results are recognized from the markings on the vehicle bodies in the captured images, eliminating the need to install RFID tags or similar devices on the vehicles for number recognition.

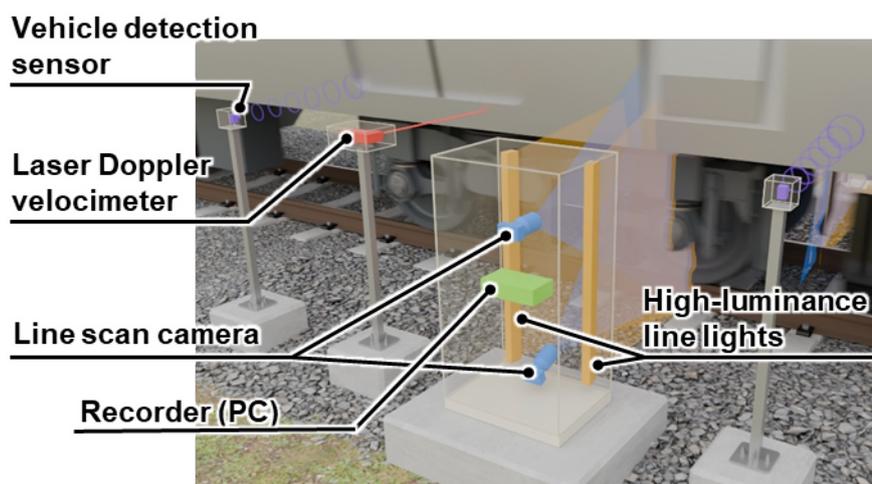


Figure 1 Conceptual layout of the imaging device

2. Background of development

One of the essential vehicle inspections to ensure the safe operation of railway vehicles is the “train inspection” (a routine pre-departure inspection performed without disassembling the vehicle). This inspection requires a considerable amount of manpower since maintenance

staff approach the vehicle and visually check the condition of each equipment, and they have to be performed on all vehicles at approximately ten-day intervals. To address this issue, RTRI has been developing technology to automate the exterior inspection (visual check) of the vehicle underbody, where many inspection points are located, with the aim of saving labor and reducing manpower.

3. Outline of the system

By installing the imaging device (Figure 2) at the entrance of the depot, side views of the underbody are captured as trains enter the depot. In this system, the line scan camera captures images while the laser Doppler velocimeter measures the passing speed of the vehicle (Figure 1), thereby providing continuous images (Figure 3).



Figure 2 Imaging device

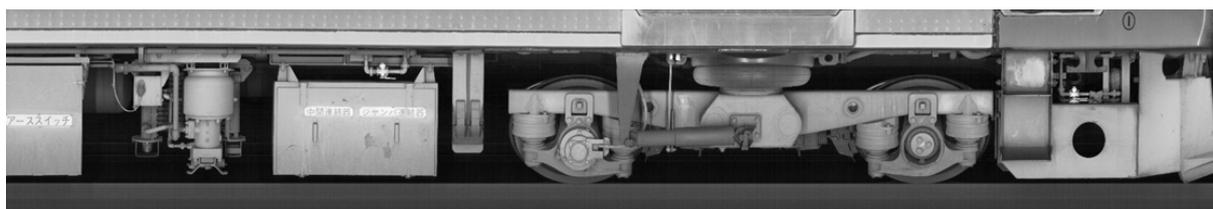


Figure 3 Example of an image captured by the system

Based on the vehicle identification numbers recognized from the captured images, the system diagnoses the exterior condition of individual vehicles using an algorithm that employs vehicle-specific template images and AI models trained for each vehicle type. In the diagnosis, while suppressing the influence of appearance changes at the inspection points caused by external factors such as sunlight or wetting by rain, the system calculates an anomaly score for each inspection point by combining AI trained on a large number of images of normal conditions with an algorithm that evaluates differences from the normal images, and determines whether each inspection point is normal or abnormal by comparing the score with a threshold value (Figure 4).

As a result of verification by imaging vehicles running in the depot over a period of one year and nine months, it was confirmed that the system can diagnose 15 types of simulated abnormalities (Table 1) with accuracies of 0% false negatives (abnormal cases judged as normal) and less than 1% false positives (normal cases judged as abnormal). This indicates that approximately 70% of the underbody areas that have conventionally been inspected visually in train inspections can be replaced by automated inspection using this system.

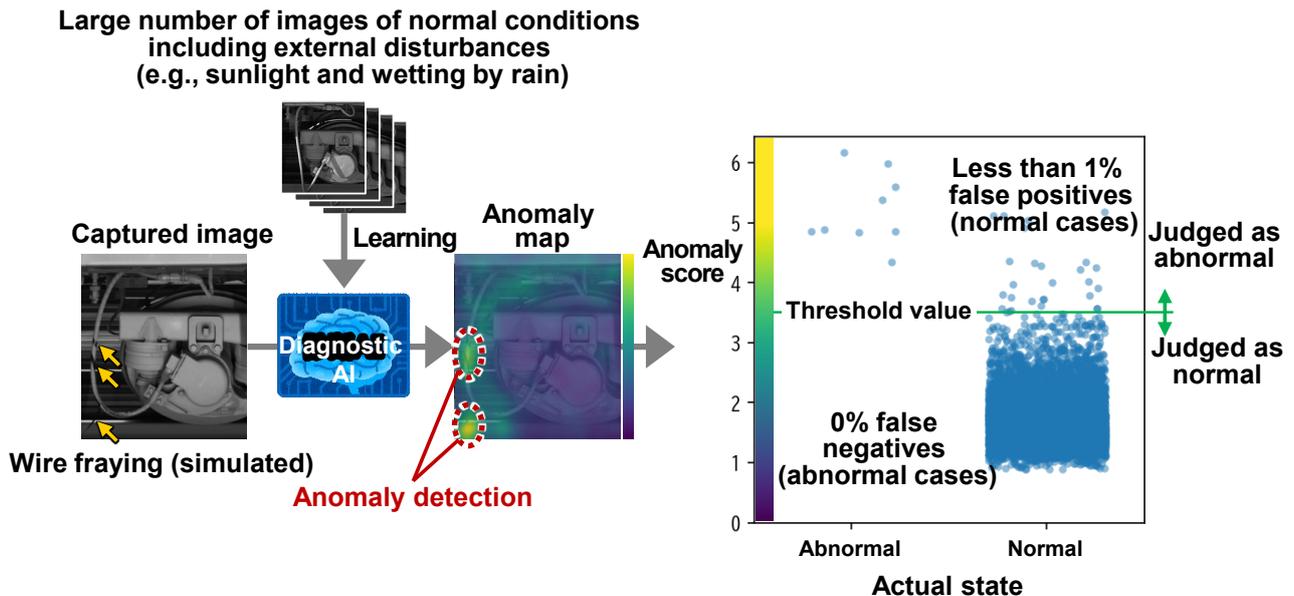


Figure 4 Diagnostic algorithm and verification results (diagnosis of wire fraying)

Table 1 Simulated abnormalities detected

Component detachment	Wire fraying or disconnection, bolt/nut loss, wire breakage, adjustment rod detachment, brake shoe loss
Deformation and damage	Lifeguard bending
Incorrect handle position	Box lid unlocked, incorrect valve state or half-opened
Foreign object	Branch, plastic bag, hammer
Others	Yaw damper oil leak

4. Application of the system

An imaging device that incorporates the imaging technology used in this system is scheduled to be introduced by the Kyushu Railway Company.