The Robot Award

First Prize
(Research and Development Category)

A 4K high-resolution deformation detection system for concrete linings of expressway tunnels traveling at 100km/h

Tokyo University /
Central Nippon Expressway Company Limited

Detecting cracks 0.2mm and up from a vehicle traveling at 100km/h

■A need for more frequent infrastructure inspections

About 30% of the tunnels on expressways have been in service for more than 30 years, and there is a need for more efficient inspections to prevent accidents due to deterioration. Detailed inspections of concrete tunnel lining are conducted by inspectors once every five years, but from the perspective of cost and accuracy, road administrators have been seeking a system that enables more frequent and accurate inspections. A traveling inspection system has been available in the past, but this system has been developed to meet the needs of users even better. The system is capable of capturing high-resolution images of cracks as small as 0.2mm while traveling at a speed of 100km/h. By identifying deterioration and damage at a higher frequency without the need for traffic control, special vehicles, or inspectors, this system will contribute to the achievement of a society in which a safe and strong infrastructure can be operated at a lower cost.

■4K High Resolution Deformation Detection System

This system uses a high-speed camera, high-speed image processing, and a rotating mirror to compensate for motion blur in real time, enabling the continuous capture of 4K-level images that are comparable to still images. Using optical axis control technology with the rotating mirror, they have succeeded in extending the exposure time, downsizing the equipment, and increasing the resolution of the captured images. The higher resolution allows the system to be used even in areas where it is difficult to see deformations due to soot and so on, and the longer exposure time reduces the amount of light required, which helps prevent distracted driving of other drivers and ensures the safety of the inspector.

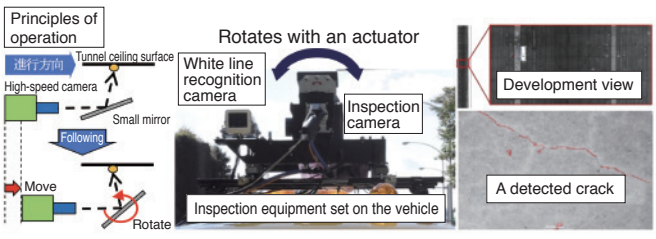
The device can be installed on the top of a regular vehicle (Toyota Surf in the photo here) using a commercially available roof carrier. Since patrol vehicles travel on highways many times a day, it is possible to conduct inspections simply by mounting the device on the vehicle and setting it to record.

Although only one camera is installed in order to reduce the size of the system, the servo motor switches the imaging angle in a circular pattern as the vehicle travels. Using real-time vehicle position information gathered from the white line recognition, the system accumulates data from the target angle, creating a development view of the tunnel.

■Achievements and Future Developments

A field test was conducted on an unrestricted expressway. As a result, the system was able to detect cracks of 0.2mm at a speed of 100km/h within the restriction of the Tomei Expressway Nihonzaka Tunnel. In addition, development maps were successfully created for the Kuragaike Tunnel on the Tokai Ring Road (at 100km/h) and the Hida Tunnel on the Tokai-Hokuriku Expressway (at 70km/h). The images were processed by the deformation detection program, and cracks of 0.2mm or larger were detected, confirming the effectiveness of the system.

The system has succeeded in detecting not only cracks in tunnels while in motion but also internal deformation such as floating and peeling by applying the system to thermal camera imaging. In the future, the system is expected to contribute to the inspection field where both high accuracy and high efficiency are required by applying the same technology to inspection of transportation infrastructures such as railways and airplane runways, as well as high speed inspection of things like factory lines.



Inspection system outline

Contact:

University of Tokyo
Address: School of Engineering Building 6, 7-3-1 Hongo, Bunkyo-ku, Tokyo
Tomohiko Hayakawa, Information Technology Center Tel: 03-5841-0024 E-mail: contact@ishikawa-vision.org

Central Nippon Expressway Company Limited
Address: 2-18-19 Nishiki, Naka-ku, Nagoya, Aichi
Hidemasa Onishi, Technology Planning and Development Division, Environment and Technology Planning Department, Technology and Construction Headquarters Tel: 052-222-3623 E-mail: y.onishi.ac@c-nexco.co.jp