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“Technical Research and Development for Road Policy Quality Improvement” Study Summary

No.	Title	Principal Researcher
No.28-9	Research and development on innovative inspection support systems that meet the needs of municipalities	Ehime Univ.　Prof. Isao Ujike

The purpose of this research is to develop a simple mobile scaffold, an inspection support system using artificial intelligence, and a three-dimensional bridge modeling method for supporting inspection and diagnosis of narrow bridges in municipalities. The research items are design and prototyping of simple mobile scaffold, data collection for artificial intelligence learning, and development of artificial intelligence and image analysis based inspection system.

1. Backgrounds and Objects

Close visual inspection has been carried out every 5 years in bridges in Japan since 2014. However, in narrow bridges managed by many local governments, it is a problem that road closure occurs when bridge inspection vehicles are used. And, it is also a problem that how to evaluate the damage is difficult, even if the inspection is carried out.

In this study, we developed a simple mobile scaffold which does not need to be closed during inspection. Next, we developed a method to evaluate the degree and progress of damage from the results of nondestructive tests and image analysis. In addition, a three-dimensional model of the bridge was constructed by SfM, and a system for mapping the damage to the three-dimensional model was developed.

2. Activities in Research Period

1) Development of Simple Mobile Scaffolding

In order to grasp the performance necessary for the simple mobile scaffold, the hearing was carried out to the road manager and the inspection worker on the performance necessary in terms of safety and workability. In addition, the functions required by the Safety and Health Law for working on a simple mobile scaffold were arranged. Based on the required performance, the design and manufacture of the simple movable scaffold were carried out based on the structural calculation.

2) Development of Artificial Intelligence Damage Assessment Support System

After the specimen is artificially damaged, a non-destructive test is conducted to investigate the relationship between the results of the non-destructive test and the degree of damage. We developed a technique that enables AI to judge damage from non-destructive test results by learning the relationship. In addition, a method for automatically detecting cracks in concrete using AI and image analysis was developed.

3) Development of 3D mapping system

A method for constructing 3D data of bridges from photographed images was developed based on Structure from Motion (SfM) . We also developed a system that can map damage to 3D data.

3. Study Results

1) Development of Simple Mobile Scaffolding

The required performance was determined on the basis of the consultation with the Kagawa and Kochi Labor Bureau and the hearing from road administrators and inspection workers, and the structural design of the simple mobile scaffold satisfying it was carried out (Fig. 1). In addition, verification of the actual bridge has already been conducted at the Shiriguro bridge built in Aki City,

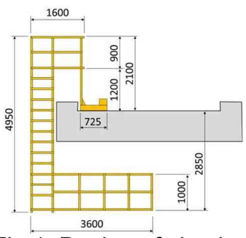

Fig.1. Design of simple mobile scaffolding

Kochi Prefecture (Fig. 2). As a result of the actual bridge verification, it was verified in the actual bridge that there was no large problem in transportation, erection, inspection work, and movement of the scaffold, and that it can contribute to "Reduction of road closures during inspections" which is the largest need of the municipality.

Fig.2 Demonstration of simple mobile scaffolding

2) Development of Artificial Intelligence Damage Assessment Support System

First, a non-destructive test was carried out on a small specimen whose damage was accelerated. From these measurement results, a system to evaluate the progress of damage was constructed using the Random Forest method. Fig. 3 shows an example of corrosion damage prediction.A system for automatically detecting cracks in concrete was also developed. This method was also analyzed by combining the Random Forest method with the image analysis. An example of detection is shown in Fig. 4. This method has very high performance compared with other methods.

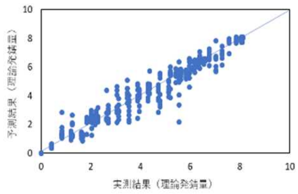

Fig.3 Damage prediction results

Fig.4 Crack detection results

3) Development of 3D mapping system

In this study, a method to restore a 3D model of a bridge by utilizing SfM and a damage mapping system to the 3D model were developed. Fig. 5 shows the restoration result of Kakijo Bridge in Kami City, Kochi Prefecture, as an application example of this method. The figure also shows the results of crack detection plotted on a three-dimensional model.

Fig.5 3D model of Kakijo Bridge

4. Papers for Presentation

P. Chun, et. al.: Deep learning and random forest based crack detection from an image of concrete surface, Journal of Japan Society of Civil Engineers F3, 73(2), pp.I_297-307, 2017 (in Japanese)

5. Study Development and Future Issues

Target results were obtained for each of the simple mobile scaffold, AI inspection system, and bridge 3D model construction method. However, cost reduction and refinement of application and photographing conditions are required for future utilization.

6. Contribution to Road Policy Quality Improvement

The portable scaffold shows a new option to avoid the road closure in the inspection, and the option of inspection means increases. The AI inspection support system can be expected to be an appropriate support in the close visual inspection, which leads to the improvement of inspection accuracy. It is also possible to evaluate the progress of damage by periodically recording and analyzing structures using this method. In particular, it is possible to support "5 (1) Diagnosis of soundness of member unit" and "5 (2) Diagnosis of the soundness of each road bridge" in the Road Bridge Periodic Inspection Guidelines. In addition, the bridge 3D modeling technique can contribute to advanced recording and cost reduction.

7. References, Websites, etc.

Not applicable