Development of an advanced performance evaluation system for existing concrete bridges

Ayaho MIYAMOTO
Prof., Dr. of Eng.,
Graduate School of Science & Engineering, Yamaguchi Univ.,
2-16-1, Tokiwadai, Ube, 755-8611,
Japan
miya818@yamaguchi-u.ac.jp

Ayaho Miyamoto, born 1949, received his Dr. of Eng. degree from Kyoto University in 1985.
His recent research activity is in Strategic Lifetime Management for Civil Infrastructure Systems with the Latest Information Technologies.

Summary

This paper describes a new performance evaluation system for existing concrete bridges with machine-learning (Fig. 1). The system evaluates performance based on load carrying capability and durability from the results of the visual inspection and specification data, and describes the necessity of maintenance. It categorizes all girders and slabs as either unsafe, severe deterioration, moderate deterioration, mild deterioration, or safe. The technique employs an expert system with an appropriate knowledge base in the evaluation. A characteristic feature of the system is the use of neural networks to evaluate the performance and facilitate refinement of the knowledge base. Generally, although a neural network is a powerful machine-learning tool, the inference process becomes a "black box," which renders impossible the representation of knowledge in the form of rules. However, the neural network proposed in the present study has the capability to prevent an inference process and knowledge base from becoming a black box. It is very important that the system is capable of detailing how the performance is calculated since the road network represents a huge investment. The effectiveness of the neural network and machine learning method is verified by comparing diagnostic results by bridge experts.

Keywords: performance evaluation, bridge, expert system, machine learning, neural network.

1. Introduction

The management of existing concrete bridges has become a major social concern in many developed countries due to the large number of bridges exhibiting signs of significant deterioration. This problem has increased the demand for effective maintenance and renewal planning. In order to implement an appropriate management procedure for a structure, a wide array of corrective strategies must be evaluated with respect not only to the condition state of each defect but also safety, economy and sustainability. Information technologies such as cellular phones, car navigation systems, etc. have been advancing more rapidly than concrete technologies, and have been applied globally. There has been growing interest in the maintenance of civil infrastructure systems not only in Japan but worldwide. Therefore, rational and economical diagnostics and remedial measures through the sharing of maintenance experience in Japan and other countries are required. One of the means of meeting this demand is rapidly advancing computers and information and communication technologies. The author has been developing a Bridge Management System (J-BMS) aimed mainly at increasing maintenance efficiency and assisting bridge administrators' decision making for concrete bridges(Fig. 1). J-BMS is an integrated system composed of the "BMS database", "Concrete Bridge Rating Expert System (BREX)", "maintenance planning optimization system" and "maintenance measure selection system". J-BMS was built using the latest information and communication technologies including database systems based on information networks, and neural networks. This paper describes the application of the concrete bridge rating expert system (BREX) to existing bridges. It specifically presents a method for efficiently building a Web-based database using the Internet, application of the durability diagnostic system to existing concrete bridges, and the effect of knowledge update (learning) in the system.

https://doi.org/10.2749/222137813806521144

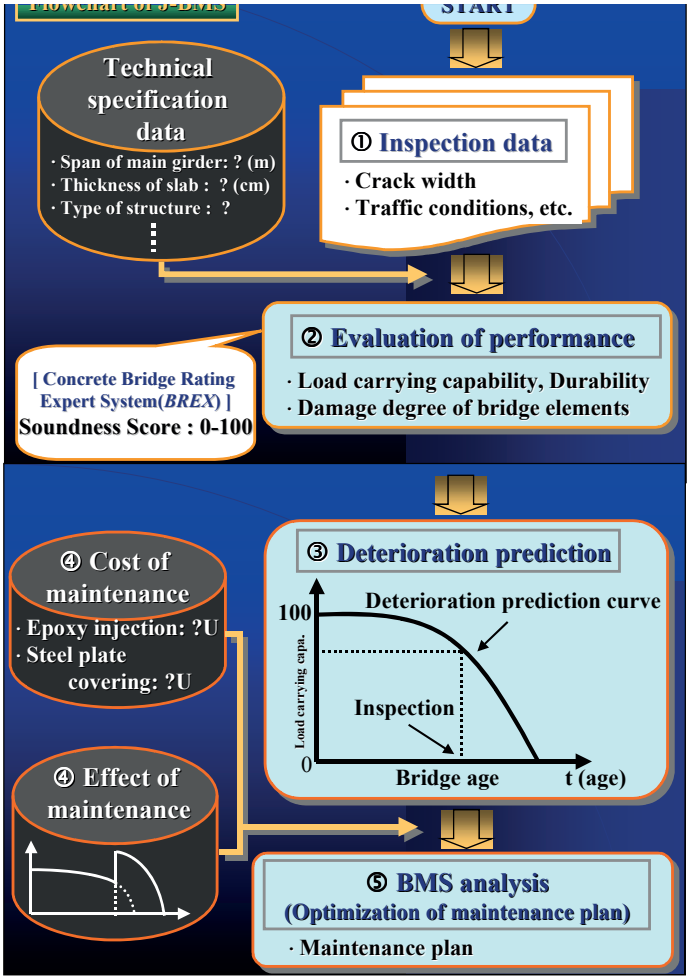

Fig. 1: System configuration of J-BMS

2. Conclusions

This paper described a new performance evaluation system for existing concrete bridges. The system evaluates performance based on load carrying capability and durability from the results of a visual inspection and specification data from an XML-based database system, and describes the necessity of maintenance. It categorizes all girders and slabs as either unsafe, severe deterioration, moderate deterioration, mild deterioration, or safe. The technique employs an expert system with an appropriate knowledge base in the evaluation. A characteristic feature of the system is the use of neural networks to evaluate the performance and facilitate refinement of the knowledge base. Generally, although a neural network is a powerful machine-learning tool, the inference process becomes a "black box," which renders the representation of knowledge in the form of rules impossible. However, the neural network proposed in the present study has the capability to prevent an inference process and knowledge base from becoming a black box. It is very important that the system is capable of detailing how the performance is calculated since the road network represents a huge investment. The effectiveness of the neural network and machine learning method is verified by comparing diagnostic results by bridge experts.