An ANN-Based Backward Prediction Model for Reliable Bridge Management System Implementations Using Limited Inspection Records – Case Studies

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Summary

Bridges are crucial components of the road-network for continuing development of the economy and well-being of the community in any country. Establishing adequate level of bridge maintenance strategies is essential to bridge service authorities for keeping their bridge asset in optimal condition at all times. However, it is not a simple task to manage large bridge network with limited maintenance funding. Computer-aided Bridge Management Systems (BMSs) as Decision Support Systems (DSSs) have been developed for effective asset management. To obtain reliable decision from BMSs, software packages must have satisfactory quality and sufficient quantity of asset information for the system's various analytical processes. Correctly predicting a mixture of future maintenance and repair needs, periodic inspection records are the key resources amongst other information requirements. However, many bridges have already been constructed long before the BMS technology was developed. Thus, many years of past inspection records for those aged structures are always lacking. In particular, the lack of such historical records, which are required as inputs to BMS's is a very common operational problem in their implementation.

This paper focused mainly on addressing the abovementioned research problem of lacking historical bridge condition rating record. One of the most significant BMS data requirements is the historical bridge element condition ratings forming part of the past bridge inspection records. Bridge condition ratings can also affect approximately 60% of the BMS analysis modules. In cases of insufficient or non-existence of such data, BMSs are provide unreliable outcomes of future bridge performance. Bridge condition ratings obtained from routine visual inspection, which is common bridge asset management practice for service authorities before the BMS technology was implemented. However, the form of condition rating is dissimilar to the BMSs input requirement. Therefore, usable data for BMSs is very limited.

In addition, condition rating incompatibility is the major barrier for establishing a BMS database. It is generally recognised that for most bridges there are big time gaps between the dates of construction and adoption and implementation of relevant Bridge Management Systems (BMSs). As a result, suitable bridge inspection records and of course the bridge element condition ratings are unavailable for the intervening years. The unavailable data, which are required as input for the relevant analysis modules of any BMS, is a major factor leading to unreliable BMS outcomes currently experienced by most bridge agencies.

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To this end, the methodology of a Backward Prediction Model (BPM) is developed as part of the research effort. Capable of generating the missing data, the BPM incorporates Artificial Neural Network (ANN) techniques and operates on the limited existing inspection records and the historical non-bridge factors such as local climates, traffic volume and population growth in the area surrounding the bridge. The methodology of the BPM is established and verified by using available bridge datasets obtained from the Maryland Department of Transportation (Maryland DOT), USA. Further validation of the BPM methodology in the form of case studies is also conducted using different sample data obtained from the Roads and Transport Authority of New South Wales (RTA NSW), Australia.

The proposed ANN-based BPM methodology aims to generate unavailable years of bridge element condition ratings using limited inspection records with minimum assumptions. The test outcomes of the BPM methodology show satisfactory results for the generation of historical condition ratings. Based on approximately 25% of total element's conditions records, the BPM is able to generate about 75% of historical condition ratings for the intervening years. The average ratio of the generated and existing datasets is about 3. The average prediction errors of the generated bridge condition ratings are, respectively, about 6-8% using NBI and about 18% using BMS's condition ratings, which are within the maximum error allowances of 10% in NBI and of 20% in BMS's condition ratings. Despite of the satisfactory prediction outcomes, further research should be carried out to refine the proposed methodology to be suitable for practical application to bridge asset management.

Keywords: Bridge Management System (BMS); Backward Prediction Model (BPM); Bridge condition ratings; Artificial Neural Networks (ANNs); Maintenance, Repair and Rehabilitation (MR&R).