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Implementation of Deep Neural Networks for Pavement Condition Index Prediction

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Abstract : In-service pavements deteriorate with time due to traffic wheel loads, environment, and climate conditions. Pavement deterioration leads to a reduction in their serviceability and structural behavior. Consequently, proper maintenance and rehabilitation (M&R) are necessary actions to keep the in-service pavement network at the desired level of serviceability. Due to resource and financial constraints, the pavement management system (PMS) prioritizes roads most in need of maintenance and rehabilitation action. It recommends a suitable action for each pavement based on the performance and surface condition of each road in the network. The pavement performance and condition are usually quantified and evaluated by different types of roughness-based and stress-based indices. Examples of such indices are Pavement Serviceability Index (PSI), Pavement Serviceability Ratio (PSR), Mean Panel Rating (MPR), Pavement Condition Rating (PCR), Ride Number (RN), Profile Index (PI), International Roughness Index (IRI), and Pavement Condition Index (PCI). PCI is commonly used in PMS as an indicator of the extent of the distresses on the pavement surface. PCI values range between 0 and 100; where 0 and 100 represent a highly deteriorated pavement and a newly constructed pavement, respectively. The PCI value is a function of distress type, severity, and density (measured as a percentage of the total pavement area). PCI is usually calculated iteratively using the 'Paver' program developed by the US Army Corps. The use of soft computing techniques, especially Artificial Neural Network (ANN), has become increasingly popular in the modeling of engineering problems. ANN techniques have successfully modeled the performance of the in-service pavements, due to its efficiency in predicting and solving non-linear relationships and dealing with an uncertain large amount of data. Typical regression models, which require a pre-defined relationship, can be replaced by ANN, which was found to be an appropriate tool for predicting the different pavement performance indices versus different factors as well. Subsequently, the objective of the presented study is to develop and train an ANN model that predicts the PCI values. The model's input consists of percentage areas of 11 different damage types; alligator cracking, swelling, rutting, block cracking, longitudinal/transverse cracking, edge cracking, shoving, raveling, potholes, patching, and lane drop off, at three severity levels (low, medium, high) for each. The developed model was trained using 536,000 samples and tested on 134,000 samples. The samples were collected and prepared by The National Transport Infrastructure Company. The predicted results yielded satisfactory compliance with field measurements. The proposed model predicted PCI values with relatively low standard deviations, suggesting that it could be incorporated into the PMS for PCI determination. It is worth mentioning that the most influencing variables for PCI prediction are damages related to alligator cracking, swelling, rutting, and potholes.

Keywords : artificial neural networks, computer programming, pavement condition index, pavement management, performance prediction
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