Predicting Asphalt Pavement Roughness with an Ensemble Learning Approach

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An accurate prediction of asphalt pavement condition is important to guide pavement maintenance practices. The existing models for pavement condition predictions are predominantly based on linear regressions or simple machine learning technics (e.g., the artificial neural network (ANN) and the random forest models). However, additional work on these models is needed to improve their basic assumptions, training efficiency, and interpretability. To this end, a new modeling approach is proposed in this manuscript, which includes a Light Gradient Boosting Machine (LightGBM)-based ensemble learning model, coupled with the Shapley Additive Explanation (SHAP) method, to predict the International Roughness Index (IRI) of asphalt pavements. The SHAP method was applied to interpret the underlying influencing factors and their interactions. 20 features were initially identified as the model inputs, and 1,706 observations were extracted from the Long-Term Pavement Performance (LTPP) database. Two benchmark models, namely the Mechanistic-Empirical Pavement Design Guide (MEPDG) model and the ANN model, were used for comparison. The results showed that the developed model outperformed both benchmark models in terms of R-square, root mean square error, and the absolute error. Feature interpretation was performed to identify the top influencing factors of IRI, and the interaction effects between two features were also analyzed. The 20-feature model was further simplified based on the analysis result. The simplified model only required five features to efficiently and effectively predict IRI using the proposed LightGBM-based approach, which can reduce the workload in data collection and management for pavement engineers.