Extending the I-95 Rule-based Incident Duration System with an Automated Knowledge Transferability Model

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Abstract

- The rule-based incident duration prediction model (IDPM), covering I-95, I-495, and I-695, has been adopted by MDOT SHA in daily responses to non-recurrent congestion.
- In light of its effectiveness and robustness in practice, expanding such a system to all other highways emerges as a desirable but challenging task due to:
  - The need of integrating field operators' expertise in generating prediction rules
  - The dependence of sufficient incident records for key parameter calibration
- To circumvent such a data-demanding and time-consuming process for extending IDPM's spatial coverage, this study has proposed a Knowledge Transferability Analysis (KTA) method, featuring its automated process to assess, select, and transfer existing prediction rules to perform incident duration estimate for the new target highway.
- Evaluation of the proposed KTA with the incident records from Maryland I-70 reveals that it can achieve the accuracy of 87% with the training dataset (i.e., 2016-2018) and of 82% with the test dataset (i.e., 2019), comparable to the current system's performance but demanding much fewer incident records for model calibration and significantly fewer efforts for system expansion.

Knowledge-based System

Rule Box Generation and Update
The function of the Rule Box is to house all effective prediction rules from existing IDPMs (i.e., I-95, I-495, and I-695). Such rules in each category are further divided into three types based on their pre-specified thresholds for classifying incident duration.

Ranking of key factors
The rule transferring priority determines not only which rules to transfer but also the execution structure of the new IDPM. Before assessing the transferability priority for each set of rules in the Rule Box, all key factors are initially classified into seven categories.

Transferability Ranking Analysis
- **Transferability Ranking-I Analysis**: Using Random Forest to identify the relative effectiveness of seven categories of factors from the perspective of how often they have been used in the existing prediction rules and the resulting effectiveness.
- **Transferability Ranking-II Analysis**: Employing the method for rank aggregation to produce final optimized ranking list for all categories.

Knowledge Transferability Analysis (KTA)

Prioritizing Candidate Rules
All rules based on their logic structure and target incident types are assigned with a customized score with following regulations:
- Take optimized rankings as grades
- The rule combined by "AND" sum up to the total score
- The rule combined by "OR" take the maximum combination and add 200

Transferring Effectiveness Test
Two MOEs, 1) confidence level and 2) support level, are used to determine the transferable rules among the rules from the Rule Box.

Conclusions
- To circumvent the demanding developing efforts and the need for an extensive dataset for calibration of an IDPM's prediction rules, this study has proposed an innovative KTA model that allows the construction of a new system to take advantage of existing IDPMs' embedded rules with an automated process.
- The effectiveness of the proposed model has been evaluated with the incident data from I-70 in Maryland, revealing that the performance of the IDPM for I-70, with 67% of transferred rules, can yield the prediction accuracy comparable to existing IDPMs that demand much more development resources.
- Future research along this line includes: 1) extending the KTA model's application to major signalized arterials mostly with a small size of incident records, and 2) constructing a supplemental module to enhance the efficiency and robustness of the rule-based IDPMs.