Leveraging Big Data for Enhanced Pavement Management

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OBJECTIVE: Apply big data techniques to pavement management.

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SUMMARY: Pavement management, a significant component of highway infrastructure asset management, involves using data, methodologies, and procedures to plan maintenance, preservation, rehabilitation, and renewal actions. This work relies on different types of data:

- Inventory data: The physical elements of a road system.
- Pavement construction history data: The pavement structure and layer composition.
- Condition data: The condition of elements that can be expected to change over time.
- Traffic and climate data: The traffic and environmental loading pavement is subjected to over time.
- Cost data: Measures historical investment used for future cost estimates.

A wide range of rapidly advancing technologies is now available to highway engineers for measuring attributes of a pavement network. Many of these technologies effectively collect massive amounts of data with little or no impact on highway users, such as the automated pavement condition survey vehicle (which collects pavement profile and image data for surface condition evaluation); the ground-penetrating radar (which collects pavement thickness-related data); and the traffic speed deflection device (which collects pavement deflection data for structural evaluation). There is also increased availability of auxiliary data sources, including:

- Modern-Era Retrospective Analysis for Research and Applications (MERRA) and MERRA-2 climate data from the National Aeronautics and Space Administration's Global Modeling and Assimilation Office.
- U.S. Department of Agriculture's Natural Resources Conservation Service soil survey database.
- Connected and automated vehicle data.
- Crowdsourced data.

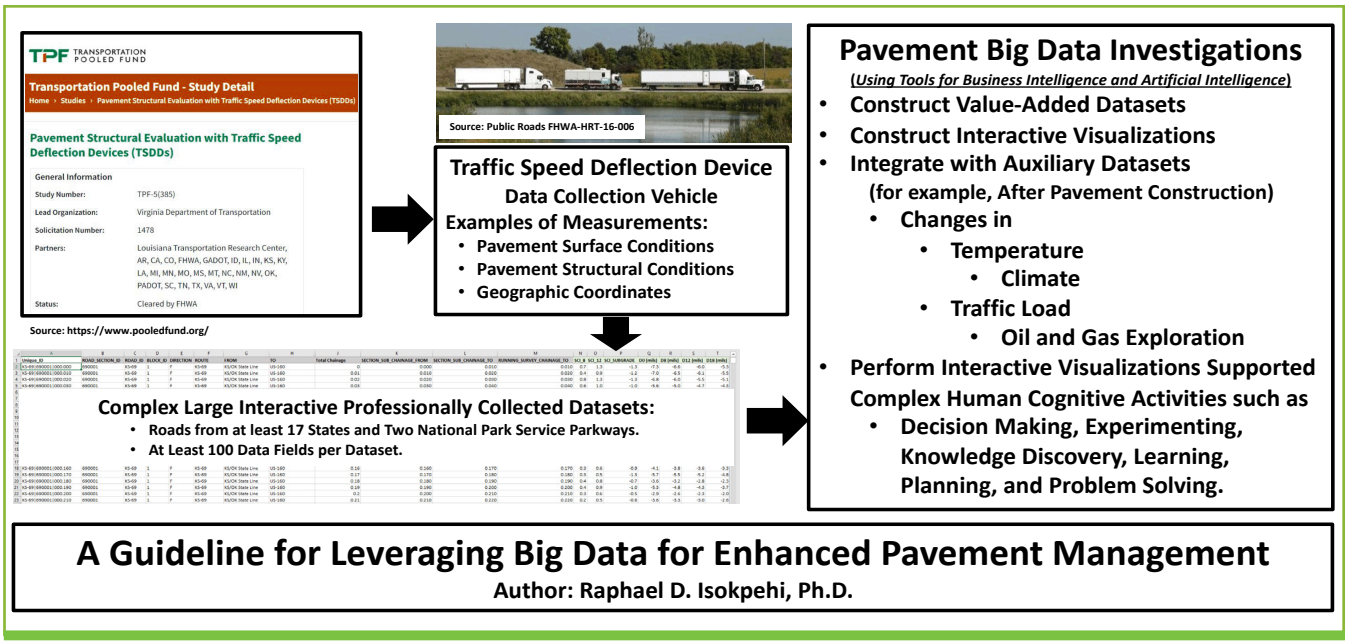
However, pavement management applications have not been able to fully utilize this rapidly expanding amount and type of "big data." Traditional analysis procedures used in pavement management are not readily adaptable to the five v's of big data—volume, velocity, variety, veracity, and value. This issue is not unique to pavement management. Recent advances in the field of data science, like the availability of open-source tools implementing artificial intelligence techniques such as deep learning (DL) and advances in data storage and processing power, provide an opportunity to complement proven traditional analysis approaches with data science and DL techniques to better leverage big data for more informed pavement management.

In his 12-mo Research Associateship Program tenure, Raphael Isokpehi, Ph.D., focused on applying big data techniques to pavement management. In his project, titled "Leveraging Big Data for Enhanced Pavement Management," Isokpehi considered:

- Diverse data types for pavement management.
- Wide range of technologies for measuring attributes of a pavement network.
- Effective collection of massive amounts of data at traffic speed.
- Auxiliary data's increased availability.

The common themes in the project were big data to knowledge, knowledge sharing, knowledge management, and knowledge visualization. After the first 6 mo of the project, the following three research objectives were established:

- Objective 1: Construct integrated datasets for pavement management from diverse data sources, including data collected for pavement management and other readily available auxiliary data.



- Objective 2: Design interactive analytics for geospatial data investigations and DL of pavement conditions and performance predictions.
- Objective 3: Evaluate the benefits of interactive knowledge visualizations to stakeholders in pavement management.

The project's primary data source was a series of datasets collected by a traffic speed deflectometer (TSD) on road sections from 17 State highway agencies and the National Park Service. A version of the constructed TSD data contained 180 million data points providing pavement big data for diverse investigations (objective 1). Another constructed dataset was the geographic coordinates (longitude and latitude) for the road sections with TSD data and the 2,581 sections of the Long-Term Pavement Performance program.

Additionally, Isokpehi obtained datasets on oil and gas wells in Kansas and Pennsylvania. These auxiliary datasets provided examples to design interactive analytics for investigating the geospatial data of pavement conditions (objective 2). He developed several interactive analytics to support decisionmaking, learning, planning, and other complex cognitive activities.

Isokephi and his team engaged and collaborated with pavement management experts through participation in conferences (objective 3). The research project collaborated with other pavement engineers and researchers in the public and private sector as well as academia through the Transportation Pooled Fund study "Pavement Structural Evaluation with Traffic Speed Deflection Devices" and the Big Data for Smart Pavement Management and Deflection at Road Traffic Speed User Group.

RESOURCES:

Isokpehi, R., A. Nadkarni, and N. Sivaneswaran. 2022. "Big Data Investigations to Knowledge for Enhanced Pavement Management." Presented at the *11th International Conference on Managing Pavement Assets*. Chicago, IL: Transportation Research Board.

Isokpehi, R., A. Nadkarni, and N. Sivaneswaran. 2022. "Big Data Investigations to Knowledge for Enhanced Pavement Management." Presented at the *101st Annual Meeting of the Transportation Research Board*. Washington, DC: Transportation Research Board.

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