Breakthrough in travel behavior research with artificial neural networks

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Table 1: Comparison of DNNs, DCMs, and TB-ResNets

Models	Prediction	Interpretability	Robustness
Deep neural networks (DNNs)	High	Low	Low
Discrete choice models (DCMs)	Low	High	High
Theory-based residual neural networks (TB-ResNets)	High	High	High

A comparison summary of deep neural networks (DNNs) and discrete choice models (DCMs) characteristics Credit: Singapore-MIT Alliance for Research and Technology (SMART)

Researchers at the Future Urban Mobility Interdisciplinary Research Group at Singapore-MIT Alliance for Research and Technology, MIT's research enterprise in Singapore, have created a synthetic framework known as a theory-based residual neural network (TB-ResNet), which combines discrete choice models (DCMs) and deep neural networks (DNNs), also known as deep learning, to improve individual decision-making analysis for travel behavior research.

In this research paper, theory-based residual neural networks: A synergy of discrete choice models and deep neural networks, recently published in established transportation science journal *Transportation Research: Part B*, SMART researchers explain their developed TB-ResNet framework and demonstrate the strength of combining the DCMs and

DNNs methods, proving that they are highly complementary.

As machine learning is increasingly used in the field of transportation, the two disparate research concepts, DCMs and DNNs, have long been viewed as conflicting methods of research.

By synergising these two important research paradigms, TB-ResNet takes advantage of DCMs' simplicity and DNNs' expressive power to generate richer findings and more accurate predictions for individual decision-making analysis, which is important for improved travel behavior research. The developed TB-ResNet framework is more predictive, interpretable, and robust as compared to DCMs and DNNs, with findings consistent over a wide range of data sets.

Accurate and efficient analysis of individual decision-making in the everyday context is critical for mobility companies, governments and policy makers seeking to optimize transport networks and tackle transport challenges, especially in urban cities. TB-ResNet will eliminate existing difficulties faced in DCMs and DNNs, and allow stakeholders to take a holistic, unified view towards transport planning.

Postdoctoral associate at MIT Urban Mobility Lab and lead author of the paper, Shenhao Wang, said, "Improved insights to how travelers make decisions about travel mode, destination, departure time, and planning of activities are crucial to urban transport planning for governments and transport companies worldwide. I look forward to further developing TB-ResNet and its applications for transport planning now that it has been acknowledged by the transport research community."

SMART FM lead principal investigator and associate professor at MIT Department of Urban Studies and Planning, Jinhua Zhao, said, "Our Future Urban Mobility research team focuses on developing new paradigms and innovating future urban mobility systems in and beyond

Singapore. This new TB-ResNet framework is an important milestone that could enrich our investigations for impacts of decision-making models for urban development."

The TB-ResNet can also be widely applied to understand individual decision-making cases as illustrated in this research, whether it is about travels, consumption, voting, among many others.

The TB-ResNet framework was tested in three instances in this study. Firstly, researchers used it to predict travel mode decisions between transit, driving, autonomous vehicles, walking, and cycling, which are major travel modes in an urban setting. Secondly, they evaluated risk alternatives and preferences when monetary payoffs with uncertainty are involved. Examples of such situations include insurance, financial investment, and voting decisions.

Lastly, they examined temporal alternatives, measuring the trade-off between current and future money payoffs. A typical example of when such decisions are made would be in transport development where shareholders analyze infrastructure investment with large down payment and long-term benefits.

Provided by Singapore-MIT Alliance for Research and Technology

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