A mathematical analysis of urban traffic models clarifies a dispute over which approach is the best

June 15 2016

A long-running debate among traffic engineers has been resolved by two A*STAR researchers who have discovered that two seemingly very different models of traffic flow in cities actually have similar underlying mathematical structures.

Traffic models play a vital role in assisting urban planners and traffic engineers to minimize congestion in our towns and cities. Unfortunately, modeling traffic turns out to be considerably more challenging than modeling many natural systems because traffic flow lacks inherent symmetry, which could be used to simplify models. As a result, the traffic modeling community is overwhelmed by a plethora of models. "It can be very difficult to determine which is the most appropriate model to use for a particular traffic system," notes Bo Yang of the A*STAR Institute of High Performance Computing.

The community is also divided between two apparently different approaches—some modelers advocate so-called two-phase traffic theories, while others champion three-phase ones. "The two-phase and three-phase traffic theories were deemed incompatible, and both schools of thought believed their own approach was the right one," explains Yang.

Now, Yang and Christopher Monterola have successfully resolved this dispute by showing that these two approaches are intrinsically related mathematically. In particular, any three-phase traffic model can be approximated to an arbitrary degree of accuracy by an appropriately tuned two-phase model.

"We believe that our study has made one of the most crucial steps in resolving this long-standing controversy," says Yang. He adds that although it could take time to gain complete acceptance, the team has been encouraged by initial responses they have received from leading proponents of the two approaches.

Furthermore, Yang and Monterola's analysis allows different models to be objectively compared with each other. "Our study reveals a universal mathematical structure that underlies all deterministic microscopic traffic models," says Yang. "This structure can be used to classify all such traffic models in the literature." This will allow any two traffic models to be appropriately compared and assessed. "Different traffic models can now be compared quantitatively by performing controlled expansions around steady states, and the various different assumptions used by these models can now be understood in a systematic way," explains Yang.

In addition to helping to improve our understanding of collective human driving behaviors, the pair's analysis is useful for designing driving algorithms for autonomous vehicles, which are fast becoming a reality.

The pair has been continuously collecting data of actual traffic flow to test and optimize their theoretical analysis.

More information: Bo Yang et al. Classification and unification of the microscopic deterministic traffic models, *Physical Review E* (2015). DOI: 10.1103/PhysRevE.92.042802

Provided by Agency for Science, Technology and Research (A*STAR), Singapore