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Connected Vehicle Technology and AI Could Help Reduce Highway Congestion through Better Utilization of Park and Ride Facilities

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Issue

Considerable advancements have been made in traffic management strategies to address highway congestion over the past decades; however, the continuous growth of metropolitan regions has impeded such progress. In response, transportation planners have given special attention to integrated corridor management (ICM)[1], an approach that coordinates various traffic control units (e.g., ramp metering) to optimize their operations along the entire freeway. Emerging connected vehicle (CV) technology is expected to substantially benefit ICM, where vehicles can communicate with each other and surrounding roadway infrastructure. The combined potential of ICM strategies and CVs could be even greater if combined with strategies that leverage underutilized infrastructure (specifically park-and-ride facilities[2]) to reduce the total number of vehicles on the roadway.

The synergy between CV technology and existing infrastructure, such as park-and-ride facilities, is severely understudied. To address this gap, we explored how AI (specifically deep reinforcement learning[3]) could be used to process data collected by roadside infrastructure on the level of roadway congestion and then prepare and transmit messages to vehicles directing drivers to a park-and-ride facility where drivers can park and continue their journey via public transportation. To do this, we developed a realistic traffic model of a portion of I-5 in Los Angeles that incorporated highway-related transportation infrastructure (e.g., ramp metering), vehicle-to-infrastructure (V2I) units, and park-and-ride facilities, and then conducted a proof-of-concept hardware test, demonstrating how V2I technology could provide useful traffic information to commuters (i.e., sending messages to their vehicles) to our centralized server and vice versa.

Key Research Findings

Utilizing AI and CV technology to divert drivers from a congested highway to public transportation available at park-and-ride facilities may improve throughput, average travel time, and CO2 emissions. Specifically, we observed a 4% increase in the overall throughput (i.e., the overall rate at which vehicles travel through the corridor per unit time), a 4.7% reduction in the average travel time of vehicles passing through the corridor, and a 3.1% reduction in average CO2 emission savings due to the overall improvement in traffic flow. We believe additional reductions in CO2 emissions could be achieved by adjusting the schedule and frequency of bus service at park-and-ride facilities in accordance with the commuters' supply and demand in addition to congestion patterns.

These improvements come at the cost of increased travel time for diverted drivers. The drivers who opted to exit the freeway and access public transportation at a park-and-ride facility experienced a 52.6% increase in total travel time delay. This time penalty significantly reduces the incentive for individual drivers to voluntarily choose to exit

the highway. However, we observed that as more drivers complied with the recommendation to exit the highway and take public transportation the smoother the traffic flow. This highlights the need to devise marketing and/or financial incentive strategies to encourage more drivers to comply with the recommendation to exit the roadway. Compliance would likely increase with the introduction of fully autonomous vehicles where the vehicle would automatically exit after receiving the message versus a human driver voluntarily deciding to do so.

AI offers promising scalability to support a CV-enabled strategy for reducing congestion, however, more evidence and analysis is needed. Adopting AI-based solutions to orchestrate a unified CV-enabled approach to traffic management is practical and scalable. AI-based solutions can handle large amounts of data and use the data to derive corridor-wide traffic management strategies based on current and historical observations[4]. However, more work is needed to evaluate and assess the benefits of deploying ICM strategies as described in this policy brief, including feasibility studies and cost-benefit analysis to assess the efficacy and amounts of needed resources, such as the number of buses and how frequently they should be dispatched.

More Information

This policy brief is drawn from the report "Reducing Congestion Using Integrated Corridor Management Technology to Divert Vehicles to Underutilized Park-and-Ride Facilities" prepared by Mohanad Odema, Mohamad Fakih, Tyler Zhang, and Mohammad Abdullah Al Faruque. The report can be found at www.ucits.org/research-project/2022-46. For more information, please contact Mohammad Abdullah Al Faruque at alfaruqu@uci.edu.

[1] F. H. Administration, "Integrated corridor management (ICM) program: Major achievements, key findings, and outlook, 2020. Available: https://ops.fhwa.dot.gov/publications/fhwahop19016/chapter3.htm.

[2] "Park & Rides Lose Money and Waste Land — But Agencies Keep Building Them – Streetsblog USA." [Online]. Available: https://usa.streetsblog.org/2016/07/05/park-rideslose-money-and-waste-land-but-agencies-keep-building-them/ (Feb 2020).

[3] Deep reinforcement learning is a machine learning technique in which an algorithm learns to improve its output predictions over time based on reward/penalty scores from its prior predictions using observed environment states.

[4] M. Odema, M. Fakih, T. Zhang, M.A. Al Faruque., "Integrated Corridor Management for Connected Vehicles and Park and Ride Structures", UC-ITS-2022-46.

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