A Decentralized Optimal Control Framework for Connected and Automated Vehicles

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ABSTRACT: Recognition of the necessity for connecting vehicles to their surroundings is gaining momentum. In this “new world” of massive amounts of data from vehicles and infrastructure, what we used to model as uncertainty (noise or disturbance) for traffic becomes extra state information in a much higher-dimensional vector. Connected and automated vehicles provide the most intriguing opportunity for enabling users to better monitor transportation network conditions and make better operating decisions to improve safety and reduce pollution, energy consumption, and travel delays. While progress has been made, especially in the area of safety and how accidents could potentially be prevented, one particular question that still remains unanswered is “how much can we improve fuel consumption, if we assume that the vehicles are connected and can exchange information with each other and with infrastructure?” This talk will address the problem of coordinating vehicles that are wirelessly connected to each other at different transportation segments, e.g., intersections, merging roadways, to achieve a smooth traffic flow without stop-and-go driving. I will present a decentralized optimal control framework whose closed-form solution exists under certain conditions, and which, based on Hamiltonian analysis, yields for each vehicle the optimal acceleration/deceleration at any time in the sense of minimizing fuel consumption. The solution, when it exists, allows the vehicles to cross the intersections and merging roadways without the use of traffic lights, without creating congestion, and under the hard safety constraint of collision avoidance. The talk will also highlight research efforts toward making vehicles (1) becoming eco-friendly, (2) realizing the optimum efficiency based on consumers’ needs and preferences, and (3) learning how traffic information can positively impact the environment and improve efficiency.

BIO: Andreas A. Malikopoulos received a Diploma from the National Technical University of Athens, Greece, in 2000, and his M.S. and Ph.D. degrees from the University of Michigan, Ann Arbor, in 2004 and 2008, respectively all in Mechanical Engineering. His research interests span several fields, including analysis, optimization, and control of cyber-physical systems; decentralized stochastic systems; stochastic scheduling and resource allocation; and learning in complex systems. The emphasis is on applications related to energy, transportation and operations research. Before joining ORNL, he was with General Motors Global Research & Development. Andreas is the recipient of several prizes and awards, including the 2007 Dare to Dream Opportunity Grant from the University of Michigan Ross School of Business, the 2007 University of Michigan Teaching Fellow, and the 2010 Alvin M. Weinberg Fellowship. He has been selected by the National Academy of Engineering to participate at the 2010 German-American Frontiers of Engineering (FOE) Symposium and organize a session in transportation at the 2016 European-American FOE Symposium. He has also been selected as a 2012 Kavli Frontiers of Science Scholar by the National Academy of Sciences.