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Mechanical Engineering Leadership Distinguished Speaker Series

Speaker: Roberto Horowitz, Chair and Professor of Mechanical Engineering and James Fife Endowed Chair in the College of Engineering at UC Berkeley
When: Monday, March 18, 2019, 10:30am – 11:30am
Where: 117A Randolph Hall

Modeling, Control and Estimation of Traffic Road Networks

This talk discusses some of our recent advancements in management and estimation of traffic road networks. Traffic congestion is a major source of world-wide inefficiency, with one study estimating that, in 2014, delays due to congestion cost 7 billion hours and $160B in the US alone. However, mitigating congestion through management techniques is difficult, as traffic congestion exists in a confluence of complex phenomena, such as nonlinear shockwaves, emergent macroscopic network effects from multiple agents, and low system observability and controllability. Growth of traffic demand shows no sign of decreasing, so continued infrastructure expansion must be combined with continued development of traffic control engineering to abate these societal costs. Some of today's traffic control efforts make use of novel formulations of these nonlinear systems and new sources of data provided by the connected and autonomous vehicles now entering the fleet.

In this talk I will describe a set of modeling and simulation tools for traffic operations planning to provide quick and quantitative assessments of the benefits that transportation management center control policies can provide on freeway corridors, in order to decrease congestion. In addition to describing some basic controllability and observability properties of traffic dynamics, I will briefly describe a set of parameter calibration, ramp flow estimation and sensor fault detection algorithms that were developed in order to achieve reliable simulation of freeway traffic. Subsequently, I will focus on traffic management. I will first present ramp metering and variable speed advisory techniques to ameliorate freeway congestion, followed by a framework for freeway ramp metering, using both a Model Predictive Control (PMPC) framework and a framework that maximizes the aggregate utility of onramp flows. I will subsequently extend the network utility design framework to the simultaneous signalization and joint perimeter control of arterial traffic networks. Finally, I will present recent results on the analysis of traffic networks with mixed autonomous and non-autonomous vehicles. Autonomous and connected vehicles can potentially travel using shorter headways via platooning and therefore their deployment can potentially increase flow capacity in the roadways. I will present result pertaining to the network-wide mobility impact of the presence of smart (autonomous and connected vehicles) on traffic networks. In particular, I will analyze Wardrop equilibria, where vehicles choose their routes in order to decrease their own travel costs, in traffic networks with mixed autonomy. I will present the conditions under which the

replacement of regular vehicles by smart vehicles is guaranteed to improve network mobility. However, when these conditions do not hold, counterintuitive behavior might occur such that increasing the proportion of autonomous vehicles in a network leads to decreases in overall network throughput. Finally I will show how the Wardrop travel cost equilibria can be shifted to coincide with the traffic equilibrium conditions that minimize the overall social travel time of the traffic network, through the use of discriminating tolling, in which autonomous vehicles are charge different tolls from non-autonomous vehicles, as they transverse certain roadway sections.

Bio:

Roberto Horowitz is the current chair of the Department of Mechanical Engineering at UC Berkeley and holds the James Fife Endowed Chair in the College of Engineering. He received a B.S. degree with highest honors in 1978 and a Ph.D. degree in 1983 in mechanical engineering from the University of California at Berkeley and became a faculty member of the Mechanical Engineering Department in 1982. Dr. Horowitz teaches and conducts research in the areas of adaptive, learning, nonlinear and optimal control, with applications to Micro-Electromechanical Systems (MEMS), computer disk file systems, robotics, mechatronics and Intelligent Vehicle and Highway Systems (IVHS). He is a former co-director of the Partners for Advanced Transportation Technology (PATH) research center at U.C. Berkeley. Dr. Horowitz is a member of IEEE and ASME and the recipient of the 2010 ASME Dynamic Systems and Control Division (DSCD) Henry M. Paynter Outstanding Investigator Award.