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Canonical Instabilities of Autonomous Vehicle Systems

The Unsettling Reality Behind the Dreams of Greed

Springer

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Preface

> *...[T]he psychological actions of drivers make traffic different from any other flow* (Orosz et al. 2010).

The asymptotic limit theorems of control and information theories make it possible to explore the dynamics of collapse likely to afflict systems of autonomous ground vehicles that communicate with each other and with an embedding intelligent roadway. A vehicle/road system is inherently unstable in the control theory sense as a consequence of the basic irregularities of the traffic stream, the road network, and their interactions, placing it in the realm of the data rate theorem that mandates a minimum necessary rate of control information for stability. It appears that such V2V/V2I systems will experience large-scale failures analogous to the vast propagating fronts of power network blackouts, and possibly less benign, but more subtle patterns of individual, platoon, and mesoscale dysfunction.

An atomistic perspective on autonomous ground vehicles—seeing them as having only local dynamics in an embedding traffic stream—embodies a profound failure of insight. Traffic light strategies, road quality, the inevitably rapid-shifting "road map space", the dynamic composition of the traffic stream, communication and machine sensory system bandwidth limits, and so on, create the synergistic context in which single vehicles operate. It is necessary to understand the dynamics of that full system, not simply the behavior of an individual vehicle atom within it. The properties of that system will be both overtly and subtly emergent—subject to sudden "phase transitions" into both massively and locally unstable modes—as will the responses of individual cognitive vehicles enmeshed in context, whether controlled by humans or computers. The triggering of adverse events at various scales and levels of organization by unfriendly external agents will likely become routine.

In sum, while clever V2V/V2I management strategies might keep traffic streams temporarily in a "supercooled" high-flow mode beyond well-understood critical vehicle densities, such a state is notoriously unstable, subject to both random and deliberately caused "condensation" into large-scale frozen zones. More subtle

patterns of individual vehicle and mesoscale "psychopathology" characterizing autonomous systems may be even less benign (Wallace 2017).

Despite marketing hype and other forms of wishful thinking, the safe operation of large-scale V2V/V2I autonomous vehicle systems may be exceedingly arduous at best, and, at worst, simply not possible, particularly in the US context of rapid social and infrastructure deterioration.

It has been said that "The language of business is the language of dreams". Business dreams, as we are now seeing, do not serve as a sound foundation for the design and implementation of public policies affecting the well-being of large populations.

New York, USA Rodrick Wallace

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About the Author

Rodrick Wallace received an undergraduate degree in mathematics and a Ph.D. in physics from Columbia University. He completed postdoctoral training in the epidemiology of mental disorders at Rutgers University and is a research scientist in the Division of Epidemiology of the New York State Psychiatric Institute. A past recipient of an Investigator Award in Health Policy Research from the Robert Wood Johnson Foundation, he was technical director of a public interest consulting firm for a decade before returning to research and is the author of numerous peer-reviewed papers and books across a variety of disciplines. His work focuses on how government policy and socioeconomic structure determine patterns of public health and public order. This monograph is, in fact, an expansion of a chapter from his recent book *Computational Psychiatry: A systems biology approach to the epigenetics of mental disorders*, Springer, New York (2017), which uses similar methods to examine the failure of cognition at and across different modalities, scales, and levels of organization.