Modeling Behavioral dynamics of Road Networks as Interacting particle systems

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Motivation

Roadway traffic in cities and many other countries may be characterized by lack of lane discipline and a high degree of heterogeneity in the types of vehicles, driving behaviours, roadway geometry, and infrastructure conditions. However, existing literature in this area is based on rather stylized representations of traffic streams, including assumptions of lane discipline and homogeneity in vehicle types. These assumptions are difficult to justify and can potentially misguide traffic management practices such as traffic signal control and roadway capacity estimation. The challenges to be overcome in this context include, among others: (a) realistic representation of vehicular movements and (b) the consideration of various sources of heterogeneity mentioned above. An equally important challenge is the measurement of traffic streams at both microscopic and macroscopic levels. In this context,there is a pressing need for accurate modelling, and management of vehicular traffic.

Background

Interacting Particle systems have been widely used in applications pertaining to finance, social networks and viral marketing. Many toy models of stochastic phenomena have been invented since the term is coined in Liggett's 1985 book.A brief description of relevant Literature on problems which share common traits from ours follows

In [1] David Kempe et.al characterize distortion in voting systems when candidates and voters are embedded in a common metric space.

With regards to Social networks,in [2] the authors study the effect of external events on the networks change in structure and communications.

In [3], the authors give asymptotic limits of a stochastic model for self propelled interacting particles.

Problem Statement

Roadway capacity is a key component in constructing and maintaining a road network. As the number of particles increases, holistic approaches become increasingly desirable than just tracing the path of one individual in the system.

In this regard, we would like to identify the factors influencing the stability of the system and hope to solve the following key challenges ubiquitous to any transportation network.

1) How does the net flux of vehicles induces distortion in the network?

2) How averaged quantities like density of vehicles change over time?

3) What is the efficient control strategy for the given model, which maximizes utilization of the network to its fullest?

4) Can the system reach steady state behavior under sporadic disruptions.

proposed solution

we define the intersections in the road network and vehicles as the two types of particles.The former being a static particle or (Type-1) particle, the latter is a self-propelling particle or (Type-2)particle. Assuming that there is no interaction between particles belonging to the same category,we model the vehicles as self propelling particles.

Under the current model, we wish to employ techniques from [1] to characterize the networks evolution and effects of

References

[1] On the Distortion of Voting with Multiple Representative Candidates [2] Social Networks under stress [3] Self propelled interacting particle systems with roosting force.