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Abstract

Introduction

Totally asymmetric process (TASEP) has been widely used in various field, ranging from chemistry [3] to model vehicular networks [2]. Originated from statistical physics, an instance of TASEP allows making macroscopic behavior of the system based upon the microscopic behavior of individual particles. As a related problem, we explore the problem of parking; namely, given K parking spots in a road of length L, we explore the following phenomena:

a) How often do people find parking? b) What is the overall road density? c) Which parking spots are preferred? d) How does parallel updating compare to random updating for TASEP?

TASEP with parallel updating has been studied before [4] to model traffic. This model is equivalent to Nagel-Schreckenberg model with a maximum velocity of 1 [2]. In particular, it has been shown that there are phase transitions depending on the car income and departure probabilities. Here, we show what happens to these phase transitions when the phenomenon of parking is introduced.

Model

Our model consists of two lanes, L_1 and L_2 and our lanes consist of cars c. The idea of the model is that L_1 is the driving lane, and L_2 is the parking lane. As such, cars move on L_1 until they find parking, and then they park to L_2. If they are already on L_2, then they park there for some time T_{park} where T_{park} is exponentially distributed with rate p. For modeling purposes, since time will be discretized, we need to pick $p \leq 1$. If high departure rates are desired, then the time for each timestep can be scaled instead. For convenience purposes, we say that both our lanes have the same length. Once they are done parking, they are assumed to leave the street as soon as possible.

From a mathematical standpoint, define $\eta_{L_i}(t, x), i \in \{1, 2\}, t \in R^+, x \in \{1, .., L\}$ to be the state function. $\eta_{L_i}(t, x) = 0$ if the i th lane at position x is unoccupied at time t, and 1 if it is occupied. For our analysis, since every event has an exponential rate associated to it, we can come up with a set of t_ks where t_ks are exponentially distributed on R^+. So, instead of having our state function take continuous xs, we can have it take an index k to indicate kth time step. Thus, we can reexpress η_{L_i} as $\eta_{L_i}(t,k) = 0$ if the i th lane at position x is unoccupied at time t_k, and 1 if it is occupied.

Now, at each time step, perform the following update rules:

a) A given car c at some position on L_1 checks to see if there is already a car in L_2. If so, it parks there by switching there. If not, it checks if there is a car in $x+1$ in L_1 if so, it moves the car.

b) A given car c at some position on L_1

Simulation data

Discussion

Summary

Future Work

To further investigate the parking problem, we would like to use the queuing networks and Petri nets. Queuing networks can give rise to analytically solvable Markov chains that can explain the boundary conditions and Petri nets can allow for more generalized models while observing potential deadlock states in deterministic modeling systems.

In terms of the simulation, we can modify the simulation such that once a car is done parking, with probability g it can keep going on the road (without looking for parking). Also, perhaps, instead of parking every time after seeing a park, we can park with probability h, and then compare these two proposed models. We can also loop the lanes to reflect the behavior of not finding parking and going through the same street again. We can also modify our simulation so that it has a variable upper velocity limit (like Nagel-Schreckenberg model). We can also allow for random parking in a continuous setting [7]. Finally, we can have the lengths of the parking lane be different than the actual lane and have a mapping to indicate which cars can park to which spot at some arbitrary time.

References

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[5] Modeling Parking

[6] Positive congestion effect on a totally asymmetric simple exclusion process with an adsorption lane

[7] The Random Parking Problem

[8] Macroscopic car condensation in a parking garage