CS166 - Traffic Simulation

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I. Part 1: Traffic jams on a circular road

In the cellular automation model, the overall average traffic flow rate of the model varies as a function of traffic density. The peak flow is achieved at the traffic density of about 11%. Before that density value, the flow is still optimal in the sense that cars advance at their maximum velocities, but it is not optimal in terms of the road capacity. After this critical point of 11%, we can observe that the flow gradually decreases and the formation of traffic jams begins. We can also see that the 95% confidence intervals of the estimates are quite big, given the randomness of the cars' initial velocity distributions as well as irrational deceleration.

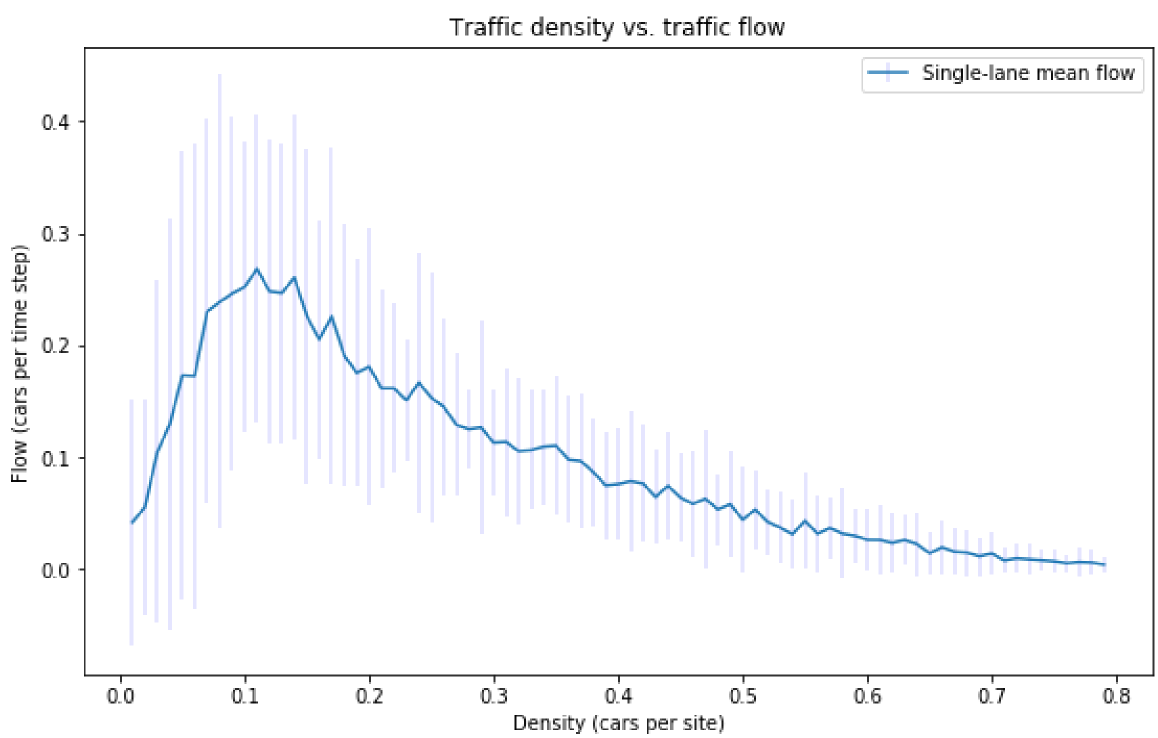

Figure 1. The blue line represents the means of the traffic flow as a function of density for a single-lane CA, the error bars represent 95% confidence intervals.

II. Part 2: Multilane highways

There are a number of assumptions as well as update rules that govern the two-lane CA model. Firstly, similar to a single-lane CA, the movement is unidirectional. It is also assumed that drivers' behavior is mostly rational but nevertheless imperfect. Specifically, drivers accelerate (up to the allowed speed limit) when possible and slow down when acceleration is impossible because of other vehicles on the road. However, there is also an element of random (irrational) deceleration which ultimately causes the formation of traffic jams. In a two-lane model, however, drivers have the option of passing other cars that impede their movement at intended velocities.

The multi-lane model we have developed for this assignment is symmetric, i.e. cars do not aim to return to their original lane after passing a car on the way since they do not have a preference upon which lane to be in. The rate of lane changes would be much higher for the asymmetric model than for the current one. In our model, cars can only switch lanes if they cannot advance at their intended velocities in their current lane, given that there are no obstacles for them to do so in the other lane. Additionally, no cars should be approaching from the back to prevent collisions from occurring. Since we are assuming good driver behavior in our model, no drivers will pass unless there is enough space behind them for a car with up to a maximum velocity to advance.

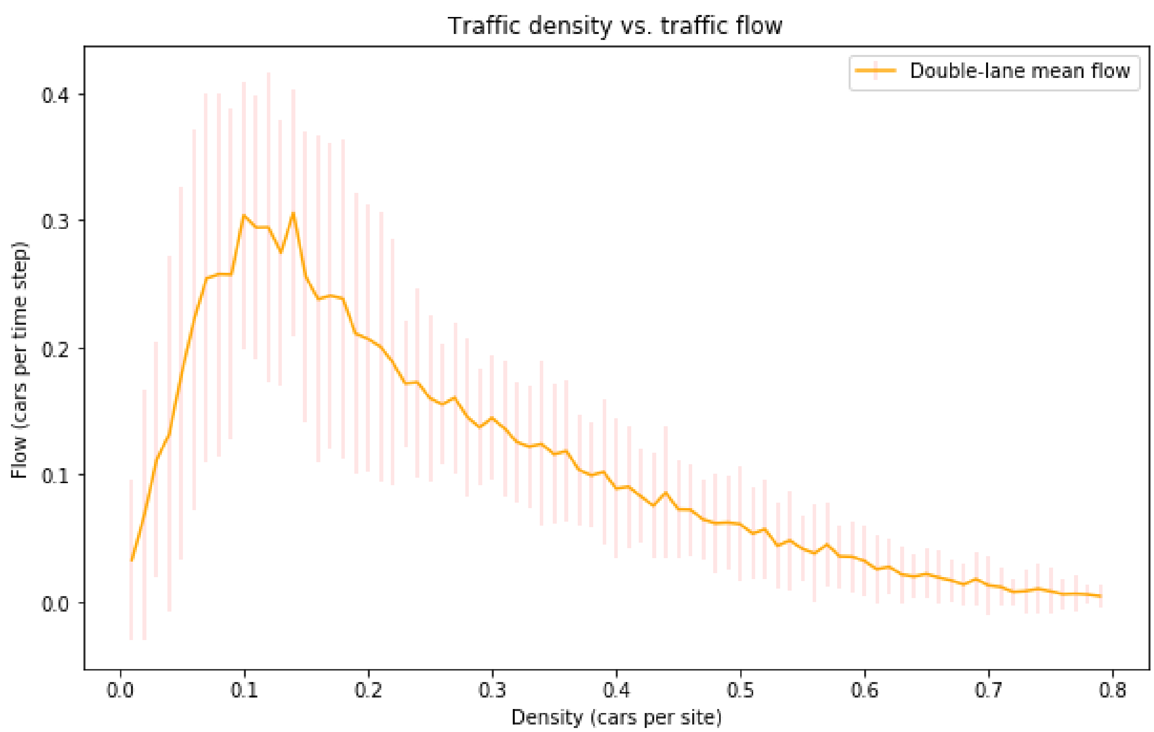

Figure 2. The orange line represents the means of the traffic flow as a function of density for a double-lane CA, the error bars represent 95% confidence intervals.

III. Comparative Analysis

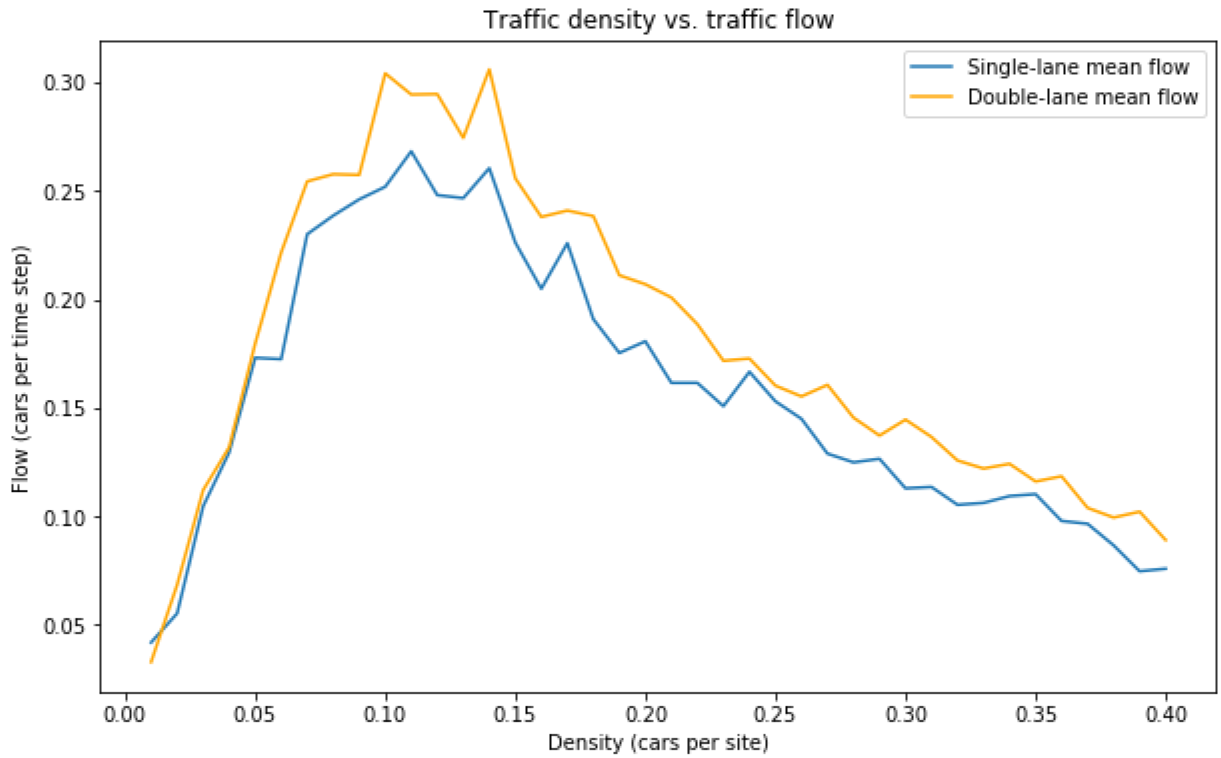

Figure 3. Traffic flow as a function of density for a single-lane and a double-lane CA.

As seen in Figure 3, traffic flow is 20% higher for a two-lane road as compared to a single-lane one. That is, the flow peaks at the density of about 11-14% for both the single- and the double-lane roads, however, the peak flow is higher for the double-lane road. Based on this observation, as the number of lanes increases, we can assume that the traffic flow is going to have an ever-higher peak point, which will exceed that of the single- and double-lane roads. However, as the number of lanes becomes sufficiently larger, the peak value will most likely increase at a slower rate.

This traffic model is quite applicable to Buenos Aires, Argentina, since drivers tend to adhere to traffic rules such as the speed limit and unwritten passing conventions. If I were to encode pedestrian crossings, however, I would make sure to add another irrational behavior component of cars failing to stop before crossings and stopping on crossings themselves (as well potentially colliding with pedestrians). This would be an example of bad driver behavior.

IV. Future Work

In the current model, we are allowing cars to slow down irrationally even after they decelerated rationally, so this happens in two separate independent steps, which is not entirely realistic. For example, if a car had the velocity of 2 and it only had one space to move forward, so it slowed down to 1 and then it slowed down again due to the random deceleration parameter, it now completely stopped moving. Additionally, we could incorporate more realistic road conditions, such as having traffic lights and varying speed limits throughout the road.

Link to Gist:
https://github.com/AlexandraPukhova/CS166_Traffic_Simulation/blob/master/Double-lane%2BSimulation%2C%2BPukhova.ipynb