Autonomous Vehicle Agent-Based Simulation of NYC

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Project Description

- Pollution and traffic are high priority issues to address in modern cities, so we introduce autonomous vehicles (AVs) to try to reduce emissions, parking demand, trip waiting time, and traffic.
- There are many models that use generic grid cities to address these problems, but we simulated Ney York City (NYC) with real data to generate realistic results.
- We created an agent-based model to simulate NYC for 24 hours to fine tune parameters to find reliable solutions and accurate estimations.

Scientific Challenges

- Finding real and relevant datasets that we can apply to our model.
- To get a more accurate model, we used massive amounts of data to sample from.
- Using Google Maps APIs to generate realistic trip routes and times, we needed to optimize code to reduce API calls and thus potential run costs.

Potential Applications

- Reducing environmental impact of transportation by attempting to minimize AV fleet size while keeping wait time in acceptable threshold.
- Simulate future city events to estimate traffic and parking demand, attempting to mitigate both with autonomous vehicles initial distributions.

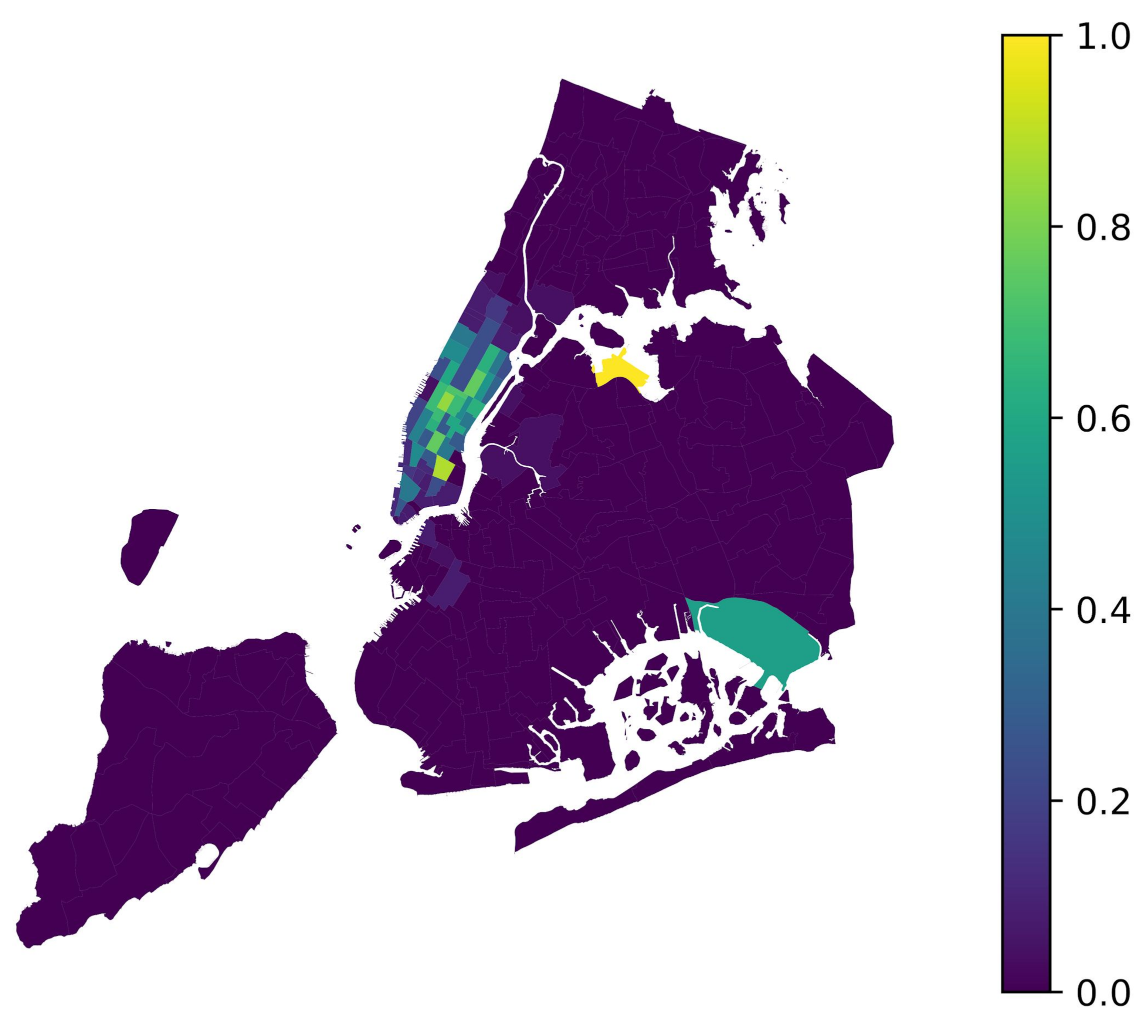

Figure 1. Initial distribution of autonomous vehicles based on distribution of trip start locations samples

Methodology

1. Gather and parse New York City Taxi and Limousine Commision [2] data
2. Generate data distributions and initialize model (Figure 1)
3. Model parameters: AV fleet size (n), population utilization percent (p), roam tolerance ($\lambda_{critical}$)
4. Simulate autonomous vehicles picking up and dropping off clients
   - Model uses real trip travel times, wait times, and routes taken via Google Maps API
5. Roam zone is determined by how 'far' the current AV distribution, λ_i, is away from population's trip pick up distribution, λ_0, by $D_{Bhattacharyya}(\lambda_i, \lambda_0)$
6. Standard autonomous vehicle routine:
   - Picks up nearest client request
   - Drops off client at their destination
   - Roams to new zone, ready to pick up new clients along the way
     - Zone decision rule: if $D_{Bhattacharyya}(\lambda_i, \lambda_0) > \lambda_{crit}$, randomly sample and assign from λ_0, else uniformly assign random zone (Figure 2)
   - If client is not assigned by end of roam, park in current zone
7. Examine the effects on city parking demand and regional wait times

Results

As fleet size n increases, we see parking demand saturation increase mostly near the edges of the city while minimizing wait time in dense areas. (Figure 3, Figure 4)

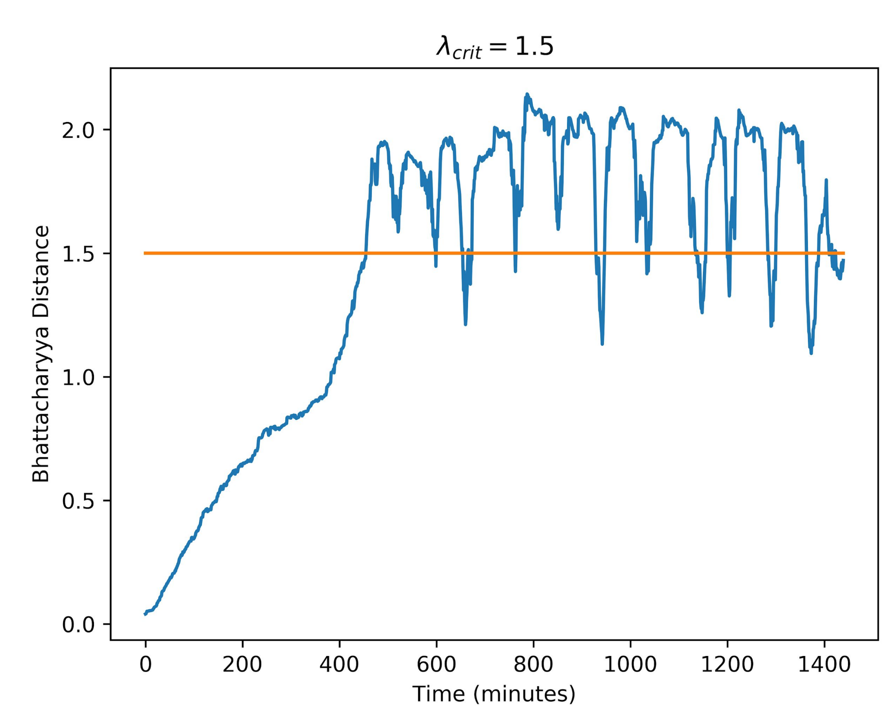

Figure 2. Current AV distribution distance from ideal pick up distribution vs time

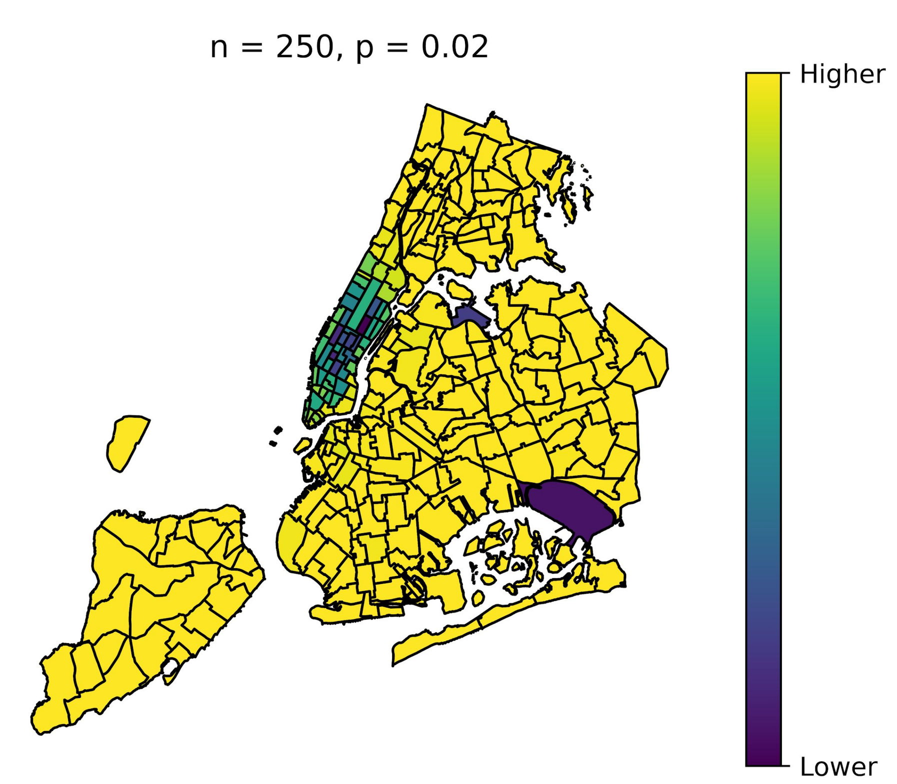

Figure 3. Relative average client pick up waiting time for each zone

Glossary of Technical Terms

Agent-based Model: Used for simulating the actions and interactions of autonomous agents with a view to assessing their effects on the system as a whole

Bhattacharyya Distance: A measurement of the similarity between two probability distributions

Google API: Application program interface for utilizing Google services such as Google Maps

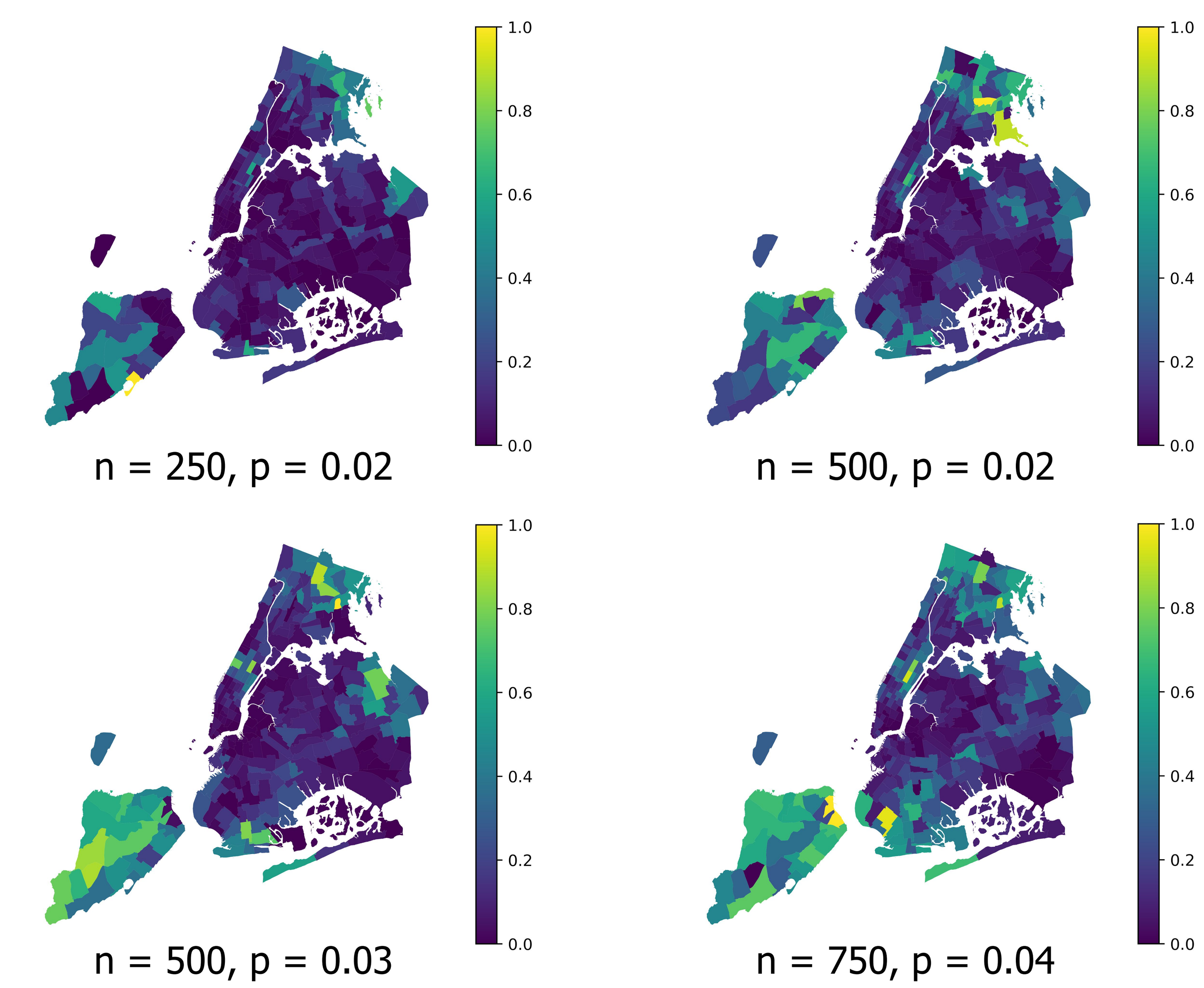

Figure 4. Parking demand distributions for differing fleet sizes and traffic percents, all with $\lambda_{crit} = 2.0$

References

1. Fagnant, Daniel J., Kara M.Kockelman. *The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios.* Transportation Research Part C: Emerging Technologies 40, 1-13 (2014)
2. "TLC Trip Record Data", Taxi & Limousine Commission. Retrieved from https://www1.nyc.gov/site/tlc/about/tlc-trip-record-data.page
3. Krueger, R., Rashidi, T. H., & Rose, J. M. (2016, August 27). Preferences for shared autonomous vehicles. Retrieved from https://www.sciencedirect.com/science/article/pii/S0968090X16300870

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