Lane changing and lane choice in an urban congested environment

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Introduction

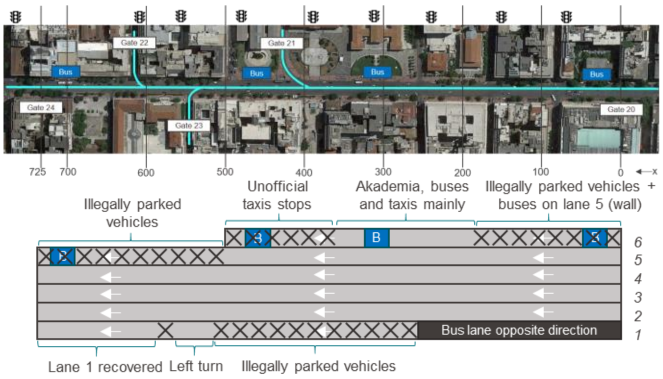
Understanding how vehicles drive in an urban congested environment has drawn the attention of the transportation research community for years. Yet, the lack of reliable data has prevented researchers from properly studying traffic phenomena in such a context. Recently, new data collection techniques have emerged allowing to study traffic phenomena in an urban context. This is precisely the pNEUMA dataset, an open large-scale dataset of naturalistic trajectories (~0.5 million trajectories) collected with a swarm of drones flying over Athens, Greece

Two traffic phenomena are studied thanks to pNEUMA:

- Lane changing: where lane changes happen, differences across types of vehicles...
- Lane choice: how turning vehicles approach the turning lane, metrics of the last lane change to join the turning lane...

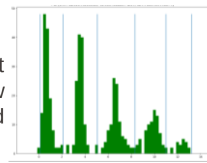
} Valuable traffic information to model the drivers' intention to turn (ML classifiers)

Methodology



Area of study: Panepistimiou street, a 6-lane arterial in central Athens. Vehicles splitted into exit gates to keep track of their destination (3 turning gates and 1 straight).

- Only vehicles starting at Gate 20 and exiting at Gates 21, 22, 23 and 24.
- 1769 vehicles over 4 days (1645 cars + taxis + motorcycles). Buses, medium and heavy vehicles are not enough to include them in the analysis.
- 1/3 of turning vehicles (Gates 21, 22 and 23 combined).

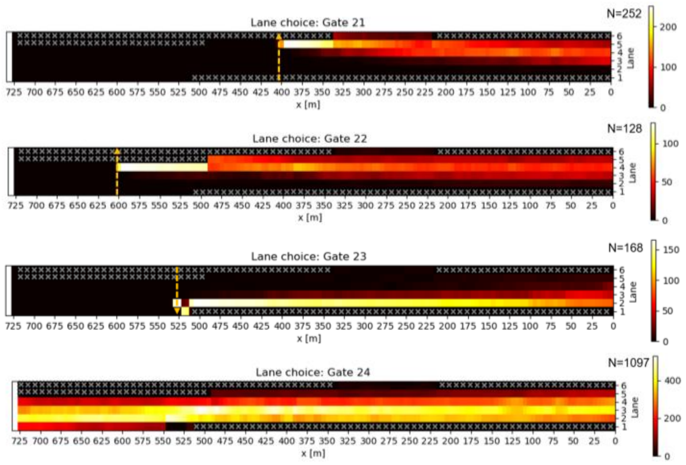


Lane detection: result of clustering the trajectories along the street using the Jenks natural breaks algorithm. The lanes obtained show the real use made by vehicles. Illegally parked vehicles, buses and unofficial taxi stops reduce the available space for traffic.

Lane assignment: lanes converted into polygons. Simple belonging check. Smoothing process of the lane assigned to guarantee its veracity and continuity (irregular lane borders and high frequency of datapoints).

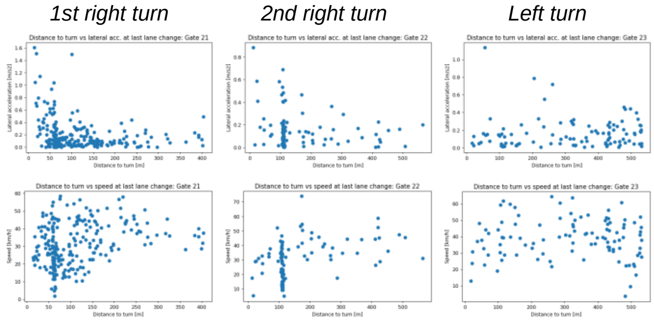
Lane choice

Successive histograms of the lane chosen every 5m to visualize the choice. Right-turning vehicles wait to join the turning lane in the last 100m before the turn. On the other hand, left-turning vehicles perform a smooth transition towards the turning lane. Straight vehicles choose central and left lanes to increase their speed and to avoid the frictions on the right part of the road.



Last lane change (to join the turning lane)

1st right turn *2nd right turn* *Left turn*

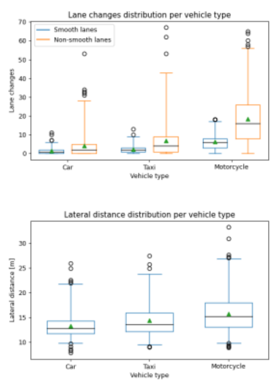


When right-turning vehicles wait to join the turning lane their lateral acceleration increases. They are also forced to reduce their speed. Influence of the frictions on the right part of the street.

Left-turning vehicles do not encounter frictions and can join the turning lane at their convenience (no trend).

Distance to turn: distance between the last lane change and point where vehicle leaves the street.

Lane changing



A change is detected when the lane assigned changes. Distributions show cars and taxis perform few changes compared to motorcycles. Differences are accentuated when the lane assigned is not smoothed. Moreover, taxis driving on the right part of the street encounter frictions inducing more changes than cars. Motorcycles have a different behavior (filtering): they drive on the edge of lanes doing small lateral movements.

Prediction

11 ML classifiers to predict drivers' intention to turn based on the traffic information in the first 300m. Oversampling strategies to tackle data imbalance (turning classes are a minority).

Max	Gate 21 vs. others	Gate 22 vs. others	Gate 23 vs. others	Straight vs. turning	Right- vs. left-turning vs. straight
AUROC	0.8272	0.7694	0.7881	0.6880	0.8475
Accuracy	0.9301	0.9179	0.9088	0.7781	0.7751

The closer the turn to the start the better the results. Metrics highly influenced by data imbalance (turning class metrics are not excellent). Spliting turning vehicles into left and right provides better results. Perfect distinction between them. Still, some turning vehicles labeled as straight.

Conclusion

This research allows to understand how vehicles drive in cities. Illegally parked vehicles, unofficial taxi stops, and buses constitute the main frictions (they influence the use of the lanes made by vehicles). Regarding the lane changing study, evidence on the motorcycle filtering phenomenon is provided The study on lane choice allows to detect the difference in behavior of left- and right-turning vehicles, as well as the type of changes performed by straight and turning vehicles (preemptive vs. discretionary). Lastly, a methodology to predict the drivers' intention to turn based on the analysis on lane changing and lane choice has been introduced. This research shows the potential of how detailed datasets and powerful analysis tools can be useful to model how vehicles drive in cities.

References

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