

Propagation of congestion using naturalistic data from a swarm of drones

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Abstract :

This project takes place in the wider context of a first-of-its-kind large-scale open science traffic monitoring experiment nicknamed pNEUMA, that took place in the city of Athens :

"pNEUMA is a large-scale dataset of naturalistic trajectories of half a million vehicles that have been collected by a one-of-a-kind experiment by a swarm of drones in the congested downtown area of Athens, Greece. A unique observatory of traffic congestion, a scale an-order-of-magnitude higher than what was not available until now, that researchers from different disciplines around the globe can use to develop and test their own models."
(source : <https://open-traffic.epfl.ch/>, 30.07.2020)

In this paper, the focus is laid on the impact of taxi servic-related stops on congestion. The problem is tackled by using a step by step task-oriented approach, in order to develop methods that can be used for further research on the dataset.

Keywords : open science, large-scale dataset, traffic monitoric, UAS/UAV, congestion propagation, service-related stops, programming.

The Dataset :

"The total duration of the recordings is 59 h, sizing more than 2 TB. The study area to be analyzed includes:

- i) a total of 1.3 km2 area
- ii) a 10 km road network
- iii) low, medium and high-volume arterials
- iv) more than 100 intersections (signalized or not)
- v) more than 30 bus stops » [1]

Objectives :

This project the following objectives, of educational and academic nature :

- Discover the Python programming language. Indeed, this project is the author's first experience with this language (the "pré-étude" to this project had been conduded using Matlab). This objective serves two purposes :
 - Facilitated future use of the results obtained, since the other participants in the project also use Python;
 - For the author : development of competences with an open source tool widely used in the industry.
- Produce methods (scripts and functions) oriented towards the goal of quantifying the impact of taxi service-related stops on congestion, that can be reused or adapted for their research by the current and future participants of the pNEUMA experiment.
- In the context of the pNEUMA experiment, participate in the development of the new era traffic models.



Study area of the pNEUMA experiment (source : [1])

List of the functions :

- stopflag (f,j):
- duration_stop_and_movement (f,j):
- stop_and_movement_before_threshold (f,j):
- change_stopflag_at_index (f,j):
- change_stopflag (f,j):
- main (f,j):

List of the variables :

- taxi (f,j):
- speed_limit (f,j):
- taxi_stopflag (f,j):
- taxi_stopflag_change_index (f,j):
- stopflag_durations (f,j):
- movement_durations (f,j):
- movement_before_threshold (f,j):
- first_stopflag (f,j):
- index (f,j):
- change (f,j):
- taxi_updated (f,j):

Dataframe containing the data of a recorded trajectory

parametrized speed threshold below which the taxi is considered to be at a stop

taxi Dataframe updated to contain a "stopflag" column

taxi Dataframe updated to contain a "change" and an "index" column

list containing the durations of the stops of the taxi

list containing the durations of the movements of the taxi

list containing boolean values indicating if the stops of the taxi lie below a parametrized time threshold

list containing boolean values indicating if the movements of the taxi lie below a parametrized time threshold

stopflag value at the beginning of the trajectory

list containing the index values at which the stopflag values should be changed (noisy stopflag values)

number of updated stopflag values to compute the duration of the converted stop/movement

taxi Dataframe with a "stopflag", a "change" and an "index" column, which comes as an output of the f_j function

Legend :

- variable
- function
- input to function
- output of function
- function is called by function
- variable contains variable

Flowchart – script 1

Analysis tasks :

- Identify when the taxi stops – stopflag definition
- Determine and store the durations of the stop and movement periods
- Identify and correct the "false stops and movements" (stopflag noise)
- Check wether the taxi stops take place on the right lane

Conclusion :

A dataset such as the one at hand holds great potential for analysis, but at the same time, it can be difficult to come up with efficient methods to tackle the concrete engineering problems. In the future, experiments such as pNEUMA will probably become common practice and it will be the task of transportation engineers, and students in the domain, to develop their data-analysing skills in order to extract the best possible understanding of the networks they study.

List of the functions :

- stop_before_and_after_stop (f,j):
- points_before_and_after_stop (f,j):
- asimuths (f,j):
- asimuths_list (f,j):
- stop_with_coordinates_and_asimuths (f,j):
- squares_around_taxi_stop (f,j):
- point_inside_square (f,j):
- coordinates_x_y (f,j):
- taxi_trajectory (f,j):

List of the variables :

- stop (f,j):
- stop_longitude (f,j):
- stop_latitude (f,j):
- stop_time (f,j):
- stop_coordinates_and_asimuths (f,j):
- asimuths_list (f,j):
- stopflag_durations (f,j):
- stopflag_latitude (f,j):
- stopflag_longitude (f,j):
- stopflag_time (f,j):
- stopflag_coordinates_and_asimuths (f,j):
- stopflag_squares_around_taxi_stop (f,j):
- stopflag_point_inside_square (f,j):
- stopflag_coordinates_x_y (f,j):
- stopflag_taxi_trajectory (f,j):

Dataframe containing the data of a recorded taxi trajectory, processed by script 1

list containing the longitudes of the taxi stops

list containing the latitudes of the taxi stops

list containing the times at which the taxi stops take place

lists of coordinates of points b (before the taxi stop) and a (after the taxi stop)

list containing asimuths between the points b and the points a, returned by f_j

list containing the asimuths of the taxi trajectory around the stops

list containing the longitude, latitude, asimuth of each taxi stop and the time at which they take place

longitude and latitude of a taxi stop (contained in v_{i,j})

squares on the left and right sides of a taxi stop

boolean value that indicates whether a point lies inside a square

Dataframe containing the raw data of a recorded vehicle trajectory

Dataframe containing the data of a recorder vehicle trajectory, with the addition of two columns containing the longitude and latitude in local cartesian format

longitude and latitude of a point from a vehicle trajectory (contained in v_{i,j})

integer value (1, 0 or -1) that indicates whether the vehicle trajectory crosses a taxi stop on the left or right side or not at all

float value that indicates the time at which the vehicle trajectory crosses the taxi stop (takes the value -1 if it is not the case)

Legend :

- variable
- function
- input to function
- output of function
- function is called by function
- variable contains variable

Flowchart – script 2