A decision support tool to model freight transportation flows in city centers

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1 Decision support tool: Nantes case study

Many city logistics projects, such as the implementation of new pedestrian areas, limited traffic zones, or new logistics facilities contribute to modify the circulation plan and logistics flows. In particular, freight transportation represents a big challenge for city logistics, since perturbations or careless modifications in the street network can cause significant economic losses for the city stakeholders. Decision makers in local authorities need Decision Support Tools (DST) to anticipate these changes and better integrate logistics flows, especially in city centers. Specifically in this study, we are focused on providing information at a strategic level.

In that sense, the present project, still in its earlier phase, aims to develop a DST that will be able to predict, in a macro scenario, how freight transportation flows will be impacted by major projects in city centers, like adding/removing links and limited traffic zones. We propose a prototype of the DST that is being developed in partnership with two regional companies: *Energies Demain* and *Logiroad*. Our presentation is based on a case study using data from the city of Nantes.

Figure 1 presents an example of a DST outcome. Green points represent the main depots from where vehicles start their delivery routes and return to. Red points represent delivery points. The blue lines represent an estimation of the current delivery flows, and the congestion rate is given by the opacity of the lines. Congested routes are represented by darker lines.

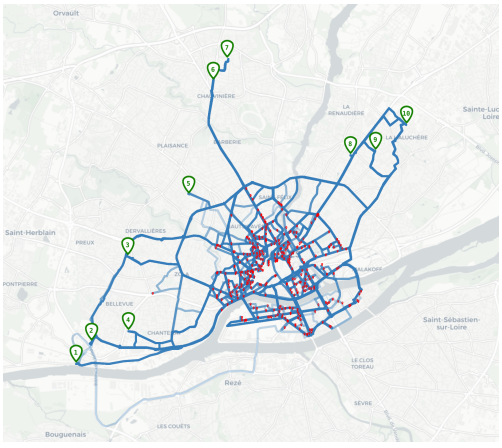

FIG. 1: DST outcome example for the city of Nantes - France, using OpenStreetMap and OSRM [1]

Although the DST outcome is pretty simple, the process to provide the desired information is challenging. The main issues, developed in sections 2 and 3, are how to estimate these flows in terms of routing and quantity, and how to validate the extracted information in practice.

2 Traffic estimation

The flow on an arc of the network is defined as the number of vehicle routes using this arc at a given moment (or within a given time interval). The vehicle routes are determined by solving Time-Dependent Vehicle Routing Problem with Time Windows (TD-VRPTW); see [2] for more details on the problem. In other words, a series of TD-VRPTW instances are solved, and their solutions are overlapped into the same street network to determine the current flow. These routes determine the sequence of customers to be visited and their associated service starting times. Given the street speeds, one can compute the approximate position of the vehicle at a certain time. Hence, to determine the current traffic map at a certain moment, we must count the number of vehicles actually present in each street section. The routes are determined by a Large Neighborhood Search (LNS) metaheuristic [5].

Another issue is related to the real data, and how to build TD-VRPTW instances. In this regard, data scientists of *Energies Demain* have been collecting real time data from [3] in order to determine the street speeds. Additionally, local companies like *Les coursiers nantais*, as well as *Nantes Metropole* have agreed to provide data related to transportation demands.

3 Sensor Location Problem

The *Logiroad* company has developed traffic counting devices based on an image recognition system that is able to identify several types of vehicles. These sensors will be installed at several locations in the city and will count the real number of delivery vehicles. This observation will then be compared with the estimated flows. The main question is then to identify locations where to install sensors in such a way that the observed traffics will be maximized. This requires solving a sensor location problem (see, e.g. [4]).

4 Conclusion

We present two main components of the future DST: the estimation of freight delivery flows in a city center and the validation of this estimation with sensors. The overall project contains several other issues, such as the feedback loop between the data collected by sensors and the traffic estimation algorithm, or the estimation of future traffic after modifications of the city map. We will conclude the presentation by the roadmap of the research project, that integrates data science, operational research and image recognition.

References

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