Studying the feasibility of a MFD control in Zürich

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1 Introduction

The main goal of this paper is to understand how a Macroscopic Fundamental Diagram (MFD) operational scheme can bring further gains to the already innovative traffic management strategies carried out by the city of Zürich. For that purpose we have obtained through simulation a MFD for the inner city of Zürich and compared it to the existing access control mechanism. In addition, we have explored certain properties of the MFD related to the type of simulation used to obtain it, the demand, and the number of loop detectors needed to achieve a reliable monitoring control scheme.

2 Background

The city of Zürich currently employs an adaptive control system as a macroscopic operational scheme for reducing congestion in the city (ZüriTraffic). The system constantly monitors several links in the inner city. It also estimates, through a demand model elaborated in 2007, how much traffic on each of the monitored links comes from the different roads accessing the city. When there is a drop in the Level Of Service on the monitored inner city links, the traffic light cycles on the roads accessing the city (and supplying the traffic to those specific links) are modified. In the morning, the red lights entering the city are typically extended to control the number of incoming cars. In the afternoon, the green lights exiting the city are typically extended to allow more cars to leave.

This system is very innovative but it has 3 main drawbacks: i) Although it monitors the links in real time, the influence of the roads accessing the city is based on a static demand model estimated in 2007. ii) The traffic light schemes are restricted to 2 scenarios, making the system relatively rigid. iii) Measuring individual links rather than whole network conditions might not give the proper network view.

To the authors' knowledge, the MFD operational scheme has not yet been implemented in any city. We believe that Zürich has a great potential for it, given its characteristics and existing traffic management strategies. The research presented here could be considered the first step towards the future implementation of the MFD.

3 Construction of a MFD

It has been proved that for a city area, there is a relationship between the accumulation of vehicles and the number of trips ended [1]. Such relationship can be described with a MFD. Through monitoring, the MFD allows to know at every time how the urban area is performing. By controlling the area perimeter, the system can be moved to less congested traffic states.

A MFD can be obtained with data from loop detectors. However, we need an extensive loop detector network. In [2], a MFD for Zürich was obtained using the agent-based simulator MATSIM. In this project, another MFD for the inner city of Zürich was obtained using the traffic microsimulator VISSIM. Both MFDs were compared for reference purposes.

The VISSIM simulation was used with a demand model for the 5-6pm period on workdays. Flows and densities were averaged in every link emulating loop detectors. The result was a well-defined MFD. Nevertheless, it presented some scattering in the congested part, linked to very high demands. In order to emulate all the traffic states, different multiples of the 5-6pm demand were employed. However, the microsimulation characteristics (e.g. route choice model) remained the same. Such scatter, and its possible relation to a rigid route choice model is analyzed and discussed in this paper. The influence of other microsimulation factors (e.g. resolution, diffusion time, warm-up time, random seed) on the MFD is also analyzed. In the next months, the 5-6pm demand model will be updated. A comparison with a new MFD, based on the updated demand, will show how sensitive the methodology is to the demand assumptions.

Empirical vehicle counts in 15-minute intervals for around 500 loop detectors over a period of 2 years will be used to partially verify the MFD (unfortunately there is no density data available). For the comparison we will assume a conversion factor between the 15-minute and the 5-minute flow averages.

4 Comparison of ZüriTraffic and the MFD

We have used the same VISSIM simulation to compare both traffic management techniques. The individual fundamental diagrams of some of the links monitored by ZüriTraffic were plotted. They show how a single traffic state in the MFD corresponds to different levels of service in the individual links. Further analysis will focus on two main issues: i) how ZüriTraffic determines that the city is congested; and ii) the flows of vehicles that can enter or exit the city in the congested periods (ZüriTraffic has only two possible scenarios, whereas the MFD should provide more flexibility).

5 Number of loop detectors required to achieve a valid MFD

The VISSIM model was also used to explore the number of loop detectors required to create a reliable MFD. The VISSIM model has 1707 links. Each link is a street section with the same characteristics. We generated different MFDs with 6 random combinations ranging from 25 to 250 links. The purpose was to determine how many links are necessary to achieve a good accuracy level. For every one of these MFDs, we compared the different traffic states with the original MFD (with the 1707 links), calculating the relative errors in the weighted flows and densities. MFDs created with less than 150 random links presented high variability (among the 6 different combinations employed in each case). Although further research is required, these preliminary results imply that in order to achieve a relatively good MFD (average relative error below 10 %), we need a coverage of at least 10% of the network links.

Evidently, one would expect results to be different if the location of the loop detectors was carefully selected (instead of randomly generated). To address that we will study different scenarios where loop detectors are located based on: i) flow and hierarchy of the street; and ii) proximity to the city center. Both strategies are often used by traffic engineers to place detectors in urban areas.

6 Conclusions

This paper shows the advantages that the implementation of the MFD can bring to the current adaptive control system in Zürich. In addition, it evaluates some of the issues to consider when implementing a MFD operational scheme in a city (e.g. the number of loop detectors required). Further research should include a full comparison with real data in order to consolidate the MFD as a common operational technique.

References

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