CALIBRATION AND COMPARISON OF SIMULATION MODELS FOR ROAD NETWORK PLANNING: THE CONGESTED NETWORK OF POZZUOLI

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1 INTRODUCTION

The classical models of transportation systems are based on the assumptions of stationarity. This assumption, which has been acceptable for many applications like City planning, does not allow to simulate satisfactorily certain types of transportation systems such as heavily congested urban road networks. Phenomena such as the formation and dispersion of queues are relevant and cannot be reproduced by traditional static models (see Cascetta 2001 for a good introduction to the problem).

In the last years the research efforts in traffic modeling and traffic assignment have been focused on the modelization of dynamic behavior of the several components making up a transportation system. Micro-simulation models have been used mainly in research applications and only recently has been possible to apply those models in planning applications due to increasing computer power and the development of commercially tested packages.

In this paper a before-after study is presented for the case of a new road infrastructure opening. A static assignment model and a micro-simulation model have been calibrated and applied to predict the impacts of different planning alternatives. The main object of the work is trying to establish advantages and disadvantages of using different modeling techniques in a real case study. So in the following, not only, the performances of different models are discussed and compared, but also, some major practical problems that can arise in a real applications.

The studied network is relative to the city of Pozzuoli (see figure 1). The simulated network is relatively small and is often over-saturated during peak hours; this obviously is the cause
of many inconveniences for the resident population. A preliminary traffic demand analysis has been completed before the planning of any intervention (1996). The analysis has showed that most of the network traffic during the peak period (early morning hours of the average day) originated from outside the city and was crossing the network in one prevalent direction. For this reason a fast crossing road was planned to collect all the crossing traffic so to lower the traffic load on the slow congested old urban network. An accurate verification of the new road construction was needed due to the high costs of building a new road infrastructure in a dense population environment and what is also more relevant in the presence of archaeological sites to be preserved.

The relatively small network dimension was a perfect case for the utilization of micro-simulation models. But because the use of this techniques is not so established it has been decided to apply a micro-simulation model and to compare the results with a static assignment classic model, which was able to acceptably reproduce flows on the network before the intervention. The new by-pass fast road was then built and completed in the beginning of year 2000 after some long interruptions, due to new archeological discoveries. The original network was modified completely by the opening of the new road and attracting (as forecasted) most of the traffic before aggravating the historical center of Pozzuoli.

Results of simulations performed before the road construction have been compared with traffic and o/d travel time data collected after the road opening for verifying the agreement of the two different predictions to the real world (for the travel time data collection has been used, among others, an instrumented vehicle with a GPS-GIS integrated system connected to the control station via GSM).

With the traffic data available after the road opening a new o/d matrix has been estimated. The special traffic flow pattern on the network and a particular choice of centroids and traffic count sections allowed to estimate the o/d demand matrices from traffic counts without relying on a specific assignment procedure (either static or dynamic). In fact, it was needed an o/d matrix not distorted “in favor” of one of the two approaches used, without making a new and expensive direct estimate through interviews. The new o/d flows obtained were used for repeating the road system simulations, with the aim of purifying the previous results from the errors due to demand variations (occurred in the period from 1996 to 2001) not directly caused by the new road construction.

2 O/D FLOWS ESTIMATION

2.1 The a priori o/d matrix (1996)

In year 1996 a first study has been conducted at the DIT to evaluate the o/d matrix from the above described traffic counts and from an on vehicle traffic interview survey. This o/d matrix (named the a priori o/d matrix) has been used in many of the successive simulations:
- In the simulation of the state of the network before the new road construction intervention (scenario 0).
- In the simulation used to forecast the state of the network after the new road construction intervention (scenario 1).
- In the o/d matrix correction performed from traffic counts after the road construction in 2001.

### 2.2 o/d matrix correction (2001)

The o/d matrix obtained in 1996 has been used as a base to estimate o/d flows for the new network configuration (situation in year 2001). The correction of the original o/d matrix was conducted with the use of traffic flow counts with a 5 minutes aggregation. Two different approaches have been followed to obtain two different corrected matrices:

- A static approach, that was used to produce a single o/d matrix relative to the whole simulated time period (7.30-9.30 a.m.);
- A dynamic approach, that was used to produce a set of o/d matrices for the 15 minutes intervals contained in the simulated time period (8 matrices);

The road sections for the counts have been chosen by peeking only the links that connect centroids to the network. In fact, in the simulated traffic network all centroids are connected to the rest of the network with a single entering link and a single exiting link.

The particular choice of the centroids, all identifiable with cross sections, and the successive choice of these ones as count sections, has allowed a great simplification in the application of the o/d estimation procedure, but also has allowed to obtain an estimation of o/d flows that is not dependent on the assignment model. This condition was considered absolutely necessary to make a comparison between results of simulation carried with different approaches. In other words, it was needed to get “neutral” o/d flows relative to the simulation approaches used.

In the dynamic case a simplified approach similar to the one used in the static case has been adopted. This approach has permitted to obtain 8 time varying o/d matrices, 15 minutes long, using the 5 minutes traffic volumes gathered in 2001 survey.

### 3 SIMULATION SCENARIOS

Four different scenarios were simulated:

- Scenario 0 – in which was simulated the state of the network before the new road construction intervention (1996 network – 1996 o/d matrix)
- Scenario 1 – the experiments attempted to forecast the state of the network after the new road construction intervention hypothesizing a null variation in o/d flows (2001 network – 1996 o/d matrix)
- Scenario 2 – these simulations were performed with the aim of comparing forecasts with the actual state of the network after the new road opening. The o/d matrix is stationary
over the entire simulation period and has been corrected from the a priori one (1996) with a static approach, (2001 network – 2001/2hour o/d matrix).

· Scenario 3 – This scenario differs from n. 2 for the o/d flows input data: it has 8 different o/d matrices relative to 15 min intervals obtained with the simplified estimation dynamic approach (2001 network – 2001/15 min o/d matrices).

4 SIMULATION RESULTS

In order to quantify the ability of the models to reproduce the actual o/d flows pattern and the network performances, simulated o/d travel times have been compared with the ones measured in the last survey (2001, after intervention). All the comparisons have been performed on the mean values of the o/d travel times registered over the entire period of the analysis (2h). Different statistics were used as measures of accuracy: mean square error, relative root mean square error and least Poisson error.

Differences between real travel times and simulated travel times are presented in table 1. Travel times obtained with the micro simulation model are closer to observed data than travel times obtained with the static model. Results of the simulations performed with the micro simulation model are even closer to experimental measures in the case of corrected origin destination matrices (the corrections have been applied to eliminate the error introduced by variation in demand not connected with the new road construction, scenario 2 and 3).

It is interesting to observe the different level of accuracy of the micro-simulation model in reproducing the real system in the static and dynamic demand scenarios. The increase in accuracy in the case of time varying demand is of 3%. But this corresponds to an error reduction of 20%. This difference is even more evident observing the comparisons between the simulated and the actual volumes of traffic measured every 5 minutes at the entrance and exit sections of the network (i.e. centroid connectors). In the static case, due to the stationary demand input, the correlation among observed and simulated volumes on the entrance sections is obviously very poor. A better fitting of the data can be observed for the exit sections. In the dynamic case too, despite what we could have expected, the better correlation is obtained for the volumes at the exit sections rather than the ones at the entrance sections.

5 CONCLUSIONS

In this paper a comparison, on a real network, between two different approaches is presented. The approaches are a static model and a microscopic simulation model. The comparison has given a quantitative measure of differences in reproducing the real conditions of a traffic network. The obtained values, however, can be considered significant
only in general terms, being obtained for the specific network simulated, and the specific characteristic of the simulation software used.

The work has evidenced how results of the microscopic traffic model are affected in a significant way from the choice of simulation parameters (behavioral parameters of drivers, link variables and path choice model parameters) and the importance of a good level of accuracy in the choice of the right traffic variable in the calibration of models with regards with the complexity of the network. Especially in old cities road networks (as old towns in the Mediterranean area), the great number of unexpected and unsimulated disturbances to traffic flow, may dramatically change network performances.

In such an aim, travel times on o/d pairs have revealed as being an optimal tool for model validation. A too lower or too high travel time for o/d flows from the same origin or to the same destination was the key to easily detect mistakes on the link parameters, or in the intersection simulation parameters.

REFERENCES


Figure 1 The city of Pozzuoli with the simulated road network.
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Table 1 Statistics on Mean o/d Travel Time Deviations