The role of Vehicles’ Identification Techniques in transportation planning – The Qatari case study

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Abstract  In a previous paper [3], the present authors introduced through a set of developed interfaces the concept of real-time transportation modeling, and justified the need and importance of Radio Frequency Identification (RFID) Technique in achieving a comprehensive database for strategic planning parameters that can affect passengers’ travel behavior and consequently the transport modal split. The research modeling work was based on PTV-Vision software, VISUM and VISSIM that are currently used in most of the international research studies. The research applications are programmed in Microsoft excel and visual basic and thus are compatible with any modeling software. This research application uses the official transport model of Qatar for performing a specific run for the core CBD area of Qatar as a case study for this thesis. The same run was conducted also using the developed research interface, and both results were close and consistent.

Finally, and based on the comprehensive literature review undertaken in this research, in addition to the high accuracy and efficiency proven by the developed real-time modeling tools, the research recommends the implementation of Vehicles Identification Techniques in all countries that have a preliminary ITS infrastructure.

1. Introduction

This research adds a set of intelligent transportation applications that are compatible with existing ITS systems and provide for traffic and transportation studies a highly accurate real time environment, management, and control. A VISSIM micro-simulation model was created for the purpose of this research with a connection to a set of visual basic applications running simultaneously and performing a real-time re-calculation for the generated traffic based on land use and socio-economic data of each zone, and then redistribute trip matrix using the general concept of production–direction gravity model. The research applications are able to do real-time tests...
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2. Case study – Qatar

2.1. Study area overview

Qatar is a leading developing country in the Arab Gulf, and
possesses a strong economy which is growing sustainably with
a wise optimization between oil and gas fortune and a
sufficient investment and development for the local society’s
economic productivity and scientific capabilities. Qatar popu-
lation has increased significantly since 2004 (0.7 Million), to
reach 1.7 Million in 2010. Future population projections are
not finalized yet, and they will be effected by the requirements
and consequences of the recent achievement of Qatar in win-
ning the hosting of 2022 FIFA world cup event [1].

The study area (Fig. 1) includes 51,272 population, 30,370
employees, 54,875 employment potential work places, 6870
student seats, 1307 university students seats, 49,618 employers
business attractions, 25,935 medical related and other personal
business attractions, 1550 restaurants capacity, 10,044 leisure
and sport attraction, and 32,125 shopping persons capacity,
in addition to 65 mosques. The strategic modeling zones in-
cluded in this study are shown in Fig. 2.

2.2. Road network

The study area road network includes the following major
corridors:

- **Khalifa Street:** this corridor is a major route carrying trips
coming from west of Doha towards the west bay area.
- **Mohamed Bin Thani Street:** it carries a major share of trips
coming from south-west of Doha towards west bay.
- **Majles Al Taawon Street:** Captures the heaviest percentage
of trips coming from Khalifa and Mohamed Bin Thani Streets.
- **Corniche Street:** Collects a big share of the demand coming
from Khalifa, Mohamed Bin Thani Streets, and from south
of Doha.

2.3. Public transport

Regarding public transport network, it was limited in 2006 to
some bus routes serving the above mentioned corridors. The
headways in the peak hours is around 15–20 min. Thus the
quality of public transport service in 2006 was limited as in
most of the private car dependent societies and could not cap-
ture more than 5% of the total person-trips demand.

2.4. The Qatar transport model

Transport Master Plan of Qatar (TMPQ) was accompanied by
the development of Qatar strategic transport model in 2006,
whose purpose was to guide the transport master plan and pro-
vide the basis for conducting current and future transportation
studies. The TMPQ Model was requested in order to perform
the strategic modeling work of this research, but regarding the
micro-simulation software, the researcher did request from
PTV Vision a student code meter VISSIM dongle in order to
connect the research interface to a dynamic micro-simulation
file and collect vehicles’ data second by second as if reading
floating traffic data from the real field.

Figure 1  Study area land use distribution.
Qatar Ministry of Municipality and Urban Planning were very supportive for this research and have accepted the usage of the TMPQ Model for the purpose of this research. And PTV has accepted the student dongle request, and has provided the VISSIM software (version 5.20) with a 15 km length network license that was very helpful for the research [5].

TMPQ Model is an activity based model which deals with 20 population groups and 56 chains of activities. Population groups are defined based on nationality; age group; job type; income level; etc. and the activity chains cover all major activity combinations such as: Home-Work-Home, Home-Education-Home, Home-Shopping-Home, and Home-Work-Shopping-Home. The model defines a rate for each population group to do each activity chain. And it has a predefined time series for all activity pairs, so that daily trips are spread over the whole day with a predefined percentage for each hour.

The model includes land use and planning data for whole Qatar, and it provides the attraction potentials for people activities and distributes their trips according to a ss gravity model which is built within the model structure [6]. The model defines separate mode choice parameters for each population group, and they are used to split the projected person trips demand according to the private and public transport supplies and the standard multi-nomial logit algorithm. In order to represent travel demand realistically and allow for a detailed traffic assignment onto the network model, more condensed areas in terms of population and land use, require a smaller partitioning of traffic zones in the model as can be seen in Fig. 3.

2.5. Network coding

The topology of the Qatar VISUM network was derived from a NAVTEQ database. The NAVTEQ database was transferred into a VISUM readable network file. This process is done by an existing interface integrated in the modeling software. All other attributes provided by NAVTEQ, besides the network topology (e.g. turning prohibitions) have also been transferred to the model. However, the NAVTEQ network representation is not always accurate and reflecting current conditions, mainly because of the rapid growth in Qatar and ongoing construction.

Therefore, the development of the base year model included a number of tasks to update the initial NAVTEQ model [5]:

- Definition of a functional road hierarchy.
- Definition of physical road characteristics.
- Assignment of road net links to the defined types (Fig. 4).
- Revision of the assigned road types in cooperation with Public Roads Authority (PWA).
- Categorization of junctions and intersections using the node object of the network model (Fig. 5).
- Insertion of the public transport stops, lines and service trips (according to timetable, Fig. 6).

3. Model calibration

The model was calibrated using extensive household, OD, and traffic surveys in 2006, in addition to a comprehensive census database that was provided by Qatar Statistics Authority.

3.1. Trip generation

The trip generation model determined the number of trips originating and terminating in each traffic zone. This was based on forecasts of population and employment in each zone, with the household being the main determinant of trip generation. Information gathered from the household surveys conducted in August 2006 was used to determine existing trip generation rates for the base year model. Trip generation rates (per group) are illustrated in Fig. 7.
3.2. Trip distribution

The distribution of trips and thus the travel patterns, which are also very important for the forecasting models, are reflected very accurately in the model. Fig. 8 shows the compliance between model data and HIS results regarding average trip distances within GDA. It needs to be noted that trip distribution has to be adjusted after major changes of impedances and assignment parameters.

3.3. Mode choice

The mode choice model is also calibrated to a very high level, showing only minimal discrepancies between model data and HIS data. Fig. 9 presents the number of trips per mode. However, the very small share of public transport trips means that mode choice parameters cannot be used for future scenario forecasting, taking into account that new PT supply will be provided and a substantially higher public transport modal split is anticipated [4].
4. Model validation

4.1. Trip distribution validation

The validation test for trip distribution is the evaluation of trip movements by clusters of planning zones. There are 90 planning zones within the State of Qatar. The evaluation was conducted by clustering various planning zones to provide a more controllable summary of the information [2].

The figures below provide a comparison between HIS and Model for the trip movements to and from each clustered planning zone. As the HIS does not cover the whole of Qatar and not all Zones within Greater Doha Area are covered by the sample size of the household survey, trip movements between HIS and Model are not absolutely comparable. Some clustering of household survey’s trip generation and attraction to certain zones must be factored in.

The results indicate that the trip distribution model, represented by trip movements between clustered planning zone, are not exactly identical to the values in the household survey. Still, for all important trip movements the modeled trip distribution is very similar to the trip distribution observed in the HIS.
Figure 7  Trip generation comparison graph.

Figure 8  Graphical trip length comparison.

Figure 9  Number of trips per mode.
4.2. Trip assignment validation

Assignment validation for the strategic model was carried out using aggregated volumes by corridor (identified by screen lines and individual links), type of service (facility type), size (volume group) and time period (AM or PM peak hours). Speeds and travel times were also used in road network and public transport validations to ensure that these are accurately represented in the strategic model [5]. A series of six screen lines were developed for validation of the 2006 model as shown in Table 1, Fig. 10, and Fig. 11.

5. Results and discussion

The case study run was done twice in this research. The first run has used the official calibrated transport model of Qatar, and its generated demand was connected to VISSIM dynamic micro-simulation. And then a second run was performed using the research developed visual basic applications which are called the “VIT Interface”.

The second run was simulating the collection of vehicles’ floating data from VISSIM as a representative of the case study network flow, and the collected demand was re-generated, re-distributed, and re-split using the developed thesis applications. The following are the results of comparing the research interface re-created demand to the original demand resulting from the run of Qatar transport model.

5.1. Real-time trips regeneration

Regression analysis is a common approach used for deducing trip production and attraction formulae. Regarding the AM peak, the following variables are considered in the trip generation module and tested in this interface:

<table>
<thead>
<tr>
<th>Production</th>
<th>Attraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Employees</td>
<td>Number of Work Places</td>
</tr>
<tr>
<td>Number of School Students</td>
<td>Number of School Student Places</td>
</tr>
<tr>
<td>Number of University Students</td>
<td>Number of University Student Places</td>
</tr>
</tbody>
</table>

Study area trip generation results are shown in Fig. 12. The analysis of the results presented below reveal that 86% of the productions and attractions are located within the GEH acceptance value of 5. However, it is worthy to mention that this result could have not been achieved without revising the attractivity values that are presented in the “Att_Weigth” column shown below. So it can be deduced that attraction densities of employment and education as surveyed are not accurate for three zones out of the eleven zones tested in this study.

5.2. Real-time trips re-distribution

The gravity model used in this application is a production direction model so that it is constrained by the produced trips

![Figure 10](image-url) Trip movements between clustered zones (HIS).
that are distributed to different destinations proportional to their attractions and inversely proportional to the time required to reach those destinations.

However trip distribution performance is controlled within research applications by the GEH criteria whose values are preferable to be less than 5 for at least 85% of the OD pairs.
Trips re-distribution results (Fig. 13 and 14) show that around 98% of the OD pairs trips were forecasted by this interface with a GEH value less than 5.

5.3. Real-time mode split

Mode split implemented in this interface is based on the common multi-nomial logit equations as function of cost and time impedances per each transport mode. The mode split performance is controlled in this application also by the GEH criteria. Mode re-split results are presented in Fig. 15. The application could achieve all of the OD pairs splits with a GEH value less than 5, which is very encouraging as a case study replication.

6. Findings

Comprehensive inter-connected interface was programmed and developed in order to comprehensively analyze the data im-
ported from Vehicles Identification Technique (VIT) systems, and deduce strategic transportation planning parameters. A big effort was invested in developing the VIT interface of this research, and it was applied on a case study area in Qatar. The study area comprises 51,272 population, 54,875 potential work places, 49,618 as Employers’ Business attractivity, 1550 restaurants capacity, 6870 schools student capacity, 1307 university students capacity, 10,044 leisure and sport capacity, 32,125 shopping capacity, and 65 Mosques.

A baseline run was conducted for the case study using Qatar Transport Model and PTV Vision software. And this run was intended to provide a realistic replication for the case study demand. Another run was performed using the research developed VIT interface for the case study in order to conduct a real-time replication for Qatar Model trip demand data. And the test was successful and could closely match the results with an average accuracy exceeding 90%.

7. Conclusions

The following are the main conclusions of this research:

1. VIT systems can be used for collecting OD trip matrices, and for traffic operational applications such as congestion pricing, rod tolls, and detecting traffic violations.
2. VIT systems are not yet fully adopted for transportation purposes because of constrains in developed countries, and low-tech conditions in developing countries.
3. VIT systems are compatible with ITS infrastructure fiber optic or wireless information networks. Thus the implementation of such system can be a direct extension to any available network infrastructure.
4. Congestion pricing, rod tolls, parking fees, and traffic violations detections are all potential fields of applying VIT systems within the same required infrastructure. However, such applications are already operating in many developing countries.
5. Vehicles’ security is a separate compatible field of application for VIT systems that can be further customized and developed by concerned authorities in order to control and improve the status of public and national security.
6. Since strategic transportation behavioral parameters are critical in forecasting future transportation demand, and based on the efficiency proven in the developed research interface run; and due to the potential traffic operation and national security benefits, and the obvious deficiencies in the existing data collection and transportation modeling practices, the research highly recommends the implementation of Vehicles Identification Techniques in all countries that have a preliminary ITS infrastructure.

References