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RESEARCH ARTICLE

Etraffic – an Open Access Transportation Model

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Abstract
This paper presents a modular transportation modelling approach. In the proposed system travel demand is determined using existing statistics. All data describing a national road network and corresponding traffic demand is loaded into the software application, consisting of a web interface and managed database. Users have access to this dataset and may freely modify it to create their own models and scenarios for transportation studies.

Keywords
open-access, transportation modelling, network modelling, travel forecasting, travel demand, traffic assignment

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1 Introduction

Deriving and forecasting traffic demand are not simple tasks. Road users' individual choices of travel mode, route and frequency are affected by a multitude of factors. Describing demand with available statistical data is not a straightforward process, and is based mostly on results of road-side and household surveys and traffic measurements. While the latter requires significantly less manpower and could be easily automatized, the former needs a lot of human resources and post-processing. Another problem of surveys is statistical sampling: since covering the whole population with the survey is not feasible, engineers have to employ some degree of sampling, thus trip patterns are uncovered only partially. Cross sectional volume measurements mainly support local traffic planning studies but they are not suitable to deduce trip patterns or travel demand: it is not possible to either separate individual route choices or highlight relational traffic flow between two points of the network. Hence these measurements cannot supply adequate data for planning tasks associated with structural changes in the transportation network.

Transportation modelling ties the two aspects of travel demand – relational trip data and cross sectional traffic volumes. Through modelling it is possible – or rather: it's required – to describe the underlying mechanics of observed trip patterns based on household- and roadside surveys, traffic volume measurements, and other existing empirical data. Then it is possible to work out answer to most questions of transportation planning, two amongst the greatest import being utilized routes corresponding to traffic demand and traffic flow values. Therefore transportation modelling provides traffic data about projects still on the drawing board: a possible distribution of traffic, and its characteristics according to the proposed project scenario. This feature is necessary for scenario analysis – finding the most beneficial, most advantageous project variant – and for supporting decisions with a wide array of numeric results [1].

The two most data-intensive component of a transportation model is the road network – with specified attributes – and travel demand – usually conceived as an Origin-Destination (OD) matrix. Although the common abstraction of the real road network (junctions and road sections in between) into the model is through a directed graph, network elements hold many attributes describing physical and metaphysical properties of individual elements. Translating – or 'coding' – the network into a computerized model and parametrizing its elements (e.g. number of lanes, speed limit, allowed vehicle categories, horizontal and vertical geometry, traffic control characteristics, etc.) may be achieved by using geospatial databases. Travel demand however is determined through reviewing statistics of socio-economy and demography, carrying out surveys and taking long series of measurements to be analysed later. Only then calculation of numeric travel demand is possible in the form of a trip matrix – or Origin-Destination matrix.

A general approach to modelling is through the four-step procedure [2] :

- Trip generation (attraction and production)
- Trip distribution
- Mode choice
- Traffic assignment

Since even on medium-sized networks manual calculations are unfeasible – due to the computational complexity of the required methods – there are numerous modelling software applications on the marker today. Although these software take the burden of numeric calculations from the modeller, filling its database with information (network coding, parametrization, defining travel demand, etc.) is still the user's duty. Results highly depend on how thoroughly the modeller performs these tasks. [3]

2 Modelling practice

Hungarian modelling practice has a historical past. Monitoring of traffic volume on the national road network is executed periodically by the Hungarian Road Administration. Results are published yearly in the form of a "traffic measurement handbook" consisting of cross-sectional traffic volumes and yearly flow rate distribution on distinguished links of the network (mainly motorways and major arterials). Country-wide trip matrices – which are necessary for adequate modelling – are actualized by an average period of ten years since the 1950's. The last update was performed by the Institute For Transport Sciences Non-profit Ltd. (Közlekedéstudományi Intézet – KTI) in 2008. Main result of the project "Acquisition of Data for and Creation of the National Trip Matrix" ("Országos Célforgalmi Adatfelvétel lebonyolítása, a célforgalmi mátrix létrehozása") was an actualized trip matrix of year 2008 the National Trip Matrix (Országos Célforgalmi Mátrix) – referred to as "OCF".

Results of a transportation network model show the effects – for instance – of a development project: how traffic is redistributed on links, how travel time and cost change according to the proposed investments [4]. Hence numerous road administration strategies and plans include transportation modelling as a basis for scenario evaluation, cost-benefit analyses, feasibility studies and project ranking. Organizations tasked with jobs related to these plans also have to employ or work in close relationship with modellers – professionals of this industry.

Since methods supporting transportation modelling require overwhelming quantity of calculations, computer hardware and specific modelling software has a significant role in the process. Supplying the software with adequate data and parameters consumes substantial resources of time and money: gathering and processing survey and statistical data, analysis and forecast and integration of this information into the model needs skill and experience on behalf of the modelling professional.

3 Open access concept

Evaluating different solutions for a single project or comparing the benefits of separate investments in a transportation network are all necessary elements of transportation network management. As it was detailed in the previous section these tasks make extensive use of modelling principles and transportation models. Making every data and modelling procedure constituting a country-wide transportation model accessible to the public is one of the important goals of the current concept. Providing the data input and a user friendly – i.e. accessible – interface in a whole package delivers more value than a specific modelling software as it solves the problem of investing in a – usually expensive – set of surveys, network data, then analysing and implementing them into a sound transportation model. Hence this open access solution not only provides computational tools for modelling but a transportation model itself and vital information and tools for demand forecasting as well (e.g. trip generation parameters).

This concept provides access to a theoretically sound model – where advanced techniques are implemented – for a wide array of users,. The open-access concept divides the modelling process into two stages: model development and model application. This way the most demanding and resource intensive tasks of model development such as implementation, data collection, calibration, validation and model update, are separated from the daily tasks of project evaluation. The concept is flexible, any type of transport demand model can be adapted into this approach.

Although upon definition of this open modelling platform, making space for independent modelling decisions of the users (customization of individual parameters, etc.) had also high priority, having to have a rich modelling background is not a necessity. Users only have to define a small number of parameters, specific to their scenario, while all background information (data and parameters) are already set in the model.

This modelling framework runs on a connected server solution (may be a singular server, a cluster of computers or a virtual machine instance run on cloud-computing services), which stores the model's database as well. Registered users have reading access to the whole network model and economic environment, have permissions to define new projects, and commit modification sets of network accordingly. They can also customize trip production and attraction parameters to their project's needs, and have options for travel forecasting as well. Projects defined this way are computed by the server machine using the classical four-step modelling approach (Trip Generation, Trip Distribution, Mode Choice, Traffic Assignment). Output of the algorithms are displayed visually (i.e. on a map) and provided numerically in lists (see Fig. 1).

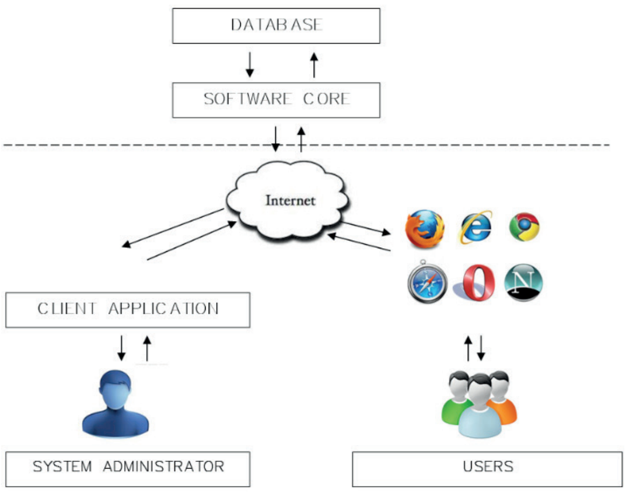

Fig. 1 System integration diagram

4 Novel approach on travel demand

Trip generation of the developed model is based on different classes of traveller activity. Separate travel demand models were developed for each activity class, such as work, education, business, recreation, healthcare or freight.

The main novelty of the applied trip generation model that necessary input data are based on periodically renewed, extensive national socio-economical data (statistic data), provided by the Hungarian Central Statistical Office ("Központi Statisztikai Hivatal", KSH). Deriving analytical relationship between travel demand and relevant statistic data sets was a significant part of the research. Analysis of the wide range of available data in relation of trip production and attraction resulted in a trip generation model consisting of 21 separate activities – motives of travel. Separation to these 21 classes was necessary due to the individually different explaining variables behind every activity thus these have their own sub-model (i.e. set of functions) mapping statistical data to travel demand.

Part of these statistics may usually be obtained from the Hungarian Land Development Information System ("Országos Területfejlesztési és Területrendezési Információs Rendszer", TEIR), in by-settlement lists. The model also consist of global, aggregated data which needed preliminary disaggregation to a settlement-specific format, where variables of the by-settlement lists provided a basis to calculate individual weights for disaggregation. These weights were complemented by a settlement-classification system to calculate final specifics of trip production and attraction.

The global trip generation model also includes an economical macro-model to support travel forecasting. This model simulates the socio-economic environment and predicts values of major variables (e.g. population, GDP, fuel prices etc.) affecting by-settlement data, thus trip production and attraction. With this method, the trip generation model had three layers altogether:

economical macro model → by-settlement data → trip generation

These layers are incorporated into the open access transportation model, providing its trip generation sub-model. Factors affecting travel behaviour are generated and disaggregated sequentially from the economical macro model to the settlement-specific model then productions and attractions are calculated for each settlement and each one of the 21 activity classes. Each model was calibrated and validated based on up-to-date available traffic counts and data on the performance of the transportation sector.

5 Implementation

Architecture of the proof-of-concept software was modular, a database – described in section 3 – linking the separate modules acting as a data transfer protocol and also providing data storage. As an example module 'Data output' also accesses this database and gives graphical (e.g. maps, charts) and tabular (e.g. lists) feedback for the user. Modules and system architecture is displayed on Fig. 2

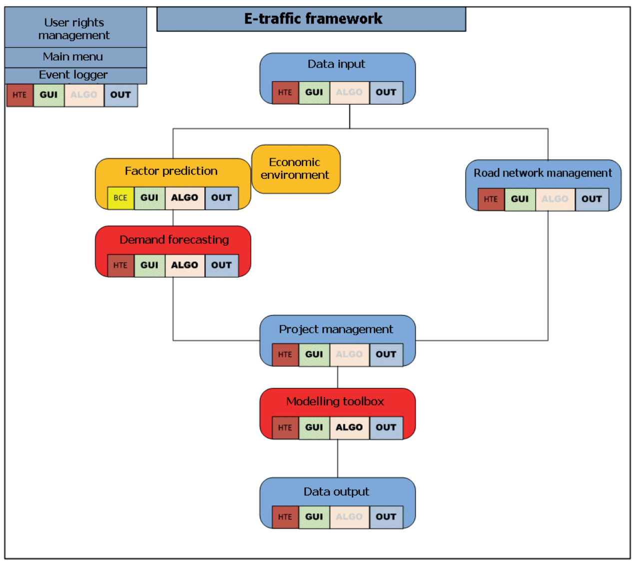

Fig. 2 System modules

Each module has a set of distinct tasks and functions, reading their parameters and working data sets from the database and writing results back into it. These modules were specified according to the previously mentioned theoretical framework. Following is the short functional description of each module:

Framework: Management of the whole modeling application-system. Also controls user access and permissions.

Data input: as it was demonstrated above data from KSH and TEIR are necessary for the model – these represent essential input data for various calculations. Topologic data and meta-information about the road network are also imperative for the system. This module provides connection to appropriate databases containing these crucial information and handles data transfer to the system's database.

Economic macro model: Forecasts of future traffic demand are based on predictions of multiple macro-economic characteristics. It is possible to query and modify forecasts of major socio-demographic indicators in the form of time-series in this module.

Factor prediction: As this kind of data is only available for the current or rather past years, variables for future scenarios are created here as a settlement-based forecast by adopting results of the economic model. The process involves an aforementioned disaggregation weighed by settlement characteristics. It is also possible to change individual settlement's characteristics in case of a proposed scenario where changes in a settlement's attributes have significant implication on traffic demand (e.g. a major industrial investment)

Demand forecasting: The relationship of settlement-based data and trip generation was established above. The demand forecasting module calculates origin (O) and destination (D) traffic volumes utilizing the output of the previous two modules. Although the results are called as "vectors O and D" the process involves the creation of demand vectors for every trip purpose.

Road network management: Although the network model is based on a geospatial database of the national road network, transportation modeling often requires the amendment, extension or abridgement of the current infrastructure network to analyze proposed investments, changes in policy etc. This module supports network adjustments of this kind.

Project management: Supports input data in the form of scenarios for calculation of trip distribution and traffic assignment – the next module. Scenarios are created by designating various vectors of traffic demand (i.e. describing different economic environments, just different time horizons, etc.) to various proposed states of the transportation network (i.e. different solutions for a project, etc.). Since not all combinations of vectors and network states are viable, users have to review or define attachments manually.

Modelling toolbox: Processes model calculations based on the previous – project management – module's output. The last two phases of the classic 4-step procedure are computed: trip distribution and traffic assignment.

Data output: Graphical (i.e. map) and tabular presentation of modelling results.

6 Evaluation

The Etraffic open-access concept - A novel approach to transportation modelling – has the benefit of both making the tools of network modelling widely available and also providing a large, consistent database – suitable for a multitude of modelling tasks. With this approach modelling would not be limited to modelling professionals – which also could be considered as a drawback, since the appropriate selection of input data and interpretation of results still requires expertise and experience on the field of modelling.

While the oversimplification of modelling tasks and toolsets might be also a drawback, there are other – uncontroversial – benefits to the proposed framework. Today, development of a transportation model requires significant resources: network coding, acquiring household and demographic data, conducting and analysing household surveys, conceiving travel demand. While the cost of commercial grade network modelling software are substantial, these applications generally have a steep learning curve and running a complex model requires up-to-date hardware. Thus investing in adequate IT resources – including hardware, software and personnel – is a financial setback making a venture into modelling profitable only in case of multiple job assignments. The proposed framework alleviates the financial burden.

Results of the open-access are model have a higher degree of comparability across projects – when they were developed using transportation network data and economic forecasts provided by the Etraffic system – compared to projects developed by independent organizations or independent model-bases of the same organization. This feature raises the value of the unified open-access platform in the assessment of multiple – governmental – projects as effects on transportation network and ranking, classification of different project may be accomplished on an equal basis.

Further benefit of the concept is that new modelling paradigms and methods can be adopted in a centralized manner –the task of keeping all models and procedures up-to-date is performed by a single – supporting – organization. Users of the framework does not have to purchase newer software versions nor develop new models for their assignments.

7 Conclusions

A model was created through theoretical research and practical development for travel demand forecast based on trip purpose and supported by existing statistical data from KSH and macro-socio-economic forecasts. Calculated travel demand is handled individually – by purpose – through trip generation and trip distribution, aggregated only at the step of traffic assignment. The framework is loaded with existing information from various sources and appropriate algorithms providing a high level of access to the tools and data required for traffic modelling.

8 Further work

Although the presented framework contains multiple elements of integrated land-use and transportation models, and an activity-based model, there is still room for improvements. The analysed time period is rough, it covers yearly average of daily traffic. First it is necessary to distinguish between work-day and holiday traffic, then further segregate traffic demand by periods of the year and finally the most desirable resolution would be to incorporate peak and off-peak periods as well.

Improvement and fine-tuning of the trip generation models should also be accomplished in the future.

Acknowledgement

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