ISSN 1849-6466

KoREMA

Zbornik radova
Proceedings

Tridesetšesti skup o prometnim sustavima
s međunarodnim sudjelovanjem
AUTOMATIZACIJA U PROMETU 2016

36th Conference on Transportation Systems
with International Participation
AUTOMATION IN TRANSPORTATION 2016

November 9-12, 2016

Krapina – Croatia / Maribor, Ljubljana - Slovenia

KoREMA

Zbornik radova / Proceedings

Tridesetšesti skup o prometnim sustavima s međunarodnim sudjelovanjem
AUTOMATIZACIJA U PROMETU 2016

36th Conference on Transportation Systems with International Participation
AUTOMATION IN TRANSPORTATION 2016

Cestovni promet / Road Transportation

Pomorski promet / Maritime Transportation

Zračni promet / Air Transportation

Željeznički promet / Railway Transportation

Studeni / November 9-12, 2016

Krapina – Croatia / Maribor, Ljubljana – Slovenia

Sponzori / Sponsors:

Elektrokem d.o.o. Zagreb
HŽ - Infrastruktura d.o.o. Zagreb
Knorr-Bremse GmbH, Austria
KONČAR – Elektroindustrija d.d. Zagreb
SIQ Ljubljana, Slovenia
TRCpro d.o.o., Kranj, Slovenia
Tvornica elektro opreme Belišće d.o.o.
Zračna luka Split d.o.o.

Izdavač / Publisher:

KoREMA, Unska 3, Zagreb, Croatia

Urednik / Editor:

Željko Šakić

ISSN 1849-6466

Svi radovi su tiskani kao rukopis
All papers are printed in their original form

Organizator / Organized by:

KoREMA

Hrvatsko društvo za komunikacije, računarstvo, elektroniku, mjerenja i automatiku /
Croatian Society for Communications, Computing, Electronics, Measurements and Control

Član Međunarodne federacije za automatsko upravljanje IFAC /
Member of the International Federation of Automatic Control IFAC

Tajništvo / Secretariat: Unska 3, P.O.Box 473, HR-10001 Zagreb
Phone: (+385 1) 612 98 69, 612 98 70, Fax: (+385 1) 612 98 70
E-mail: korema@korema.hr, URL: http://www.korema.hr

Pokroviteljstvo / Sponsorship:

Ministarstvo pomorstva, prometa i infrastrukture RH / Ministry of Maritime Affairs, Transport and Infrastructure RH

Ministarstvo gospodarstva RH / Ministry of Economy, RH

Ministarstvo znanosti, obrazovanja i sporta RH/ Ministry of Science, Education and Sports RH

Grad Krapina / City of Krapina

Krapinsko-zagorska županija / Krapina-Zagorje County

Fakultet elektrotehnike i računarstva Sveučilišta u Zagrebu / Faculty of Electrical Engineering and Computing University of Zagreb

Fakultet elektrotehnike, računarstva i informacijeske tehnologije Sveučilišta Josipa Jurja Strossmayera u Osijeku / Faculty of Electrical Engineering, Computer Science and Information Technology University Josip Juraj Strossmayer of Osijek

Fakultet elektrotehnike, strojarstva i brodogradnje Sveučilišta u Splitu / Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture University of Split

Fakultet prometnih znanosti Sveučilišta u Zagrebu / Faculty of Transport and Traffic Engineering University of Zagreb

Pomorski fakultet Sveučilišta u Rijeci / Faculty of Maritime Studies University of Rijeka

Pomorski fakultet Sveučilišta u Splitu / Faculty of Maritime Studies University of Split

Veleučilište Hrvatsko zagorje Krapina / University of Applied Sciences Hrvatsko Zagorje Krapina

Zajednica saveza osoba s invaliditetom Hrvatske – SOIH / Croatian Union of Associations of Persons with Disabilities

Hrvatska akademija znanosti i umjetnosti - Znanstveno vijeće za promet / Croatian Academy of Sciences and Arts - The Scientific Council for Traffic

Hrvatska komora inženjera tehnologije prometa i transporta Zagreb / Croatian Chamber of Transport Engineers Zagreb

Hrvatska gospodarska komora / Croatian Chamber of Economy

KONČAR – Elektroindustrija d.d., Zagreb / KONČAR – Electrical Industries Inc.

Associazione Nazionale Ingegneri ed Architetti Italiani ANIAI, Roma, Italy

Österreichische Verkehrwissenschaftliche Gesellschaft, Wien, Österreich

Österreichische Ingenieur- und Architekten - Verein, Wien, Österreich

Közlekedéstudományi Egyesület, Budapest, Hungary

SADRŽAJ / CONTENTS

CESTOVNI PROMET / ROAD TRANSPORTATION

POMORSKI PROMET / MARITIME TRANSPORTATION

GRAPHICAL PRESENTATION OF ORIGIN-DESTINATION MATRIX IN R STATISTICAL ENVIRONMENT

Mia Filić
Faculty of Science, University of Zagreb, Croatia

Renato Filjar, Krešimir Vidović
Ericsson Nikola Tesla d. d., Krapinska 45, 10000 Zagreb, Croatia

Summary

Origin-Destination Matrix (ODM) represents the status of the multi-discipline socio-economic (including transport) activity in the observed spatial area (city, region, country) and is therefore used in support of the strategic planning and decision-making on the wider scale. The interpretation of the ODM can be a daunting task, since the traditional representations of may hide the necessary evidence. Here we propose a novel approach in graphical presentation of an ODM, that allow for friendlier interface to the user, and thus improve the usability of the ODM in strategic planning process. The proposed graphical presentation approach is validated through practical deployment in statistical and software development R environment.

1. INTRODUCTION

Spatial analysis of socio-economic activities of a community renders a foundation for every strategic planning process. Origin-Destination Matrices have been seen traditionally as a valuable source of information for strategic planners. Still, the wide differences in the ODM definitions and the lack of clarity in the ODM presentation often reduce the potential of inference from ODM. Here we propose several novelties in the graphical ODM presentation, aiming at revealing the potential of a valuable measure of socio-economic development. The socio-economic outlook comprises numerous specific subsets, such as those related to (road) transport and telecommunications [11].

2. O-D MATRIX

Optimal spatial strategic planning calls for understanding of the nature of migrations that occur in particular time windows. As an example, migration of a population in the morning hours are well correlated with travels conducted in order for people to reach their offices, universities, schools or health services. The strategic planning requires the data describing those internal (within a city, region, or a country) migrations to be systematically collected, analysed and presented in order to allow for the appropriate decisions and actions. Description of migrations in question is often given in a form of an Origin-Destination Matrix [2]. The Origin-Destination Matrix (ODM) is a measure of a socio-economic activity in the region (city, county or country) at a given time span [4]. The motivation behind its creation is to identify clusters of activity the population is attracted to a larger extent, in order to provide such areas with the necessary infrastructure to support the socio-economic growth [8]. This means not only the strategic planning of the appropriate transport infrastructure, but also the planning of a wide variety of supporting services (shops, theatres etc.) as well as co-ordinating their activities to optimise the socio-economic growth [4].

The ODM consists of rows and columns comprising identified regions of major attractions (corporate buildings, factories, universities, schools, hospitals, theatres, shopping-malls, stadiums – to name the most attractive ones.), understood as origins and destinations of local migrations. An ODM matrix element presents either absolute or relative indicator of the usage of a link between the particular origin (in rows, for example) and the particular destination (in columns, for the same example).

Traditionally, the ODMs are based on the field-collected data (interviews, public transport records of passenger count, analysed CCTV footage etc.)[2]. Recently, the identification of migration has been achieved through statistical inference from anonymised data collected in mobile communication networks.

3. GRAPHICAL PRESENTATION OF AN O-D MATRIX

An ODM with a reasonably small number of nodes (origins and destinations) can be presented in numerical form, where the importance of origins, destinations and links can be identified with a relative simplicity. However, more detailed ODMs provoke the problem in the ODMs comprehension and interpretation [6]. In recent developments, several attempts have been made to graphically represent large and detailed ODMs in order to allow for a clear visualisation of their findings [5]. Here we report a novel approach in graphical presentation of an ODM, as follows. Determination of the area of attraction (i. e. origin or destination) is traditionally based on the presumption that a certain area will attract socio-economic activity due to its nature and available infrastructure, leaving socio-economically inactive areas unexplored. Here we utilise a different approach, with spatial segmentation of the whole area of interest into a Voronoi diagram [1]. The utilisation of Voronoi diagram allows for relation of the patches of migration-inactive areas to those active and topographically close, thus rendering the socio-economic description seamless and more accurate.

We presumed the importance of the identification of the activities that are related to the specific time span (or time-window, say 15 h – 18 h, for example). With the completed ODM in numerical form at hand, we identify the ODM's most influential (the busiest) link of all, and take it as a normalisation benchmark. Then, we normalise all the ODM elements in a way that the absolute number of links are divided by the benchmark value for the time span in question, thus transforming the absolute values into relative in the range [0, 1] (0% - 100%). A visualisation algorithm is then applied to assign every ODM element a coloured picture element, with the intensity in direct relation to relative activity. All the elements now form a graphical representation of an ODM.

4. UTILISING R FOR O-D MATRIX GRAPHICAL PRESENTATION

A variety of commercial and open-source environments can be utilised for implementation of the algorithm presented in Chapter 3. The R language and environment for statistical computing (analysis, modelling, and simulation) [9] has gradually become a programming standard for the reason of its extensive and robust support almost all the statistical procedures imaginable, as well as for its excellent support to spatial data analysis discipline. Along the main R package and RStudio Graphical User Interface, the following packages were used in this research: ggplot2, maptools, sp and stplanr [7].

5. RESULTS OF THE ANALYSIS AND DISCUSSION

The R-based software was used for the ODM originated from the urban environment telecommunication data [4, 10], legally available on the internet [12]. The Voronoi spatial segmentation was conducted based on the available data on telecommunication network base-station positions, as presented in Fig 1.

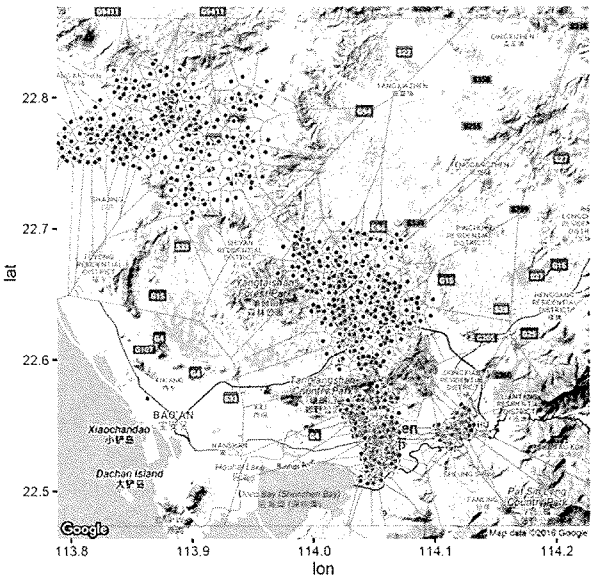

Fig. 1. Voronoi spatial segmentation for ODM representation

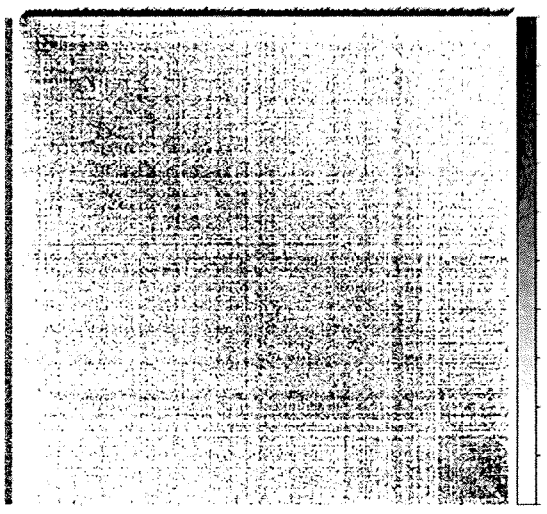

Fig 2. Graphical representation of an ODM using heath-map style

After the ODM calculation, the matrix elements were converted into a heath-map style (Fig 2) using our R-based software.

The availability of original ODM data allowed us for portioning the ODM according to particular requirements needed for interpretation, such as the quantified presentation of attractive destination for population from a particular origin, as depicted on Fig 3.

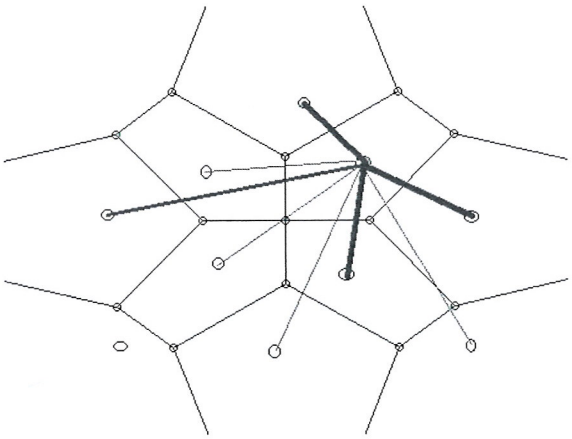

Fig 3. Partitioning ODM – attractiveness of destinations for population from a particular origin area

Graphical presentation of ODM allows for a more accurate interpretation, revealing the information hidden behind the numbers. In addition, it can fine-tune the spatial segmentation in order for the algorithm to return clearly shaped clusters of socio-economic activities, an outcome expected from the ODM determination process.

6. CONCLUSION AND FUTURE WORK

Considering the Origin-Destination Matrix (ODM) a measure of socio-economic activities, a proper OSM graphical representation becomes an important process that will support the appropriate OSM interpretation. We present a novel approach in the ODM graphical presentation that allows for complete spatial segmentation of areas of local migration attractiveness, a human-centred presentation of ODM that emphasises local and temporal centres of socio-economic activity, and the ODM partitioning based on particular requirements.

The future research will concentrate on refining the ODM estimation methodology in relation to graphically represented ODM.

7. REFERENCES

[1] Aurenhammer, F, and Klein, R. (2000). Voronoi Diagrams. In Handbook of Computational Geometry, Chapter V, (J. Sack and G. Urrutia, editors), 201-290. Elsevier Science Publishing. Amsterdam, The Netherlands.

[2] Carey, M, Hendrickson, C, and Siddharthan, K. (1981). A Method for Direct Estimation of Origin/Destination Trip Matrices. *Transportation Science*, **15**, 32-49.

[3] Crawley, M J. (2013). The R Book (2nd ed). John Wiley & Sons. Chichester, UK.OTHER REMARKS

[4] Gonzalez, M C, Hidalgo, C A, and Barabasi, A-L. (2008). Understanding individual human mobility patterns. Nature, 453, 779-782. doi:10.1038/nature06958

[5] Groff, E R, and McEwen, T. (2006). Visualization of Spatial Relationship in Mobility Research: A Primer (Final Report). Institute for Law and Justice. Alexandria, VA. Available at: http://bit.ly/2cdC9Li, accessed on 19 August, 2016.

[6] Hoffman, P, and Grinstein, G. (2016). Visualizations for High Dimensional Data Mining – Table Visualizations.University of Massachusetts Lowell. Lowell, MA. Available at: http://bit.ly/2c1zyRp, accessed on 19 August, 2016.

[7] Lovelace, R. (2016). Introducing stplanr. R-project. Available at: https://cran.r-project.org/web/packages/stplanr/vignettes/introducing-stplanr.html, accessed on 19 August, 2016.

[8] Peterson, A. (2007). The Origin-Destination Matrix Estimation Problem – Analysis and Computation (PhD thesis). Institute of Technology, Linkoeping University. Norrkoeping, Sweden.

[9] R Development Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. Available at: http://www.R-project.org, accessed on 5 September, 2016.

[10] Timms, P M. (2001). A review of methods for estimating origin-destination trip matrices using link counts (working paper No. 556). Institute of Transport Studies, University of Leeds. Leeds, UK.

[11] Varun, J et al. (2013). On the Analysis and Visualisation of Anonymised Call Detail Records. Proc of ADCOM 2013, 5 pages. Chennai, India.

[12] Wang, P et al. (2012). Understanding Road Usage Patterns in Urban Areas. *Scientific Reports*, **2**, e01001. doi: 10.1038/srep01001

[13] Zhang, D et al. (2015). UrbanCPS: a cyber-physical system based on multi-source big infrastructure data for heterogenous model integration. *Proc of the ACM/IEEE Sixth International Conference on Cyber-Physical Systems ICCPS '15*, pp 238-247. Seattle, WA. Supplementary data sets available at: http://bit.ly/2bTEkWk, accessed on 6 September, 2016.