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REPORT

**on the dissertation presented by Anastasiya Pavlovna Shirokolobova,
titled "Optimization Methods for Estimation of Travel Demands
Between Intersections in Urban Road Networks"
submitted for the Candidate of Science degree
in specialization 01.01.09. "Discrete mathematics and mathematical cybernetics"**

In the thesis reviewed the author presents mathematical models and methods purposed for estimation of travel demand. Actually, application of different mathematical models for determining the travel demand requires relevant data concerning demand of movements between intersections in urban road networks. In turn, availability of these data allows traffic engineers, managers and other experts in the area of transportation to find suitable solutions concerning the effective modifications of infrastructure.

Given that nowadays we observe the world-wide growing level of motorization, the issues of transportation and infrastructure become a matter of emerging priority and strategic importance, which confirms the significance and relevance of the thesis presented by A.P. Shirokolobova. In addition, it is should be noted that development of models and methods for estimation of travel demand, on one hand, makes it possible to obtain extensive results in theory and, on the other hand, allows to create new approaches and algorithms for solution of different kinds of optimization problems. Therefore, this research has both theoretical and practical significance for the subject of study.

In the first chapter of the thesis the author deals with the problem of equilibrium traffic assignment in road networks. She introduces the concepts of primal and inverse generalized problems of equilibrium traffic assignment, and primal and inverse generalized problems of equilibrium time searching. Primal, dual and inverse problems of equilibrium traffic assignment are presented in form of problems with determined mappings. The author investigates the properties of the introduced mappings and finds the conditions of existence and uniqueness of the inverse problem solution. Besides, the author presents the explicit form of the mapping operator for specific cases of the networks consisting of non-interfering routes.

In the second part of the thesis the author presents a bi-level model for travel demand estimation in which the given values of network loads are used, while the data on a prior travel demand are not available. Besides, in this chapter the combinatorial approach and the evolutionary methods for solving the bi-level model are successfully used. In the end of the chapter the author carries out the analysis of the optimization algorithms to find their sensitivity to various parameters of the problem.

The third chapter of the thesis is focused on practical application of the proposed models. The author explains which models are more appropriate for one or another way of obtaining data on traffic network loads and equilibrium travel time.

The scientific novelty and theoretical significance of the thesis mostly consist in the developed bi-level optimization model purposed for evaluation of travel demand in accordance with the link load estimates and with the values of actual travel time. Besides, the author has proposed various algorithms for such model in order to deal with different road network topologies.

The following key results of the thesis should be singled out:

1. The dual and inverse problems of traffic assignment are formulated. The conditions of existence and uniqueness of the traffic assignment inverse problem are found.
2. The analytical solution of the travel demand estimation problem for the case of a network with parallel routes and with one pair of origin and destination nodes is found for linear and exponential link performance functions.

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3. A bi-level model for travel demand estimation by the network load data is developed.
4. An approach for solving a bi-level model is suggested for a network of non-interfering routes with one pair of origin and destination nodes and with the nonlinear link performance function. Unique solution has been obtained.
5. The principles of evolutionary methods have been implemented to cope with real urban road networks.

The practical significance of the research is of a high value as it is primarily aimed for practical application. Accuracy of the obtained results is confirmed by strict proofs of all the formulated mathematical statements. The results of the research have been published in 18 scientific papers. Besides, the key results of the research have been presented at different international conferences and workshops. Moreover, A.P. Shirokolobova has successfully participated in several business and research projects which concern this area of study.

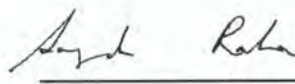
However, there are several remarks on the research:

1. It would have been interesting to consider the usage of combinatorial approach for a network of higher dimension. Is it true that it could allow to determine the travel demand values or just the possible origin-destination nodes with non-zero travel demand values?
2. In Section 2.4 the author demonstrates the evolutionary approach to estimate of travel demand by considering data on the network arc travel time. The respective coordinates of the origin-destination nodes and the values between them were found for 5, 6, 7, 8, and 9 OD-pairs. The obtained results demonstrated non-uniqueness of the solution, however, the vertices tend to appear in the same areas. As a follow-up of this study the author should create a map of the most frequently occurring areas of source and sink.
3. The thesis contains several mistakes and misspells.

Despite the above-mentioned remarks which do not spoil the general positive impression made by this research, the thesis deserves to be positively evaluated.

The thesis of A.P. Shirokolobova "Optimization Methods for Estimation Travel Demand Between Intersections in Urban Road Networks" fulfills the requirements established by the Decree № 6821/1 dated September 01, 2016 "On Order of Granting Degrees in St. Petersburg State University", and Anastasiya Pavlovna Shirokolobova deserves to be granted with a Degree of Candidate of Sciences (Specialization 01.01.09 "Discrete Mathematics and Mathematical Cybernetics").

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