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Evaluation of modal-choice rules through ground transportation modeling using subway data

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Abstract

One of the most important issues in transportation and urban planning is an understanding of passenger choice while commuting in existing transport infrastructure. Big modern cities offer a multimodal selection of methods to transfer between the parts of the city, including various types of ground transportation and a subway. On the other hand, passengers' model choice depends on the available routes, often historically formed without regard to modern passenger needs and fast-changing of cities life. As a result, for the optimization of public transport systems we should understand how the rules are formed, followed by passengers when choosing a specific route. This paper discusses the evaluation of modal-choice rules through ground transportation modeling using historical data collected from turnstiles in the subway and census data. The results should help in identifying the critical places in the existing infrastructure and transportation planning of big cities. The modeling results are shown on the example of St. Petersburg.

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Keywords: transport modeling; public transport; urban mobility; multimodal transportation

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1. Introduction

A modeling of daily activity and travel patterns roots in work about urban planning. Recently a fraction of the population in the big cities are living in towns or districts located out of the center city in suburban and dormitory districts [1]. Thus, the most people rely on efficiency of public transport. In view of this, railway system is one of key parts of urban transportation that is a part of comprehensive network including various modes, namely rail, subway, tram, trolleybus and bus. Thereby we emphasize the important property of modern urban transportation system is multimodality. Transportation system of a modern city is based on the movement of individuals following the complex patterns for activities comprising all options of commuting with public transport [2] [3]. The vision of the routes and transport systems are undergoing sharp and continuous changes. Nowadays, an interest to the multi-modal urban transportation modeling is increasing, the inter–modal and multi-modal transportation is a key pattern of an urban environment [4]. The multimodal model gives us an opportunity building the more real transportation systems of the large urban areas and reproduce urban mobility in big scale. However, the use of the multi-modal and multi-layer model of urban transport leads to the emergence of new challenges. Considering the specific of the big cities, we need integrate multi-modal model of urban transportation system and modal-choice rules on micro level. Authors of the paper [5] presented a first attempt to combine multi-modal model and the space syntax axial mode for making the integrated multi-modal network model of railway, underground and pedestrian movement networks. As result they proved that this approach improves the description of individual movement network. The similar approach is considered in the paper [6], where authors introduce development of the integrated spatial topology modeling of multi-modal urban public transport networks based on walking paths. Thus, authors emphasize the walking path is important for connection of transport model and interaction between multiple urban transport networks. More studies and investigation tried to reproduce multi–modal transportation system for different cities. In 2001 Yu [7] described the multi-modal public transportation system for Hong-Kong with integrated the spatial and non-spatial information about multi-modal public traffic routes. This model is based on GIS applications on transportation. Recently, Chen [8], [9] have used the similar approach for building integrated multi-scale and multi-modal transportation GIS-based data model for the Guangzhou in China that depends on different transportation modes. In addition, study [10] introduce a multi-modal network model of the Randstad region in the Netherlands. Authors identified a topology of ‘modality environments’ with specific patterns of mobility, i.e. walking, cycling, car use, local and regional transit. Lantseva et. al [11] reproduced urban mobility in Saint-Petersburg using the multi-modal model of public transport routes with the choice of the optimal path. In papers [12], [13] authors considered the bi-modal network model of London within M25 that combined streets and metro as a concept for the multi–modal space syntax network analysis. The method builds a simple variation of the multi-modal network and investigates the spatial differences in transportation attributes. Likewise, there are other methods working with transport systems. In 2003 Horn [14] explained an extended model for planning multi-modal passenger journeys based on the Dijkstra shortest-path finding algorithm. Some researchers focused on the study of optimal transit path algorithm, considering walking paths [15] [16] [17]. Zografos et al. [18] represented itinerary planning algorithm that optimize a set of criteria: travel time, number of transfers and walking time.

2. Problem statement

The goal of this research is an evaluation of modal-choice rules of passengers in the ground transportation system in a big city on the example of St. Petersburg. The main hypothesis under investigation is a rationality of choice while commuting in existing transport infrastructure. The minimization of expected travel time is considered as a most reasonable assumption for building the model, which should help in answering the following questions:

- How many people from a specific area (with detailing to a single building) use metro as a commuting mode?
- What is the role of suburban areas in the formation of the overall passenger’s flow in the city?
- Is it possible to validate the model using subway data?

The subway data, in this case, is considered to be the most accurate source of data on passenger flows, since information on each passenger is accurately recorded while passing through turnstiles.