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Procedia Technology 22 (2016) 290 – 297

Procedia Technology

9th International Conference Interdisciplinarity in Engineering, INTER-ENG 2015, 8-9 October 2015, Tirgu-Mures, Romania

Analyzing Public Transportation for The Effects of Individual Characteristics on Mode Choice with Multi Agent Simulation

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Abstract

The movements of modes of transport in network can be analyzed with micro-simulation method. As the development of computers the micro-simulation methods such as multi-agent systems become more popular in transportation analysis. In this study, the problem of individual and trip characteristics on the mode choice are effective or not, is solved. Network, facilities, daily travel plans and transport vehicles were accepted as an agent. Considering parameters that will be effective in mode choice, how transportation road network is distributed spatially, how the personal and trip characteristics of trip makers effects on mode choice spatially were analyzed in study area. As a result of this study, personnel and trip characteristics of trip makers are affected on different transportation mode.

Peer-review under responsibility of the "Petru Maior" University of Tirgu Mures, Faculty of Engineering

Keywords: Transportation; mode choice; multi-agent simulation; individual characteristics; decision analysis.

1. Introduction

The demand of moving which is resulting from the desire of satisfying needs of people living in cities causes the necessity of benefiting from transportation systems. This generates the needs of effective implementation of transportation systems. In order to do this, available alternative trips needs to be analyzed in detail. There are different processes of transportation models generated for this purpose and can be grouped into four stages as

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Peer-review under responsibility of the "Petru Maior" University of Tirgu Mures, Faculty of Engineering
doi:10.1016/j.protcy.2016.01.100

generating trip, distribution, mode choice and assignment. Mode choice is the least considered step among them. Urban transportation modes are included car, bike, public transportation etc. There are factors (personal and trip characteristics) affecting mode choice of individuals. These factors were identified with using one of data-mining methods called “decision-tree” in previous studies by authors. Analysis can be performed with collected data from study area for modelling urban transportation. While implementing this process, household survey data including personal and trip characteristics of travelers in study area was used. Collecting data from all population in metropolitan cities might be difficult and also it may be impossible to collect frequently.

Considering parameters that will be effective in the process of mode choice in transportation modelling, how transportation road network is distributed spatially, how the personal choice of trip makers affects transportation mode choice spatially were analyzed. By this way, the importance of establishing transportation network considering with personal and trip characteristics of people by decision-makers in cities is was exposed.

In this paper, the purpose is to develop a method in the process of mode choice which is a part of steps in transport demand modelling with reference to individual travel behavior by using multi-agent simulation. Forming a method for decision-makers, the effects of daily travel behaviors on mode split is to be releaved. First of all, after giving theoretical background about main topic, the model created is defined. At last, the application in workspace selected is demonstrated.

2. Theoretical Background

2.1. Factors affecting the mode choice

Transportation modelling provides local transportation solutions for urban planning. Transportation models separated to four stages as generating trip, distribution, mode choice and assignment. Mode choice is the least considered step among them. There are many factors affecting the process of mode choice in transportation modelling [13]. There are many factors affecting the mode choice. Various methods can be used determining the factors. One of the factors is decision trees that is the one of the subjects of data mining techniques. With the method of “decision trees” which is one of the classification techniques in data mining, is used to determine the factors affecting transportation mode .With the help of these factors, how the individual travel behavior is trying to be revealed. By the help of household data, daily travel behavior of individuals can be determined. Mode split used in travel by individual is arised with reference to this data.

Mode choice models are separated as aggregated and disaggregated models. For determining mode choice with individual behavior, researchers take into account disaggregate models [5] [13].

2.2. Multi-Agent Simulation

Traffic simulation models are categorized as macroscopic, mezoscopic, microscopic and sub-microscopic [4]. In microscopic simulation, there is a high detail level. All vehicles and other objects are easily shown. Movements of vehicles is examine on the road line.

Micro simulation allows the combination of disaggregated models. Developing prototype of geographic multi agent system of highway traffic in rush hours is used for increasing the effectiveness of highways [4]. In traffic micro simulation, all vehicles are included in modelling and given the characteristics.

In [11] study, ILUMASS Project (a group project of institutes of the universities of Aachen, Bamberg, Dortmund, Cologne, and Wuppertal under the coordination of the Transport Research Institute of the German Aerospace Centre (DLR)) micro simulation modules will include models of demographic development, household formation, firm lifecycles, residential and non-residential construction, labour mobility on the regional labour market and household mobility on the regional housing market. ILUMASS will work completely microscopic, i.e. land-use changes and traffic flows are simulated by micro simulation. The interactions between travel demand, car ownership, and residential and firm location as well as the interactions between land use, built form, and mobility behavior are simulated. Furthermore the environmental impacts of transport such as traffic noise or exposure to air pollution are included.

Analyzing these models, it was stated that this study is the level of microscopic. Because, the movements of different modes of transport in road network can be analyzed with micro-simulation method. Traffic simulation is an important tool for control and management of urban traffic systems as the experiments on the real traffic systems are usually very costly. As the development of computers the micro-simulation methods such as car following model, Cellular Automata and Multi-Agent Systems (MAS) become more and more popular in traffic analysis and forecasting [19].

Agent-based simulation seems to form the ideal modelling paradigm for activity scheduling models as it supports individual decision making, flexible interaction between agents and their environment and multi-level modelling and simulation [15].

There is no common accepted definition for agents but it also have common properties. These properties as listed as below [3] [6] [9] [14] [18]:

- An agent is an autonomous entity, i.e. it acts only on its self-decisions.
- An agent is situated in an environment. It perceives the environment and performs action according to its goal and perception.
- An agent plays one or several roles inside the system, in order to reach its objectives,
- Clearly identifiable problem solving entities with well-defined boundaries and interfaces,
- Designed to fulfill a specific purpose—they have particular objectives (goals) to achieve,
- Capable of exhibiting flexible problem solving behavior in pursuit of their design objectives,
- Agents will need to interact with one another agents/humans, either to achieve their individual objectives or to manage the dependencies that ensue from being situated in a common environment,
- They share an environment through agent communication and interaction,
- Reactivity: an agent need to have the ability to perceive their environment and respond to it,
- If the environment is changed the an agent cannot longer exists and
- All agents have the most up to date and the most accurate data with coordination and interaction.

The most important point for multi-agent simulation is the issue of data grounding and validity. Socio-demographic data is used for generating the synthetic population. Not only the configuration of agents, households and facilities has to be realistically set, but also the decision making processes are in need of empirical foundation [15].

A multi agent simulation of the generation of individual activity programs was developed based on the ideas of a simulation of the scheduling processes [15]. Agents are conceived in terms of which goals should be followed, at what time, and by whom. Secondly, as agents are flexible problem solvers, operating in an environment over which they have only partial control and observability, interactions need to be handled in a similarly flexible manner [3].

2.3. Multi-Agent Simulation in Mode Choice Studies

Multi-agent simulation concentrates on learning coordination of route and mode choice. The main components are individuals and vehicles [9]. The core advantage of agent-based microscopic traffic simulation is to be more realistic. With agents, that the factors affecting mode choice brings capability of analyzing movements in road-network in public transportation is considered. By this way, with describing the agents, the problem of individual and trip characteristics of decision-makers on the mode choice are effective or not, is solved.

Main advantage of agent based microscopic traffic simulation is more realistic [4]. Multi-Agent simulation is also used for simulation of land use or land cover change [14].

When transport-oriented studies about multi-agent simulation were analyzed, movement of only one mode on the road was researched. In this study, having more than one mode was simulated is advantageous. Network models that used in traffic simulation includes road network, nodes (intersection points) and lines (for each segment). Besides these, lanes, average vehicle capacity and Street names would be in network [17].

There are several multi-agent simulation software which are open source and supported with geographical information systems. Some of them are Agent Analysis, MASON, NetLogo, Repast Symphony, MATSim, StarLogo, SWARM, UrbanSIM. In this paper MATSim simulation toolkit is used for MAS.

MATSim is an agent-based transport demand modeling framework that operates on the basis of individual agent plans; a plan being a schedule of activities, their locations and the travel legs connecting them [2]. MATSim

provides framework to implement large-scale agent-based transport simulation. MATSim is capable of simulating private car traffic and public transport in large detail and support additional modes. Simulations cover one full day the mobility behavior of a large number of single persons ("agents") is simulated simultaneously. It is able to simulate scenarios with several millions agents on network with thousands of road segments. MATSim allows for easy replacement or addition of functionality. Users are add their own algorithms for agent behavior [16].

Java based MATSIM-T software used to model the initial individual demand is able to combine various data sources via standardized XML formats in order to generate daily activity plans. These data are network, count data, activity facilities and public transport.

An initial demand of a full day plan of activities for each agent is generated and executed in a mobility simulation. Plans are scored after the simulation step and, based on the score, agents adapt their plans in response to conditions that arose during the simulation. Each agent's set of feasible plans improves with increasing iterations. Feasible new plans can be derived from existing ones by changing activity timings, locations, re-routing travel legs between activities, changing transport modes connecting activities or dropping activities from the activity schedule altogether [2].

Travel demand data is simulated and optimized on a given transport network in typical MATSIM simulation. Simulation and optimization process have 5 stages as shown in Figure 1. Initial Demand stage contained the full list of agents and each of them has at least one day plan. Execution stage called as mobility simulation which means the agents and their vehicles are moved around in the network. After the execution finished, the agents plans are evaluated based on their experienced in scoring stage. Agents may modify their plans for not getting bad scores. These modifications are in such as activity times, stating times and changing of mode or trip. In analysis stage, at the end of the simulation, one is often interested in some key performance values of the simulation. MATSim performs multiple iterations within one simulation run, consisting of multiple mobility simulation, scoring and preplanning executions, until the end result is available [16].

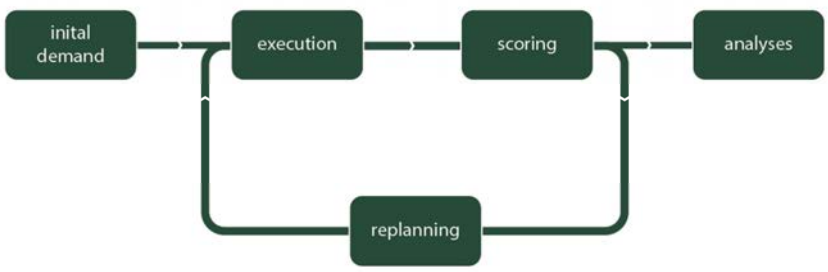

Fig. 1. Stages of MAS in MATSim

An agent can hold a set of activity plans in its "memory", and chooses one of them for the traffic simulation. The agent will thus not immediately "forget" the activity plan it executed the iteration before, but may use it again in later iterations. The evaluation of the plan may change from iteration to iteration, depending on the respective traffic conditions [10].

MATSim is used for simulation for different purpose in this study area. The aim of using two simulation software's is to be able to compare evacuation time estimates and to obtain reliable results from evacuation simulations which are crucial and critical in creating emergency plans. Evacuation simulations are carried out for Aliaga, the industrial zone of Izmir, Turkey. And in the other study (MATSİM web site), a simulation for existing urban transportation, and three simulations for gulf crossing scenarios, for Izmir, Turkey are made using MATSim for determine the effects of different scenarios to existing traffic. But none of these studies, used MATSim for simulate individual behaviors effects on mode choice.

3. Research Methodology

There are many factors affecting the process of mode choice in transportation modelling [13]. These factors were evaluated for one of the districts in study area called Buca, Izmir which is the third biggest city in Turkey with approximately 4 million inhabitants [12]. In Buca, that trip time, purpose of trip, number of people, driver license, and number of vehicle, house type, house ownership, age groups, working status and public transport card ownership were obtained. Considering with those factors determined, in mode choice, not only one kind of mode of transport but also movement of different kinds of modes on road network such as car, public transportation, bike, walk etc. was implemented by the method of simulation.

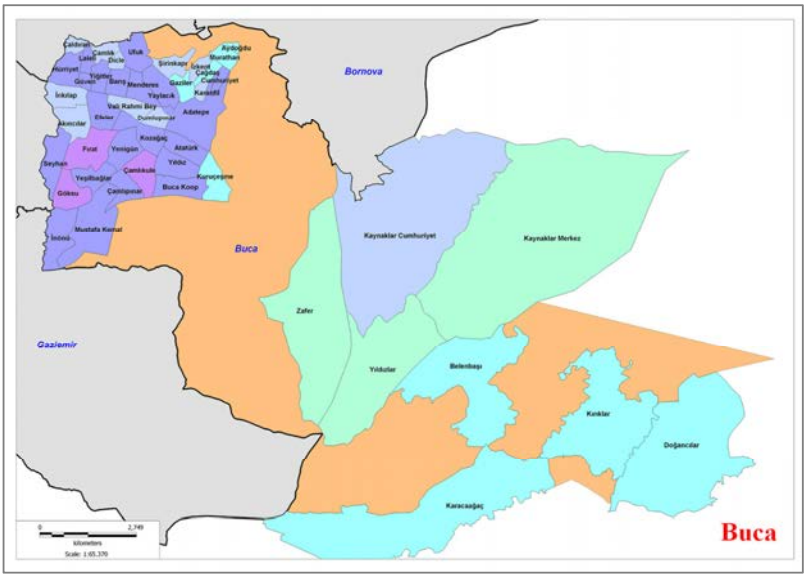

Fig. 2. Study Area: Buca Izmir

Considering parameters from household survey data, the technique of multi-agent simulation was used. Road network, facilities, timetables belonging to public transport vehicles, daily travel plans of fixed number of population and transport vehicles used were accepted as agents. Input files considered for simulation are network (links, nodes, and coordinates, capacity), plans (personnel and trip characteristics) and config (file for determination of simulation scenario). After all the agents were described as input, the process of description of how simulation behavior will be based on mode choice was identified. In this way, the interaction among agents was taken into consideration. In the output, with selecting the household's location data as baseline spatially, scenarios were revealed. When implementing these processes multi-agent simulation software MATSIM which is GIS-based, open-source, platform-independent and sufficient documentation were analyzed.

Table 1. Input xml file types

File Name	properties
network.xml	links, nodes, coordinates, capacity
plans/population.xml	that trip time, purpose of trip, number of people, driver license, and number of vehicle, house type, house ownership, age groups, working status and public transport card ownership
facilities.xml	Facilities which are related with plans coordinates, activity types, start and end time of activities.
config.xml	Behavior of simulation is defined. Mode choice model is defined.

For simulating individual public in MATSim, network, plans/population, facilities, public transport vehicles and their schedules and some specific settings in the configuration are created. Plans/population file is created from household survey data. All parameter from household survey data didn't use in plan file. Only the factors that affecting mode choice from study of [12] are considered. Network file is shown in Figure 3. For network file, road network of Izmir is downloaded from Open Street Map as .osm file. Then it is transformed to .xml file in MATSim.

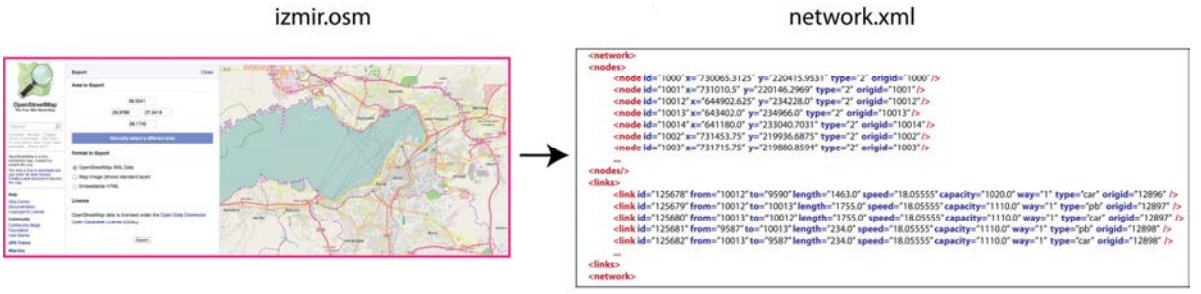

Fig 3. Network file

Mode Choice model is defined in config file. Hence there is lots of alternative mode exist in data, multinomial logit model is used for mode choice. Structure of multinomial logit model in MATSim is defined in strategy module as SelectExpBeta. The scores are taken as utilities and the betaBrain parameter from config file is taken as the scale parameter [16]. Equation is:

$$p_i = \frac{exp(\beta_{brain} * S_i)}{\sum_j exp(\beta_{brain} * S_j)} \quad (1)$$

where p_i is the probability of i. mode. S_i is score for i. mode and Sj is score for other j mode. Structure of simulation is shown in Figure 4.

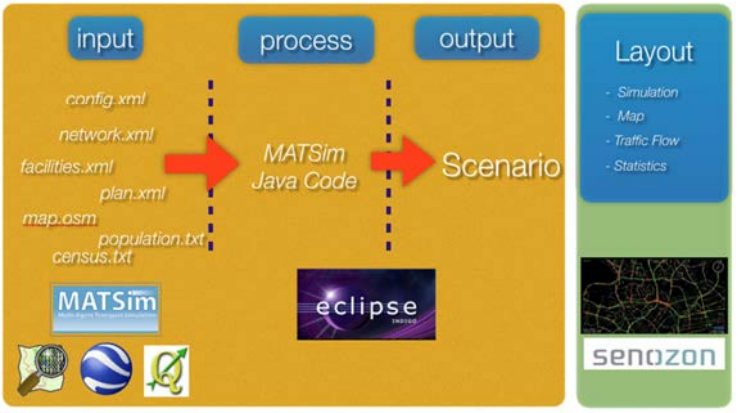

Fig 4. Structure of Simulation

At the end of simulation, distribution of the personal choice of trip makers affects transportation mode choice spatially based on individual behaviors is demonstrated by the help of visualization software Senozon.

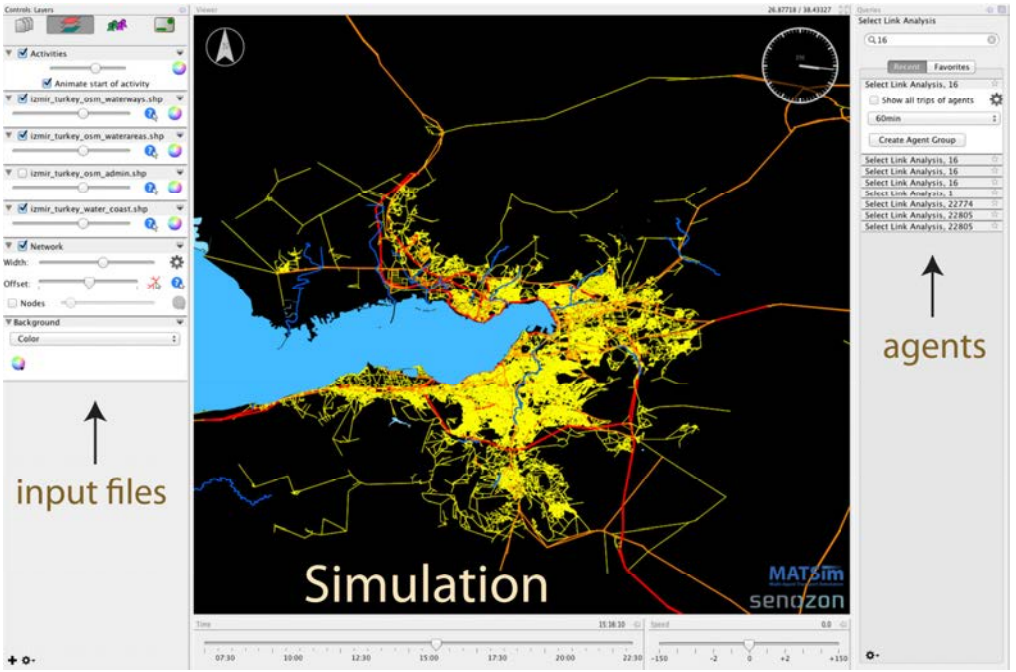

Fig. 5. Screen shot of simulation window

4. Results and Conclusion

Considering parameters that will be effective in the process of mode choice in transportation modelling, how transportation road network is distributed spatially, how the personal and trip characteristics of trip makers effects on mode choice spatially were analyzed. This study demonstrated the effects on mode choice with multi-agent simulation for decision-makers according to individual behaviours and trip movements. As a result, mode choice in specific routes is going to be effective in direction of transport investment. In further studies, as a result of iteration of scenario can be increased, alternative mode suggestion will be demonstrated. Every iteration has derived a score point. These score points are showed the utility of iterations and mode. By the average score of executed plans are increased, optimal modes will be chosen from decision makers.

While making decisions about developments of urban transportation, decision-makers in local authority should consider personal characteristics of people living in cities and generate road-networks satisfying the demand of individuals properly. While doing this, methods that enable transformation of data available in local authority, interaction with others should be utilized. Data undertaken with this methodology, should be an example for urban transport studies belonging to different cities and provide generation of sustainable urban transportation network.

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