Travel Demand Modelling Of Electric Mobility
Standpoints of existing Approaches

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1. Introduction

In recent years enormous efforts have been made to reduce the polluting emissions created by road transport. Many developed countries through their leading counties and pioneering cities have started taking apt leaps towards sustainability aiming to have smart ecosystems. On a different note, researchers have looked at the usefulness of virtual spatial suites for exploring different social sciences phenomena as being a great catalyst for analyzing, forecasting and planning. Vehicular movement modeling is one of the most popular spatial models that deal with relevant aspects of urban regions and communities.

This paper presents the bibliography of possible approaches to simulating travel demand models of electric vehicles-(EVs). It gives a broad overview of the altered standpoints of most likely used practices which were formerly utilized to predict vehicle network movements. It sheds light on the pros and cons of each approach with respect to simulating EVs-systems. Finally the paper discusses the authors' recommended approach, which fits more to the study context. The evaluation is based on a closer review of the literature and the conceptual model that has been developed using spatial configurational method. Observations shall clarify the rationale behind choosing such approach and the potential possibility of linking it with hybrid simulation techniques.

1.1 EV Simulation Environment

The use of spaces might change though the relation between spots and streets tend to remain consistent (Erickson and Lloyds 1996). The closer review of the literature showed that the crowd flow simulation models at the micro-level of abstraction fall under two main categories: 1-these incorporate based origin-destination matrixes and 2-space syntax models which utilize conifgurational analysis (Nkwenti, 2008). Several researches have tackled drawing comparison between the two theories with respect to conventional-traffic simulation. This study focuses on a particular mobility system; EVs-clusters.

Electric mobility (e-mobility) is a sub set of the conventional-mobility data. It is a small part of a large group which shares common paradigms e.g. roads network layer, some of the agents' behaviors and traits, goals scale, visualization and GIS purposes. However, EVs-population has other unique features and parameters e.g. battery state, charging preferences, number of destinations and parking areas that exist. Depending upon the applications and end users’ drives, the simulation set up is formulated. (ElBanhawy, Dalton et al. 2012 B).

2. Traffic Correlation Studies- Spatial Interaction Models

Transportation network growth is correlated to the land use and economic activities, which both affect the cars passengers' route choices. This study discusses the urban pattern and movement prediction within a simulation environment designed to present one of the EVs-systems. A constructed virtual environment of such population requires distinctive spatial set up to mimic the parallel real environment. The paper shall address a set of points:

- Conventional traffic modelling approaches (pros and cons)
- Proposed e-mobility travel demand modelling
- Integrating EVs' travel demand layer with agent based-discrete event hybrid simulation technique

Spatial behavior is not a new topic on the social sciences. Vehicular movement network simulation and analysis have been conducted for several applications. Research on movement through space found that way finding behaviour is partly influenced by the system pattern itself. It revealed the strong tendencies the trip makers have in taking the easiest way to their destination which safes time, money and effort.

2.1 Metric-Trip Distribution Approach

It is a contemporary theory that has been used to determine travel demand which works on analyzing the trip maker's route choice between the system's origins and destinations. The basic generator of the trip is the time and distance (Paul, 2011a). The relation that generates the origin-destination matrix is based on production zones being attracted to attraction zones. These zones are known as traffic analysis zones-(TAZs). The level of congestion counts for the free-flow of each route. Congestion is being calculated via the equilibrium analysis using expressed by the level of services (LOS) that a network would have. Regions and countries vary in the LOS categories and linking them to the volume and the capacity (V/C) of routes and arteries. One of the main drawbacks of this approach is defining the boundary of a zone to coincide with the edges of census tracts, fig. 1. Simulation speculates having particular trip purposes, which can be summarized in 4 types. Conventional traffic models replicate these spatial patterns in real time simulation platform Fig.2, forming trip-based travel forecast models.

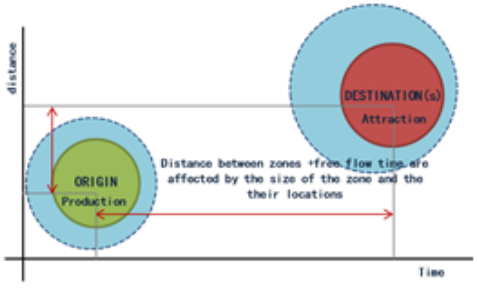

Figure 1. Trip makers 'interchanges graph

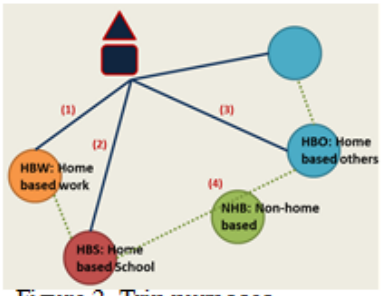

Figure 2. Trip purposes

Each of these models has pros and cons which lead to the more convenient one, which is the intervening opportunities model. It does not require O-D matrix, and counts more on probabilities. This type opens channel to spatial configurational models.

2.2 Topological- Spatial Configuration approach

Space syntax is an alternative approach to estimate conventional vehicular travel demand without using O-D matrix trip data, which is difficult to be obtained (Paul, 2011a). Different shapes of relations and levels of interactions between spaces each other and or with society, have superbly shaped the space syntax notion and its principles in analyzing the spatial patterns of cities (Jiang and Claramunt, 2002). In transportation and land use context, the spatial configuration of simulation objects is a crucial issue due to the observed correlation between graph-based configurational measures of street networks, represented as lines, and vehicular and pedestrians navigational choices, observed movement, and flow patterns (Hillier and Iida 2005). It is observed that this correlation could strongly provide great insights on understanding cities and visualizing its impact within the field of urban studies, urban planning and urban economics (Law, Chiaradia et al. 2012).

Many studies were conducted on the human movement behavior with respect to angularity. Kim and Jaepil Choi 2009 pointed out that individuals tend to minimize angular deviation from a straight line to destination as human tend to make the least physical effort. Turner 2001, pointed out that ease of directional change can be varied as turning angle, and proposed Angular-Segment-Analysis methodology that applied the shortest angular path based on angular depth to segmented axial map. Recent related research reveals that ASA shows more remarkable predictability for the actual movement pattern than existing traditional space syntax methodology (Turner 2007).

3. EV-Trip Makers Notion of Movement

This study focuses on the public and non-domestic available charging points. The EVs are presented in the simulation as heterogeneous agents while their flow of movement in the road networks is simulated using discrete event-(DE)-technique. Agent based modeling-(ABM) is a decentralized approach of portraying emergent behavior of a crowd/ individual autonomous heterogynous agents which is why it is known as a bottom-up approach. A hybrid model is proposed as it might better serve the present problem due to the fact that the main paradigms of the model are being a large-group simulation of active objects that has timing, sequential events, and individual behaviors. The proposed algorithm in this study, fig. 3, shows the overall picture of the agent system design as other factors likewise iteration time, number of agents, charging schedules, charging types are to be considered in later stages.

Figure 3. Agent movement algorithm (state diagram)

4. Outcomes and Applications

Northumbria University is partaking in an international project that works on promoting e-mobility in the North Sea region, e-mobility NSR Intrreg project. This study is a part of a PhD research, which falls under work package number 4 of the project. The research focuses on integrating space syntax theory with hybrid simulation techniques to simulate EVs-systems. It is considering the inner urban core of Newcastle-Gateshead metropolitan area that has the main traffic arteries of the city.

Observations show that the utilization of space syntax theories fits more to the nature of EV-population's virtual representation. The space syntax forms the urban layer of the simulation to predict the vehicular movement considering the battery state of the EVs' drivers. Having said the main paradigms of EVs clusters, other factors count for the simulation set up and configuration.

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