Journal of Transport Geography 37 (2014) 19–27

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

Route choice and residential environment: introducing liveability requirements in navigation systems in Flanders

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ARTICLE INFO

Keywords:
Navigation systems
Liveability
Transport planning
Flanders

ABSTRACT

Vehicle route planning and navigation systems aim to provide the most beneficial routes to their users while disregarding the impact on the liveability of the surrounding residential areas. Therefore, future integration of route choice behaviour by route planners and measures to improve liveability and safety standards should be pursued. The Spatial Plan for Flanders, which is the overarching spatial policy plan in the northern part of Belgium, determines a system of road categories aimed at optimising the liveability of sensitive areas, such as residential neighbourhoods or school precincts, without jeopardizing accessibility. This paper examines to what extent routes proposed by commercial route planners differ from more socially desirable routes that are guided by the policy principles of road categorisation in Flanders as proposed by the plan. Results show that commercial route-planners' routes choose more often roads of the lowest category than socially acceptable. However, for some of the assessed connections, the socially desired alternative is a feasible route as well, which is not excessively increasing time consumption or distance travelled. It is concluded that the implementation of the prevailing road categorisation system in Flanders in routing algorithms has the potential to promote more sustainable route choices, while infrastructural measures that discourage cut-through traffic may help materialising the categorisation system.

1. Introduction

In recent years, route planners and navigation systems have become standard attributes for the Western motorist. Commercial route planning systems aim to provide the fastest or the most efficient route between two user-specified addresses. In 95% of all cases, navigation aid is used to take the user to an unfamiliar destination, although there is even a minority which uses navigation while heading to familiar destinations (Van Rooijen et al., 2008). Accurate mapping of the achievable speed on the entire road network, in combination with shortest path algorithms allow modern route planners even to offer an optimised route choice solution for a trip that was already known by the user. A human actor will follow his or her intuition, which is usually based on the hierarchy of the road network as it occurs in the mental map of the driver (Car and Frank, 1994). This means that such a user has no access to the complete network information, and is therefore obliged to exclude a number of possible routes beforehand. Also in the case where the driver would use a printed street map, the problem of incomplete information is still present. A route planner, however, is a powerful tool that calculates the fastest possible route in a rational way, not avoiding local roads whenever use of these would lead to shorter travel time. But the dominant use of navigation gives also rise to potential harm, facilitating cut-through traffic and associated liveability problems of neighbourhoods, village centres and school precincts. Besides, such problems are not limited to car traffic, but are even more severe in the case of freight transport. Trucks do not only cause more pollution than cars do, they are also more often heading to unknown destinations, while using almost always an on-board navigation system.

So, we hypothesise that parallel optimisation of individual route choices leads to suboptimal solutions for the system as a whole. This problem was recognised long before the general use of route

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http://dx.doi.org/10.1016/j.jtrangeo.2014.04.005
0966-6923/

planners, primarily in the context of congestion problems, but also in relation to liveability and safety threats. In the past, governments have often anticipated socially undesirable route choice through appropriate signposting (Akçelik and Maher, 1977; Wright, 1978). Research into signposting methods has been followed recently by a new line of inquiry on dynamic traffic signalisation (Taale, 2008). Nevertheless, hardly any literature can be found about the consequences of the introduction of in-vehicle navigation systems on travel behaviour. The link between navigation system based route choice and liveability is not even addressed at all in the academic literature, although a number of authors, such as Ericsson et al. (2006), point out opportunities regarding travel efficiency optimisation in terms of energy consumption or emissions. Hoogendoorn et al. (2011), is one of the few scholars who outlines a perspective in which individual navigation could be influenced aiming at a better functioning of the traffic system as a whole.

Departing from the identified research gap, the present study is an exploratory investigation intended to gaining insight into the difference between route choice behaviour of car navigation systems, and route choice according to scenario that have been developed by urban and mobility planners. Based on a limited number of case studies, lessons are learned and policy recommendations are developed, aimed at preventing through traffic in environments where this is undesirable. We do so by comparing the route choice of a number of commercial route planners with a route that would be in line with the requirements of the Spatial Plan for Flanders (SPF), which is the overarching spatial policy plan in the northern part of Belgium.

2. The difficult choice between fast and socially desired

Although developers of route planners realise that the fastest route is not necessarily the most responsible choice, their paramount interest remains in serving their own customers. Consequently, truthful information is recorded in digital maps as much as possible, and is supplemented by legal conditions. As long as it is not illegal to use a given street, it will be included in the map as a possible link.

However, the reasoning behind the road categorisation system that was introduced in SPF and consequently applied in provincial and municipal policy plans, is different. Road categorisation is based on the principle that the major part of an itinerary should follow a road, which is ranked as high as possible in the designed hierarchy, even if this would entail a significant detour. In this way, nuisance caused by cut-through traffic would be minimised. Below we will illustrate the difference between commercial route planner behaviour and policy based route guidance.

2.1. Route planner approach

Route planners calculate an optimal itinerary between two locations, depending on the available data. Route calculation relies on a road map enriched with additional information to guide vehicles efficiently through the road network, and on an algorithm to calculate a suitable route based on the available data.

2.1.1. Map database

Data needed for route planning are structured as a digital map. Such a map is a geospatial database (Güting, 1994), which is optimised to store and query spatial data such as road networks. Map makers collect and receive geospatial information, store and process it in a local database, and provide their maps to the end users, i.e. the navigation system vendors. The delivery of spatial data from source to end-user is referred to as a 'data (update) delivery chain'.

Mapmakers' databases contain the geometry of the road network, the road classification[1], characteristics of roads, such as direction. Mapmakers construct this database by collecting their own data or receive data from third parties (Rennemo et al., 2008). Data can be derived from topographic maps, aerial photographs or satellite images. Additional data are collected by fieldwork (Chen et al., 2009; Tao, 2000). Such fieldwork enables to verify parameters, such as narrow passages, one-way streets, street names, signposting, number of lanes, geometry of roads, physical barriers, obscure locations, and inaccessible roads. Other data are obtained from various institutions, mostly regional or municipal authorities. For example, a municipality can inform a mapmaker of (physical) modifications in the road network or the addition of new traffic signs. Such applicable data are transferred to the mapmakers, and consequently processed and stored in the databases.

The next step in the data provision chain is delivering the maps to the navigation system and to route planner developers. Mapmakers' databases are not designed to be used directly by applications. Such databases are organised for efficient storage and management of digital map data, but are not compact enough for use in navigation devices and not suitable for fast calculation of routes. Therefore, suppliers of navigation systems will compile the database in order to obtain a file system, which meets the needs of the navigation device. Such custom map databases are referred to as a physical storage format (PSF), and may differ among vendors of navigation devices.

Apart from traditional static maps, systems handling real-time data are in full development, and are already used by the latest version of some route planners. But since most navigation systems that are in use in Belgium, take not yet account of real-time traffic information, the scope of our research is limited to static route planners.

2.1.2. Algorithm

A routing algorithm is in charge of an efficient and up-to-date route calculation, taking into account a whole range of predefined network properties that jointly represent a travel cost per kilometre. The algorithm finds the optimal route through minimising the total travel cost.

One of the main algorithms to calculate routes is the Dijkstra's shortest path algorithm (Dijkstra, 1959). The algorithm searches for the lowest cost path between a node and every other node in the network. This process is labour-intensive and delivers lots of redundant results. While planning a route, the general direction of the route is known in advance (Fu et al., 2006). This knowledge allows to search for results in a limited area and can be used to accelerate the search process. A^* is an algorithm (Koenig et al., 2004) that applies this principle, and is widely used in route planners and navigation systems. The calculation can be further accelerated by applying bidirectional search, in which case the algorithm simultaneously searches from origin towards destination and from destination towards the origin. So, these two searches will meet somewhere in between. Furthermore, road networks are often modelled according to a hierarchical structure. This has introduced the idea of an efficient, hierarchical search algorithm for road networks. The basic idea is to search in an abstract area in the first place, rather than in the entire area. Such an abstract area can be demarcated for each hierarchical level. This allows an incomplete first route search at the upper level in the hierarchy. Next, details can be added using roads from a lower level. In a large road network it is recommended to apply a heuristic, bidirectional and hierarchical search method (Zhao, 1997).

[1] In this paper, the term "road classification" refers to the technical hierarchy that is used in route planner maps, while the term "road categorisation" refers to the desired hierarchy as introduced by SPF. The present research will clarify that significant differences exist between class and category.