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Road and Rail Infrastructure II

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THE ROLE OF A POLICY MADE ROAD CATEGORISATION FOR SUSTAINABLE ROUTE NAVIGATION UNDER NORMAL AND CONGESTED TRAFFIC CONDITIONS

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Abstract

Travellers can reach a destination easily and fast by using navigation systems and route planners, which are often able to dynamically adjust a route according to changing traffic conditions. However, navigation systems primarily focus on the interests of the individual road user. Too often, the impact on safety and liveability along the suggested routes is neglected. Policy makers aim at a sustainable use of the road network with a focus on public interest, rather than on the individual profit of a navigation system user. To avoid improper use of the road network, many countries have developed a functional road categorisation. In the Flanders region this was defined in the Flemish Spatial Structure Plan (RSV 1997).
This research examines to what extent the route planners induce improper road use. Several route planners are used to calculate routes between origins/destinations relations. Between each relation exists a preferred sustainable route. The routes suggested by route planners are compared to the corresponding preferred route, after which the road classification usage of route planners can be evaluated. Routes are calculated under normal (static) and congested (dynamic) traffic conditions. The in–depth analysis of this research indicates an over–(mis) use of local, in particular in a congested road network. It is concluded that the implementation of the Flemish road categorisation in route planning has the potential to stimulate a more sustainable route choice, but does not provide a sustainable alternative route if congestion occurs. The categorisation system itself needs a critical review, especially in congested areas.

Keywords: route planning, dynamic route planning, navigations systmes, traffic liveability, road categorisation

1 Introduction

Recently, the use of navigation systems and route planners has increased. These systems are capable of guiding travellers to their destination by presenting the most appropriate route to the user, and even information to avoid traffic can be included [1]. However, if the navigation system suggests roads that are not intended to be used by through–traffic, they might put at risk the liveability and safety of the environment. It is not clear to what extent the available route planners take into account the traffic annoyance they may cause by their suggested routes.
In the Flanders Spatial Structure Plan (RSV)[2] a functional road categorization is introduced. The basic principle is to selectively prioritize the roads by 'giving access' or 'liveability'[3]. By applying this policy–made road categorization, a routing methodology that is preferred by policy makers can be developed and the liveability of neighbourhoods can be protected [4]. However, digital maps suppliers use a different, usually private road categorization based on functional importance and road characteristics [5]. A comparison between the preferred (RSV) routes (as indicated by the policy makers) and the (fastest) route from route planners seems

necessary. This study examines to which extent route planners take into consideration the principles of the RSV road categorization to determine a route choice. This is done by examining the categories of roads that are used to travel from origin to destination by using route planners and by using a preferred RSV–based route. This study will consider both static routes and time dependent routes. The later implies that routes may vary depending on time and day of the planned trip. This paper will first explain the principles of the road categorization according to the RSV. Secondly, the study describes and elaborates on the available technologies. Next the methodology used for comparing static routes is explained, followed by the similar methodology used for comparing time dependent routes. Finally, some conclusions are given.

2 Network and road categorisation

The existing road categorization of the Flanders Spatial Structure Plan is based on selectively prioritizing either accessibility or liveability. Within the road network in Flanders four categories of roads are distinguished: the main road network, primary roads, the secondary and the local roads. Three main functions are distinguished on functionality: the connection function, the collection function and the function of giving access [2](Afdeling Ruimtelijke Planning, april 2004. A main function and a complementary function are assigned to each category. In addition a distinction is made between three hierarchical levels (International, Flemish, (super–)local) depending on the relation between origin and destination.
On the highest level, the road network must be consistent. Roads of Flemish and (supra–)local level do not need to form a coherent network. They do have to form a coherent road network with the higher level network on which they are connected via links. This creates a tree–like structure with branches to lower levelled roads [6]. The underlying idea of the tree is to avoid connections within a mesh, which would start to function on a higher level. The traffic flow at various levels must be in proportion so that the lower levelled road network does not get overloaded by through–traffic ('cut–through traffic ') and that the road network of higher level is not loaded with traffic at a subordinate relationship ('improper road use').

3 Navigation functionalities

Route planning allows calculating an optimal route between two locations, depending on the available data. To generate these routes, two aspects are indispensible: the data including the road network with additional information to guide vehicles efficiently through the road network, and a process or algorithm to calculate a suitable route based on the available data. Depending on the source data, a wide variety of criteria can be taken into consideration while calculating a route. The quality of the route depends on several factors such as distance, travel time, number of turns, traffic lights, dynamic traffic information and even aspects that may ensure traffic liveability. Together these factors make a total trip cost. The routing algorithm will attempt to minimize this travel cost. Classic route planners and navigation systems are static in calculating routes. Based on the user's preference (fastest, shortest), only on route will be presented which will not vary over time (not considering the possibility of map updates). Recent technologies go beyond these static routes, and include time dependant information. This implies that route suggestions may vary depending on time and day of the planned trip. The least recent system is TMC. TMC [7] is the abbreviation of 'Traffic Message Channel' and can send digital information concerning traffic conditions at a limited amount of locations, with a delay of approximately 5 to 15 minutes after the incident took place. New technologies such as the tracking of vehicle location, by gps signal or by mobile phone signal provided by telecom operators, allow the calculation of travel times based on real traffic data. The collected data is used to recommend routes with a more accurate time of arrival expectations depending on the time of day and day of the week. These technologies are referred to as 'quasi static'. TomTom's 'IQ Routes' and Garmin's 'trafficTrends' rely on this technology [8–10]. The latest technologies such as TomTom's 'HD Traffic' [8,9] include real time traffic data in the routing algorithm. The navigation device receives traffic nearly continuously by connecting to the databases to collect new traffic information. If a traffic situation changes rapidly, user can be informed on the fly due to fast update times (every 2 minutes). These systems apply a dynamic routing strategy.

4 Comparing static routes

The aim of this study is to determine to which extent the routes – calculated by existing route planners – take into account the policy–made categorization based on the principles of the RSV. For this purpose several origins and destinations were selected, on a 'preferred' route (taking into account the RSV–principles) between these location was calculated. These routes were compared to their corresponding static and dynamic routes, suggested by route planners. The Flemish road categorisation and network has a tree–like structure. To calculate a 'preferred' route, a routing process based on the RSV can be developed which follows a fixed progression of road use [11]; the route departs from the starting point on a road with a low category and moves gradually to the nearest road with a higher category until the highest categorized road for the route is reached. While approaching the endpoint, the category of the used roads gradually decreases until the destination is reached. This algorithm calculates a shortest pad between two locations in a network. A 'shortest path' can be defined as a path with the lowest resistance. This can be the shortest time, shortest distance or any other value assigned to the network. To calculate a RSV route, the 'shortest path' is defined as the route with the shortest distance dependant on the used road categories and the function of the trip, e.g. travelling on international, Flemish, supra–local or local level. To do so, the distance of each road is multiplied by a weight factor. Each road category has a corresponding weight factor, and for each origin/destination relationship, different weight factors are assigned to the categories. This means that different sets of weights are used for different travel functions. Higher weights on a stretch of road will cause higher resistance on that road, so the use of this road for route planning will become less favourable. This implies that low categories should have high weights, and vice–versa.

5 Comparing time dependent routes

5.1 Method

Five well chosen origin–destination relations were selected where different navigation systems generated different routes. The applied technologies are TMC, IQ Routes, trafficTrends and HD Traffic. All tests were executed on a Thursday evening around 5 P.M.. This point in time was selected based on peak hours, and longest traffic congestion in Flanders, which generally occur on Tuesdays and Thursdays. The policy based and preferred RSV–routes are compared to the static and time–dependant routes suggested by the navigation systems.
First, while comparing static routes with time dependant routes, attention is given to the difference in the use of the road network. Will the time dependant routes use higher categorised roads, or use lower categorised roads than the original static route? If the trip uses roads of a higher level than the desired RSV route, this can be considered to be improper road use. If the trip uses roads of a lower level than desired, on may refer to this as cut–through traffic. Changes in road use by time dependent routs can be defined as a 'mesh increase' or a 'mesh reduction'. A 'mesh increase' indicates the use of higher level roads to make a trip, while a 'mesh reduction' indicates the use of lower level roads. Consequently it is possible that a mesh increase (or reduction) could provide a more favourable route which is in correspondence with policy based principles (and thus the RSV–route).
Secondly, the differences in the use of road categories between RSV–routes and both static and time–dependant routes by route planners is analysed.

5.2 Results

The results for the different technologies are presented briefly. First the results for the quasi static routes are presented followed by the results of dynamic routes. Each technology is analysed based on two tables. The first table represents the mesh reduction, mesh increase or absence of both and their impact on the road network. If the initial static route is defined as cut–through traffic, a mesh increase is desirable. If on the other hand the initial static route causes improper road use, a mesh decrease is desired. The second table represents the use of the road categories along a trip. The differences in road use between the static routes and the time dependent routes are rather small.

5.2.1 Quasi static routes

Table 1 shows that in 5 out of 20 cases the quasi–static route makes use of road categories that are preferred according to policy principles. In 3 cases a mesh reduction is performed where this is undesirable and stimulating or worsening cut–through traffic. In 8 cases, the quasi–static route is similar to the static route and makes improper use of the road network. A mesh increase is performed in 3 cases. One of these is desirable, but the other 2 cause improper road use where previously no problem occurred.

Table 1 Change in use of road network for quasi static routes

Initial state	Total	mesh reduction	no action	mesh increase
Cut–through traffic	5	2	2	1
no problem	5	1	2	2
Improper road use	10	2	8	0
Total	20	5	12	3
	quasi–static route causes preferred road use			
	quasi–static route causes cut–through traffic			
	quasi–static route causes improper road use			

Table 2 Percentage of road use by category

Road use (%)	Highway	Primary I	Primary II	Secondary I	Secondary II	Secondary III	Type I	Type II	Type III
RSV	31.1	1.8	27.5	3.1	5.4	6	14.1	7.1	3.9
static	42.5	0	13.05	0.85	1.5	8.4	15.05	12.5	6.25
quasi static	45.1	0	11.3	0.9	1.85	6.2	14.9	13	6.75

The results in table 2 include all routes. However, not all quasi static route planners suggest a route that differs from the static route planners. The average use of road categories doesn't vary much (static vs quasi static). Use of highways has slightly increased (42.5% to 45.1%) and the use of local roads type III has not changed (6.25% and 6.75%). However, differences in local road usage of individual routes can vary up to 15%, so these average results should viewed with care. If we compare the RSV–route to the (quasi–)static route, we see an increase of local road use, in particular Local roads type III (4% to 6.5%).

5.2.2 Dynamic routes

According to table 3, dynamic routing technologies have a positive influence on the use of the road network. For 6 out of 9 cases, problems were solved. In 5 cases there is a mesh reduction where this can be preferred. A mesh reduction implies the use of the lower road network. In Flanders however, the lower road network is not thoroughly developed (mostly because of built–up areas along important roads) so it can be argued if a mesh reduction is really desirable. On the other hand, the higher level road network is often over saturated, so a mesh reduction would relieve the highways.

Table 3 Change in use of road network for dynamic routes

Initial state	Total	mesh reduction	no action	mesh increase
Cut–through traffic	3	0	2	1
no problem	1	0	1	0
Improper road use	5	5	0	0
Total	9	5	3	1
dynamic route causes preferred road use				
dynamic route causes cut–through traffic				
dynamic route causes improper road use				

Table 4 Percentage of road use by category

Road use (%)	Highway	Primary I	Primary II	Secondary I	Secondary II	Secondary III	Type I	Type II	Type III
RSV	26,3	2,3	32,4	4,1	3,5	3,9	14,7	8,2	4,8
static	29,4	0,0	16,8	0,4	0,3	11,9	19,6	12,8	8,8
quasi static (only one system)	36,2	0,0	14,1	0,3	1,3	5,5	21,5	13,9	9,6
dynamic	17,2	0,0	15,0	5,0	4,2	4,6	22,9	17,9	13,0

In table 4, it is observed that the use of local roads by navigation systems is higher than the RSV–routes. This is in particular the case for local roads type III. It is also apparent that dynamic routes cause a shift from main roads to secondary and local roads (up to 13%). This can be expected since congestion often occurs on the main roads. Nevertheless, the use of local roads type III should never increase because they should only be used to give access to residences. It is however not possible to make conclusions concerning the effect of dynamic routing on cut–through traffic. Cut–through roads are scarcely or not at all covered by the technology. Congestion and incidents on these roads is unknown.

6 Conclusion

The aim of this study is to demonstrate to what extent the existing policy–made road categorization is implemented by navigation systems, and whether these principles may contribute to a more sustainable route navigation. Particular attention is given to the use of local roads by through–traffic. A comparison of routes generated by navigation systems to 'preferred' RSV–routes illustrates a difference in road use and highlights the possible excessive use of local roads by through–traffic due to the use of navigation systems. The findings of this study show that the static routes calculated according to the RSV principles make less use of local roads than routes proposed by navigation systems. By applying RSV routes, the use of local

roads Type III can be reduced and it can limit the use of this low level roads during the trip and may contribute to a higher livability of residential areas. The navigation industry provides the user of a wide range of travel support options to calculate time dependent routes. All these technologies aim to reduce the travel time in case of traffic congestion. The influence of the technology on the road network and the traffic liveability is highly dependent on the network coverage. Although this technology might have the potential to fully make use of the entire road network by spreading traffic according, dynamic technologies do not cover the entire road network. The absence of a full coverage has a negative impact on road usage of the calculated dynamic routes. Therefore, traffic is often redirect to secondary and local roads.
For the calculation of RSV routes in this study, the existing policy–made road categorization is used. New interpretations of the road categorization in Flanders are possible, with enhanced attention to road safety, multimodal use, multiple functions of highways in urban areas, etc… This may influence the 'preferred' route due to addition of other features and parameters to the routing algorithm. A routing based on road classification is static. If an incident or congestion occurs along a 'preferred' route, an alternative route will be sought on the local road network. But can a routing method, based on the principles of the RSV, make the adjacent road network available? The study 'Cut–through traffic in the South–East of Antwerp [12] shows that RSV road categorization is unable to form a solid basis to deal with traffic in congested networks. Thus time dependent routing may spread traffic in a beneficial manner, but it is currently unknown whether the road network is capable of supporting this technology, and more generally, supporting alternative routes in the road network.

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