Decision Loads and Route Qualities for Pedestrians – Key Requirements for the Design of Pedestrian Navigation Services

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Based on studies about human orientation behaviour, the contribution presents a synopsis of main requirements for pedestrian navigation systems, focussing on the key qualities for designing pedestrian wayfinding systems and the consideration of landmarks as spatial information in portable pedestrian navigation services (e.g. in smart phones, PDA's, etc.). Mobile navigation services can enable pedestrians to achieve precise spatial information; yet the actual systems are not responsive to individual preferences of route characteristics.

In contrast to car drivers, pedestrians are characterized by several specific attributes: they are sensitive in terms of distance, acclivity and climatic conditions; they need salient landmarks for orientation and try to minimize the extent of mental work during the navigational process. Therefore, pedestrian navigation services have to offer a wider range of route qualities: e.g. convenience, attractiveness or safety.

To provide efficient navigational information for pedestrians, the consideration of three main route qualities is required: topography (physical quality), topology/attractiveness (psychological quality) and complexity (mental quality). Additionally, the definition of specific route characteristics is of great importance for the simulation of pedestrian flows to imitate route choice behaviour.

We give an outline of the most important design qualities for the development of route networks suitable for pedestrians' needs.

1. Introduction

Transport Telematic Systems so far have been mainly focusing on systems to enhance travel and transport by road bound vehicles or by public transport. They offer the possibility to plan highly complex interactions between different transport modes. The major fields of interest are positioning technologies and navigation systems. Navigation services for individual drivers are available as so called in-vehicle technologies and VMS (Variable message signs). Usually they provide the user with information about the "shortest" or "fastest" route leading to a desired destination.

There are two basic findings supported by the work done in research and implementation projects: first that different methods of positioning technologies should be combined in different layers to get as accurate information as possible in the most effective way, and secondly that the HMI (Human Machine Interface) design is a key element in the acceptance and usage rates.

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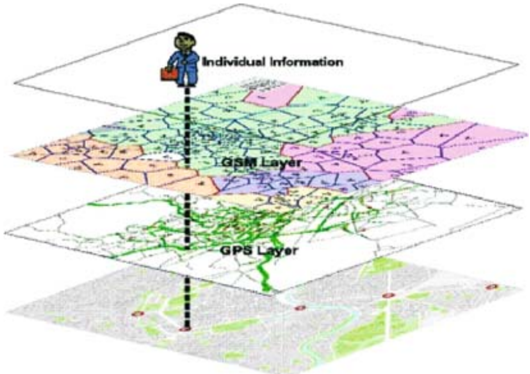


Figure 1: Information Layers (arsenal research).

Research shows that drivers perceive familiar routes as shorter and quicker, even when the navigation software calculates different routes. Therefore the users only change familiar routes when the benefit in time or cost is substantial and when the information about it is offensively presented and absolutely clear.
The same is true for pedestrians, but the challenge to precisely inform the users according to their needs is even higher.

In recent times technological progress has led to the development of portable navigation services (e.g. mobile systems applied to smart phones or PDA's), which allow pedestrians to gain navigational aid at any unfamiliar place. Still mainly common concepts for car navigation services are used to assess routes and to communicate spatial information to users on foot.
However, pedestrian's movements occur under different terms and conditions than the way drivers reach their destination. People travelling by car are bound to road networks and formal restrictions like one-way streets, speed limitations, etc. Pedestrians possess greater freedom in movement; they can walk in any directions they like and have access to places, where vehicles are excluded[1]. Another aspect concerns the fact, that car drivers own the opportunity to control their environment and are provided with a constant level of comfort (protection against climate impacts, dust, pollution, noise, etc.), while on the other hand walking people are exposed to a great variety of environmental impacts. Mobile navigation systems for pedestrians have to take these constraints into account and must consider individual preferences concerning specific route qualities to provide individually "optimal" routes.

In fact, the "shortest" route to a desired destination is not chosen in many cases. People often prefer the "most beautiful" or the "safest" route[2]. Studies on environmental preference and route choice behaviour confirm that pedestrians prefer certain routes owing to their environmental qualities, such as relative quietness and greenery[3].
Pedestrians are very sensitive in terms of different route attributes. But the definition of an "optimal" route network for pedestrians is hard to put into practise, as several

findings reveal differences in people's route choice behaviour[4, 5, 6]. These differences are on the one hand caused by several route characteristics and on the other hand by individual preferences. In this contribution the main characteristics influencing the perceived quality of a specific route are discussed.

2. Effects on Route Choice Behaviour

To identify the quality of a specific route, several attributes of the implied paths have to be taken into account, as the following examples show:

» Convenience: This issue is composed by many different factors. Convenience may be influenced by distance, acclivity, "Level of Service" (LOS) (frequency of pedestrians and broadness of the path) or environmental conditions like weather, noise or pollution.
» Safety: This issue includes aspects of traffic safety as well as spaces evoking fear in people passing through (e.g. dark underpasses or parks, disreputable quarters etc.)
» Attractiveness: People rather feel up to walk longer distances, if the surroundings are appealing.
» Simplicity: Given the choice between a short, complex route and an easier, but longer route, most pedestrians would choose the longer route[4]. The simplicity of a route depends on the number of decision points to be traversed and the number of salient landmarks along the route.
» Availability of facilities: A route where several attractive facilities can be found will be preferred to routes offering fewer facilities (e.g. shops, sights, rest areas, etc.).
» Availability of landmarks: Landmarks are vitally important in human navigation as they are used for the mental structuring of the environment and help to find the right way to a specific destination[7]. Routes with many salient landmarks can be followed and remembered easier and are considered a higher quality than routes with fewer landmarks.

Due to the numerous attributes influencing the quality of a route for pedestrian's needs, the proposition of the "shortest" route is insufficient and mainly required, if the individual is in a hurry. Depending on individual preferences and the actual purpose of the route, additional qualities are demanded, e.g. the "most beautiful", the "safest" or the "simplest" route.

3. Dimensions of Route Qualities

The different attributes affecting the perceived quality of a route partly interact among each other and can be combined to three main, interdependent route qualities concerning the topography, the topology/attractiveness and the complexity of a route.

Topography (physical quality)	Topology/Attractiveness (psychological quality)	Complexity (mental quality)
» Distance	» Attractiveness	» Number and complexity of decision points
» Acclivity	» Availability of facilities	» Availability of landmarks
» Level of Service	» Safety	
» Protection from negative external effects		

Table 1: Dimensions of Route Qualities.

3.1. Influence of Topography on Route Quality

The term topography refers to a wide range of physical route characteristics. Physical qualities can raise or diminish the effort needed to walk along the route. The main components of physical route quality include distance, acclivity, LOS and protection from negative external effects.

Distance

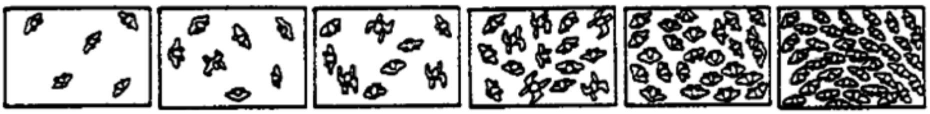
The length of a given route is a crucial factor when estimating the route quality. The distance to be covered is one of the critical factors which determine, if a destination is reached by walking or if other modes of transport are chosen. Under normal circumstances, a pedestrian will select the shortest path among several different potential routes to reach a desired destination.
The willingness to walk a certain distance varies individually. Young children and elder People naturally have difficulties to walk long distances; similarly disabled persons have fewer difficulties to reach their destination if the distance is rather short.
However, the effort to cover a longer distance can be alleviated, e.g. by appropriation of seating facilities.

Acclivity

Although people naturally try to avoid detouring, in some cases longer routes are preferred if the shortest path is too steep. Differences in level are also crucial factors of route qualities, as they may cause the exclusion of specific persons from some areas (e.g. if places can only be reached by crossing stairs, people in wheelchairs have no chance to arrive without help).
The installation of ascension facilities is very important to ease physical exhaustion and can improve the quality of a route to a great extend.

Level of Service

One of the key requirements for route quality is the provision of adequate space for the people using routes. The Level of Service (LOS) is an internationally recognized standard for the capacity of pedestrian spaces, which is defined by the broadness of the actual path and the amount of people passing. Level A describes the highest quality level, providing an average pedestrian area occupancy of at least 3.25 m^2 per person. Under these circumstances, standing and free circulation through the area is possible without disturbing others. On the contrary, the lowest quality level is defined by level F: the average pedestrian area occupancy amounts to less than 0.46 m^2 per person and practically all persons within the area are standing in direct physical contact with those surrounding them. This density is extremely discomforting, as no movement is possible within the crowd[8].



LOS A LOS B LOS C LOS D LOS E LOS F

Figure 2: Density of pedestrians defined by Level of Service.

Simulation models currently take this aspect into account. However, actual concepts assume that all persons behave equally. But the individual sense of discomfort varies and is determined by several factors (e.g. age, sex, cultural background, etc.); hence in future individual influencing factors have to be considered in the context of agent-based-modelling.

In urban surroundings due to limited space many pedestrian areas can not fulfil the highest quality level. Nevertheless, a low level of service creates great discomfort; therefore the achievement of the highest possible quality should be realised to improve the quality of pedestrian route networks.

Protection from negative external effects

People afoot are usually very sensitive to external effects like adverse weather conditions, noise and pollution[9]. They prefer routes providing protection from rain, snow, intense insolation, traffic noise and pollution. Planting can improve the route quality very effectively, e.g. by shading, reducing wind and keeping off the rain.

3.2. Influence of Topology/Attractiveness on Route Quality

Topology and attractiveness refer to psychological characteristics of route quality. The structuring of an environment can strongly influence the perceived comfort of a route. People usually prefer routes arousing a general feeling of well-being. Of course also physical characteristics may cause discomfort and have a bearing on the psychological perception of route quality. Apart from that, the main factors influencing the psychological qualities of a route are attractiveness, availability of facilities and safety.

Attractiveness

As already mentioned, many pedestrians forbear from walking the shortest route, choosing a "more beautiful" path instead. Highly structured environments providing a great amount of visual clues lead to the tendency to accept longer distances, while poorly structured environments have a boring affect and force people to become aware of the physical effort they have to make[8]. Despite that, salient objects (landmarks) can easily be found and remembered and help people to find the right way; thus the fear of getting lost decreases and a higher level of comfort is perceived.

Availability of facilities

Depending on the intended purpose of a trip, pedestrians demand the existence of specific facilities along their route. Generally, routes providing resting facilities are considered having a higher level of quality than routes without seating or similar amenities [10]. Additionally, several purposes of moving around require visiting specific places or services (e.g. certain shops on a shopping tour or places of interest for tourists). Frequently, people combine several aims; so some tasks are dispatched "en route" while walking to a specific destination. These supplementary intentions are taken into account when choosing a route – the probability of a route to be chosen increases with the amount of opportunities along the way.

Safety

Safety is a very crucial factor of route quality. Feelings of discomfort and insecurity can force people to avoid specific areas of a city. Although the feeling of safety usually has little in common with the actual crime rate[11, 12], route choice behaviour is strongly influenced by the fear of "dangerous" district and pedestrians prefer to give them a wide berth. Additionally traffic safety is an important factor of route quality, e.g. children are teached to use the safest path to reach school to minimize the risk of getting injured in an accident. Many pedestrians are well aware of their vulnerability and feel uncomfortably when being forced to choose routes with heavy traffic (e.g. under time pressure). Actions being taken to enhance the safety of pedestrian ways can increase the number of people choosing to walk there.

Nevertheless, some efforts to improve the safety of foot traffic are not successful. Pedestrian underpasses for example may protect people from serious traffic accidents, but contain other disadvantages like the necessity of overcoming the differences in level or a psychological founded unpleasant feeling.

3.3. Influence of Complexity on Route Quality

People walking afoot try to minimize the extent of mental work during the navigational process. Hence, routes offering a minimum amount of decision points are preferred, even if an alternative route is shorter. An adequate number of salient landmarks along the route can also help to reduce the required mental effort to reach a destination. So the main influencing factors of mental route qualities are the number and complexity of decision points along the way and the availability of landmarks.

Number and complexity of decision points

The less information has to be remembered, the smaller is the risk of forgetting or overlooking important facts within the description of a specific way. Consequently the simplest path offers a high quality, as both mental efforts and the fear of getting lost are diminished. The simplicity of a route and hence the danger of losing one's way are determined by the number of decision points to be passed and the complexity of the traversed intersections (i.e. the number of streets on an intersection) [13].

Availability of landmarks

The importance of landmarks in human navigation is revealed in several studies[14, 15]. Landmarks are stationary, distinct and salient objects or places, which serve as cues for structuring and building a mental representation of the surrounding area. The saliency of a landmark is a crucial characteristic: objects or places which are remarkable can easily be recognized and remembered and help to simplify the navigational task, as visual clues are mentally less stressing than the need to remember distances, directions or street names.

Figure 3: Landmarks can be situated along (local landmarks) or distant from the route (global landmarks) or they can be a remarkable part of the route itself.

Any object can be perceived as a landmark, if it is unique enough in comparison to the adjacent items. Routes providing salient landmarks at critical points are therefore easier to be followed than routes with few or less conspicuous landmarks.
Landmarks do not only serve as mental clues for remembering or recognizing the correct route to a specific destination, they also have great influence on the perceived psychological quality of a route. The presence of a sufficient amount of reliable landmarks minimizes the fear of getting lost and offers the possibility of paying attention to other concerns than wayfinding.
Considering the importance of landmarks and their positive effect on the solution of navigational tasks, it is obvious that future research has to concentrate on efforts to identify and include salient landmarks in route instructions for pedestrians.

4. Conclusion

Pedestrians show different preferences when choosing a particular route to a specific destination. The main dimensions of route qualities regard physical (e.g. distance, Level of Service, etc.), psychological (e.g. attractiveness, safety, etc.) and mental (e.g. complexity, availability of landmarks, etc.) qualities. Some attributes have influence on different types of route qualities. The estimation of different aspects of route qualities has to be focussed on in future studies.

As research has shown that landmarks are vital elements in pedestrian navigational strategies, some of the major challenges lie in the concept of Landmark Orientation itself and in the recognition of visually salient objects and their inclusion in guiding tools, as well as in the automation of the analysis process of the motion behaviour.
The research process about quality criteria for Landmarks is on a very early stage. The reliability of the chosen landmarks has to be determined by a quality measurement system to avoid ambiguous landmarks misleading the user. A system for qualifying landmarks has to be established to speed up future projects, data mining methods to provide a mechanism to automatically extract objects with a relative uniqueness in a given environment have been researched by Elias[16], but are so far only working in outdoor surroundings.

This paper summarizes the main dimensions of route qualities and their interaction with each other as a starting point for future research as a basis for further development of simulation tools for pedestrian flows in non emergency situations. «

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