Concepts for the Cartographic Visualization of Landmarks

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Abstract
Landmarks are an indispensable part of maps in mobile cartography applications.
In this paper we propose a design concept for the visualization of building landmarks in mobile maps. We consider four categories of building landmarks: well-known shops (trade chains), shops referenced by their type, buildings with a specific name or function and buildings described by characteristic visual aspects and examine how each of these groups is most effectively visualized. Possible visualizations differ in their abstraction levels, ranging from photo realistic image presentations, over drawings, sketches and icons to abstract symbols and words. As a guideline to designers we provide a matrix representation of the design space from which possible and recommended presentation styles for each building type can be identified.

1 Introduction
Maps are a very important means to provide spatial knowledge and communicate route information (MacEachren 1995, Kray et al. 2003). Therefore, pedestrian navigation systems rely heavily on maps in addition to positioning and routing functionality to convey wayfinding information to their users. Many recent research projects have developed prototypes for mobile services like GiMoDig, NEXUS, LoL@ and NAVIO. While some have focused on the technical aspects of mobile applications, others have examined the cartographic repercussions of small displays (Radoczky and Gartner 2005, Gartner and Uhlirz 2001). The effective integration of landmarks into such maps has not been examined in detail so far.

Research in the field of spatial cognition investigates the structure and elements of wayfinding instructions and provides another important foundation for the design of pedestrian navigation systems. Daniel and Denis (1998) have identified route actions (instructions about the next movement), orientations and landmarks as the basic components of (verbal) route directions. Further experiments have shown that the integration of landmarks into routing instructions enhances the perceived quality of the description (Denis et al. 1999). Tversky and Lee (1999) have compared the basic elements of route maps and route directions and found that both consist of the same underlying structure and semantic content.
Consequently, a good pedestrian route map should include the same elements as verbal directions. Landmarks will therefore form an indispensable part of maps in mobile cartography applications and appropriate visualization techniques for their effective presentation must be provided to designers.

2 Related Work
2.1 Landmarks in Wayfinding Instructions
Landmarks are significant physical, built, or culturally defined objects that stand out from their surroundings and therefore help locating the geographic position (Golledge 1999). They are classified as local and global or on-route and off-route landmarks (directly neighboured to the route or in the far distance like a tower or mountain chain). Furthermore, on-route landmarks are positioned between nodes, at decision points (a junction where a navigation

decision is to be done) or at potential decision points (where a navigation decision is possible but the route goes straight on) (Lovelace et al. 1999).

Currently, landmarks are not part of commercial navigation data sets. In fact, all available route planning and guidance applications use data sets that are tailored to the requirements of car navigation. With the increasing amount of pedestrian navigation applications on mobile devices, the urge to integrate important information for pedestrians rises, but is not incorporated in the databases yet. If information about landmarks were available, it could be integrated into the database and used for wayfinding descriptions.
Different research approaches try to develop formal models or extract landmarks automatically from databases and focus on local landmarks at (potential) decision points (Raubal and Winter 2001, Elias 2003, Elias and Brenner 2004). While these approaches currently confine themselves to the investigating of buildings as landmark objects, other topographic objects like parks, bridges, and railroad tracks are also suitable as landmarks and can be extracted from existing databases (Elias and Sester 2002).

The integration of landmarks into wayfinding descriptions requires a detailed analysis of the elements and structure of verbal wayfinding instructions. Research in this direction has resulted in an ontology for the wayfinding task (Winter 2002). As an alternative, the concept of wayfinding choremes (Klippel 2003) can be applied to fit the landmarks in the context of each route (Klippel and Winter 2005).

2.2 Graphic Design of Landmarks

For pedestrian navigation it is most important, that the user is able to recognize the landmark information provided by the system in his real environment without significant effort. Further constraints for the presentation are implied by the mobile context of use, e.g. a low cognitive load for the user and the requirement to derive landmark data efficiently (by automatic means) from existing information. The mode of presentation can either be verbal instruction transferred via speech output (problematic in public environments), textual instructions on the display (requiring high levels of attention) or a graphical map-like depiction of the situation. Here we focus on the visualization of landmark information with cartographic instruments for optimal communication.

Obviously, the user's perception of visualizations is the key to their effective use. Therefore, the design of visual representations of landmarks should be informed by knowledge about their recognition and interpretation. Designers as well as perceptual psychologists study the recognition and interpretation of visual information by users. Cartographer typically rely on empirical know-how: For conventional 2D maps practical experience over centuries of use has evolved into a collection of visual presentation techniques, design principles and guidelines that are widely accepted by designers (e.g. Bertin 1973). However, such empirical guidelines are difficult to apply outside their source domain as evidenced by the absence of directly applicable guidelines for the visualization of landmarks and for new forms of geo-visualization (e.g. 3D maps) in general. Several researchers have examined the impact of different visual designs in navigation applications:

Deakin (1996) examined the integration of landmarks into graphic representations or maps for wayfinding purposes and discussed several aspects. The user test with street maps indicates that supplemental landmarks improve navigation performance. In this study two different kinds of landmark portrayals were used: a geometric, symbol-like representation and pictorial, stereotype sketches. It was assumed that the stereotype sketches would provoke a strong natural association for the map user and would therefore be more effective than abstract geometric symbols. However, no significant difference between the two presentation styles could be found.

A test in the field of car navigation systems by Pauzie et al. (1997) investigated how landmarks could be represented in guidance systems. In their system the background portrayal on the screen was reduced to a turn-by-turn instruction represented by an arrow indicating the next driving action. Two types of pictorial designs were examined: a generic and a specific presentation of the landmark information. The generic pictogram was relevant for all cases belonging to the same category (like church, bridge, park, shop, bank). The specific one represented each landmark object located at the route in a realistic manner.
The experiment found that the way the landmarks were presented did not have a strong impact in terms of visual workload. The analysis of a follow-up questionnaire indicated that users preferred a generic portrayal for some of the object categories (church, bar, pharmacy, bridge) while a specific drawing was seen as more useful to represent other objects (bank, fast food, garage, supermarket). The difference depends mostly on the use of trade marks (or logos) as highly familiar elements in the graphics. The study concluded that the recognition and understanding of a landmark is closely linked with its familiarity to the driver (regardless of generic or specific characteristics of its design).

In Lee et al. (2001) a prototype for visual navigation using a multi-media map was developed. It used photographic images to represent landmarks and matched them directly on a perspective view of the map. Furthermore, full panoramic views from road nodes or sequential photographs along a path were used to provide visual information. The evaluation of the prototype has shown that landmark photographs must be taken from the line of sight in which the object is approached. Therefore several images for one landmark are required. Additionally, a truly effective landmark photograph should only show the landmark itself, and visual clutter like neighbouring buildings have to be removed. Radoczky (2003) also recommends photorealistic images for the presentation of landmarks, because no generalization operations are needed. The hitch with such an approach is the need for consistency with the real environment, requiring not only appropriate images for different seasons but also updates when structural changes are made to the landmark object.

A further aspect is to visualize salient objects by means of cartographic generalization. For example important information in a map can be emphasized by using generalization operations like enhancement of the target object itself and simplification or aggregation of the background objects (Sester 2002).

2.3 Aspects of Visual Cognition

Another source for information on how users interpret what they see is the domain of perceptual psychology, where researchers aim to develop a detailed understanding of the function of the human visual system. Two prominent theories aim to describe how objects are recognized visually: Image-based object recognition and structure-based object recognition. The first proposes that we recognize an object by matching the visual image with a snapshot stored in our memory. The second follows the idea that objects are analysed in terms of primitive 3D forms (geons theory) und structural interrelationships (Ware 2004).
While significant progress has been made in the understanding of individual processing steps within the human visual system, it is currently not possible to derive accurate predictions regarding the effectiveness of visualization techniques from these, as many processes remain active areas of research and complex interdependencies are involved in the whole process that are still little understood. However, design guidelines can be derived for perceptual

psychology research with regards to the (potential) impact of certain visual features like texture patterns, preattentive visual features as well as silhouettes and contours.

Silhouettes as part of the structure-based object recognition assume an important role in perceiving the structure of objects. Simplified line drawings are often equal to silhouettes and many objects have particular silhouettes that are easily to recognize. One of the consequences of structural theories of perception is that certain simplified views should be easier to read. So a depiction of a hand could be perceived more rapidly in the form of a simplified line drawing than in the form of a photograph. But others studies show that time is needed to perceive details, so simplified line drawings may be most appropriate only when rapid responses are required (Ware 2004).

If the necessary information is not perceivable from the silhouette itself, line drawings are the least effective mode of presentation: Ryan and Schwartz (1956) tested the speed of perception of relevant details in different presentation forms. The four principal illustration modes analysed were photographs of the object, shaded drawings, line drawings and cartoons (comparable to cartographic generalized depictions: the original figure is distorted to emphasize the essential spatial relationships). The time needed to perceive the detailed structure was measured and it showed that cartoons were the most quickly perceived group and line drawings were the most difficult to perceive. Photograph and shaded drawings were about equivalent and fall somewhere between the others.

The adequate presentation of point information should take into account the research of ergonomic guidelines for the design of pictorial information (Bruyas et al. 1998): Basic requirements regarding recognition and understanding of symbolic information demand fast understanding with no ambiguity of graphical representations. Well designed pictorial messages enable quick visual information processing in comparison to textual messages. And because of their compactness pictograms are more efficient than textual information in case of limited surface display. The recognition performance depends on the combination of essential, neutral and additional elements in the pictogram: Essential elements are the typical attributes that are necessary to recognize the object at all, but too much unnecessary detail disturbs the quick understanding of a symbol. Whether confusion of the sign with similar objects occurs, depends on the familiarity of the user with the typical attributes of the object. This can be different according to the user's population, his culture and his belonging to a generation.

For the development of appropriate visual presentation techniques for landmarks and corresponding design guidelines this suggests an approach that builds on existing design and cartographic expertise and insights from perceptual psychology to explore the options of the design space in a systematic way. The different options for presentation techniques are systematically examined to select promising options and refine the designs that are then evaluated in user studies.

3 Types of Landmarks

3.1 Classification of Features Types

As part of a master thesis a user questionnaire was conducted in which 20 people were asked to describe two different pedestrian routes in the city of Hanover (Lübke 2004). One of the routes leads from the main train station to the main university building, crossing the inner city centre with shops and pedestrian areas. The other leads from a student resident building to the cafeteria of the university, crossing a residential district of the city. Both routes are about 2 kilometres long. The participants were 10 male and 10 female students of the university that have all lived in Hanover for several years. They were instructed to recall the routes from their mind and to write down the wayfinding instructions for a pedestrian unfamiliar with the area. The routes were given by naming the start and end points of the route. For both routes the descriptions resulted in a number of different route choices, so not all descriptions have the same content.

The route descriptions were analysed with regards to the landmarks used. All referenced objects were counted and divided into groups of object types. Here five different groups were distinguished: Buildings, monuments (statues), plazas (like market squares or big traffic junctions), references to public transport (underground stations, bus stops, tram tracks) and others (parks, bridges, pedestrian zones, stairs, cemeteries). The distribution of the objects in the route descriptions is shown in Table 1.

Table 1: Distribution of object types in route descriptions

Object Type	**Route 1 (University District)**	**Route 2 (City Centre)**
Buildings	20 (50 %)	32 (55 %)
Monuments	1 (2,5 %)	6 (10 %)
Plazas	3 (7,5 %)	5 (8 %)
Public Transport	6 (15 %)	7 (12 %)
Other	10 (25 %)	9 (15%)
Total	**40 (100 %)**	**59 (100 %)**

Despite the fact that the routes differ significantly in their environment (Route 2 leads through the shopping area in the pedestrian zone, Route 1 leads through a typical residential area and the university campus), in both routes about 50 % of the referenced objects are related to buildings. The proportions of the other groups stay the same. It should be kept in mind, that these are only preliminary observations, since only two different routes described by twenty people were examined so no assured statistic statement is possible. Based on the previous research on landmark use and backed by these findings we focus on the visualization of buildings as landmarks. Since most navigation aids are used in urban areas, an optimal representation of buildings as landmarks is a central issue.

3.2 Characteristics of Landmarks

Buildings can be further divided into groups depending on the function or kind of description of the building in the route instructions. For the purpose of this study we distinguish four, groups (see Table 2). The first group consists of shops and restaurants referenced by their trade name (like H&M, Kaufhof, McDonalds), the second group of other businesses is described more general with the type of function (like hotel, pharmacy, hairdresser, butcher). A third category is formed by buildings that are referenced by their general function (library, church, university building or unique name (like Anzeigerhochhaus, Regenwaldhaus). In most cases the proper name is combined with the function (Luther church), so we combine those. The fourth category covers buildings that are specified by a description of specific visual aspects (the large yellow house, the red clinker brick building).

Table 2: Distribution of different building types in route description

Building Type	**Route 1 (University District)**	**Route 2 (City Centre)**
Shop (referenced by name)	4 (20 %)	18 (56 %)
Shop (referenced by type)	3 (15 %)	8 (25 %)
Function / Name	7 (35 %)	6 (19 %)
Visual Aspect	6 (30 %)	0 (0 %)
Total	**20 (100%)**	**32 (100 %)**

If we compare the distribution of objects, it seems that the route environment determines the kind of landmark building description. In the city centre the trade names of shops are preferred, whereas in areas where no trade chains are available other building descriptions using the function or the visual appearance of the object are given. Consequently, it can be hypothesised that the communication and recognition of trademarks is easier than the comprehension of a more complex description of individual visual aspects.

3 Designing Visualizations

4.1 Developing Guidelines for Visualization

Because the building landmarks separate into four categories, we propose an individual designed visualization for each group to communicate the landmark information in an ideal way. This means that the user must be able to recognize the graphics fast and identify its correspondence in the environment easily. Several approaches to the visualization of buildings have been proposed. Some of them are used especially for landmarks, others stem from the field of 3D-City Models: In Lee et al. (2001) cutouts from photographs are taken and put directly on a map to illustrate the individual facades of landmarks. In contrast to this, non-photorealistic rendering techniques abandon the idea of images close to reality and present 3D city models in a comic-strip like style rendered by computers (Döllner et al. 2005). This kind of design is comparable to traditional Bollmann maps and is now often used for touristic maps to present important tourist sights as a 3D-representation on a 2D-map (see Figure 3). A further cartographic technique is to substitute the original object with a map mark whose style may range from mimetic to arbitrary (see Figure 1). If the presentation is shrunk to a point symbol, there are different ways to compose the sign (see Figure 2): the iconicity of the symbol is very high if the sign is pictorial designed, and very low if the sign is a geometric, abstract marker (MacEachren 1995). Pictorial signs have the advantage to be recognised easily, because no sign interpretation process is necessary. It is sufficient to match the pattern of the sign to the environment. This requires that the sign is not too detailed or confusable (Bruyas et al. 1998). From this point of view logos of trademarks represent pictorial symbols and are therefore useful candidates to depict trade name shop landmarks (see Figure 4).

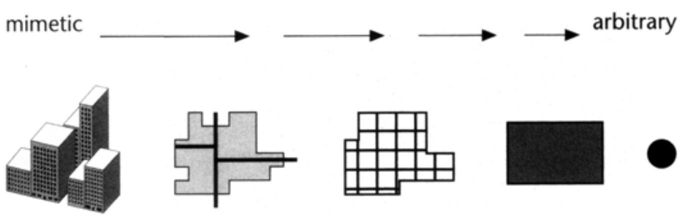

Figure 1: Mimetic to arbitrary continuum of map markers (taken from (MacEachren 1995), pp.259)

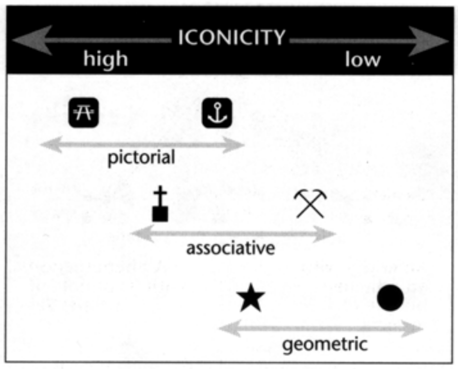

Figure 2: Abstractness of point symbols (taken from (MacEachren 1995), pp. 262)

Figure 3: Touristic map with 3D-tourist sights (taken from touristic map of city Kempten)

Figure 4: Logo icons as landmark representations (cut-out taken from (Klippel 2003))

Altogether, these kinds of depictions form a continuum of different levels of abstractions: on the one side realistic reproduction (in form of a photographic image or realistic textured 3D-model) on the other side abstracted presentation as (geometric) symbols or even as words (considering the alphabet as abstract signs) (see Figure 5). A key challenge for map designers is to select appropriate visual presentations while considering secondary design constraints (e.g. desired visual style, restricted color schemes or consistent visual appearance). Also aspects of cartographic generalization have to be taken into account: the image of the original object has to be scaled down to a size suited for a representation in a map. Therefore, some of the conditions under which generalization procedures have to be used in maps also apply here (Shea and McMaster 1989): congestion (too many features in limited space), coalescence (visible details depend on resolution of output device) and imperceptibility (feature falls below a minimal portrayal size) necessitate the abstraction of the visualization of an object.

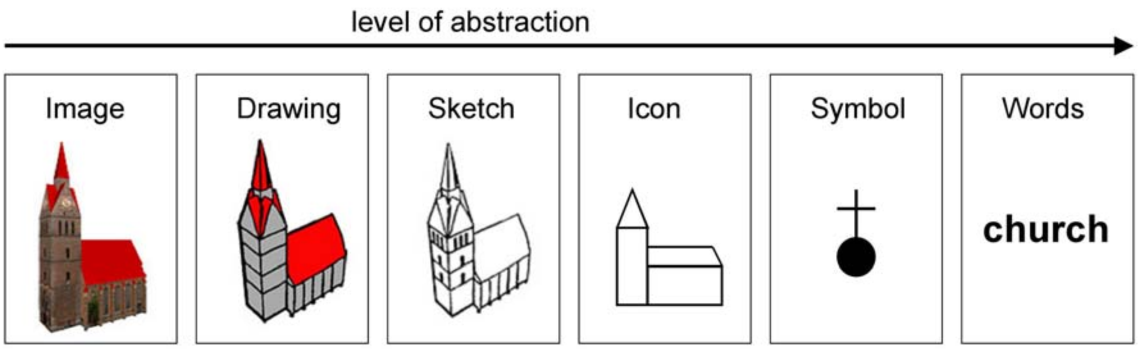

Figure 5: Level of Abstractions for Visualization

To provide designers with a systematic approach we propose to base the visualization of landmarks on different levels of abstractions in order to communicate the different landmark characteristics appropriately. The combinations of landmark types with possible visualization styles spans a design space that can be represented as a matrix. In this matrix each landmark type is associated with one or more adequate abstraction levels for their visual representation (see Table 3). The information in this matrix captures experience in practical use and can serve as a guideline to designers. Of course, using words is always possible to convey the information properly, but is not the best choice regarding visual and cognitive workload (time needed to process the information). Therefore, words are only regarded as appropriate presentation form if there is no better way to convey it with graphical depictions.

Table 3: Design proposals for landmarks

	Image	Drawing	Sketch	Icon	Sign	Words
Shop (Name)			(+)	+		
Shop (Type)				+	+	+
Function/Name	+	+	+			+
Visual Aspect	+	+				

A trademark logo is accounted as something generally well known and easy to recognise, so a pictorial icon is the easiest form to convey the landmark information. Generally, no building description is necessary, but if the building is something (architectural) singular, a sketch with the outline the building may be useful additionally. If the shop is only referenced generically, especially designed pictorial icons or associative signs are suitable. In case there is no appropriate graphical sign to portray the shop type, words have to be used. Generally, the outline or visual details of the building have no relevance for the landmark information. Specific building functions are often linked to a particular appearance of the building, e.g. typical silhouettes (churches) or size, position and style (town halls and opera buildings are often large, singular buildings, sometimes built in a historic architecture style). Therefore, at least a sketch from the silhouette of the building, sometimes a drawing or image with more details about the façade is needed to recognize the object. The only solution to convey a proper name of a building is to reference it by name with words. If visual aspects are the important facts to describe the landmark, they have to be depicted by a detailed drawing or image of the object.

4.2 Design Examples

To receive an impression, first drafts of visualizations are designed. As we focus on pedestrian navigation services with mobile maps, we target small PDA and smartphone displays (specifically the HP hx4700) (see Figures 6-8). The drafts depict a reduced background map for navigating through a city environment: streets with names and building outlines are given. The colours are reduced to grey scale to improve the figure-ground contrast of the landmark objects. The landmarks are positioned at their original geographic location; therefore parts of the map are overlapped and not visible.

Figure 6: Image of function building

Figure 7: Drawing of function building

Figure 8: Icon of shop logo

The hypothesis of the design matrix has to be proved by a user test. The next step is to develop an adequate user test to provide evidence for appropriate abstraction levels.

Therefore, for each building type visual representations of all abstraction levels (see Figure 5) are generated. These will be presented to test users checking if the kind of depiction is recognizable and convey the landmark information completely. Besides the subjects will be asked, how they liked the type of illustration (to check if their anticipation about visualization is fulfilled). The results will allow to compare the relative usefulness of different landmark presentations and can serve as the basis to improve the design matrix for the visualization of building landmarks.

5 Conclusion and Outlook

The approach presented here is work in progress and proposes a design matrix as a visualization guideline for landmarks.

We have examined the different feature types that are useful as landmarks. We have found that about 50 % of all landmarks used in common wayfinding instructions are buildings and identified 4 different categories of building landmarks (well-known shops (trade chains), shops referenced by their type, buildings with specific name or function and building described by their visual appearance). For the visualization of landmarks from each of these categories the impact of different abstraction levels in visual design were examined, based on knowledge from cartography and perceptual psychology. These resulted in design recommendations that are captured in a design matrix that proposes different levels of abstractions as appropriate visualizations for different categories of building landmarks.

The next step of future work is to test these recommendations as experimental hypotheses with a user test. The results of this study will allow to replace the general judgments in the current matrix with detailed information on effectiveness and user preferences.

As a further outlook this knowledge could eventually be used in an automatic tool to provide designers with advice or provide a set of rules to produce the visualizations automatically from databases. Further work is necessary to understand the dependencies between user und preferred visualization. With this it would be possible to automatically adapt the visual presentation to a user and his specific task at runtime.

At last, the building landmarks discussed here represent only half of all landmarks used in common wayfinding descriptions. The extension of the approach to other types of landmarks is therefore another obvious direction for future work.

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