You Are Not Lost — You Are Somewhere Here

Falko Schmid, Denise Peters, Kai-Florian Richter
Transregional Collaborative Research Center
SFB/TR 8 Spatial Cognition,
Universität Bremen

Abstract

We present the concept of *route aware maps*. Route aware maps are a specific form of map-based wayfinding assistance. These maps focus on the essential information for getting from an origin to a destination (the route), but provide enough additional information to allow for error recovery and a wayfinder's global orientation within an environment. We believe that these maps are a promising approach to overcome two key problems of route-based wayfinding assistance: being lost due to unrecoverable navigation errors and lack of spatial learning due to the key-hole problem. Furthermore, we expect route aware maps to increase a wayfinder's confidence in the wayfinding task, which in return is assumed to improve the navigation performance.

1 Introduction

To successfully navigate, wayfinders need to know which decision to take at the crucial spots along their way, namely the decision points. If the environment is unfamiliar, wayfinders need assistance in taking these decisions. There is evidence that assistance is more efficient if wayfinders feel confident about taking the correct decision (Ross et al., 2004; Ishikawa et al., 2008). An important step in evoking this context is to keep a wayfinder in context, i.e., allowing for global orientation and, thus, providing "a sense of place" during navigation. In this paper, we will explore an approach to map-based assistance that enables just this sense of place.

Maps are frequently used in wayfinding assistance. Broadly, two different types of maps are employed. On the one hand, there are strip-like maps that only present the route to take.[1] These maps provide the smallest possible set of complete route information that is required to get from origin to destination; they have very little visual clutter as they *only* depict the route. Accordingly, in case a wayfinder deviates from the depicted route by mistake,

[1] This is essentially also what happens in today's mobile navigation systems: they provide information on the next action to be performed when it is due, but hardly provide any overview information that would allow users to orient themselves more globally.

there is no information available to reorient. As a result, the wayfinder is lost. This also holds for sketch maps as they are often provided by other humans. These maps usually depict some salient features encountered along the way additionally to the route, but still do not allow for a more global orientation as the embedding of the route in the evironment is missing.

On the other hand, there is the classical city map (or nowadays the electronic map printed from the internet). These maps show the depicted information evenly distributed accross the selected area. Such maps contain a lot of excess information and, thus, visual clutter; extracting, understanding and keeping track of the route to take is cognitively demanding. In principle, these maps allow for communicating a sense of place, however, this is masked by having to deal with a lot of unnecessary information.

In the following, we outline an approach to combine the best of both (map) worlds. We present the concept of *route aware maps* (RAMs) that concentrate on the route as the essential information to reach a destination, but also depict the information needed for (global) reorientation in case a wayfinder loses track. Route aware maps are supposed to provide a wayfinder with a sense of place along the complete way from origin to destination and to impart the feeling of efficient and safe navigation.

2 Route Aware Maps

Route aware maps combine the concept of strip maps with means to allow a wayfinder to keep a global orientation and to recover from wayfinding errors. Additionally they should increase a wayfinder's confidence during navigation. By embedding the route in its spatial context on different levels of granularity, we create a tool which also allows for approximate navigation. Even if a wayfinder makes an error, due to the additionally presented information we enable approximate localization and navigation (see Section 2.3.1 for more details).

The starting point of route aware maps is the route itself. This information is extended to include additional information for orienting at origin and destination, for recovering from wayfinding errors by providing alternative routes, and region and landmark information for global and local orientation. These aspects are detailed in the following. Section 3 provides an example of a route aware map that illustrates the combination of all these aspects.

2.1 Initial and Final Orientation

Origin and destination of a route are crucial parts for successfully finding one's way (Michon and Denis, 2001). At the origin, wayfinders need to initially orient themselves in order to get off in the right direction; the destination needs to be clearly identifiable in order to know that wayfinding has been successful. Therefore, around origin and destination we display the environment in more detail. This means we represent the street network in these areas in full detail, which allows a wayfinder to match the spatial situation perceived in the environment with that depicted on the map.

For the destination region, this serves another purpose. Especially in dense urban areas, such as a city center, there is an increased chance to miss crucial decisions and an increased need for reorientation. For example, this may be caused by a complex system of one-way streets or the need to find a parking space. Thus, it is sensible to not only guide wayfinders exactly to the destination location, but also to enable them to freely navigate in the nearby surroundings.

2.2 Along the Route: Local Error Analysis and Alternative Paths

As discussed in the introduction, wayfinding is a complex process in which errors easily occur. The sources of these errors are manifold. Errors may happen due to the wayfinder being inattentive, because the provided assistance (in form of a map) does not match with the encountered situation in the environment the way it has been expected, or simply because the environmental situation itself is ambiguous and hard to understand. While it is impossible to predict every possible error that may occur during wayfinding, in route aware maps we integrate information that allows recovery from two classes of errors:

1. *Local ambiguous* or complex configuration of an intersection: based on capturing how humans conceptualize turns at intersections (Klippel, 2003; Haque et al., 2007), we can identify how many possible choices there are at an intersection and whether these choices potentially conflict with each other.

2. *Global ambiguous* situations can originate from 'monotone', recurrent, cueless environments (as they often occur in modern suburbs). Decision points, i.e., the relevant intersections, can be easily confused with other intersections due to the similarity in the environmental structure and the density of intersections.

The first error is tackled by analyzing the configuration of an intersection's branches. We employ a method we term *Choreme Analysis* (CA): we discretize all angles formed by the incoming branch with all other branches based on the wayfinding choreme direction model (Klippel and Montello, 2007). If according to this representation two or more branches head in the same direction and if any of these branches is relevant for the action to be performed at this intersection, a potential conflict is identified (cf. also Richter and Klippel, 2005). Figure 1 illustrates such a conflict: two outgoing branches of the intersection share the same direction concept. In this case we compute for every additional branch that heads in the same direction an alternative (sub-)route to the destination. This alternative route follows the 'simplest path' approach introduced by Duckham and Kulik (2003). The alternative route may (but does not have to) merge with the main route again.

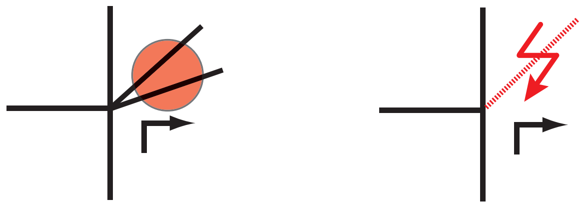

Figure 1: Choreme Analysis: Two outgoing branches share the same direction concept (left). A potential source for a navigation error is identified (right).

The second type of errors, namely errors resulting from the recurrent, uniform structure of an environment is analyzed in a similar qualitative fashion. A (configurable) number of intersections before and after[2] the relevant decision point is selected. For all selected intersections, we calculate a qualitative representation of their configuration using the CA analysis explained above. A similarity measure comparing possible turn directions that match across intersections is used to determine how similar these intersections are. Additionally, we check whether any of the intersections is uniquely identifiable by environmental features (see Section 2.3.2). If the similarity measure is below a threshold, we have identified another potential conflict and calculate alternative routes from the conflicting intersections.

2.3 Local and Global Orientation

So far we have only discussed information directly related to the route. But to be able to navigate successfully using only sparse information, we need context to clarify the relation of the presented information to the actual environment navigation takes place in. An important concept in this respect are regions. Some of the regions may be identifiable by using signage in the environment (e.g., districts in a city labelled on street signs), others may be clearly visible, such as large parks and water bodies. Further, local environmental features ('classical' landmarks) may help to ground the information represented on the map in the environment.

[2]Before and after are to be understood relative to the current movement direction.

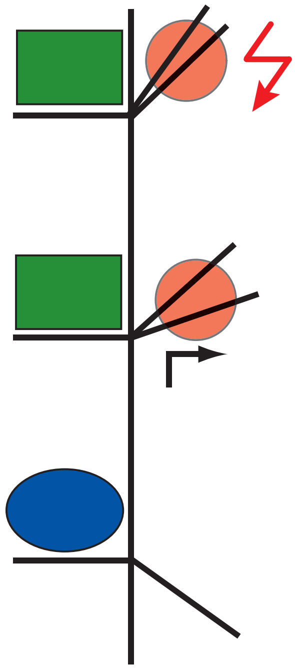

Figure 2: Similarity Analysis: Two intersections are similar due to the same features (similar outgoing branches based on the CA analysis; environmental features (the green areas) that are represented the same way). A possible conflicting situation is identified.

2.3.1 Regions

Currently, the impact of regions in human spatial conceptualization is increasingly recognized. Wiener and Mallot identified region based navigation strategies (Wiener and Mallot, 2003). Seifert et al. introduced a hierarchical spatial planning approach based on regions as primitives (Seifert et al., 2007). Schmid introduced an approach to generate maps based on individually known places and regions (Schmid, 2007). Thus, just as landmarks (see below), regions are recognized as primitives in spatial orientation, navigation and communication.

As a basis, we use a hierarchy of administrative regions (countries, states, cities, districts, etc.). Furthermore, large environmental features, such as parks or lakes and rivers, are treated as regions as well. To determine the initial granularity of a route, we identify that region which fully contains the route (e.g., "Bremen" if looking at an inner-city route, or "Germany" for a route connecting Hamburg and Berlin).

We then determine regions that are relevant for the route at hand. These are those on lower levels of the hierarchy than the encompassing region. To restrict the amount of information presented, we limit the represented regions to those being one or two levels lower than the encompassing region. We include regions the main route crosses or touches (as routes may incorporate the borders of regions which are often along main roads). These are the regions with immediate impact on the route, as they directly contain the route. Since these regions only indicate the spatial context of the direct surrounding, wayfinders may still get lost when wandering off the route. For this reason we also include those regions that are adjacent to the crossed regions. This allows for unambiguous relative localization, if the displayed regions are referred to in the environment (e.g. via signs). However, a distance threshold determines whether adjacent regions are really displayed—if they are too far off adjacent regions are excluded. This may, for example, happen if large regions are crossed by the route. Those regions crossed or touched by alternative routes are also displayed and, additionally, large environmental features in the vicinity of the route are included as well (again, this is determined by a distance threshold). We do not include regions adjacent to those crossed by alternative routes, unless they are enclosed by the main route and the alternative route at hand. Alternative routes are included for error recovery, but should not introduce unnecessary visual clutter.

Figure 3 illustrates the selection process:

- Regions A and D contain the starting point and the destination of the route
- Regions B, J, I are adjacent to regions A and D, respectively.
- Regions C, E, H are touching a depicted route (main route or alternative route, respectively).
- Region F is included as it is enclosed by the main route and an alternative route.
- G is intersected by a route (in this case the alternative route).

All other regions are excluded as they do not match with the presented selection criteria.

The depicted regions do not only provide context for navigation along the route at hand, they also allow for coarse navigation and orientation when offside the route. Reaching a specific region, wayfinders may approximately relate their current location to the depicted information and use this to decide on the further way to take; this is especially possible employing environmental features represented as regions, for example, a river. This way, regions contribute to fostering a wayfinder's confidence in navigating correctly and in being able to recover from errors.

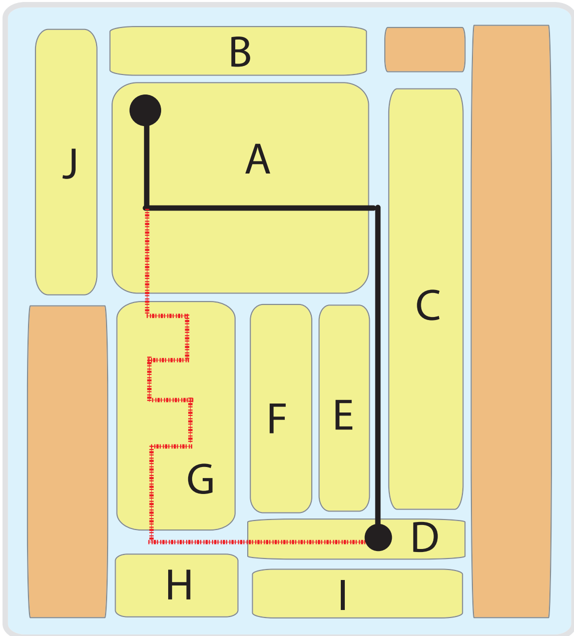

Figure 3: The region selection process: The outer blue region contains the complete route, the yellow regions are the regions with an impact on the route that are depicted in a RAM, the orange regions are excluded from presentation.

2.3.2 Landmarks

Finally, local landmarks are used in creating route aware maps. These landmarks serve two purposes: they help to disambiguate intersections and they foster orientation of wayfinders. In areas that are made up of structurally similar intersections, i.e., where the street network is very regular (see Section 2.2) landmarks may make the difference it takes to identify the intended intersection. Accordingly, for intersections identified to be structurally similar to their surrounding intersections, we check whether some landmarks may be used to identify them. This check is done as explained in our previous research (Richter and Klippel, 2005; Richter, 2007), but extended to include depictional considerations, i.e., whether other features located at neighboring intersections are depicted using the same cartographic style. If two different types of features are depicted the same way (e.g., a river and a channel may both be depicted as a blue line), they are not easily distinguished on the map and, therefore, do not unambiguously identify an intersection if both features are present in the surrounding area. In case a landmark located at the intended intersection unambiguously discriminates this intersection from its neighboring ones, it is included in the route aware map and, thus, solves a potential conflict.

Local landmarks may also be used to foster orientation, similar to global ones, i.e., those environmental features represented as regions. To this end, it is checked whether highly salient landmarks are located along the route (such as highly visible shops or monument buildings); these are added to the route aware maps. However, to avoid visual clutter, we limit the number of landmarks added this way to only a few key features. Checking for such landmarks, again, is based on previous work.

3 Closing Remarks

Figure 4 shows a made-up example of a route-aware map based on geographical data of Bremen. The example illustrates the different components of RAMs explained in the last section. The depicted street-network is embedded in the surrounding districts[3], alternative routes are presented at places that are likely to be problematic, and the map is annotated with global (the river) and local (the park, the pharmacy) landmarks for better orientation.

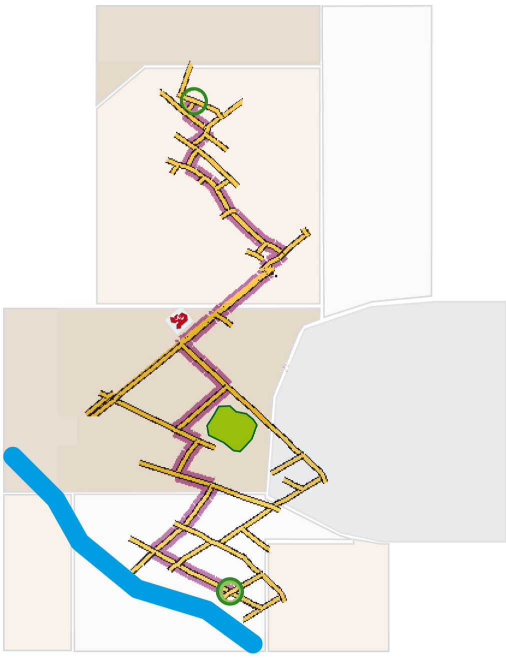

Figure 4: A sample route aware map. The origin is at the top, destination at the bottom (denoted by the circles).

While most of the basic functionality is already present in our map generation toolbox (Richter et al., to appear), we are currently implementing

[3] which, in the final application, would be labelled

a dedicated application for generating route aware maps. This application will be based on detailed geographic data provided by the Ordnance Survey and will allow for testing different parameter settings. We also plan to test the performance of RAMs in empirical wayfinding studies.

We believe that route aware maps as they have been presented in this paper are a promising approach for solving two (related) problems in map-based navigation assistance: 1) provision of focused, easy to access assistance that still allows for error recovery; 2) the key-hole problem. Thus, route aware maps are not only more reliable in a given wayfinding situation, they may also help to overcome a major problem of today's assistance systems, namely that users do not really understand the spatial situation they are in and hardly remember anything of the route after reaching the destination (Ishikawa et al., 2008).

Acknowledgments

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