Adaptive presentation of itineraries in navigation systems by means of semantic models

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ABSTRACT

In this paper, we introduce a technique for adaptive presentation of itineraries in navigation systems based on semantic models. We enrich waypoints with semantic information and display only those waypoints to the driver that he is really interested in, hiding information that will most probably be distracting.

Author Keywords

Model-driven UI Generation, Navigation Support

ACM Classification Keywords

D.1.2 Software: Programming Techniques—*Automatic Programming*

INTRODUCTION

Navigation systems are widespread tools in automobiles. According to recent german studies [5], the percentage of pre-installed navigation systems increased from less than 6% to 18% within the last six years (in Germany). The percentage of mobile navigation systems even rose from 1% to almost 31% in the same period. With regard to usability [7] and traffic routing [3, 11], constant progress has been made during the last years. However, there is room for improvement in many ways.

Usually, the presentation of the itinerary is very detailed – even if the driver knows parts of the route very well. This is often distracting and annoying. Presentation techniques that take the users knowledge and driving behavior into account can improve the user experience considerably.

Present solutions aim at optimizing routes without taking the driver's personal knowledge, experience, and preferences into account and, thus, are not personalized. However, incorporation of personal information could improve presentation of routes significantly. On the one hand, instructions should be rather short and abstract, if the user knows the particular area, and, on the other hand, more detailed, while driving through unknown territory.

In this paper, we introduce a concept to enhance the presentation of the route by adapting it to the driver and his preferences and experience. For that purpose, we use semantically enriched models of the itineraries. In the end, the user should only see and hear *necessary* and helpful information instead of every single detail. Besides automated adaptation, the user has always the option to adjust the level of detail of the presentation manually.

RELATED WORK

Even if not focused on the particular problem depicted in the introduction, research has been conducted, in order to enhance presentation of itineraries.

A generalization technique that is geared to hand-drawn route descriptions and tries to solve the visibility problem of minor parts of an itinerary on a constant scale factor, is presented by Agrawala and Stolte [1]. They assume that humans describe routes in a different way than systems. People always relate to their own knowledge of the environment in a route description.

In addition, humans are mainly interested in information about the main waypoints and not the connections between them. They rather neglect the length of individual roads and instead raise their visibility or specific route characteristics (e.g. a big building or a roundabout) that they consider to be relevant to the navigation process [9].

In [6], Klippel et. al. propose a formal characterization of route knowledge, that allows for communicating information on how to reach a destination (even if a specific route is not known). Therefore, changes of granularity in route directions resulting from combining elementary route information into higher-order elements (so called spatial chunking) are discussed.

The authors of that paper also point out, that if environmental features are taken into account for structuring route knowledge, a coarser perspective on the required way-finding action than simple turn-by-turn directions can be provided. Variable granularity in route directions is also focused in [10]. However, while these approaches attempt to improve the route guidance by structuring route knowledge, they disregard the individual needs of the user.

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Most users have at least some knowledge of the vicinity they live. Although most people are familiar with their hometown or parts of it, they receive detailed route instructions from their device. A personalized granularity in route directions regarding the special knowledge of a user about the routing environment could lead to a more intelligent navigation system.

Such a comprehension of the user's knowledge about several parts of the route has been largely neglected by device manufacturers and suppliers of relevant web services, so far. The fact that such navigators would need an extended learning phase to provide customized assistance, is mostly seen as a major drawback.

To address this problem, Richter and Tomko present an approach to generate adaptive route directions generated through a dialog-based knowledge recognition process [9]. Therefore, the way-finder by default is presented with with destination descriptions, assuming that the environment is known, and can request more detailed directions using a provided dialog facility, if the currently presented information is not adequate.

We argue that a system could automatically provide user specific route directions based on a learning process that primarily is supported by a dialog-driven approach. Therefore, we act on the dialogue suggestion by Richter and Tomko, which in a first step can enhance the learning process to solve the cold start problem of completely unknown user preferences and also avoids the user from unnecessary interactions while driving.

ITINERARIES AS SEMANTIC MODELS

In order to personalize the route descriptions, we need a detailed and machine-readable model of the route in order to adapt it to the user's knowledge and preferences. Thus, we have to encode all information that may be helpful to decide whether a particular part of the route should be displayed in detail, only briefly, or not at all.

Itineraries usually are described by a set of waypoints, which represent positions between origin and target location. The idea is now to semantically enhance the waypoints in order to use the semantic information for filtering.

We therefore propose a layer model where each layer represents a degree of granularity in the route presentation. The lowest layer contains the default route directions including all details of the itinerary, as known from conventional systems. All upcoming layers show, depending on the level of abstraction, only certain parts of the route and provide the related routing instructions.

To achieve this goal, we transform the route description into a semantic model, which allows us to characterize each waypoint on the basis of its properties comprehensively. In addition to the general information of an itinerary, such as location coordinates, street name and driving instructions, a semantic description includes further information, such as a classification of each route point on the nature and type of geographical conditions. This means that a place can either be characterized as town, city, region or even a country and the connection between two places as a street, road or motorway. This hierarchical distinction enables later filtering to distinguish the different levels of abstraction. For the transformation every route object provided by online web services like Google Maps[1] can be used.

If a user has sufficient knowledge about the environment in a particular area, only a few instructions, limited to the issue of the next motorway link and the direction of the nearest town, may be appropriate, while in areas less or not at all familiar, a detailed route guidance without any abstraction will be a better choice.

For enriching semantic itinerary models with further information, geo-services such as LinkedGeoData.org[2] can be used. Those services provide comprehensive background knowledge related to spatial features of the ways, structures and landscapes around the waypoints of an itinerary [2].

Other services that provide additional information for route enhancement are, for instance, OpenStreetMap[3], GeoNames[4], or Topocoding[5], which enables us to add the related altitude value to each waypoint. Figure 1 shows such a semantic route representation enhanced with additional information.

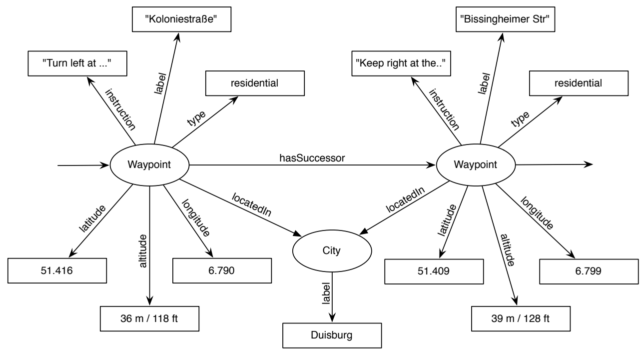

Figure 1. Semantic route representation enriched with additional information.

An itinerary that has been semantically enriched in that way, finally, facilitates the applications of particular "views" on the route. This mechanism can be used to show or hide certain waypoints and create an optimal presentation based on the users' preferences and experiences.

The navigation system could, for instance, only display prominent waypoints such as freeways (if the user already has basic knowledge of the area). In this case, the directive could simply be "Head for Freeway 1", whereas other users would receive a set of detailed instructions leading the driver to the particular freeway.

[1] http://maps.google.com/
[2] http://linkedgeodata.org/
[3] http://wiki.openstreetmap.org/
[4] http://www.geonames.org/
[5] http://www.topocoding.com/

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The use of semantic models has different advantages compared to traditional ways routes are displayed in navigation systems:

- *S*tandardization: As information comes from various sources, each with their own formats and specifications, we need a standard to cover all these information. Semantic models are flexible enough to import all information provided by the original sources and make them accessible in a unified way (e.g. via SPARQL).
- *E*xtensibility: The characteristics of semantic models mentioned in the last paragraph allow integration of new information sources as well, regardless of their format.
- *E*ase of data processing: If the models are encoded in a standardized language like RDF or OWL, they can be queried using the *SPARQL Protocol and RDF Query Language (SPARQL)*.
- *A*dditional services: The use of standardized semantic models lays ground for future services apart from classical navigation. Recommender systems that incorporate semantic data [4], could for instance find filling stations with attractive bargains or popular restaurants on the way. Ideas for realizing such value-added services have been introduced in a german publication written by some of the authors [8].

LAYERS OF DETAIL

As an intermediate step towards a personalized presentation, we create a layered model based on the semantic route, so that the distinct layers reflect a particular level-of-detail. The bottom layer contains all waypoints, whereas the level-of-detail decreases on each layer (see Figure 2). SPARQL queries can be used as a filtering technique in order to show or hide certain waypoints for each layer.

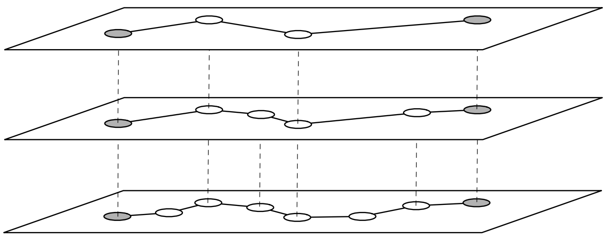

Figure 2. Particular "views" on the route of a semantically enriched itinerary.

Each layer can be seen as a "view" on the itinerary showing or hiding certain details. The base-layer corresponds to the way traditional navigators would display a route; it simply contains every single waypoint. If a higher level of abstraction is selected (either automatically or by hand), the navigator hides certain waypoints and only displays more prominent ones. If the adaptation process is supposed to be automatically instead, the level of detail can be adjusted rule-based or by other means.

ADAPTIVE ROUTE GENERATION

The layered model now allows us to switch between the levels-of-detail, such as zooming in or zooming out details of the route presentation. We provide means of manually and automatically switching between the degree of detail as well as choosing the granularity based on user profiles.

Manual Adjustment

A simple way of adjusting the presentation could be by interacting with the driver. Initially the user should be able to convey known regions dialogue based at the beginning of the guiding process, where the route has been calculated. Therefore, he can check the known parts of the itinerary step by step. Such a procedure is necessary on each guidance where no part has been marked as well known, yet. This approach is similar to the dialog-driven process described by Richter et. al. [9].

The significant deviation in our approach is that we use the dialogue initially to customize the whole route guidance on the users individual needs, while Richter provides abstract instructions by default and requires user interactions at any time the user needs more detailed ones. Nevertheless, that kind of interaction facility we will provide additionally. The user can use a simple widget such as a slider or a turning knob, which he can set up or adjust the level of detail manually.

This functionality is available at each stage of the guidance process to allow the user to react appropriately in any situation depending on his individual perception. The opportunity to interact with the system at any time also enhances the satisfaction, thus, the acceptance of the automated process can be improved. Figure 3 shows an example of such an interaction widget. The user interface provides two buttons for changing the level of detail. If the user pushes the "More" button he receives more details of the itinerary presented on the screen and as driving instructions. A push on the "Less" button on the other hand causes a higher level of abstraction.

Figure 3. Interaction widget for manually adjust the level of detail.

User Profiles

For more sophisticated adaptation effects, dedicated user profiles cam be maintained to keep track of the user's knowledge and preferences. The system keeps track of all places and routes the user has marked as well known. It then can

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provide recommendation for the levels of detail on new calculated itineraries. In this way, a user knowledge model evolves from the users interaction in a step by step manner. Figure 4 shows a schematic example of a map representing the users area knowledge, where the dark regions are assumed as well known and the lighter ones as unfamiliar.

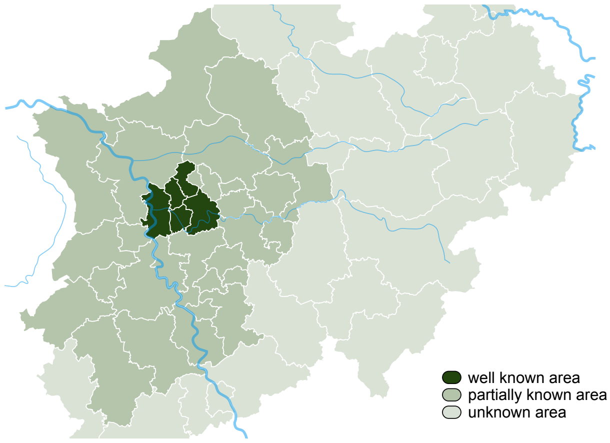

Figure 4. Schematic representation of a users individual area knowledge. Dark areas represent well known areas while bright regions are less known.

Automatic Adjustment

In order to automatically switch between the levels of detail, knowledge about the user is necessary. On the one hand, the system could incorporate information explicitly entered by the user or, alternatively, keep track of his itineraries, in order to "learn" such a profile. The first case requires user interaction, for instance by tagging certain areas on a map as "well-known" or selecting them from a list of areas.

If the system should learn and update the profile automatically based on the driver's routes, it has to keep track of the waypoints on these routes and autonomously mark them as "rather known" or "well-known". The level of detail then is based on the supposed degree of familiarity with the particular route section.

Combining explicit profile information with learning, of course, is an opportunity as well.

DISCUSSION

In this paper we presented an approach for enriching the waypoints of itineraries with semantic information, enabling a route guiding system to provide an adaptive user interface. If a driver already knows parts of the itinerary very well, the system presents the route by adapting it to the drivers preferences and experience.

During the workshop, we would like to discuss, among other issues, the following questions: What would be better? Tagging a route object with semantic information vs. converting the whole route as a semantic model? What could be alternatives for interactive definition of already known waypoints (e.g. marking them at the route planning process). How could a learning system look like that recognizes frequently used route parts or repeatedly visited places?

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