Using Focus Maps to Ease Map Reading

Developing Smart Applications for Mobile Devices

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Maps are good means for representing spatial knowledge. They are commonly used to aid in spatial tasks. Today, Geographic Information Systems (GIS) allow for the construction of digital maps on the fly, but the process of map reading still involves a lot of cognitive work. We aim at the development of GIS components that create maps taking into account that different tasks demand different affordances. In this paper we present the concept of *Focus Maps*. Focus Maps ease map reading in that they focus a user's attention on the region of a map that is currently of interest to her.

1 Introduction

Location Based Services (LBS) and mobile applications on next generation smartphones and Personal Digital Assistants (PDAs) promise to offer a wide range of new services on new electronic devices. Designing such applications in a way that makes them easily usable for untrained users is a necessity to make the sometimes "overhyped" mobile services a success. This means we have to think about how these services can be designed such that their use requires as little cognitive effort as possible. Focusing on LBS and services for mobile devices, applications exploiting knowledge about the current location (seem to) offer some benefits. Such applications often provide navigation support and need to show the current position of the user or the location of nearby shops or sights. For each of these application types maps are of major importance as they express a lot of information in a single representation (Freksa, 1999). Fundamental interfaces for map services are defined in the Web Map Server Specification (WMS) by the Open GIS Consortium (OGC, 2001) as creating maps for the internet on the fly is now state of the art. But the design of these maps is in most cases "hand-made", since the automatic design of maps is still a challenge (Zipf and Malaka, 2002). Examples of specific algorithms include the design of route-instruction maps (Butz *et al.,* 2001). An additional task is the incorporation of appropriate landmarks (Werner *etal.*1997; Kray 2002).

Designing maps for mobile devices with specific technical limitations (first of all screen size) require special considerations. Within the Deep Map Framework (Malaka *et al.,* 2000) and as part of the EU funded CRUMPET project (Creation of user-aware mobile services personalized for tourism) (Poslad *et al.,* 2001) the European Media Laboratory (EML) develops such next generation mobile services in the context of a mobile tourist information system.

The developed system is based on a number of software agents that solve different tasks and communicate their results and requests using the FIPA ACL (Agent Communication Language of the Foundation for Intelligent Physical Agents) (FIPA, 2000). One of these agents, the Map Agent, is used to create and present maps to a user according to a range of previously specified parameters.

2 Towards a Framework for Adaptive Map Production

As we get closer to the automatic production of user specific maps, we find that there are different information requirements for users with different interests, knowledge of the area and cognitive capabilities – influenced by age, education, physical capabilities (Golledge *et al*., 1999). Handicapped persons, e.g. visually impaired people, are a typical example as they require larger symbols and can, thus, only be provided with less detail. Another example are children as they have different mental capabilities and different previous knowledge than adults (cp e.g. Siegel & White, 1975).

Furthermore, it is helpful to know about the familiarity of a user with a given area (e.g.Lloyd, 1989). This influences the detail needed and the amount of descriptive text on a map. A framework for map generation taking steps necessary to adapt a map to the broad range of parameters into account is further discussed in Zipf (2002). For different types of maps this framework, that does not yet cover all parts and parameters, needs to be extended or modified. In the following sections we give an overview of a part that has already been implemented. In a similar approach to research in natural language processing (Haller & Ali, 1990) it allows to create maps that focus a user's attention on a specific area of the map (cp. Egner, 1998).

3 Concept of Focus Maps

The maps created by the Map Agent need to offer the best help possible for a given task, e.g. finding the way to a specific location or determining the current position. Therefore, the design of such maps and the way they are presented in a GIS is of special concern. These maps ought to emphasize the relevant information in order to be easy to process for a user (e.g. Freksa, 1999). Ideally, a map allows a user to identify and extract that part of information needed for her given task instantly while she reads the map (Barkowsky & Freksa, 1997).

Looking at the tasks mentioned above, the relevant (spatial) information is clearly contained around the path a user of a GIS is about to take or in the area she is currently in. Thus, these areas are of special concern to her. At first sight this seems to be all information needed to perform the task successfully. Even though it is tempting to skip all other information this is troublesome. Localization and orientation might be aggravated: a user may use regions of the map well known to her to orientate herself by relating the area of interest to these, which is impossible if they are not displayed. And changing the current navigational goal or the task is unnecessarily severed if she has (visual) access only to the regions that were previously deemed relevant.

Thus, other strategies must be applied. We came up with the concept of *Focus Maps*. A Focus Map is designed such that a user's attention is directly drawn towards the region of interest,

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i.e. the processing is focused on the relevant information. The map construction process concentrates on this region without ignoring other parts of the geographic space; it is shown in full detail while the rest of the map is displayed such that it is easily recognized as neglible. With Focus Maps a user's interpretation process is inadvertently focused on the region of interest. Thus, we are able to ease the map reading process.

4 Implementation

This section explains a prototypical implementation of the concept of Focus Maps. We show how the region of interest can be determined and some ways to focus a user's attention. But first we give an overview of the process of map creation performed by the map agent.

4.1 Process of Map Creation

The data, i.e. the representation of a spatial area a map will be created for, is organized and structured according to the specifications of the OGC. It is stored in a spatial database on a server. The Map Agent requests the currently needed data from this server.

The amount and kind of data that gets requested by the Map Agent depends on the scale the map will be displayed at and the area that will be shown. Using a bounding box that comprises the chosen area, a spatial request is sent to the database which returns all data that lies within the boundary with each element representing a feature. Features are objects of the real world like water bodies or buildings, but may also be knowledge about objects like place names or objects' functionality. As usual in GIS applications the data is organized in layers, i.e. there is a single layer for each class of (spatial) features.

The map is organized in layers, as well, created by the Map Agent for each class of features. During the display process layers are drawn successively in the order they were created. All features are generalized using the Douglas-Peucker algorithm (Douglas & Peucker, 1973) unless their extend is smaller than a certain threshold in which case they are omitted. The degree of generalization depends on the scale chosen.

4.2 Determining the Region of Interest

The region of interest comprises the region a user is currently located in and, if the current task involves movement, the regions she is about to encounter.

The actual shape of a region is not fixed in our implementation. The map gets divided in different areas we call *zones*. In the simplest case one zone is the region of interest and another makes up all the rest of the map. By using more than two zones, it is possible to define different degrees of interest. There exists no predefined relation between these zones. Thus, it would be possible to use disjunctive zones. But as one zone has to be the area of interest, also called *innermost zone*, and all other zones represent regions of decreasing interest they get ordered with respect to the degree of interest they represent and each zone is contained in the zone that represents the area of next lower interest.

Different parameters are used to determine a zone. A zone given in world coordinates represents exactly this area of geographic space. It is also possible to set the center of a zone, its size determined by a percentage value. Such a zone comprises a region whose size is calculated according to the percentage given. These two kinds of zones are called *fixed zones* as their center is always located at the same position. A third kind is called *centered zone*. To create such zones a percentage value is given which determines the region of a map the zone covers; its center is always in the middle of the current view. The area covered by this zone may change but the region of interest is always located in the map's center.

4.3 Focusing a User's Attention

We achieve the effect of focusing a user's attention by taking into account two factors: generalization and color. One determining factor of which region a user's attention is drawn to is the amount of features and the degree of detail in that region. Therefore, an effect of focusing can be created by generalizing different parts of a map differently. Features lying inside the innermost zone are generalized just as far as this is necessary according to the given scale. With each following zone features are more and more generalized and more and more features are omitted. This works – as with increasing distance to the region of interest zones contain less and more generalized features – almost like a funnel drawing a user's attention in to the region of interest.

Currently, only basic geometric line simplification using the Douglas-Peucker algorithm is implemented. But a more general framework is already provided with a generic generalization process that allows a different generalization principle for each layer. While, for example, it makes sense to generalize buildings by removing points of the polygon determining their shape, this is not true for other features like woods which typically are generalized using aggregation. Additionally, as the algorithm currently used can result in violations of topological ordering other generalization algorithms need to be explored.

The other determining factor to focus a user's attention is color. Bright, shiny colors are more noticeable than greyish and dull ones. As in map design color is used to encode class membership, it is not possible to use two totally different colors for features belonging to the same class but lying in different areas. Thus, we use colors of the same category for all features of a class; but features outside the innermost zone are drawn in a duller, softer color of the category. This effect increases with increasing zone, again, resulting in some kind of funnel. Using these two effects allows for constructing maps that focus a user's attention on a specific region.

4.4 Example

The concept of Focus Maps was integrated in a test environment for the city of Heidelberg. A range of vector-based geodata-sets were available as individual map layers. Digital building footprints were provided by the Bureau of Surveying (Vermessungsamt) of the City of Heidelberg.

Focus Maps can be used in a variety of tasks. The presented framework allows creating tours through town that are adapted to an individual user's needs and preferences; this is done by the so called 'Tour Agent'. With Focus Maps these tours can be highlighted by choosing a buffer polygon around the tour's route. Another application can be seen in Figure 1a. Here, the map is centered on a user's current location in the city. The innermost zone comprises a rectangular area and is fixed around the user's location; its size is determined depending on the current scale of the map. To further enhance the focusing effect additional two rectangular zones are created. A user's attention is focused on the area around her current location. Additionally, the focusing effect provides positional information: self-localization is eased. Therefore, fixing the innermost zone is sensible

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to retain positional information. Zooming in and scrolling the map does not change the zones (see Fig. 1b). This way, getting back to the region of interest is easy. A user just has to scroll the map in direction of increasing detail.

5 Conclusion and Outlook

In this paper we introduced the concept of *Focus Maps*. These present a map design strategy that allows the construction of maps in a GIS that help a user focus on the (spatial) information relevant for her current task. A first (prototypical) implementation has been realized for the mentioned Map Agent.

There is still further work needed regarding the presentational aspects, i.e. the way features are to be displayed. But by providing a map that clearly distinguishes between the region that is currently of interest to the user and the part of the map that is not, we believe that a user's task of reading and interpreting a map is eased. The user instantly focuses on the area that is of interest to her and, thus, saves cognitive effort. Further work is needed to evaluate the results and to prove our hypothesis. In order to do that, additional integration work is needed, as well as user trials for getting empirical results.

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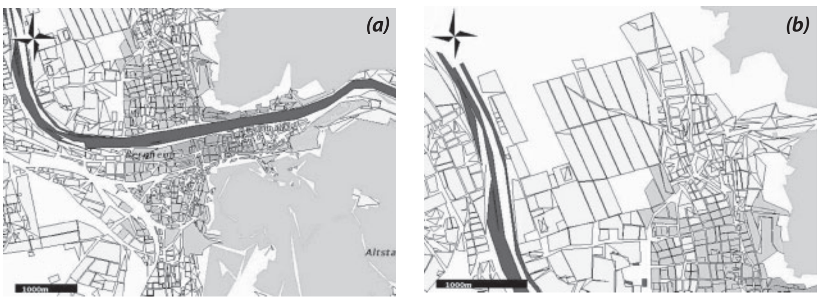

Fig 1: Examples of a Focus Map used to portray a user's current location (a); the same map zoomed in and scrolled to the north (b)

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