# Generating Focus Maps Using Open Standards

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## 1. Introduction

In recent years maps have become a commonplace for communicating spatial information within the internet. But especially the design of context-adaptive mobile maps that support the user in aggregating the information, that is relevant to her individual purpose, is a challenging task (Meng et al., 2005). One approach to make map design more effective is the concept of Focus Maps (Zipf and Richter, 2002). Focus Maps support the user in reading a map by emphasizing regions that are relevant to the user, whereas regions, which are not relevant, are leaved untouched or are even de-emphasized to not distract the user's attention. Emphasis can be achieved by different cartographic scopes of design, e.g. different coloring or different detail in representation of important regions. By nesting regions with different accentuation the user's perception can be funneled to the relevant regions on a map.

Within the internet standardization has become a main concern for GIS applications, facilitating the interoperability of different GIS components. As standards are often tailored to be applicable in a wide range of scenarios, they tend to ignore individual aspects of usage.

The endeavour of this work lies in extending the concept of focus maps by introducing formalism for calculating the individual object's relevance, instead of considering aggregating buffer zones. The relevance of an object is differentiated from the intended saliency of the object's representation. Additionally this formalism is combined with open geographic standards to permit the automatic generation of context-aware digital maps supporting map readers in perceiving the individual task-relevant information.

## 2. Relevance and Context

Focus maps accentuate relevant regions on a map. To determine what is relevant to the user, and what is not, it is necessary to know anything that actually has an impact on the user's task, e.g. the personal preferences, the physical abilities of the map reader and the usage context, to name a few. Context is closely related to relevance, because a change of context alters the quality of being relevant (Reichenbacher, 2007). Several researches in the past was made on the importance of context for context aware-applications (Dey and Abowd, 1999) and how maps on mobile devices can adapt to different contexts (Nivala and Sarjakoski, 2003). But as context is influenced by an elusive list of factors, it seems unfeasible to create maps, which respect all context factors influencing map representation. In the following it is assumed that contextual information is sufficient, thus that the relevance for a subset of objects or types of objects is known. The required contextual information may be directly given by the user or automatically gathered by the application through sensor information. For an overview of available technology for aggregating contextual information in mobile applications see e.g. Schmidt et al. (1999) or Chen and Kotz (2000).

## 3. Generating context-aware Focus Maps

For creating Focus Maps Zipf and Richter (2002) propose to divide the map into different regions of interest. By emphasizing regions in accordance to its relevance to the user, she is supported in perceiving the relevant information of the map. Further accentuation of relevant regions can be achieved by nesting regions with different accentuation, causing a funnel-effect.

Arranging the map in different regions of interest can easily get accomplished by common GIS applications. On the other hand, regions may not always be appropriate to reflect the user's interest in certain objects. Map readers are generally interested in objects on a map that relate to their purpose, e.g. a street that is part of a route or POI. By differentiating the user's interest on the object level, a more fine-grained differentiation between different aspects of the user's interests can be reflected. In contrast regions of interests subsume objects of interest at a coarser level.

Furthermore emphasizing or de-emphasizing individual objects or object types instead of regions of interests allows more control on the perception guidance.

While Richter et. al. (2008) took a similar approach for generating focus maps, they do not differentiate between the relevance and saliency of a displayed object for map generation. While former relates to geographical space, the latter refers to map object in the visual map space (Reichenbacher, 2008). A differentiation between relevance and saliency is necessary, because they are not always linearly related.

Let $R \in G$ denote a known subset of relevant objects, and $\omega_i \in [0:1]$ the relevance value of $g_i \in R$ in respect to the user's context $C$. The closer $\omega_i$ is to 1, the greater is the user's interest in $g_i$.

A continuous funnel-effect can be achieved by drawing all remaining objects salient in respect to their distance to the initial relevant objects. Let $d(x, y)$ be a distance metric, than an individual relevance value for all objects $g \in G/R$ can be calculated by: $rel(g) = \max_{i=0}^{n} \omega_i * (1 - d_{\text{norm}}(g, g_i))$. This value is referred to as (spatial) relevance, because it reflects the spatial proximity to the relevant object set $R$. Because of the maximum function $rel(g)$ may even exceed the relevance for certain $g_i$. Actually the choice of the maximum function is arbitrary. Alternatively the minimun, a mean value or other aggregating functions may be used, each resulting in a different relevance value for a given object and thus affecting the overall focus map design.

In general for map representation the objects should be represented with a saliency dependend on its relevance value and the user's context: $sal(g) = f_c(rel(g))$. This dependency may not necessarily be linear, e.g. salient buffer zones can be emulated by discretizing the relevance values using a step function. In fact different transitions from salient to less salient features may have different effects on the readability and applicability of a focus map.

There are several well-known cartographic methods to create accentuation or de-accentuation for specific features, e.g. by adjusting the contrast, exemption or by changing the size of a feature's representation. In fact every scope for map design that possibly has a visual impact on the recipient's perception may be considered. As a map consists of graphical and textual representations of objects, the saliency of the object's labels can additionally get adjusted to achieve further guidance of perception. Typography offers a variety of techniques for modifying the appearance of textual symbols based on perceptibility aspects.

Landmarks, as a point of reference (Lynch, 1960) have a special importance, most notably by facilitating orientation and localization. This importance is not reflected by $rel(g)$, because landmarks may be relevant to a user basically independent from spatial proximity. Therefore the relevance and visualization of landmarks is excluded from relevance calculation. How actually landmarks and there importance can be determined is beyond the scope of this work.

## 4. Technical Study

To evaluate the proposed concept for generating personalized focus maps a technical study using open standards was implemented. A user requests a focus map by providing a query for relevant features to the focus map generating process. A query consists of one or more objects, groups of objects (e.g. objects that are of the same type or have similar semantics) and attributive numerical relevance values. These user-given relevancies are assumed to represent the actual user's interests and are not changed throughout the map generating process. If the relevance of any object is not given, it is calculated according to the preceding section.

The saliency of the symbols must than get adjusted to the map user's perception for visual representation. For this reason several functions where implemented that are basically intended to represent different map readers abilities to recognize, e.g. functions that provide a smooth transition between different relevancies or functions, that limit the range of relevancies to discrete values. Additionally the intensity of the focus-effect can be adjusted to match the map user's ability to recognize based on a given intensity value. The intensity value reflects the compromise the user is willing to take between level of map detail, the strength and character of the focus effect. As the context of a user may change while reading a map, it can be beneficial to dynamically adapt the intensity value to this change.

After the adaption of relevance to the map reader's perception, the objects must be rendered accordingly. The OGC introduced the Symbology Encoding Specification (Müller, 2005) offers a standardized way for describing the appearance of objects to be rendered. There are several possibilities, how to incorporate relevancies into the symbology encoding specification:

1. Modifying the styling rules by relevance, such that every spatial object has its own styling rule respecting its relevance, resulting in a set of context-adaptive styling rules (Zipf 2005). Depending on the number of objects and their relevancies, this may result in very large rule sets. To reduce the number of rules, objects may be merged into equivalence classes.
2. Adding an relevance-attribute to the objects and modifying the styling rules in respect to that attribute.

Both variants suffer from the fact, that the styling rules or the objects are enriched with individual and varying user data. In general it is advisable to have a clean separation between user-dependent contextual information, styling rules and geographical information, thus that the constituent information could be reused in different contexts.

For this reason we followed in our study the first approach, thus that the individualized styling rules can e.g. be exported and send to an OGC Web Map Service (de La Beaujardière, 2002) for map rendering. In the current state rules can be adapted to relevance by scaling, adjustment of opacity or leaving them out for rendering, if they are not relevant at all. These operations can be individually applied to both, features and labels.

Figure 1 and 2 depict the user interface for focus map generation. In figure 1 a map without any contextual adaption is build. The styling of the map is determined by a fixed rule set. There is no differentiation between represented features at the level of the user's interests, e.g. even though a user may not be interested in the suburb Nordstadt, it is displayed (in full detail) and thus may possibly distract the attention of the reader, wasting perceptual capacity. In contrast Figure 2 shows a map where irrelevant objects are drawn with less opacity in dependence to their distance, thus that the attention of the reader is guided to a predetermined set of relevant features. The size of the focus area is chosen medium and labels of features whose relevance s below a threshold are not drawn at all. The funnel effect is given a polynomial characteristic, which means that the saliency of objects corresponds to the power of its relevance, thus that the change from relevant to irrelevant features is rapid, but still smooth.

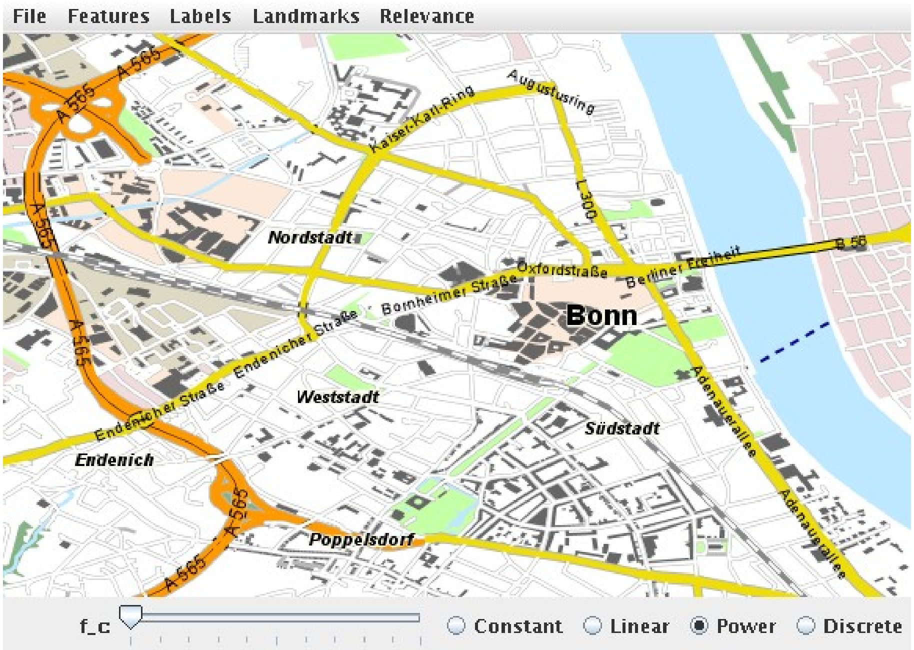


Figure 1. Map of the city of Bonn without intentional accentuation, geographical information from the openstreetmap-project (http://www.openstreetmap.org).

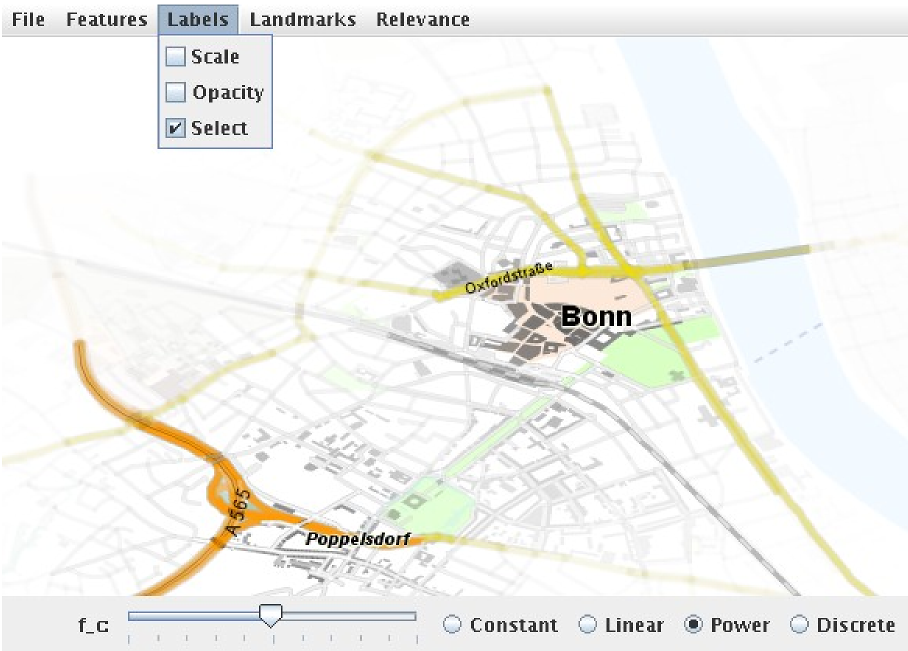


Figure 2. Focus map with accentuation of the suburb Poppelsdorf and inner city of Bonn, same data and view as figure 1.

## 5. Conclusion and Further Work

In this work a first study was presented, that uses open geographic standards to generate context-aware focus maps. Instead of dividing the map into different regions of interest, a relevance value for every feature to be displayed on the map was estimated by taking its distance to other objects or types of objects into account and a map drawn with the saliency of each drawn symbol corresponding to the calculated relevance values of their respective features. Additionally labeling was incorporated into the design of focus maps. A prototype of the presented technical study will soon be made available at http://www.focusmap.org.

In general how to bring knowledge about relevance into map design is an open question. Even though there are standards for map styling and representation, they lack the comprising of individual context information. Further research may extend on how context information can be formalized to facilitate digital map applications providing individual maps that support users in decision making.

Furthermore empirical studies are needed, that proof that focus maps do actually support the user in reading maps and how different cartographic design scopes can be exploited in supporting focus map readers the best.

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