Finding the Oasis in the Desert Fog? Understanding Multi- Scale Map Reading

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Abstract:

Fluid interactions of complex information visualizations promote flow by giving “a sense of control” and a loss of self-consciousness” during the interaction (Elmqvist et al., 2011). In the context of multi-scale geovisualization with different maps rendered at different zoom levels, fluid interactions mainly consist in smoothly zooming in the scales/zoom levels, while keeping a constant sense of place. User experience shows that current multi-scale maps are not provided with fluid interactions. Despite recent improvements, zooming in and out of multi-scale maps such as GoogleMaps, OSM, or National Mapping Agencies’ geoportals still causes a desert fog effect (Jul & Furnas, 1998) when the map changes. Desert fog can be defined as “a condition wherein a view of an information world contains no information on which to base navigational decisions.” In a multi-scale map, it means that the abstraction, content and style changes between two maps at different scales make the user lose his sense of place for a short moment wondering where his previous position (i.e. where he was looking at, or where his cursor was) is in the newly rendered map (Dumont et al., 2016). Contributions on continuous generalisation (van Oosterom et al., 2014), or on progressive generalisation (Dumont et al., 2017; Touya & Dumont, 2017) try to provide more continuous or progressive abstractions of map features across scales.

But to improve the fluidity of zooming in multi-scale maps, we first need to understand how map readers relocate after a scale change, then we would understand more easily why map readers have difficulties with current multi-scale maps and how we could improve these multi-scale maps to enable more fluidity. Past research provided many explanations on how map users read and understand a map but what happens when scale changes is still an issue (Mark et al., 1999). For instance, do multi-scale map readers use a multi-scale mental map?

Although multi-scale map reading has not been the core topic of past research in geographical information science and spatial cognition, the analysis of related research gives us hints on how it might work. Particularly, we tried to find clues on how relocation works after a zooming interaction, and on the factors that help or limit this relocation by the map user. From research in spatial cognition, we can see that there are different types of cognitive models for spatial cognition (Mark et al., 1999): the concept of *cognitive atlas* from Kuipers (1982) is really interesting because it states that geographic knowledge is a set of cognitive maps at different scales, with gaps, so the mental representation of map users is also composed of maps at different scales. Tversky (1993) proposed a similar theory calling the geographic knowledge more a *cognitive collage* than a cognitive map or atlas. The Anchor theory (Couclelis et al., 1987) is also apposite as it claims that mental maps are more topological than metrical, and places are located in relation to a set of hierarchical anchors, or landmarks: for instance, we know where a specific place is its near to a restaurant that is itself close to our workplace, a higher level anchor compared to the restaurant.

Research on wayfinding is also interesting as it involves space representation at different scales: spatial chunking is a common task in wayfinding (Klippel et al., 2008) and the mental representation of a route often contains parts at different abstraction levels or different scales (Godfrey & Mackaness, 2017). Landmarks where the route changes scale (e.g. changing from subway to bus) are keys to link the representations at different scales. We have seen that one problem with the multi-scale maps is that the potential landmarks are not represented similarly when scale changes, and they may even disappear. One solution to this problem could be to model vertical spatial relations for the important landmarks (Steiniger & Weibel 2007, Burghardt et al. 2010), or hierarchical relations (Mustière & Moulin 2002, Chaudhry & Mackaness 2007) to better abstract the landmarks when scale decreases. The importance of text in zooming fluidity should also be considered (Dumont et al., 2015): it should be consistent across scales (Schwartges et al., 2013) and could also be used to abstract the important landmarks.

One final element to note is that research on spatial cognition showed that geographical elements are remembered more regular than they really are (Mark et al., 1999): we remembered alignments, orthogonality or parallelism even when these properties are not exact in the map. So, progressive generalisation that tends to enhance such properties by making spatial relations more regular can play a key role for zooming fluidity.

To summarize this literature review, we can make the following hypotheses: multi-scale scale mental maps (i.e. cognitive collages) are used by map readers, and multi-scale anchors are key features to enable multi-scale map reading; these multi-scale anchors can be visually salient features, but can also derive for the user spatial knowledge of the space depicted in the map.

To better understand the implications of such hypotheses, I tried a little exercise with the standard OSM multi-scale map, centred on my workplace, IGN near Paris (Figure 1). I captured all consecutive maps when zooming out and I later listed the visual cues in each map, with a generic and a personal point of view. For four of the maps, the ones reproduced in Figure 1, Table 1 lists these visual cues. The table shows that visual landmarks change when scale decreases, even if some are rather visible at several consecutive scales. We can also note that the personal visual cues are not always the same as the visually salient features.

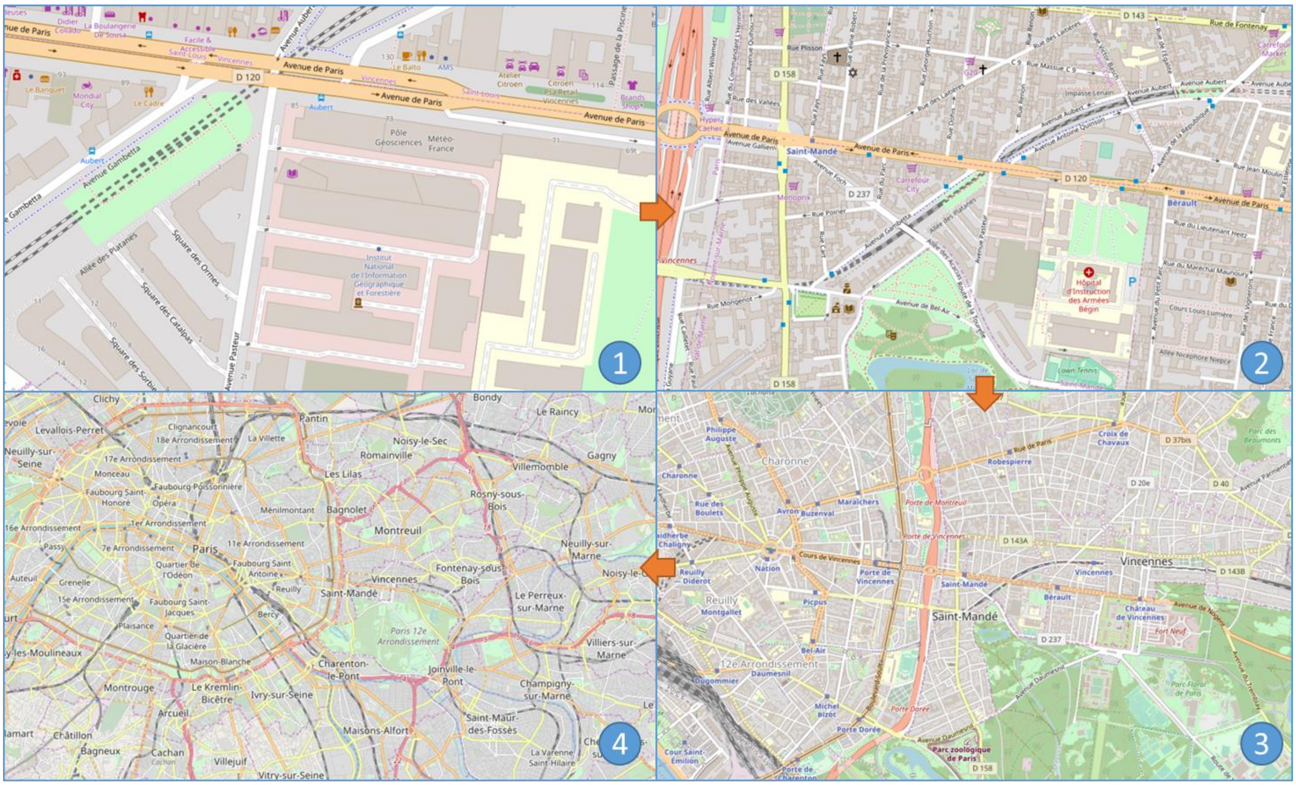

Figure 1. Zooming out from a large scale map centred on IGN France. Some visual cues are quite preserved through scales but some disappear generating some desert fog.

Scale	Generic visual cues	Personal visual cues
Scale 1 (zoom level 18)	Railways, large buildings, POI symbols	IGN buildings, orange road/railway crossing
Scale 2 (zoom level 16)	Hospital symbol, the orange road, railways	Paris ring road (top left highway), the park, orange road/railway crossing
Scale 3 (zoom level 14)	Subway stations (blue squares), Paris ring road, the large forest ("Bois de Vincennes")	Paris ring road, "Bois de Vincennes, railway/orange road crossing
Scale 4 (zoom level 12)	Highways, "Bois de Vincennes"	Paris ring road, "Bois de Vincennes"

Table 1. List of generic and personal visual cues for the four maps from Figure 1.

For now, the hypotheses proposed in this abstract are rather vague and only backed by intuitions. The next step is clearly to set up user experiments to test these hypotheses. Research collaborations are welcome to face this huge task. A first experiment is planned at the time of the workshop to generalise the exercise presented in this abstract. Then, the next step will be to use this knowledge on multi-scale map reading to improve both multi-scale map design (with multi-scale styling and progressive generalisation?), and interactions (new zooming interactions specific to multi-scale maps?). Controlled and staged animations (Tversky et al., 2002; Harrower, 2007; Bach et al., 2014) can also be interesting methods to improve the fluidity of the zooming interaction.

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