Verification of Multi-Scale Map Design

Mathias Gröbe [a, *], Dirk Burghardt [a]

[a] TU Dresden, mathias.groebe@tu-dresden.de, Dirk Burghardt, dirk.burghardt@tu-dresden.de

* Corresponding author

Abstract:

Nowadays map users expect zoomable maps in nearly all situations: Overview and detail on demand for the whole world. This circumstance is a technical and design challenge for cartographers. Data needs to be generalized and optimized for all possible zoom levels and styled in appropriate way for the scale. The map design should respect these requirements and should be adjusted to the scale as well as stay consistent over all zoom levels. We have develop a method that calculates a value for a specific map extent, which allows to check the continuity of a maps style over several zoom levels and to compare different map styles with each other. Finally, we derive possible design rules for multi-scale map design from this consideration.

1. Introduction and Technical Background

Zoomable web maps such as GoogleMaps, BingMaps or OpenStreetMap are part of everyday life for communicating information, planning spare time activities or working with geodata. The named web maps are often used as well as often criticized: GoogeMaps because of its low contrast or OpenStreetMap for the high information density. The different web maps services are comparable because of the similar technical implementation that is through the OpenStreetMap project well documented [1]–[3]. Comparable to topographic maps exists a fixed set of scales that is shown in Table 1, which are called zoom levels. Zoom level 0 shows the whole word, while level 19 can show details for road section e.g. traffic lights or crossing details. The map user can jump between these zoom levels and can see a more or less detailed map depending on the direction of zoom. In case of raster-based tiles are only the scales in Table 1 available. In contrast to this, vector tiles offer continuous zooming and enable more possibilities for styling and labelling the map [4].

The samples in Figure 1 shows an inconsistency in the actual rendering of the OSM-Carto style [3]: The colour of the forest gets significant darker and a pattern appear zooming in from zoom level 12 to 13, while the other colours does not change. Figure 2 with samples of GoogleMaps shows a distinct change in the background colour for the transformation from 15M to 10M. These two examples demonstrate cartographic errors in web maps, depending on inappropriate transition between the zoom levels. This can lead to misunderstanding the map, because the user does not understand why an object class is represented differently in nearly the same scale. From these observations results our research question: How to check and ensure a consistent map style over several map scale or zoom levels?

Table 1. Zoom levels and approximately scale at the equator for web map [1].

Zoom Level	z0	z1	z2	z3	z4	z5	z6	z7	z8	z9	z10	z11	z12	z13	z14	z15	z16	z17	z18	z19
Scale	500M	250M	150M	70M	35M	15M	10M	4M	2M	1M	500k	250k	150k	70k	35k	15k	8k	4k	2k	1k

Figure 1. Two example tiles from OpenStreetMap for zoom level 12 (left) and zoom level 13 (right): While the most colours stay, the colour for the forest gets significant darker. In addition, appears a pattern in the forest.

Figure 2. Two screenshots form GoogleMaps in zoom level 5 (left) and zoom level 6 (right). The background colour changes form a dark grey to a very bright grey.

2. An Approach to Verify Consistent Multi-Scale Map Design

2.1 A Method for the Verification of Multi-Scale Map Design

There is already a measure established in cartography to describe the map design in an abstract way. This measure is called *graphical density* and describes with other words a quantity for visual clutter [5]. Our approach for calculating the graphical density uses rendered samples of map extents for a set of zoom levels to visualize the development of the map style. The Figure 3 shows the workflow: For reaching one value for the information load, we convert the sample image for the chosen extent to a greyscale image and calculate the mean grey value for all pixels. In addition, we used the standard deviation as measure for the contrast. The result can be plotted in a diagram, showing the zoom level on the x-axis and the mean grey value on the y-axis connected with a line. In combination with the zoom levels results a graphical representation of the brightness development over several map scales. The visualization of the standard deviation using error bars shows further the more or less contrast in the specific map sample.

Converting the RGB image with its three channels to a one-channel grayscale image offers the advantage to summarise the information. Otherwise is also possible to convert the image into another colour model e.g. HSL which encode the hue, the saturation and the luminance into the channels. In such a colour model, it is also possible to check the change of the specific properties over the zoom levels.
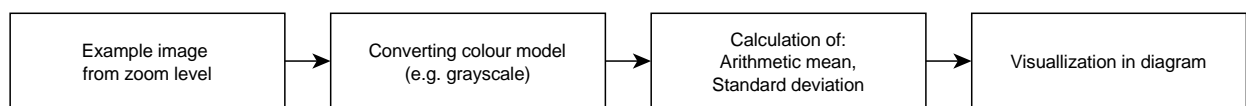

Figure 3. Workflow for generating a value for one example in one zoom level. Figure 4 shows the final visualization for a set of zoom levels.

2.2 Comparison of the Map Design of OpenStreetMap Carto and GoogleMaps

We tested our tools for the verification of the map design in multi-scale maps as in Figure 4 visible for the OpenStreetMap-Carto style [3] and for Google Maps [6]. In a zoomable environment, it is not possible to use the same area, because the map extent changes with each zoom interaction. Therefore, we decided to use always the same size of the map extent in each zoom level, which means the size of the image used for the calculation is at all times the same. We utilise the same area for each map service to make it comparable.

The change of the forest colour as shown in Figure 1 is also noticeable in the diagram in Figure 4. The mean value of grey values decreased significantly. In contrast, the change of Figure 2 in not visible in the diagram in Figure 4. If we consider the visualization of the graphical density in Figure 4 for OpenStreetMap, we concluded that the map design has several breaks (z7/z8 and z12/z13) but seems to be more contrasting from z12 to z16. GoogleMaps seems to have a more uniform design, which is visible by the small overall variation of the mean grey value. The contrast is especially low in the zoom levels 11 to 13.
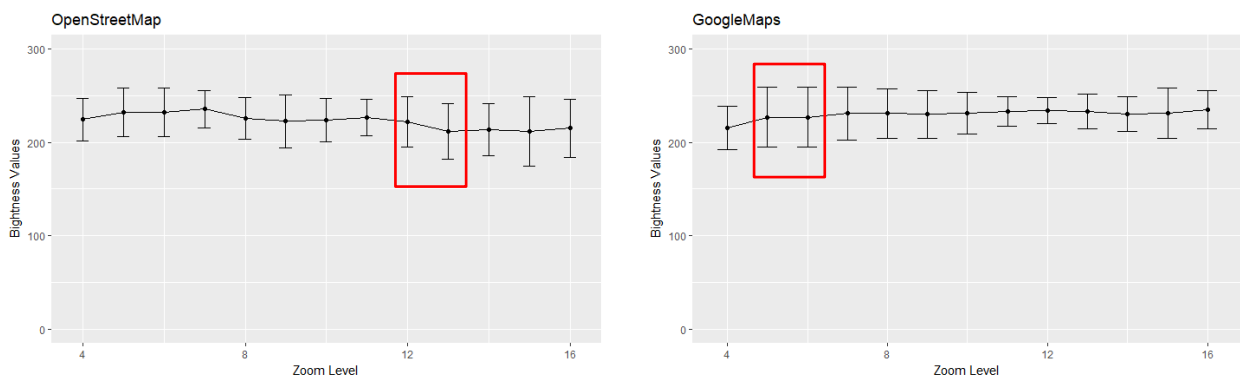

Figure 4. Calculating the graphical density from rendered maps: Using the mean grey value for a sample map extent over several zoom levels for sample form OpenStreetMap-Carto (left) and GoogleMaps (right).

3. Discussion

As the example above shows, it is possible to compare different map style over a range of zoom levels using our method. The design break visible in Figure 1 can also be identified in Figure 5. Advantageous is the very simple implementation that only need images of the map in the different zoom levels using the same area. On the one hand it offers an overview of the graphic density over the zoom levels in a very simple way. On the other hand, it is unfavourable that the colour information is discarded. This is particularly evident in the example of GoogeMaps in Figure 2. The change of the hue is not visible in the diagram in Figure 6. Furthermore, the information density on the respective map extent is not considered at all. This makes it more difficult to compare the maps. For example, the low contrast at some zoom levels might have been intentionally created in Google Maps to focus on information that might be overlaid.

4. Conclusions

We think that is very important to develop suitable design rules for multi-scale map design to produce better map for many people. From our point of view, it would be better for the examples in Figure 1 and Figure 2 to produce a softer transition between the zoom levels. From our density value calculation and visualization, we derive the following statement: If the coloured area gets bigger, the colour should get lighter or less saturated, while the hue stays. This rule can be implemented by using HSV, HSB or HCL colour space and help to ensure a constant graphical density that can be proofed by our method for the graphical density.

5. References

[1] 'Zoom levels – OpenStreetMap Wiki'. [Online]. Available: https://wiki.openstreetmap.org/wiki/Zoom_levels. [Accessed: 01-Mar-2019].

[2] 'Slippy map tilenames – OpenStreetMap Wiki'. [Online]. Available: https://wiki.openstreetmap.org/wiki/Slippy_map_tilenames. [Accessed: 01-Mar-2019].

[3] A. Allan, *A general-purpose OpenStreetMap mapnik style, in CartoCSS: gravitystorm/openstreetmap-carto*. 2019.

[4] J. Gaffuri, 'Toward Web Mapping with Vector Data', in *Geographic Information Science*, 2012, pp. 87–101.

[5] J. Neumann, *Enzyklopädisches Wörterbuch Kartographie in 25 Sprachen*. 2011.

[6] 'Google Maps', *Google Maps*. [Online]. Available: https://www.google.de/maps/@51.027852,13.720864,15z. [Accessed: 07-Mar-2019].