Point selection approaches for zoomable maps

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1. Research Objective

Today's web maps are zoomable and cover nearly the whole word: Google, Microsoft, Apple, OpenStreetMap, and Mapbox offer their map service to a broad audience and different purposes. The map styles follow the rules written as program code and less the knowledge and skills of experienced cartographers. This circumstance results in the requirement of more well-working algorithms, generalization tools, and rules to produce better web maps.

One challenge is the implementation of a rule which selects point geometries, e.g., cities and peaks with a clearly defined numerical attribute, e.g., population and elevation, which are useable for selection. Selecting all points above a defined limit for the numerical attribute results in massive cluttering effects and labeling problems in areas with high values as mountain ranges for peaks, for example. A solution can be topographic isolation in the case of peaks. It is the distance from a peak to the nearest point with a higher elevation. Using the value of the topographic isolation considers the numerical values, the distribution of similar geometries, and space. This approach for peaks is already in use at the OpenTopoMap[1] (Anon, 2020b). As a result, only the peaks with the highest elevation in a radius are shown, and while zooming in, the isolation values (the radius) is lowered to show more and more peaks. We want to present and demonstrate two known solutions for this selection problem and our approach, similar to topographic isolation. All approaches are useable in zoomable maps.

2. Approaches

2.1 Label grid

The label grid works with a grid approach: for an area defined by a grid cell, the point with the highest value is selected. This solution works fine for populated places, and the grid width can adjust the density of points. It is implemented as an SQL query for PostgreSQL/PostGIS and used at MapBox and TopPlusOpen maps (Anon, 2020a; Kunz, 2018; Peter Kunz, 2018).

Figure 2 shows the result of the label grid applied to cities; only the place with the highest population in each invisible grid cell of 156 kilometers is shown. The distribution of the cities in the example map is uniform. It seems mainly influenced by the grid origin and the grid cell size.

2.2 Functional distance

A bell-shaped curve, lowering values by the distance, creates the functional distance. The difference between the function value of different points can be stored and used for selection. We used the following formula for our example after an example from a presentation (Horman, 2020):

$$f(x) = p * e^{-\frac{x^2}{\beta}}$$

x... distance between the point geometries
p... numerical attribute value, e.g., population
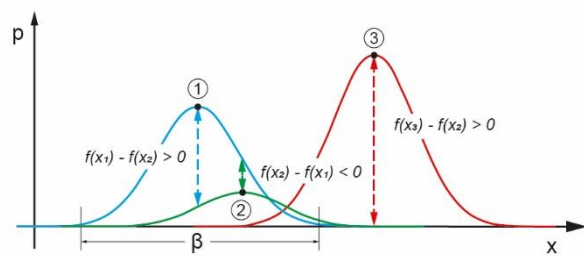β... variable to adjust how quickly the distance value is lowering and keep distance between near points

Figure 1: Visualisation of the functional distance method. Each place gets its function formed by the parameter population (p) and β. In case of a positive difference between function values, the place should be shown on the map. In this example, the points (1) and (3) would be selected.

Figure 1 visualizes the formula above and shows the influence of the parameters. By adjusting the variable β, it is possible to adjust the information load and the minimal distance between points to be shown on the map. The population results in selection or not selection of the point because the difference between the function values must be greater than zero. For point (2), is the value too low to get selected. Figure 3 shows an example using the functional distance for cities with a β-value of 78 kilometers. In comparison to the other maps also nearby cities are shown.

2.3 Discrete isolation

For our approach, we transfer the principle of topographic isolation to discrete points. Usually, the isolation is the distance to the nearest higher point from a peak, which is often no peak but just a point on a slope. In our definition, we consider only the peaks. So, there is no continuous

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surface. It means the discrete isolation is the distance to the nearest point with a higher value. The selection of a lower or higher distance value for the isolation increases or decreases the number of points shown on the map.

The map in Figure 4 offers a regular distribution of cities computed by the isolation method. Only places with a distance greater than 78 kilometers to the next place with a higher population number are shown. It also leads to sparse areas with probably less populated places.

Figure 2: Example map for the label grid with data from NaturalEarth and OpenStreetMap contributors 2020; only the place with the highest population in each grid cell is shown.
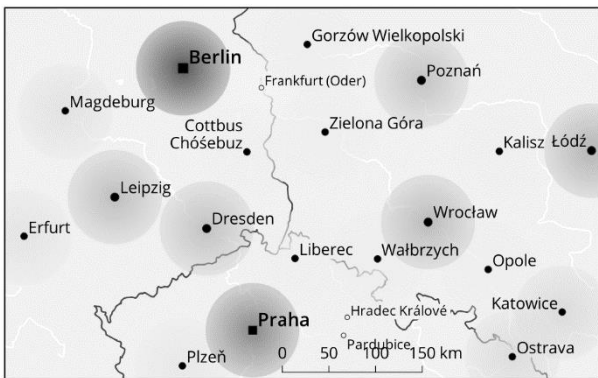

Figure 3: Example map for the functional distance with data from NaturalEarth and OpenStreetMap contributors 2020. The more or less dark circles, according to the population, show the functional distance visually.

Figure 4: Example map for the discrete isolation with data from NaturalEarth and OpenStreetMap contributors 2020. The circles show the distance to the nearest city with a higher population.

3. Conclusion

The presented approaches are less known and should be presented to a broader audience. They work well for populated places and can also be applied to similar data, e.g., data from location-based networks. Adjusting the computed value for selection is possible to alter the map load and produce good selections for different zoom levels. The example maps show slight differences in the results by using similar values for each method. The 156 kilometers grid width corresponds to a typical edge length of a tile in web maps; this means for the circle-based calculations, a radius of 78 kilometers to be comparable. For the discrete isolation method, the result is comprehensible and considers the natural distribution. The properties of the grid mainly influence the label grid approach, while the functional distance is hard to understand. It is further research needed to work out the advantages and disadvantages of the approaches and their usability.

These solutions are simple and should be combined with other attributes or measures. For example, it could be checked if a city is also the capital of an administrative. There are also more complex approaches, which offers maybe better result using new technology and more complex data source, e.g., machine learning (Izabela and Karolina, 2019).

4. References

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