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Metrics for evaluating mosaic cartograms

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Abstract:

Mosaic cartograms are a visually appealing method of thematic cartography based on the transformation of a mapped territory into a regular grid. Each region is assigned a specific number of equal-sized tiles, typically in the form of hexagons or squares. The number of tiles is determined by the value of the quantitative variable being represented and a conversion parameter (e.g., one tile corresponds to 100 inhabitants). Consequently, regions with higher values expand, while those with lower values become smaller. As with other types of cartograms, the principle is to highlight thematic content and ensure that the reader's perception is not distorted by the physical geography of the area when comparing values across regions.

Cano et al. (2015) consider several quality criteria for mosaic cartograms. The first one is the average and maximum cartographic error, which evaluates the obtained and required areas of the regions. The others are correct adjacencies, shapes, and relative positions of regions. Lastly, there is mosaic resolution, which is the average number of tiles used per region. However, apart from the cartographic error and mosaic resolution, they do not demonstrate how these quality criteria should be evaluated. Bouts et al. (2017) further evaluate the complexity of channels, which represent the complement of the region's tiles to its bounding rectangle. Apart from that, there seems to be no work primarily focused on mosaic cartograms and the specific definition of metrics for their evaluation.

However, there are many works describing metrics used for evaluating other types of cartograms or other suitable map types, for example grid maps. We conducted thorough overview of those works and most used metrics are:

- cartographic error – obtained vs. required area of regions
- shape error – local shapes of regions or global shape of the whole territory
- adjacency error / topology – correct adjacencies of regions
- aspect ratio – bounding box aspect ratio of regions
- relative position – relative positions between regions
- distance – distances between regions
- contiguity and whitespace – contiguity and holes in the map

Some of these metrics, such as cartographic error, are straightforward and calculated consistently across different map types. Others, such as the evaluation of polygon shape similarity, are assessed differently by various authors and represent a general challenge not limited to cartograms. Consequently, our overview includes a variety of methods for calculating these metrics. The objective is to test these metrics and their different calculation methods on several mosaic cartograms. This testing aims to evaluate how these metrics perform across different scales and levels of distortion, such as the deformation of regional shapes or topological inconsistencies. Based on the results, we will propose a standardised set of metrics suitable for evaluating mosaic cartograms. These metrics will then be used as optimisation criteria for the automatic generation of mosaic cartograms in future work.

Three mosaic cartograms, two representing Czech regions and one depicting European states, were selected for testing. The first Czech map visualizes the 2021 population (see Figure 1), where each tile represents 5,000 inhabitants. Since approximately one-quarter of the Czech population resides in Prague and the Central Bohemian Region, these areas expand significantly, while surrounding regions become smaller. Consequently, maintaining correct adjacencies, relative positions, and shapes simultaneously becomes challenging. The second Czech map illustrates forest area per

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region, with each tile corresponding to 1,500 hectares. In contrast to the population map, Prague's values are considerably lower than those of other regions, resulting in the expansion of peripheral areas, particularly in the west. This distribution facilitated the preservation of local shapes. Finally, a cartogram showing the population of European states in 2019 was included to enable evaluation of the metrics on a smaller scale, with each tile representing 500,000 inhabitants. Compared to the Czech maps, it contains nearly three times more territorial units and utilizes a lower mosaic resolution to test the impact of these variables on the selected metrics.

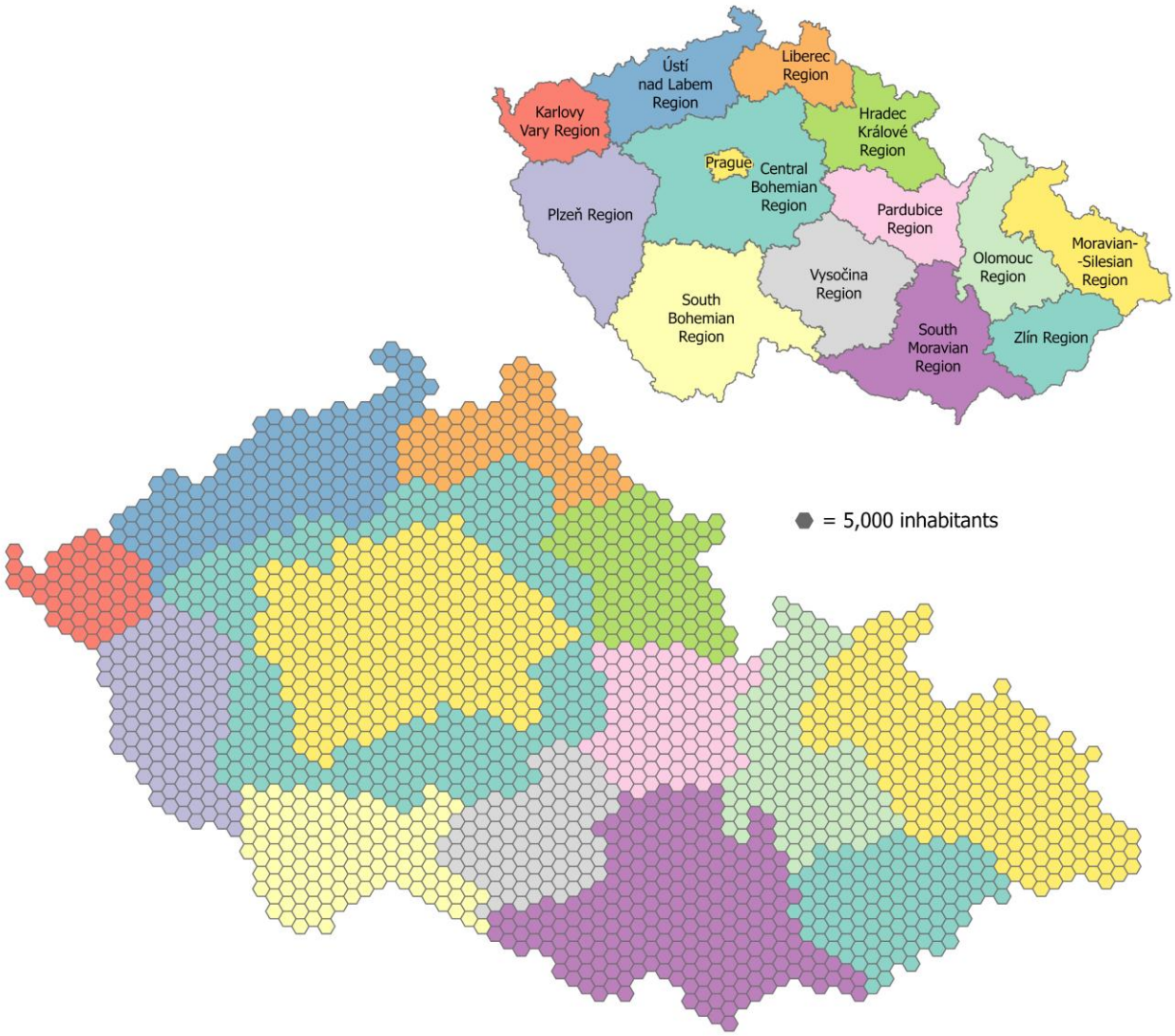

Figure 1. Mosaic cartogram of the 2021 population of Czech regions (bottom) compared to a reference map of the original regions (top right)

References

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