# Automated polygon schematization for thematic maps: an integrative review

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**Abstract:**

The term "schematic map" is often used synonymously for so called *tube maps*. Tube maps go back to Beck's (1947) effort of visualizing London's subway network. However, cartographers (Monmonier, 1992, p. 34) and computer scientists (Meulemans, 2014) claim that schematization is not only useful for transport maps (applied to lines); it can as well prove useful for thematic maps (applied to polygons). The geometry in schematic maps adheres to strict constraints, and can thus reduce visual clutter and ultimately the map reader's cognitive load. Lower cognitive load facilitates typical map interactions (Roth, 2012), e.g. identifying, comparing, ranking, finding anomalies and clusters. Furthermore, specific schematization styles (Figure 1) facilitate figure-ground differentiation (e.g. a hexilinear schematization style contrasts with circular symbols, a curved style with rectilinear symbols).

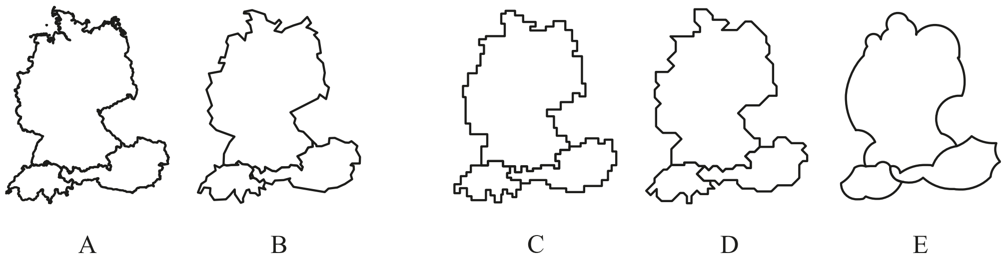


Figure 1: "Different schematization styles next to the input (A) and the simplified input (B): rectilinear (C), hexilinear (D), and curved (E)"

Another advantage of schematic maps applies in particular to statistical mapping and thematic maps, which often make use of administrative units: a schematized, and thus over-simplified or stylized geometry, of such units implicitly conveys that the mapped data is not geographically *accurate*; statistical values are usually not homogeneous across one unit but a result of aggregation. Schematic maps can convey (implicitly) that a map visualizes such "imperfect" data. Hence, schematic maps are a tool to mitigate the *false aura of accuracy* (Monmonier, 1992) or to avoid the *illusion of accuracy* (Meulemans, 2014).

However, creating such schematized maps of polygons is, until today, usually a manual and time-consuming process. Despite the considerable number of proposed approaches, no algorithms for schematizing polygons have been put into practice, i.e. published as ready-to-use software. Summarizing and classifying polygon schematization approaches, we create the foundation for their implementation.

For that purpose, we conduct an integrative literature review (Snyder, 2019, Torraco, 2005). Queries in *scopus*, *google scholar*, *web of science* and *researchrabbit.ai* led to more than 100 candidate articles. These candidates will be filtered by relevance (first by abstract screening, then by full-text screening): In this screening, schematization approaches for networks (transit maps) will be discarded; these approaches are tailored to lines and usually do not transfer to polygons. Furthermore, publications of related topics like generalization (or simplification) or the generation of cartograms will only be considered if they impose geometric constraints (e.g. parallelism, orthogonalism, angle constraints) on the geometry. We expect the final selection to include less than 20 articles.

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To enable a comparison of the identified schematization approaches, we assess each one individually. We group characteristics to assess the approaches as follows:

- A – cartographic characteristics
  - A.1 schematization style (Figure 1). Indicates the schematization style (e.g., parallel, rectilinear, hexilinear, curved) resulting from the enforced geometric constraints.
  - A.2 area-preserving. Indicates whether an approach preserves the area while imposing geometric constraints on the input data.
  - A.3 topology-preserving. Indicates whether an approach preserves topology, meaning the topological relationships are equal for input and output.
  - A.4 vertex-dynamic. Indicates whether the approach limits the schematized result to a subset of the input vertices, or new vertices can be introduced during the schematization. Such flexibility is usually preferred for cartographic purposes. This characteristic is often referred to as *vertex-restricted* or *nonvertex-restricted* (Meulemans, 2014, van Goethem et al., 2014). However, to facilitate an intuitive comparison between schematization approaches by their desired characteristics, we decided to avoid the double negative term *nonvertex-restricted* and to use the positive term *vertex-dynamic* instead.
- B – technical characteristics
  - B.1 deterministic vs. AI based
  - B.2 complexity (if applicable)
  - B.3 input and output data format (pixel vs. vector) and geometry type (if applicable)
  - B.4 intended use case (if mentioned by the authors)

Schematic maps can be useful in multiple contexts. However, they are still sparsely used because no ready-to-use tool exists to automatize the otherwise tedious manual process of polygon schematization. This review will provide an overview on state-of-the-art schematization approaches for polygons. It enables identifying the most promising approaches (or possible combination of approaches) from a cartographic point of view. This is a first step towards an accessible tool for polygon schematization.

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