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Computational Aesthetics for Geographic Maps

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Abstract

We explore visual abstraction for the generation of stylized renderings of 2D map data. We employ techniques based on the concept of shape simplification and graph layout. Using data from OpenStreetMap, we show how one can iteratively abstract and thus generate aesthetic renditions of these maps.

1. Map Graph Abstraction

Map data plays an important part in our daily lives—we use maps for many navigation tasks, both in abstract and in concrete domains. In particular geographic maps are frequently used, for example, in car navigation with a GPS device. Even though modern maps tend not to focus on their aesthetic character but on supporting navigation, map creation has historically involved much artistry, from early cartographers who have created beautiful atlases to examples in modern interactive infographics. Artists have also explored maps in their works; some art historians argue, for example, that Piet Mondrian was at least in part inspired by maps or city street layouts to some of his well-known abstract works [SBH04].

Abstraction also plays an important role in traditional map making [RSMM84]. Cartographers employ many forms of generalization and simplification, both of the core spatial information as well as of the additional data shown on maps. For example, streets are shown much wider than they should be for most map scales and smaller features are omitted in larger-scale maps. For some mapping purposes (e. g., thematic maps) the cartographer may even introduce more simplification than technically necessary for the chosen scale. Most of these abstraction techniques are applied in cartography due to the technical limitations of scale and/or to promote understanding [RSMM84].

We are interested, however, in a visual abstraction of maps (e. g., Fig. 1) that goes beyond what is technically necessary for the creation of effective maps. Our approach is driven by (personal) aesthetics rather than a need for using maps for navigation purposes. For this purpose and based on map data available from OpenStreetMap [Coa04], we employ a set of abstraction and simplification techniques: (1) progressive meshes [Hop96] as known from 3D surface mesh simplification, (2) force-directed graph layouts [BETT99], (3) a special form of a force-directed layout that alignes the map edges with the coordinate axes, and (4) the the Ramer-Douglas-Peucker algorithm [Ram72,DP73] for polyline simplification. These techniques can be applied independently of each other and in various sequences, each resulting in a different visual abstraction of the original map.

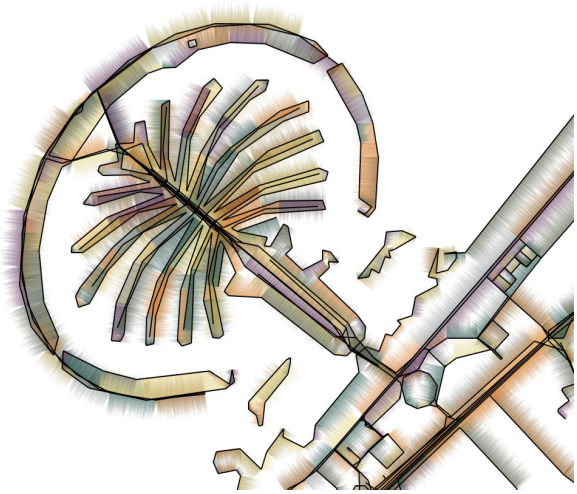

Figure 1: *Visual map abstraction: Dubai's Palm Jumeirah.*

For rendering the abstracted maps we take inspiration from the Substrate simulation [Tar03]. It employs densely drawn colored lines, placed perpendicular to the main (black) lines on one of its sides. These lines have a length that varies randomly and they fade out toward the end. This creates an effect that is reminiscent of watercolor painting and we render our abstracted maps in a similar way. The colors are randomly chosen from a palette with one color for all lines originating from a map graph edge. In addition, the colored lines have a given transparency at their start and fade out toward their ends. Inspired by the colors chosen for the Substrate simulation we use a similar color palette (e. g., Fig. 2). Alternatively, we explored color palettes from ColorBrewer [HB03] (e. g., Fig. 3), or the use of one single color for all colored edges (e. g., Fig. 4).

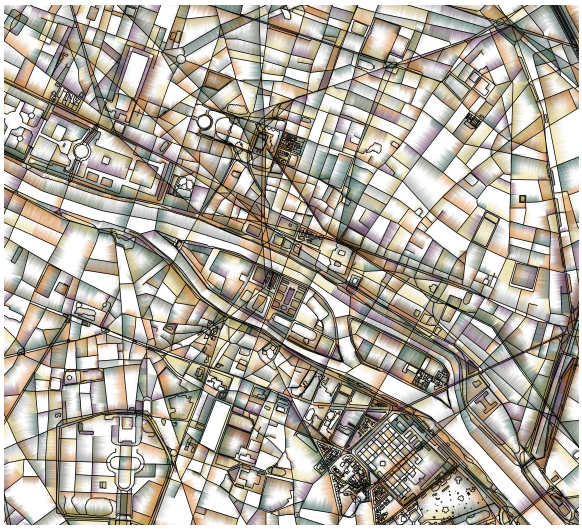

Figure 2: *The center of Paris with Île de la Cité, without any simplification/abstraction applied to the map graph.*

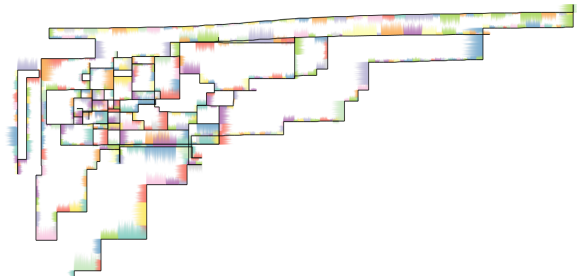

Figure 3: *Abstracted map with pastel color map from ColorBrewer [HB03].*

2. Results

Both the map graph simplification and the choice of rendering technique add to the abstraction of map data. The rendering of lines within the map as simple black lines removes much of the information such as type or importance of its associated map element. In addition, the shading emphasizes the polygonal nature of the elements. While this works well together with the map graph simplification techniques it is not even always necessary to apply them as shown in Fig. 2. Here, a part of Paris is shown with only the rendering applied and without any additional map graph simplification. The reason that this works is probably that inner cities already underwent a sort of 'abstraction process' in form of river straightening, road straightening, road widening, etc. Therefore, the specific rendering emphasizes this abstract character as it does this with simplified map graphs.

The simplification and abstraction techniques for the map graph seem to work best when there are fewer nodes with high connectivity. For example, in city centers (e. g., Manhattan in Fig. 4) there are many street intersections connected by straight streets (i. e., only one edge between two intersections). In this case it is more difficult for both the simplification techniques (progressive meshes and Ramer-Douglas-Peucker) and the force-directed techniques to introduce changes that have an abstracting effect without degenerating the map. In contrast, in regions with longer edge chains and, thus, fewer intersections abstracting changes are easier to introduce (e. g., Central Park in Manhattan in Fig. 4 or the man-made island "Palm Jumeirah" in Fig. 1).

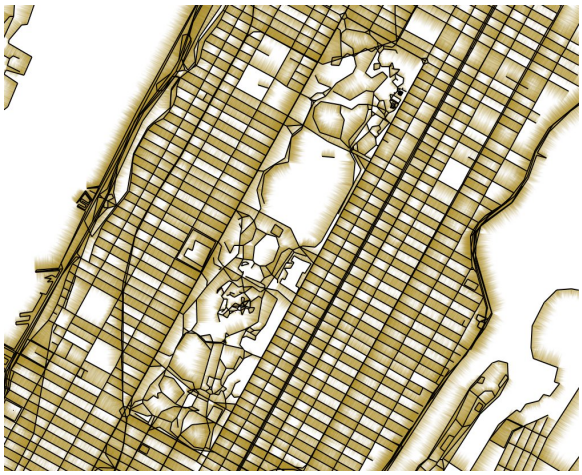

Figure 4: *Manhattan with Central Park, simplified with Ramer-Douglas-Peucker to about ½ the original edge count.*

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