A High-Resolution Representation of *n*-Dimensional Geographic Space

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Visualization has been recognized as a powerful strategy for understanding complex phenomena that are reflected in the multifaceted databases collected in all areas of contemporary society. The role of geographic visualization has typically been restricted to presenting geographic phenomena in terms of geographic location. Under this approach, geographic space itself is viewed as the dominant integrator of disparate data sources from the physical and human domains. One of the main reasons for the conceptual and visual richness of such depictions is a relatively high resolution of the geographic reference base, as compared to the relatively low resolution of the non-spatial attributes. For example, think about standard visualizations of population density in choropleth maps. While the geometric outline of base polygons can range from only three vertices (for a triangular polygon) to several thousand vertices (e.g., for a country with a complex coastline), population density for that highly detailed geometry will have an extremely coarse resolution, with single values for individual area objects that are in addition classified into only a few groups. Univariate visualizations are likewise dominant, as opposed to dealing with a large number of attributes simultaneously. All this allows drawing inferences about low-dimensional attribute relationships in *geographic space*, but one learns relatively little about complex high-dimensional relationships and structures existing in *attribute space*.

One popular alternative involves expressing individual attributes directly in geometric form. Scatter plots and parallel coordinate plots are examples of this approach, which is limited in scope to between two and a few dozen variables. Another proposed alternative relies on dimensionality reduction, such as through principal components analysis (PCA), multidimensional scaling (MDS), or self-organizing map (SOM) methods. This allows expressing a much larger number of attributes in visual form. However, dimensionality reduction has typically only been applied to a very limited number of objects, which limits seeing attribute space structures in great detail.

In this paper, we present a study aimed at creating a high-resolution map whose geometry is constructed from the attributes of a large number of geographic objects. Specifically, we spatialize all 200,000+ U.S. census block groups using a high-resolution SOM consisting of 250,000 neurons. In addition, the attributes included represent a more holistic representation of geographic reality than in previous studies. Included are 69 attributes regarding population statistics, land use / land cover, climate, geology, and soils. The diversity of this set of attributes is informed by our desire to build a comprehensive two-dimensional base map of *n*-dimensional geographic space. It is meant to support implementation of a number of novel concepts, including certain notions concerning the *experience* of geographic space, a la déjà vu. In particular, similarities and differences in the experience of *urban* space are shaped in ways that are hidden in traditional geographic visualization. For example, traditional methods do not lend themselves to simultaneous, holistic comparison of *n*-dimensional urban spaces in London, New York, Paris, or Tokyo. In short, geographic space tends to get in the way. Instead, in our approach, urban spaces are drawn towards each other on the basis of population and land use characteristics, while still recognizing differences driven by the physical environment. The paper will discuss how standard GIS methods and neural network processing are combined towards the creation of an alternative map of geographic space through a type of *n*-dimensional overlay.