Kohonen Feature Nets for Typification

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Spatial phenomena can only be analyzed and visualized at a certain level of detail at a time. In order to be understood, data has to be prepared in an appropriate degree of details for a given task. In cartography, this is taken care of using maps at different scales. There is a growing awareness, that also GIS have to provide such facilities of flexible spatial and thematic scale transitions.

In cartographic generalization, several operations can be distinguished, one of them being typification. This operation is used to present a spatial situation at a reduced scale, using less objects, however under the constraint of preserving the original structure in terms of the type and distribution of the objects. Approaches for typification have been proposed for 2D-structures using mathematical morphology [Müller & Wang 1992]. Although this is very adequate for natural phenomena like lakes, it is not adequate for man-made structures like buildings. In general, it can be applied for irregular areal objects of different shape and size. If the objects are similar, other methods are needed. For the typification of buildings approaches have been proposed that make use of the linear arrangement of buildings along a road and thus transforming the problem into a one-dimensional problem [Regnauld 1996].

This presentation proposes an approach for typification of 2D-structures of similar type and size, like a collection of buildings, trees, mines, etc. Furthermore, the objects are of same importance. The approach is based on Kohonen Feature Nets [Kohonen 1982], a neural network learning technique. The prominent property of this unsupervised learning method is the fact that the neurons are adapted to a new situation (the stimuli), while keeping their spatial ordering - topology. Applying it for typification is straightforward. A subset of the original objects is chosen to represent the new situation. The number of objects can be calculated using Töper's law. A simple, random selection then yields a reduced number of objects – however it will usually not represent the original spatial distribution. This reduced data set is now introduced as the so-called output map into the Kohonen net; its topology is given by a triangulation of the nodes. In the learning phase, the original objects act as attractors, that drag the neurons of the output map into their direction. In the learning iterations, the neurons are iteratively adjusted according to the underlying attractor structure. In the end, the reduced number of objects is distributed across the space according to the original spatial distribution.

Examples in the context of the typification of a collection of buildings show the suitability of the approach.

Furthermore, the presentation focuses on open questions:

1) First of all, it is desirable to introduce constraints into the adaptation process, e.g. concerning minimal distances between adjacent objects, in order to guarantee legibility. One option is to follow the typification operation by a displacement operator - the other is to introduce this constraint into the process itself. Another constraint could be imposed by other adjacent objects (e.g. roads).

2) Another question concerns the possibility of extending the approach to 3D. This application would be out of the scope of typification, but more in the domain of 3D terrain simplification: the number of points of a DTM is reduced by a certain factor in a random fashion; points of high curvature in 3D could serve as stimuli in order to attract the terrain points. This would have the effect, that in regions with high curvature there would be more points to describe the terrain, whereas the other regions could be represented by fewer points.

References

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