First Experiments with Neural Networks in Line Generalization

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The tools for cartographic generalization in a digital environment so far are mainly based on algorithmic approaches. There exist several algorithms for some spatial transformations, predominantly simplification and smoothing. As soon as more complex tasks are demanded, however, these methods normally fail. For example, algorithmic methods show problems in retaining the character of a line (caricature), as it is the case in generalizing a winding mountain road. A skilled cartographer would suppress most of the bends but deliberately keep a handful of them to retain the quality of the road. This task cannot be accomplished by means of changing the parameters of a simplification and/or smoothing algorithm. To overcome this deficit the use of expert systems has been proposed. The disadvantage of this approach is that first of all accurate rules have to be set up. Since the process of generalization could not be formalized in depth so far, the "fuel" for expert systems is not available yet.

That's where artificial Neural Networks (NNs) could step into the breach. They are not based on rules but "learn" through training. Training a NN means presenting hundreds of different input–output pattern pairs to the network, which is permanently changing its connection weights to produce the desired result. Provided the set of training patterns was chosen carefully, the weight changes diminish and finally the NN converges. The trained network can now recall learned patterns but should also be able to produce sensible output from input the NN has never seen before. In terms of line generalization training a NN means presenting pairs of lines at two different scales. A line exposed to the NN at source scale should now produce a generalized version of it at target scale. This process takes into account all the generalization "rules" implicitly present in the training set.

NNs have been applied to various topics in the past, but having a closer look at these applications reveals that they were used for classification purposes only. Introducing an intermediate raster level makes space discrete and allows to "reduce" cartographic generalization to a low level classification problem. "Classes" are represented by single pixels which are turned on or off, depending on the presence/absence of input-features (represented by pixel patterns). For our experiments the Stuttgart Neural Network Simulator (SNNS) was used as platform. A set of 500 line pairs has been compiled as training set, keeping aside 100 line pairs for performance tests and quality assessment. A moving window technique was used to present the data to the NN, with the drawback of the relatively local character of the method. Therefore other line representations were taken into consideration such as Fourier Series and the so-called Curvature Scale Space Image, which promise a more holistic view of the line. It turned out that the choice of the training patterns is crucial for the resulting performance. The experiments revealed that NNs are not "magic tools" that solve the problem of line generalization, but they proved to be useful for interactive generalization on the screen.