12 Methods for Interpreting Self-Organized Maps in Data Analysis

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The Self-Organizing Map (SOM) can be used for forming overviews of multivariate data sets and for visualizing them on graphical map displays, as described in Section 11. Each map location represents certain kinds of data items and the value of a variable in the representations can be visualized in the corresponding locations on the map display. Examples of such component plane displays have been shown in Figure 15 in Section 11. The component planes contain all the information needed for interpreting the map but information about the relations of the variables remains implicit. We have developed methods that visualize explicitly the contribution of each variable in the organization of the map at different locations.
It is additionally possible to summarize the characteristics of different areas on the SOM, for instance areas corresponding to different clusters, by measuring the contribution of each variable in the cluster structure within the area.
We are currently in the process of evaluating the proposed methods in case studies. Here the methods will be demonstrated with a simple data set consisting of 13 properties of 16 animals. Each variable has the value one if the animal has the property and zero if it does not. A SOM of the animal data set is shown in Fig. 17. Different regions of the map represent different kinds of animals in an ordered fashion.

12.1 Local Factors

The SOM can be thought of as a nonlinear lattice of points that are determined by the model vectors in the high-dimensional data space. It is not possible to interpret the nonlinear lattice as simply as for example the set of linear factors obtained by factor analysis. The lattice can, however, be approximated *locally* by a linear hyperplane which is fitted to represent the model vectors within a certain radius on the map. The approximation can be computed with the principal component analysis algorithm resulting in two *local factors*.
The combined contribution of a variable on the local factors, computed as the sum of squares of the “factor loadings”, at each location of the map lattice can be visualized as a gray-level display that resembles a component plane (Fig. 17**b**). It can be seen in the figure that the variable “has hair” contributes strongly to the organization of the map along a stripe in the middle of the map where the representation changes from birds to other animals. The variable “has hooves” contributes to the organization in the top right corner.

12.2 Summary Generation

The methods described above aim at making the basis of organization of the SOM explicit. They do not, however, further reduce the amount of data, and we have therefore developed a method for generating briefer summaries of the important characteristics of the maps. In this study the method is used in a partly manual mode but most of the steps can be automated.

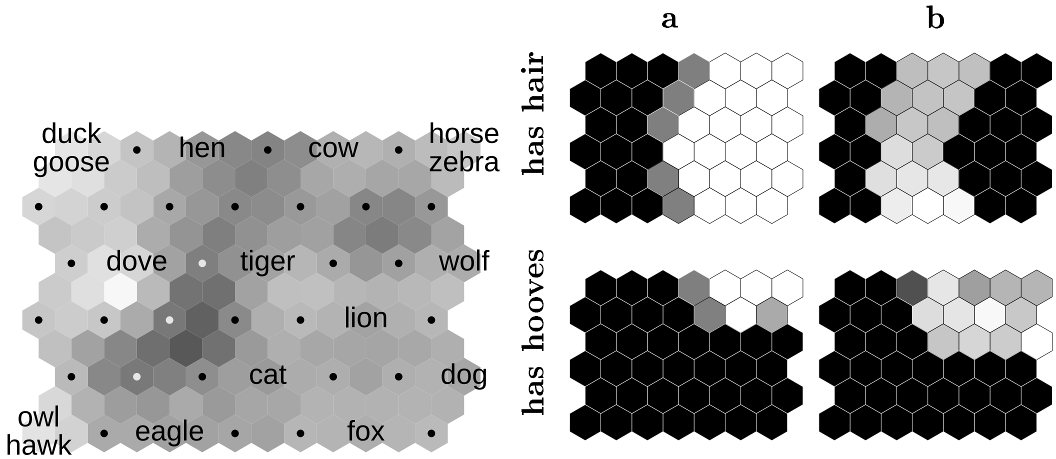

Figure 17: Sample illustrations of the methods applied to the animal data. The SOM of the animal data set is shown on the left; gray shades indicate clustering tendency (white: clustered area, dark: sparser area in between clusters). On the right, the top row visualizes the variable "has hair" and the bottom row "has hooves", respectively. **a** The component planes. Each plane describes the values of one variable at each location on the map. **b** The contribution of the variables in the two local factors (white: maximal contribution, black: minimal contribution).

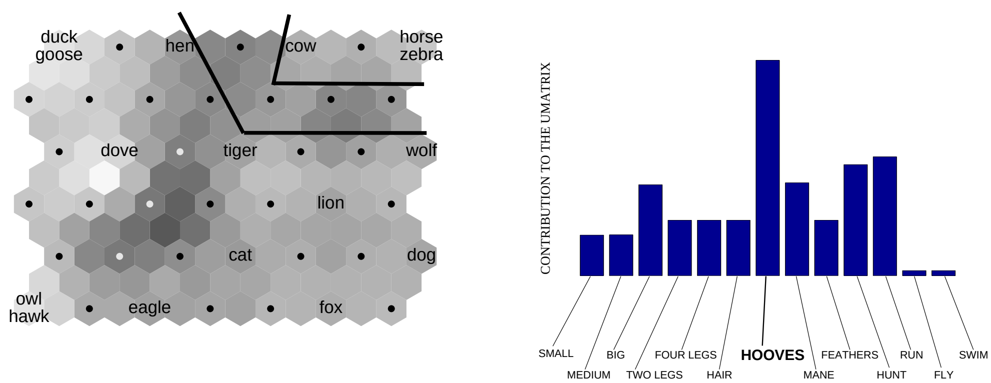

Figure 18: Characterization of a cluster in terms of the contributions of the original variables in the cluster structure. The region around the cluster in the top right corner is shown on the left, and the contribution of the variables within this area is shown on the right.

After the user has found some interesting area on the map, for example a cluster, we aim at summarizing *which of the original variables contributes most to the direction of the map around the area.* A very simple and easily computable measure of such contribution is the share of the component in the distances between neighboring map units around the cluster.
An example of the analysis of a clustered area is shown in Figure 18. The cluster consisting of cow, horse, and zebra seems to be characterized mainly by the variable "has hooves".