Recognition of Large Island Structures for Map Generalization

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INTRODUCTION

For several years various researchers (Brassel and Weibel, 1988; McMaster and Shea, 1992; Ruas and Plazanet, 1996) have stressed the importance of structure recognition or cartometric analysis as a key step placed at the beginning of the automated generalization process. The main objective of the structure recognition stage is to identify situations (structures) of special importance and select the corresponding objects for an appropriate treatment during map generalization. The focus of this abstract is on describing a procedure for the recognition of perceptually important island structures. This approach is intended to represent the structure recognition stage for the generalization of islands in topographic and thematic maps. Developing a structure recognition module basically entails four steps which will be explained below for the recoginition of island structures: 1) Identifying the important situations (structures); 2) formalizing the situation (describing the structures by measures); 3) developing a structure recognition algorithm; and 4) developing an evaluation procedure for the results.

WHAT ARE ISLAND STRUCTURES?

To answer this question we made an experiment with a group of 13 persons which were asked to mark groups of islands on sample maps. Based on the experimental results we categorized the island structures with respect to their size and shape and could relate their construction to principles of Gestalt theory. We identified three size types of island groups: micro, meso and macro structures. Whereas micro structures do consists of 2 to 10 islands, meso structures usually contain more than a dozen islands. Finally, macro structures are very large island compositions which involve several meso structures but are usually not perceived without knowledge of their existence. Considering the shape of the island groups it seems to be useful to distinguish compact groups and elongated groups.

FORMALIZING ISLAND STRUCTURES

From the experiment we concluded that meso structures are mentally formed based on only one Gestalt principle, namely proximity. Recognition algorithms that realize distance based grouping of objects are agglomerative clustering approaches and distance based graph structures. Inspired by the work of Regnauld (2001) who applied a graph based approach for the recognition of building groups we decided to build our work upon his results. Furthermore, the shapes of the individual islands are characterized by a set of shape measures (e.g. orientation, area and fractal dimension).

DETECTING MESO STRUCTURES OF ISLANDS

The procedure to detect the meso structures consists of the following six steps:

- Create from the set of islands a dynamic Proximity Graph which connects every object with every other object within a certain neighborhood. The output of this procedure will be several large and small groups of island, whereby isolated islands will not be part of the graph structure (Figure 1-B).
- Reduce the proximity graph to a Minimum Spanning Tree (MST). Thus we obtain the structural skeleton of connected islands, that is, the island will be the limbs of a chain. The advantage of forming a chain is that we only need to split it at specific points to obtain the meso groups. (Figure 1-C).
- Select seed islands which are part of the MST and form a set of potential nuclei for meso structures. (Figure 1-C).
- Create Voronoi regions from theses seeds and trace the MST from every seed to find the connected islands. The tracing will stop at the edges of the Voronoi regions. After this procedure we will obtain an initial set of meso structures, whereby the grouped islands will be within the Voronoi region. (Figure 1-D).
- Extend the meso structures by adding all remaining islands which are connected to only one meso group. (Figure 1-E).
- Finally, merge those meso structures whose seed islands are within a certain neighborhood to each other (see Figure 1-F). The neighborhood can be defined similarly to the neighborhood used in the first step.

After these six steps we obtain as primary output a certain number of meso structures and as secondary output certain isolated islands which will not be part of any structure. For the following automatic characterization of the shape of the island groups we propose to use the principal components obtained from a 2D PCA, building on point coordinates of the island boundaries. They will on one hand deliver the orientation of the group and on the other hand on can distinguish between compact and elongated shapes based on the ratio of the eigenvalues.

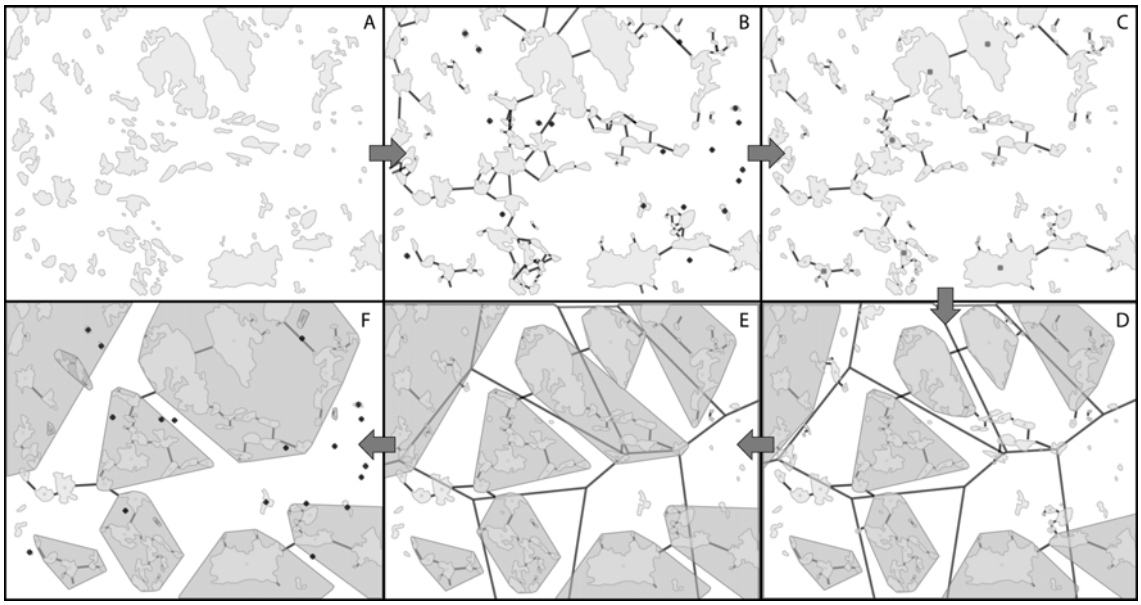

Fig. 1: The steps of the meso structure detection algorithm.

EVALUATION

We applied two evaluation procedures. First, we made a visual comparison with the references from the human subject experiment. The results were satisfying although differences in the extent of the detected meso groups could be identified. It appears that some islands should be separated from the meso groups. Candidate islands for a split can probably be obtained from the second, automatic evaluation procedure that consists of a T^2-test (Jackson, 1991) for every island group to identify those islands which can be considered as spatial outliers.

CONCLUSION

The detected island structures should be treated in a special way during the subsequent generalization process. For instance, islands forming the outline or the core of a structure should never be eliminated (Bertin, 1983). On the other hand isolated islands should not be eliminated as well since they may be an important point of orientation for map users. Such application scenarios have to be developed and tested in the future. Current research will address the recognition of mirco structures and the improvement of the algorithm with respect to the seed selection method.

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