

CARTOGRAPHIC AMALGAMATION OF AREA OBJECTS

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ABSTRACT:

A new method to control the cartographic generalization operator amalgamation is presented. An interactive prototype system is developed, which enables an user to select two areas that are subject for amalgamation. The areas are processed with a grow and shrink operator. The newly created areas are tested against acceptance criteria for acceptance or rejection. The idea is to use this system for knowledge acquisition for building a knowledge based system that can automate this task.

KEY WORDS: Amalgamation, Cartographic Generalization, Image Processing, Grow and Shrink Operation.

INTRODUCTION

Amalgamation is the cartographic process where two or several individual areal objects are merged into one object. This is one kind of simplification operator for areas (Shea and McMaster, 1989).

The reason for this work is a need to generalize topographic map data and to automate this process. Map data at the scale 1:50000 that should be used in the map scale 1:100000 needs to be simplified. At the National Land Survey of Sweden map separations are scanned from the 1:50000 topographic map series and combined into a digital raster map. It is then edited manually on screen with an interactive tool to simplify some cartographic objects and to remove errors introduced by the scanning process. Amalgamation is in some cases carried out during this step. This interactive editing is however tedious and expensive. Therefore, many small objects are left, even if they can not be presented on a computer screen or on a paper map at a map scale of 1:100000.

This paper concentrates on a method how and when amalgamation can be carried out within a raster based GIS. The main idea is to select two cartographic objects of the same cartographic class and process them pair wise. The two objects are merged together and we are given the control to check if the result is acceptable or if it should be rejected. It is inspired by the idea of making tools available in a cartographic work bench for performing cartographic generalization on digital data to collect rules for later use in a knowledge based system(Weibel, 1991).

BACKGROUND

Amalgamation of raster data can be carried out with a combination of thickening and eroding technique (Weber, 1982). The main problem with this method is that it is globally applied on all individual cartographic objects within the cartographic class processed. This gives the desired result in some cases, but also causes amalgamation of objects where it is not desired. It is difficult to control the process. The parameter of how many pixels that are used for the thickening and eroding steps is the only variable that can be changed. In a recent paper by Person and Jungert (1991) it was shown that this same approach, which they call the expand and shrink method, does not work very well when creating multi-resolution maps for path finding.

Amalgamation can also be accomplished by a gap bridging technique (Monmonier, 1983). This technique implies that a gap bridging operation is carried out in several iterations. It performs row wise and column wise gap bridging and gap bridging along the the two principal diagonals. This technique suffers from the same weakness as the method presented by Weber, i.e., it is applied globally over a map for one object class at the time. A largest gap measure is here also the only control parameter.

In the following section a procedure is presented how the expand and shrink algorithm can be improved to permit a higher degree of control of the outcome of the amalgamation operation.

METHODOLOGY

The idea behind the technique suggested here is to work on a segmented raster data base. All spatially homogeneous areas are treated as separate regions, here called objects. Two objects are interactively pointed out with the cursor on a screen. The amalgamation operation is carried out pair wise on these two objects. The method can be summarized in the following steps:

1. Calculate the shortest distance between the objects boundaries. This can be explained as a hit function when buffer zones representing the distance from one object overlap the other object. If the both objects are further away from each other then a largest distance, quit the whole procedure (figure 1b).
2. Grow both objects with the distance calculated in step 1 (figure 1c).
3. Shrink both objects with the same distance as in step 2 (figure 1d).
4. Subtract both objects from the figure created in step 3 (figure 1e).
5. Segment all areas that are created in step 4 to form spatially homogeneous areas.
6. Compare each area created in step 5 against acceptance rules. At present only one rule is used. This rule says that a newly created area object in step 5 should have both original objects as neighbours (figure 1f).

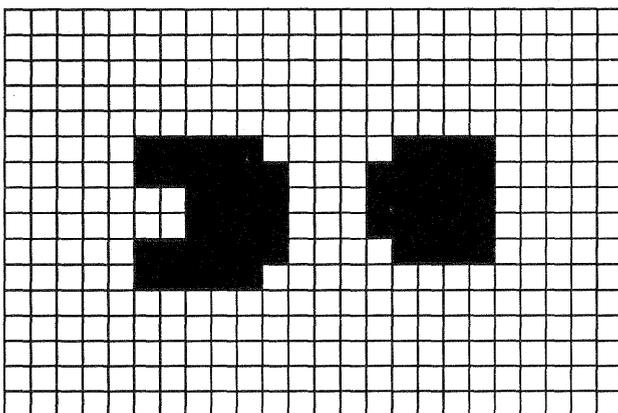


Figure 1a. Selection of two objects in a object oriented data base.

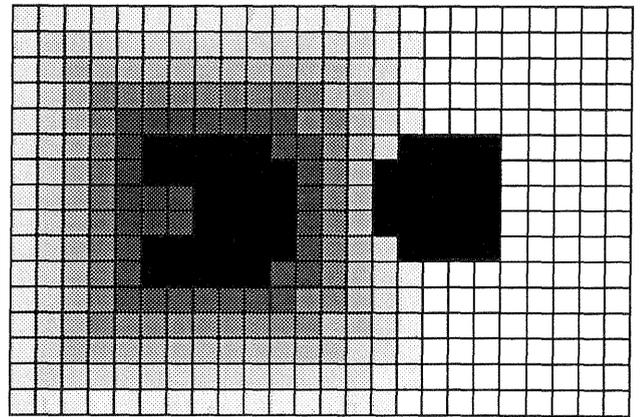


Figure 1b. Distance transformation around the left object.

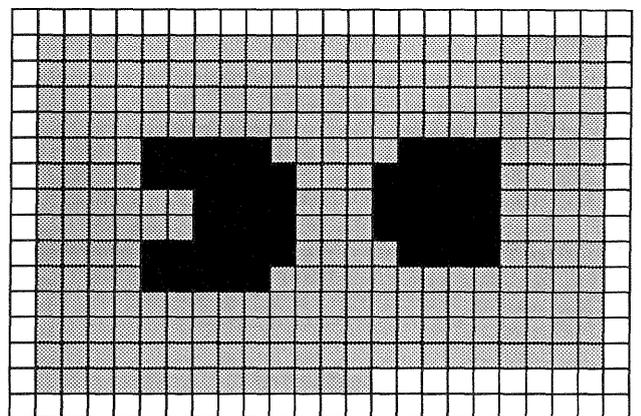


Figure 1c. Grow operation applied on both objects.

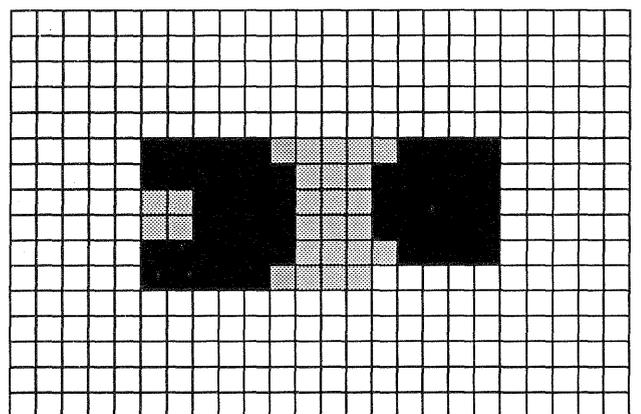


Figure 1d. Shrink operation applied on the result in figure 1c.

RESULTS

With this amalgamation method, we have obtained two improvements compared with earlier strategies;

1. With the retrieval of the shortest distance between the two objects a good estimator is found for the amount of region grow and shrink that should be performed to get the areas to join together.
2. The procedure to segment the newly created objects makes it possible to control that concave bays of the original objects are not filled in the process (figure 2).

This idea has resulted in a prototype tool which has been built within the software GRASS(Geographic Resources Analysis Support System)(Westervelt, 1991). Bourne shell scripts control the user interface and the execution of the proper modules in GRASS. This tool should be seen as one tool among others in a cartographic workbench for performing generalization. In the hands of a cartographically skilled person, it will make it possible to collect rules about when amalgamation can be carried out and how this can be done.

DISCUSSION AND CONCLUSIONS

In this paper an improved method for cartographic amalgamation of area objects has been described. In a first phase, it is supposed to be used in an interactive system for the purpose of gaining experience about the generalization process amalgamation. In a later phase the tool can be built into a semi-automatic or automatic system, based on a rule based approach with an expert system to guide the generalization process.

The rules that should be collected are of two kinds;

1. Onto which cartographic object types the amalgamation should be applied, it means which objects to select. In the currently used data set with topographic data the amalgamation process could be applied on small wetland, forest and open field areas.
2. Which rules should be used for acceptance or rejection of the newly created areas.

The second question regarding acceptance criteria is that the newly created areas should have both original objects as neighbours as mentioned above. Another rule that could be reasonable is to state that a newly created area is not allowed to cover a certain cartographic class. E.g., in most cases, we do not like the new area to cover water. A rule base that specifies these priorities between the original cartographic classes in the map could be written here. These rules could also be written as explicit rules, that handles all occurring cases if the data base does not contain to many cartographic classes.

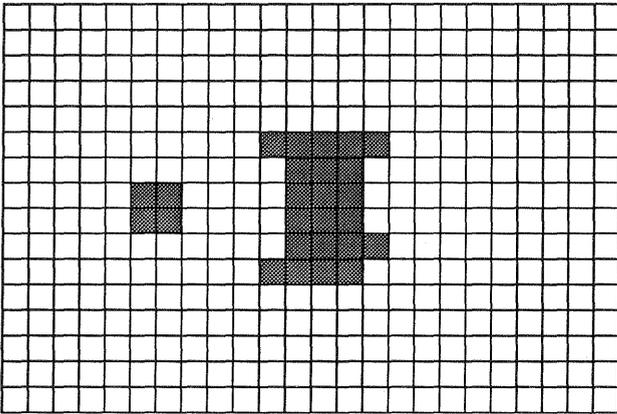


Figure 1e. Subtraction of both objects from the result in figure 1d. Segmentation of the new areas to unique objects.

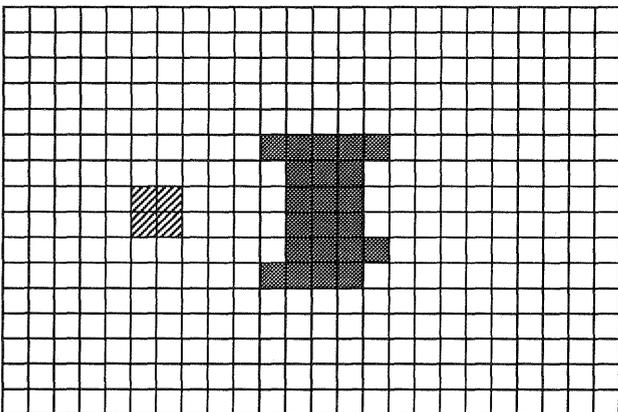


Figure 1f. Acceptance test for the objects created in the previous figure. The left object is rejected and the right object is accepted.

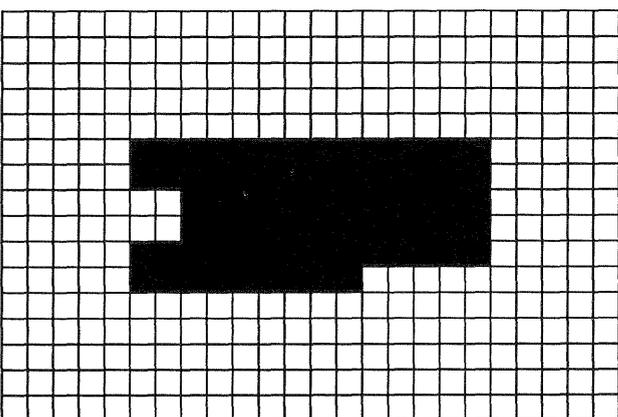


Figure 1g. Final result when the accepted object is added together with the two original objects into the raster data base.

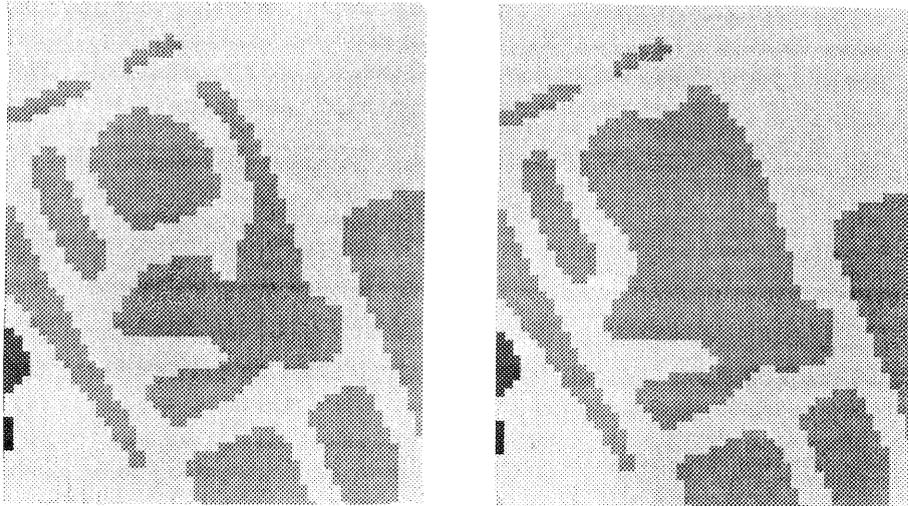


Figure 2 The original image and result after amalgamation has been applied on two objects in real raster data base.

The newly created areas can also in some cases be kept for the purpose of performing simplification of the form of the original objects. An acceptance rule for this could be that more than 75 % of the borders pixels of the new area are neighbours with one of the original objects. Another rule also has to be used here to ensure that the new area is not covering something of importance.

The method presented in this paper could also be used for exaggerating one object toward another object, e.g., if a wetland area that is close a river, but has a narrow strip of open fields in between. In this case the amalgamation could be carried out between the wetland and water objects. The newly created area between the objects can be reclassified to wetland after amalgamation and acceptance check.

The methodology shown here is general in the sense that it could be used in several application areas. The system design is aimed at generalizing topographic area data. However, this strategy could also be used as a post processing step after classification of satellite images.

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