COMPUTER-ASSISTED GENERALIZATION

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ABSTRACT

A popular scale for digital topographic data bases for series mapping in Australia is 1:25000. The data base is reduced linearly to produce maps at scales smaller than 1:25000. No automatic capability exists to assist in generalizing digital topographic data without over-representing or cluttering the output map. Existing procedures involve manual selection, symbolization, geometric change and displacement of features. These methods are tedious, inconsistent and subjective. The project discussed consists of a program which assists in the generalization of digital topographic data so as to minimize human intervention. The process includes selection, symbolization and geometric change including line filtering, line generalization, area simplification, building amalgamation and simplification, and other operations required to produce the output map.

Note: The views expressed are not necessarily those of the Royal Australian Survey Corps.

INTRODUCTION

Source digital data for series mapping in Australia are often stored at a scale of 1:25000. These base maps are then used to generate maps at scales of 1:50000, 1:100000 and 1:250000 by linear reduction of the digital topographic data base. The cartographer then has the tedious task of editing and enhancing the over-represented and cluttered map to obtain a generalized derived output.

At present no automatic capability exists to generalize the 1:25000 digital data base to scales smaller than that of the source data without over-representing or cluttering the output map. The linearly reduced maps contain the same number of points and features as the original map. The subsequent manual selection, symbolization, geometric change and displacement of features are inconsistent, tedious and subjective.

This paper outlines the processes involved in computer-assisted generalization using the objectives and principles of manual generalization. These processes are incorporated in a computer program which allows for batch processing of the data base to rid the cartographer of some of the monotonous and subjective tasks of generalization. Batch processing is necessary for an economic usage of automation in cartographic generalization because generalization processes executed solely by means of interactive graphics are too costly and time-consuming for practical applications. The program will minimize human intervention allowing the cartographer to use his visual perception ability for the more interesting processes of generalization (e.g. displacement) utilizing an interactive CRT display and light pen (or cursor).

GENERALIZATION

The parameters and criteria used in the computer-assisted generalization program depend on the scale of the derived map. These were obtained by experimentation, from various published references (e.g. Swiss Society of Cartography,1977) and from map series specifications of the Royal Australian Survey Corps. They are arbitrary and may be changed to suit the user's requirements.

The generalization procedure can be divided into two major parts. The first part manipulates data in a batch mode prior to any interactive operations. This is the computer-assisted role advocated by this paper. The second part by-passes batch generalization because it contains features which can only be generalized with the aid of a detailed picture of the local, and maybe global, features of the map.

The computer-assisted part may be subdivided into four main processes. They are:

Selection. The selection process simply selects which features are to be shown on the derived map. For example, the contour interval at 1:25000 is 10m whilst at 1:50000 it is 20m. The contour feature codes are identified and only those with modifiers divisible by 20 are selected for further generalization.

Symbolization. Area features are represented by symbols on the derived map. For example, a building or dam whose outlines are represented at 1:25000 may have to be represented by a building or dam point symbol at 1:50000 for clarification.

Geometric Change. The shape of the features selected for output, whether for linear or areal features, frequently needs to be changed to eliminate distracting irregularities caused by scale reduction. Geometric change may be categorized as follows:

1. Lines and Areas. The process of geometric change for lines and areas consist of filtering, generalization and smoothing.

Filtering eliminates excess data without changing the shape of the feature at the derived scale. Filtering substantially reduces the number of points in the data base, thus improving computing and plotting times.

Generalization is the process of selecting salient points from the coordinate set of a feature so that the overall impression of the shape of the feature is retained. This may result in lines becoming over-simplified, rugged and visually unacceptable because visual perception (e.g. smoothness) is not taken into consideration when selecting the salient points. The visual perception of the line is improved by the application of a smoothing routine.

Smoothing inserts additional points between the salient points retained after generalization to produce a smooth output of the generalized line or area. The smoothing routine is only used for derived scales of 1:100000 and over, and for features which have been digitized as continuous features. Smoothing is not used for interrupted (multi-point) features.

2. Buildings. Building generalization may be grouped according to whether the source feature code represents a scaled building or point symbol of a building.

a. Scaled Building. A building outline is symbolized if it is smaller than the area represented by a building point symbol. The pilot study area only had a small number of building outlines. Amalgamation and simplification of building outlines is a complex process. At this stage it appears to be more economical to generalize the few building outlines interactively. In any case, almost all scaled building outlines are symbolized at scales of 1:50000 and smaller.

b. Point Symbol. Distances are calculated between the building centroids and sides to determine whether they should be amalgamated. Amalgamation includes two or more buildings into what may be a complex new building. The new building is then simplified using a grid system. The amalgamation and simplification theory used was developed as part of a research project by Slade at The Royal Melbourne Institute of Technology (1983).

Feature Displacement. Frequently a reduction in scale and generalization of source data results in parts of the output still being cluttered. In some cases feature overlays may occur (see figure 4). Presently the generalization algorithms treat features as discrete entities independent of other map elements. The reason for this is that the features are stored as separate entities in the data base.

The spatial searches required to avoid overlap are computationally complex in vector mode. Feature displacement requires a perceptual knowledge of the area surrounding the feature. This can best be done interactively on a graphics screen. An order of displacement of map elements based on experimental work by Schittenhelm (1976) is suggested.

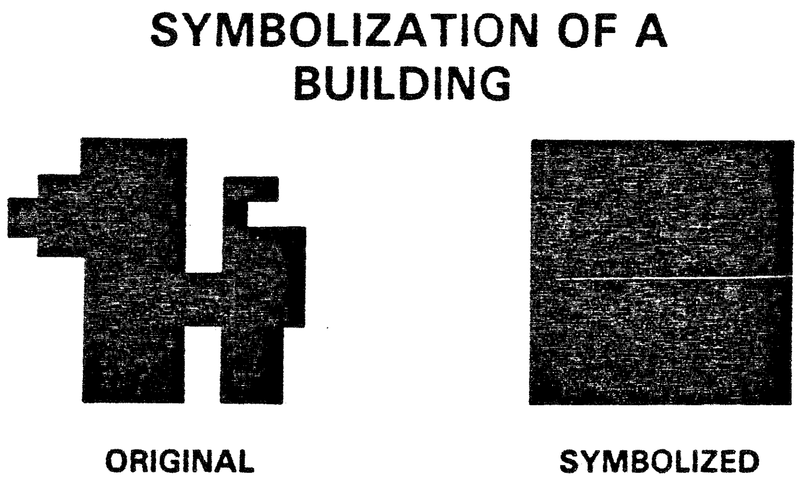

Fig. 1: Symbolization of a Building

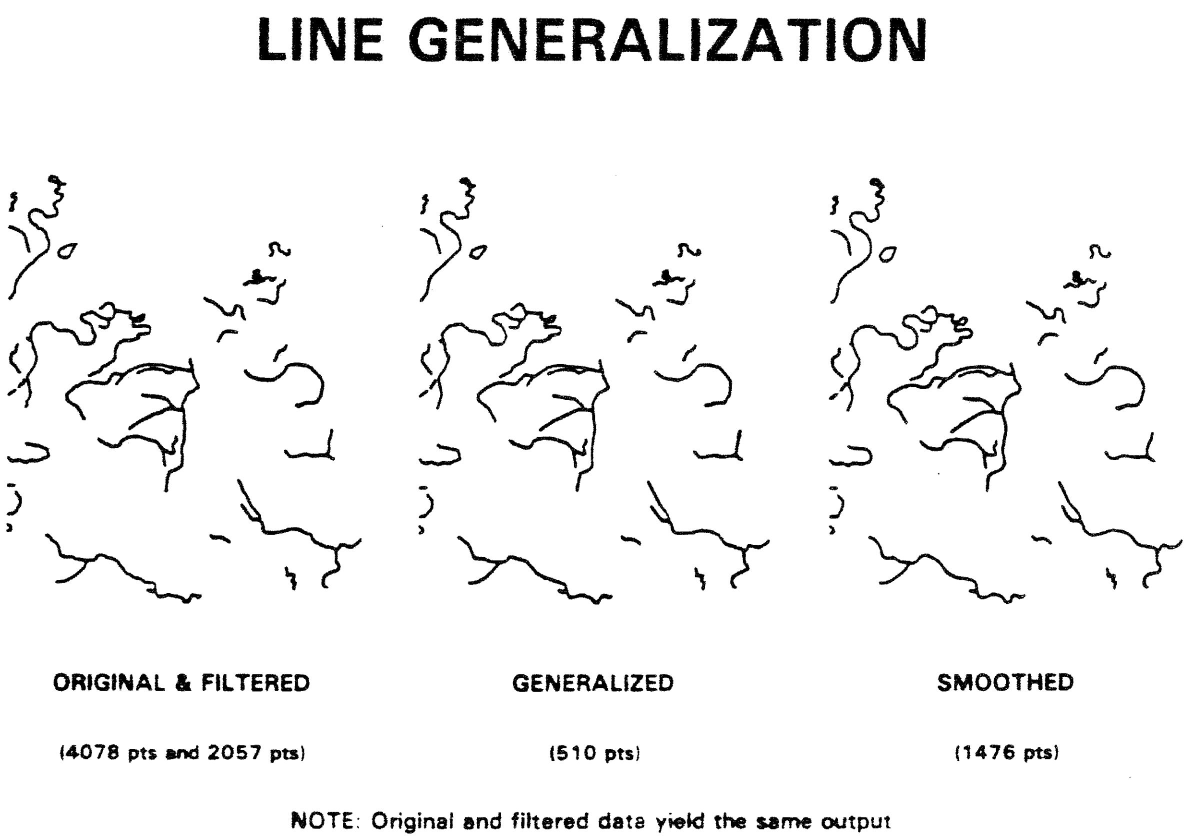

Fig. 2: The Three Basic Processes of Line Generalization

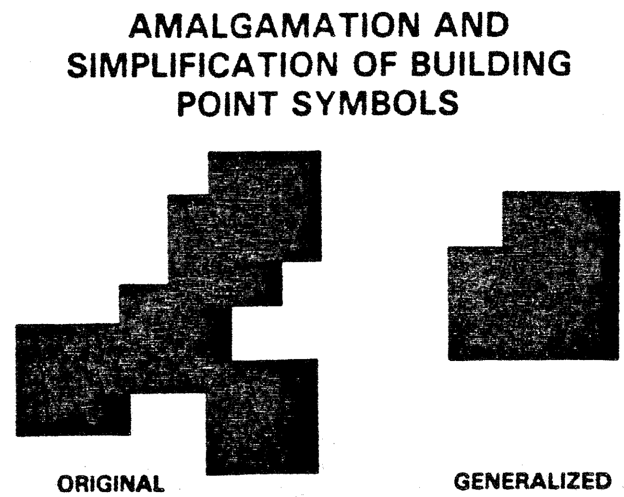

Fig. 3: Amalgamation and Simplification of Building Point Symbols

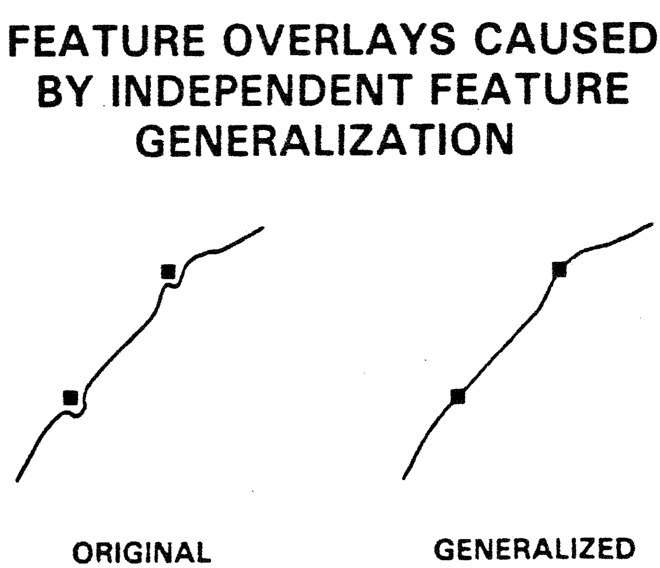

Fig. 4: Feature Overlays caused by Independent Feature Generalization

A BATCH GENERALIZATION PROGRAM

A non-standard FORTRAN 5 batch generalization program was developed by Slade at the Surveying Department of The Royal Melbourne Institute of Technology in 1983. The program, called OSGEN, assists with the generalization of digital topographic data from a source scale of 1:25000 to derived scales of 1:50000, 1:100000 and 1:250000.

A PDP 11/34 with a RSX-11M operating system supported by 4 RK05 disks, a tape drive and a Data Technology flatbed plotter was used. The digital data (Ingham 1:25000) was provided by the Royal Australian Survey Corps on magnetic tape (800bpi) using their AUTOMAP magnetic tape format.

The structure of OSGEN was dictated by the limited capacity of the system and the structure of the digital data provided. Amongst the problems encountered were: the independence of features, lack of levels of importance of features, segmentation of features and lack of automatic recognition of feature characteristics.

All the computer-assisted generalization processes discussed previously, except for feature displacement, are incorporated at various stages of the program. OSGEN is divided into nine sub-programs. Each sub-program generalizes a particular group of features which have one or more common characteristics. The subdivision is necessary because of the limited storage space on disk, the limited core memory available (approximately 32K; 16 bit words) for the program and to reduce computing time by only storing a group of features on the disk at a time. The nine sub-programs are for:

a. buildings,
b. point symbols,
c. area annotations,
d. scaled symbols,
e. interrupted lines,
f. interrupted areas,
g. continuous lines,
h. continuous areas, and
i. contours.

Each sub-program is called in turn from the main program, OSGEN. The features corresponding to those listed in the sub-program are transferred to a disk file. Various calculations and manipulations are performed, and the derived data are transferred to an output file. Area annotations are stored on a separate output file, because text generalization is best performed interactively by overlaying the text on the derived output of the point, line and area features.

Figures 5 to 8 show examples of the results of the application of some of the sub-programs to the original data base of the study area used to test OSGEN in Slade's project. The left-hand side figures are the original data at 1:25000 reduced linearly to 1:250000. The figures on the right-hand side are the generalized data at 1:250000.

CONCLUSION

The number of points and features represented at the derived scale for further manual intervention is reduced significantly by OSGEN without distracting from the overall picture of the map. For example, the number of points representing all line and areal features on the test map is reduced to an average of 18% of the original number of points for a derived scale of 1:250000 from the 1:25000 data base. For the same scale the number of buildings is reduced from 392 to 97 (approximately 25% of the original).

The derived map uses significantly less storage space, the data is easier to manipulate because of its decreased size, plotting is faster and the graphic display for interactive generalization is made much more legible. The introduction of faster, high resolution and relatively cheap graphic systems in recent years has provided the Cartographer with the facility to complete the generalization process by computer-assisted means. It is now up to the Cartographer to improve existing cartographic data structures so as to make maximum use of new technology.

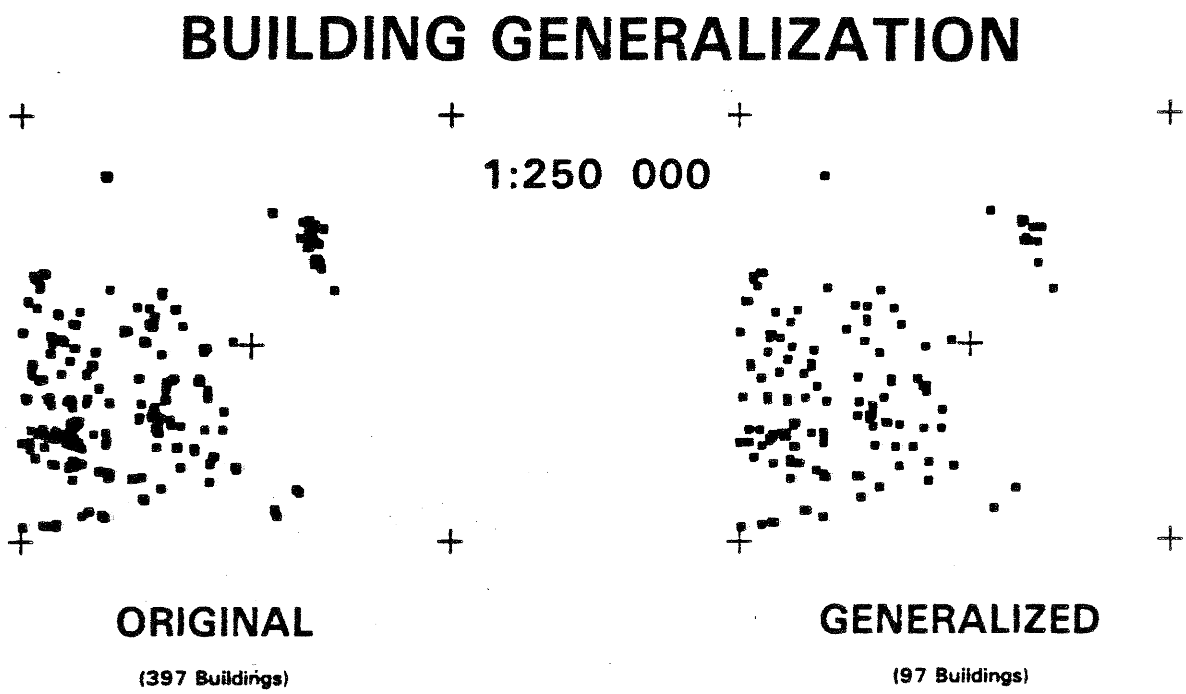

Fig. 5: Building Generalization

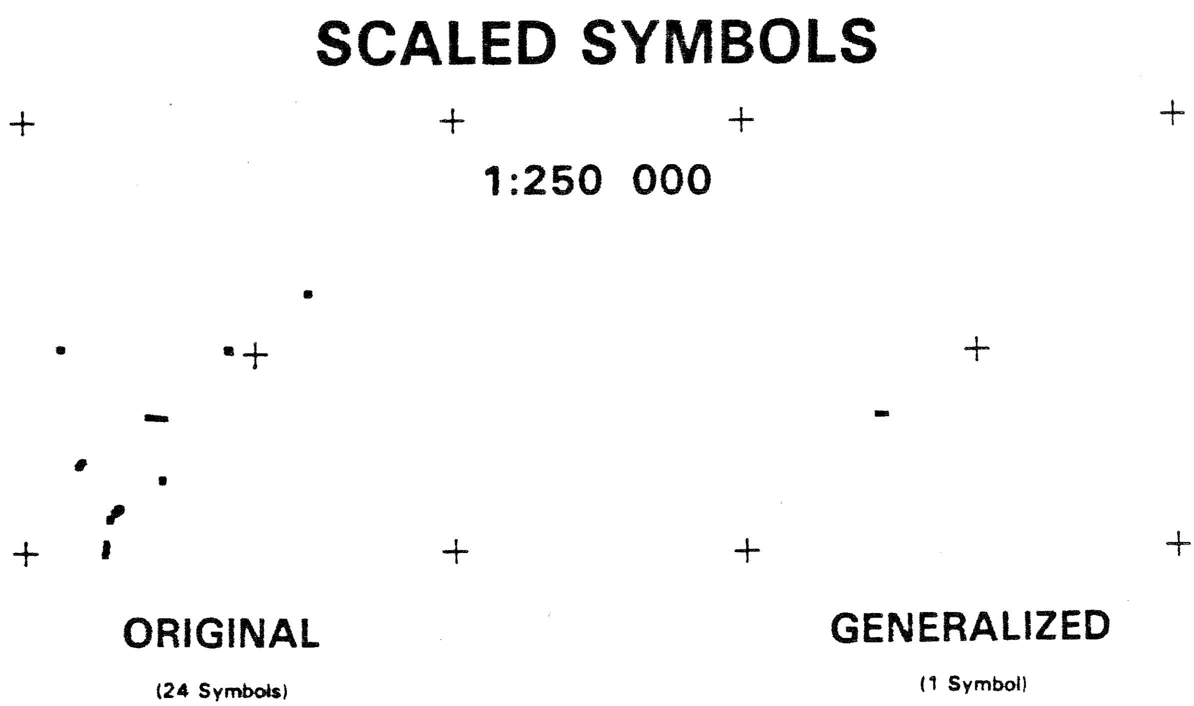

Fig. 6: Scaled Symbols

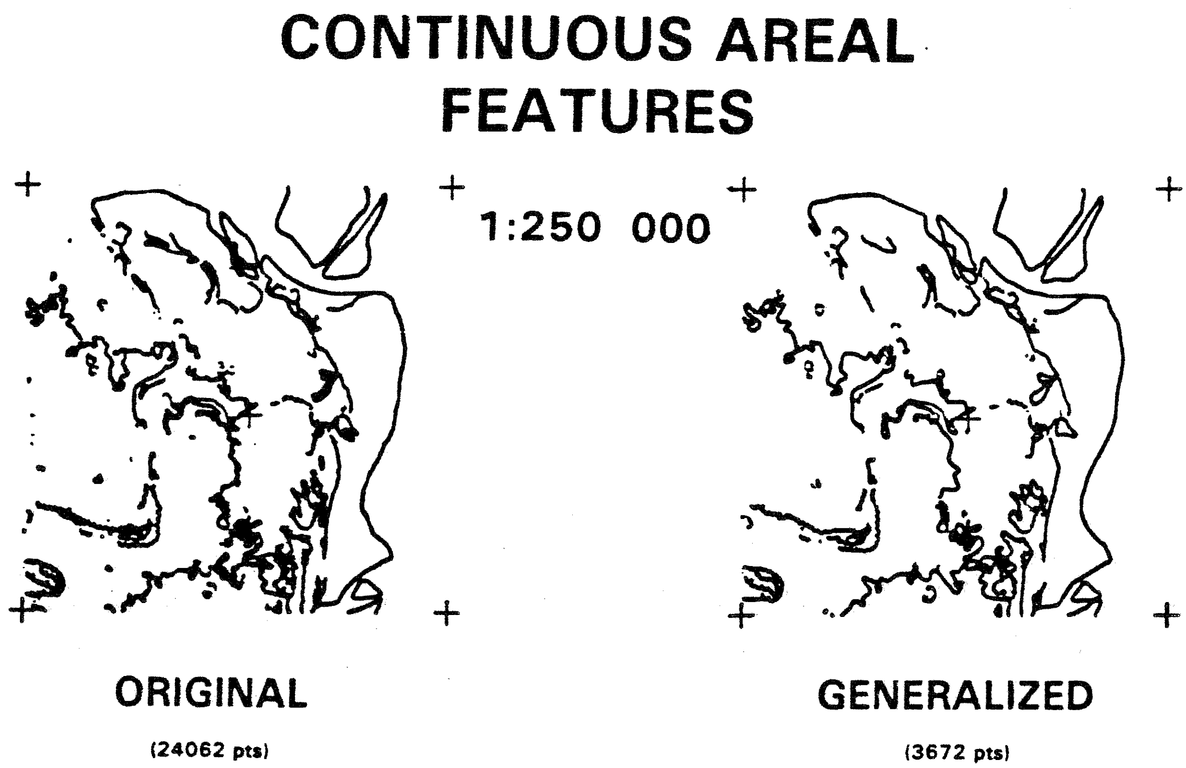

Fig. 7: Continuous Areal Features

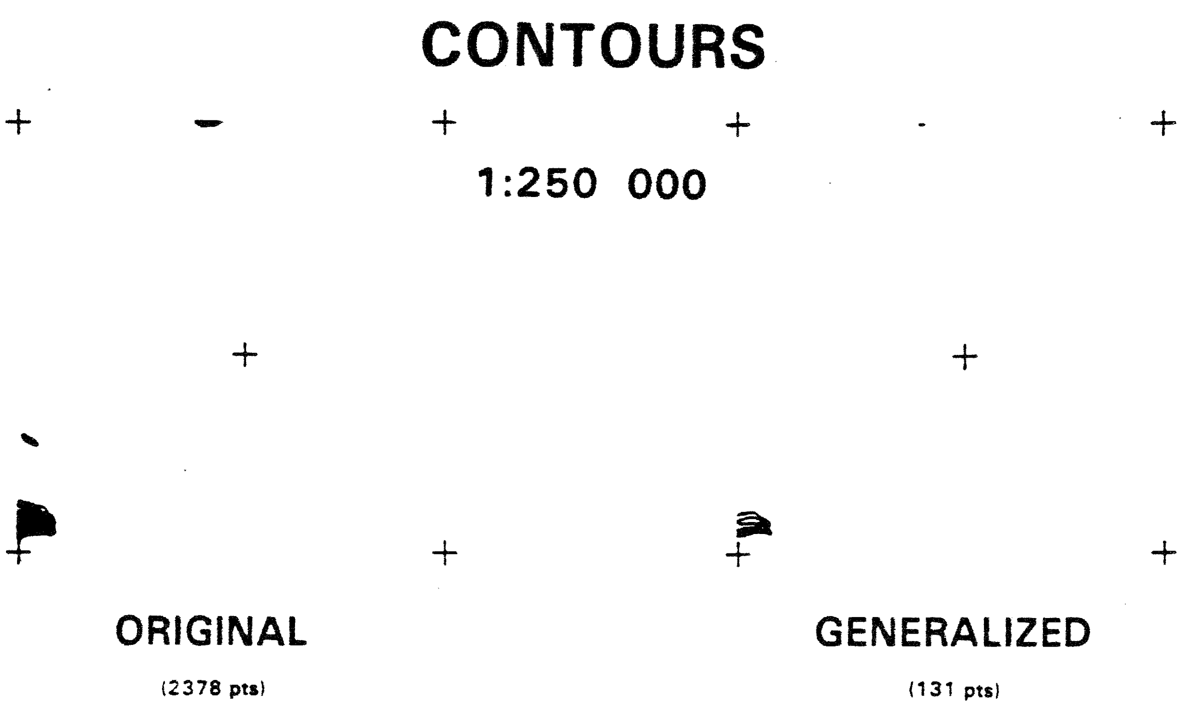

Fig. 8: Contours

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