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Automated cartographic text placement

Herbert Freeman *

MapText, Inc., 666 Plainsboro Road, Ste. 1025, Plainsboro, NJ 08536, USA

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Abstract

The most time-consuming task of producing a map—after data collection—is that of labeling the point, line, and area features depicted on it. It is a task that has been performed by skilled human cartographers for centuries but one that has proven remarkably resistant to automation. The paper describes a research and development effort extending over nearly 25 years to develop a software system that would automate this task. The software now available embodies the cartographer's rules and conventions and places the text for each feature according to a user-specified scenario, resolving placement conflicts and ambiguities over all feature layers in accordance with set placement priorities. Placement alternatives are automatically explored if the initial placement choice is not available because of lack of space, in a manner analogous to what a human cartographer could be expected to do under the same circumstances. The paper reviews the issues posed by the text placement problem and describes the solution for it that is now available.

Keywords: Cartography; GIS; Map labeling; Rule-based systems; Automatic text placement

In memoriam

It is an honor for me to dedicate this paper to the memory of Prof. Azriel Rosenfeld, a colleague and friend for over 40 years. He and I collaborated in innumerable professional activities relating to pattern recognition and image processing—in organizing short courses, workshops and conferences, and most important, in the establishment of the International Association for Pattern Recognition. His contributions to image processing will serve as a lasting monument to him. As per the ancient saying, we should look at his life as the journey of a ship that after a long voyage has returned to port laden with treasures and rejoice in his accomplishments.

1. Introduction

In the late 1970s, a problem was called to my attention that was said to be defying all attempts

* Tel.: +1 609 716 7552; fax: +1 609 716 7553.
E-mail address: freeman@maptext.com

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at computer solution—the automated labeling of the lines, points, and areas of a map. I was intrigued by the problem and accepted it as a challenge. After a number of years, with the assistance of many graduate students and researchers, we were able to demonstrate that the problem was amenable to solution (Ahn and Freeman, 1983). A company was formed to develop a commercially viable solution. After years of further development, it became possible to bring a product to market—now in use worldwide—that effectively accomplishes automated cartographic text placement. It reduces the time to label a map from weeks to a matter of seconds. The solution represents the judicious application of techniques drawn from pattern recognition, image processing, and computational geometry to solve a vexing practical problem (Freeman, 1983).

A map is a medium of communication, and the effectiveness with which it communicates spatial information depends in large measure on the quality with which the displayed features are labeled. A map should render the information of interest clearly, rapidly, and without ambiguity. Cartographers have refined the art of map making over hundreds of years and have established an extensive body of cartographic skills, conventions, and quality standards. Any automatic system for text placement must conform to the same conventions and aim at the same level of cartographic quality (Yoeli, 1972).

Maps and charts come in a wide range of styles, depending on the purpose for which they are intended. We have city street maps, highway maps, cadastral (property ownership) maps, election district maps, soil maps, forest lease maps, utility maps (e.g., for water, electricity, and gas distribution), telephone coverage maps, nautical charts, and aeronautical charts. In scale these can vary from 1:1000 for a large-scale local-area map to 1:10 000 000 for one displaying an entire continent.

Maps are used to depict a large variety of different kinds of information–villages, towns, cities, political boundaries, highways, secondary roads, railroad networks, land-use indications, as well as topographic and hydrographic information. The different kinds of information are stored in a computer database and organized as *layers*, which are then assembled (figuratively "overlaid") to form a particular map. This is illustrated in Fig. 1, where the layers shown represent (a) hydrography, (b) political subdivisions, (c) topography, (d) a highway network, and (e) municipalities. All such information is represented in terms of one of three feature types: *area features* (i.e., polygons representing lakes, mountain ranges, states, provinces, etc.), *point features* (i.e., point symbols representing small cities, villages, and mountain peaks), and *line features* (i.e., lines and curves representing rivers, highways and railroad lines). Area features are *scaled*. For line features, only the length is scaled; the width is symbolized (i.e., its value bears no relation to the width of the geographic entity represented and is independent of the map scale). Point features are represented by symbols and not scaled at all. Note that the choice of feature type is dependent on the scale. Thus a river may be depicted as an area feature on a map of, say, 1:12 000 but appear as a line feature when the scale is much smaller, say, 1:100 000. Similarly a city may be shown as an area feature at the large (1:5000) scale but convert to a point feature as the scale is reduced (Freeman, 1991).

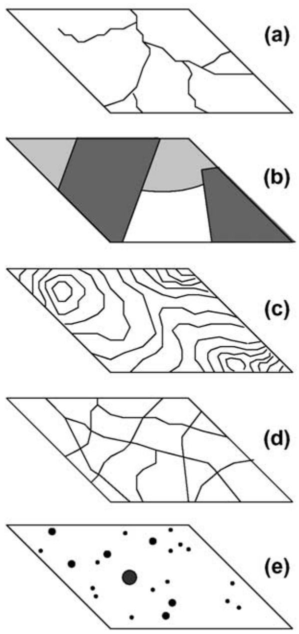

Fig. 1. Map layers.