IMPROVING MOVING MAPS: A SYSTEM FOR FEATURE SELECTION BASED ON A NEW COGNITIVE MODEL

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ABSTRACT

This paper describes a system for selecting objects for display on moving maps from a cartographic database. A cognitive model similar to spatial interaction theory is used to predict the most salient objects for display. Animated maps have been created using concepts described here.

INTRODUCTION

Electronic charting systems offer virtually unlimited opportunity for presenting spatial information to navigators. At the same time, much of their potential is often lost because information inappropriate to the task at hand clutters the screen, or important data is omitted. While there are many dimensions to this problem, the one addressed here is this: given a database of cartographic objects, which ones should be displayed to best serve the navigator?

Cartographic generalization in GIS can be considered in three distinct phases; object generalization, model generalization, and cartographic generalization (McMaster & Shea, 1992). The system described here falls into the domain of model generalization, which Weibel (1995) identifies as the step most amenable to formal modeling. That is to say it makes no attempt to determine the appropriate data model, or to determine the appearance of individual objects on the output device. Instead, this system is designed to facilitate data reduction and control how many and what type of objects are chosen for display.

Cognitive properties of moving map displays have received some attention from the aviation research community (e.g. Aretz, 1991). That attention has focused primarily, however, on map orientation rather than content.

Cartographers, on the other hand, have spent considerable effort on automating the procedures of generalization to control the appearance and content of maps. But this effort has not yet come close to reproducing the results of human cartographers, and some of it may be misguided in its attempt to reproduce traditional cartographic products (Goodchild, 1988).

In contrast, the maps displayed by the system described here change continuously. They are updated based on a number of parameters such as velocity, scale, and other inputs which will be described below. This reflects a philosophy that the information presented should be useful in a specific situation, rather than be a comprehensive reference.

The model described here is being implemented so that users can adjust parameters and see results quickly. That should facilitate the design of experiments which will attempt to test the validity of the cognitive model.

METHOD

An examination of a series of aeronautical charts at different scales shows a variety of differences. Scale, symbology, level of detail and density of selected objects all vary. In addition, there is a systematic change in the emphasis placed on different types of objects with a change in scale. This makes sense, since pilots are engaged in different kinds of tasks when they consult different charts. Small-scale flight planning charts and those used at high altitude display mostly airport and airway information. Large-scale charts used for instrument approaches, however, have more information about objects that are immediate hazards, such as mountains and high terrain, but less overall density of detail.

The approach taken here attempts to predict the best objects to display by considering three things--the class (or type) of each object in the database, the relative prominence of each object within its class, and an evaluation distance.

In order to illustrate the concept, data from the Digital Chart of the World (DCW) was chosen to portray a simulated aeronautical moving map display. In one sense this is an ideal source, since the DCW was digitized from the Operational Navigation Charts (ONC) produced by the Defense Mapping Agency (DMA). The DCW, however, lacks important detail because it was originally generalized at a single scale (1:1,000,000).

Each object in a test database of airports and mountains has been assigned an initial importance value and a distance decay coefficient. They each present an opportunity for spatial interaction (positively and negatively, respectively!). In the case of airports, length of the longest runway was used for initial importance, while peak elevation was used for mountains. By chance, these numbers are roughly equivalent across the two classes. Because mountains are likely to be more important to pilots than airports at short distances, and less important when far away, they are assigned a steeper distance decay coefficient than airports. The following equation, a standard formula for halving distance, was used:

$$I = Z2^{-R/B}$$

where:
I = importance, used to determine which objects will be selected for display.
Z = initial importance
R = evaluation distance
B = distance decay rate

This formula is used to generate a score for each object in the database. Then the top n objects are displayed, where n is a number preselected as a control for map clutter. When R is set to a large value, airports tend to be selected in preference to mountains, since distance decay is set lower for airports, and the resulting scores are higher.

The result is that the map display tends to show a preponderance of airports or mountain peaks, depending on the value of R chosen. While in this equation R is independent of scale, a logical implementation would make R a function of scale.

These rules have been encoded in ArcView 3 so that different values of each of the parameters (along with scale) can be modified by the user.

RESULTS

A set of animated maps has been prepared that demonstrates the effect of changing R, along with differences in n and scale. They can be viewed at http://www.ncgia.ucsb.edu/~vanzuyle. One characteristic that is noticeable in the animations is that some of the objects tend to appear and disappear multiple times with a continuous change of scale. This is a consequence of the scoring system using multiple parameters.

Another apparent difficulty is label placement. A better label placement algorithm is required if this is to be a practical implementation. A system of label placement based on importance level has been demonstrated by Arikawa (Arikawa & Kambayashi, 1991).

The next stage in this research is to experiment with potential users, such as pilots. The aim is to validate the cognitive model and see which of these variables produces significant differences in navigational performance. Eventually, an automated moving map system may be developed that selects the optimal value of R and n, as well the scale, for a given navigational task.

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