Optimization Techniques For Geovisualization and Spatial Decision-Making

Investigators

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Project Description

In consultation with Dr. Amy Lobben in the Geography department at the University of Oregon, we will design, develop, and apply an optimization algorithm, simulated annealing, to facilitate the use of geovisualization techniques in geographic teaching. This project will involve innovative integration of an optimization algorithm, simulated annealing, and geovisualization software, ArcGIS. The work we do will prepare NWACC institutions to take immediate advantage of the integrated approach.

The specific goals of this project are to:

1. Formulate the cartographic redistricting and name place problems so that they can be solved using simulated annealing.
2. Integrate simulated annealing with ESRI’s ArcGIS geovisualization software using Visual Basic for Applications (VBA) interface.
3. Design and create graphic user interface (GUI) for accessing VBA codes and spatial data.
4. Design and compile two hands-on learning modules and sample data sets.
5. Use the modules in teaching.

Geovisualization, a way to present spatial data as maps, is an effective method for communicating spatial information. It is an especially effective tool for geographic education (Dibiase et al 1992, Duh et al 1998), especially for introducing topics that involve arranging objects in space, a common exercise in cartography and spatial decision-making. However, despite the proven effectiveness, there are few convenient and effective tools that serve this capacity for geographic education.

Arranging objects in space is a type of combinatorial optimization problem that is computationally challenging in finding good solutions. Simulated annealing is a promising optimization algorithm for tackling such problems. Integrating the algorithm in geovisualization could greatly enhance the quality and efficiency of geographic teaching.
Project Design

Through the proposed project, we will develop two interactive geovisualization tools and two hands-on learning modules on cartographic redistricting and name placement exercises. The tools, which are capable of solving the exercises and generating solution maps, will be based on a standard simulated annealing algorithm. They will be packaged as stand-alone computer programs and as extensions of ArcGIS. The hands-on modules will include an introduction, step-by-step instructions, sample data, and evaluation questions for use in laboratories or lectures. Feedback on the tools and modules will be collected from students in the GIS and cartography courses taught in the Geography department at PSU. We will make the tools and hands-on modules available through the internet.

The optimization technique when implemented, though, could have many potential applications, will focus on the following two fundamental cartographic/spatial decision-making topics:

1. The redistricting problem (i.e., gerrymandering), involving the aggregation of several spatial objects to form a district that optimizes a given decision objective.
2. The name placement problem, involving the placement of clustered map labels (e.g., names of cities) so that they do not overlap while still being spatially associated with their intended objects (e.g., the points showing the location of cities).

Students can learn from a sequence of maps generated by the simulated annealing algorithm how different redistricting or arrangement rules manifest as maps and the interactions among spatial objects when the position or attribute of one object is altered.

Assessment and Outcomes

Student feedback will be collected from classes and used for future refinement of the tools and hands-on modules. Assessment methods will include surveys and student performance. Qualitative assessment instruments (such as surveys) have been used successfully to assess cartographic visualization and computational products (Perkins 2001, Slocum, Sluter, Kessler, and Yoder 2004). As a result, questionnaires will be created to assess student preferences as well as learning styles. Learning effectiveness will be evaluated using through graded assignments based on the created modules.

Broader Impacts

The project can have an immediate and beneficial impact for all NWACC institutions. Our work will provide interactive geovisualization tools and hands-on modules to illustrate two fundamental cartographic topics – redistricting and name placement. We will post the material on our project webpage and present the result in regional and national geographic/cartographic conferences. Some possible uses are:
• Help students to understand how different redistricting rules affect the shape and grouping of districts and how gerrymandering could be used to achieve prescribed objectives for, say, winning an election.
• Assist students to learn cartographic design principles when putting labels on the map and visualize, for example, how font size affects the difficulty of placing labels.
• Use the redistricting tool to identify the clusters of crime in a city so that a neighborhood-watch program could be established within a selected area.
• Use the redistricting tool to identify a potential site that, if preserved, can greatly improve the ecologic integrity of that region.

**Technology Transfer and Outreach**

The project team will share information learned in the project through a project web site and through presentations at NWACC and other meetings as desired by member institutions. Hands-on learning modules will be available for access and incorporating in teaching.

**Feasibility**

The project team includes a number of capable individuals. The list includes:

Dr. Jiunn-Der Duh – Assistant Professor and Interim Director of GIS Program at PSU. Dr. Duh is specialized in GIS, geocomputation, spatial simulation and optimization.
Dr. Amy Lobben – Assistant Professor at UO. Dr. Lobben is an experienced cartographer and educator. Her specialties include cartography, spatial cognition and abilities, GIS.

There is also interest in this project from the USDA Forest Service, Winrock International NGO, and Ecotrust.

**Collaboration**

Dr. Duh (PSU), in consultation with Dr. Lobben(UO) will work together to develop the hands-on learning modules. PSU faculty will assist with the programming and testing of tools.

**References**

