An Interactive Optimization Framework for Point Feature Label Placement

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Motivation

The task of label placement is important in information visualization and especially in the area of cartography. The quality of the resulting map is highly dependent on the location of the labels for the features. They shall not obscure and overlap other features or labels and have to satisfy different guidelines or preferences for better visual appearance, unambiguity and legibility.

Problem Statement

In cartography automatization is on the rise. But automatic label placement can hardly incorporate aesthetic criteria and cognitive aspects of human vision. Automatic label placement is cheap and fast but less qualitative than solely manual map creation which is expensive and time consuming. Manual postprocessing of automated created maps is tedious.

Our Solution

An interactive optimization framework that combines

- Automatic Labeling Algorithms
- Human Domain Expertises

Model

We use:
- A Fixed Four Position Model (i.e., four candidates per feature with fixed positions).
- A Conflict Graph as basis for modifications and algorithms.
- A Quad Tree to store spatial data.
- Static Geographic Maps

Algorithms

6 implemented algorithms:
- Simple (greedy) Algorithm
- Independent Set Algorithm
- Three Rules Algorithm
- MaxHS (MAX-SAT) Alg.
- Minimum Number Conflicts Alg.
- Integer Linear Programming Alg.

Evaluation and Results

For our evaluation we use:
- eight different sparse and dense data sets,
- our four implemented label number maximization algorithms, and
- the two representative modifications "font size shrink" and "font size enlarge" (they represent an edge remove and an edge add in the conflict graph)

We modify 20% of the labels in the initial solution by shrinking a subset of them and enlarging the remaining. We run each algorithm and modification combination 100 times. The aggregated results can be seen in the figure on the left.

Implementation

The framework enables the user to load different data sets, filter them by categories of the features, zoom and pan the map and set a specific zoom level for the final map.

Data

Quad Tree

Conflict Graph

Algorithm

Modification

Modification applies

Conflicts Minimization

Results:
- We built an interactive optimization framework and compared different label number maximization algorithms.
- Always applying the exact MaxHS algorithm produces best solutions, but is very slow, especially with large data sets. Combinations of the ThreeRules and IndependentSet algorithm with Simple produce fast and high quality solutions for most of the data sets. → Best choice!