Developing Effective Methods and System for Practical Redistricting Problems

Hai Jin

Geographic districting problems (a.k.a. redistricting, zoning, or regionalization problems in different contexts) are to group small geographic units into larger districts according to certain criteria and constraints. From the perspective of optimization, they can be considered as combinatorial optimization problems, which are to find an optimal (or near-optimal) solution from a large set of alternatives. Different from other combinatorial optimization problems, geographic districting problems usually consider spatial criteria and constraints such as spatial contiguity and compactness, which are difficult to integrate with mathematical models commonly used in non-spatial combinatorial optimization such as integer programming. Redistricting optimization has been shown to be NP-hard and not tractable (a problem is tractable only if a polynomial time algorithm exists that can solve all instances of the problem).

To address both the academic and practical challenges in solving real-world redistricting problems, this research tries to advance methods and tools with a computation-assisted and user-centered approach. Specifically, my dissertation work includes the following two tasks: (1) Develop efficient and effective spatial optimization algorithms for geographic districting. The developed methods can optimize multiple criteria under multiple constraints, and construct high-quality districting optimization solutions. The optimization algorithms are more efficient (being able to allow real-time user interaction), more flexible (considering multiple user-expressed criteria and constraints), and more powerful (in terms of optimization quality) than existing methods. The outcome of this task is evaluated by comparing with existing automated methods and algorithms, with real-world problems and data. (2) Develop a user-centered and computation-assisted redistricting system, which integrates the developed algorithms with an intuitive user interface and functions to leverage human judgments and computing power for
tackling complex redistricting tasks. Usability tests are conducted to assess and improve the usability of the system and to ensure that it is practically useful for users of different skill levels, such as researchers, practitioners, and the general public. Two case studies are carried out to apply the developed methodology in addressing real-world problems.