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AN INTERACTIVE GEOSPATIAL ANALYSIS PLATFORM FOR FACILITY LOCATION DECISION-MAKING

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Abstract. The Facility Location Problem is an important research topic in spatial analysis. This paper focuses on the Static and Mobile Facility Location (SMFL) Problem, which aims to identify those static and mobile facility locations that serve a target area most efficiently and equally. This paper formalizes the SMFL problem as a bi-objective model and then solves the model by using a novel heuristic algorithm, named Static and Mobile Facility Location Searching (SMFLS). The algorithm consists of two steps: static facility location searching and mobile facility location searching. In order to solve the model for large datasets efficiently, a clustering-based heuristic method is proposed for the static facility location searching while the mobile facility location searching is implemented using a greedy heuristic method. Experiments on synthetic datasets demonstrate the efficiency of the SMFLS algorithm. In addition, with the aim of conducting facility location decision-making conveniently and efficiently, in this paper, an interactive geospatial analysis platform, named Geospatial Analysis Platform using Interactive Maps (GAPIM) is proposed by combining the bi-objective models and the SMFLS algorithm with an interactive map. Experiments on Alberta public health service data are conducted, with the results demonstrating the efficiency and practicality of the platform.

Key words. GIS, Interactive map, Static and mobile facility location problem, Heuristic algorithm

1. Introduction

The 'facility location problem' is an important research topic in spatial analysis. The aim of this problem is to 'determine a set of locations for supply facilities so as to minimize the total supply and assignment costs' [28]. Given the importance of effective facility location, a large number of facility location models [28, 24] and optimizing algorithms [4, 18, 8, 7] have been developed.

The purpose of the Static and Mobile Facility Location (SMFL) problem is to identify the best locations for static and mobile facilities in order to serve a given target area efficiently and equitably. The static facility is located for improving the *efficiency* of facility locations, such as minimizing the average travelling distance between static facilities and clients. The mobile facility is located for improving the *equity* of facility locations, such as minimizing the maximum travelling distance necessary for clients to receive service either from the static facility or the mobile facility. In reality, many services have to be delivered by using a combination of both static and mobile facilities. For example, for emergency medical services, hospitals should be located to achieve full coverage of the people in a target region while ensuring the minimum average travelling distance. This usually results in hospitals being located near to, or within, dense communities. However, patients in sparse and remote areas may live far away from a hospital since the total number of the hospitals is limited. In order to offer fast response service for patients in an entire region, ambulances must be located in a way that shortens the maximum travelling distance for patients to access medical services. Compared with the facility location problems dealing with single facility type [28, 24, 4, 18, 8], the static

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and mobile facility location problem is more complicated in that it requires two different searching strategies for static facilities and mobile facilities while taking into account the inter-relations between these two types of facilities. However, none of existing methods can be applied to the SMFL problem directly.

During the past 30 years, Geographical Information Systems (GIS) have evolved to include advanced location model development and have been applied to more complicated / advanced application scenarios [9, 26]. The central element of a GIS is the use of a location referencing system so that data about a specific location can be analyzed in relation to other locations. By integrating a wide range of facility location models and optimizing algorithms, GIS is an ideal and sometimes indispensable tool for making facility location decisions [13, 37, 32, 3, 5, 23, 15]. However, two problems limit current geospatial information systems for making facility location decisions. First, for users who lack expertise in GIS, it is inconvenient, if not impossible, to use the existing GIS-based facility location analysis tools. For example, a public health planner would like to investigate locations for new screening centers (i.e., static facilities) and screening vehicles (i.e., mobile facilities) into a screening program. He/She may have a few sites in mind and can point out approximate locations on a map. However, without any GIS training, he/she cannot upload the coordinate information of those sites into a GIS system and use the spatial analysis tools provided by the GIS. Second, it is computationally inefficient for users to use existing GIS-based facility location analysis tools. The computational demand of these tools requires considerable computational resources, and hence there are limited applications within light computational environments (e.g., web environment). In addition, with web-based interactive maps (e. g., *Google Maps* and *Microsoft Bing Maps*) becoming more and more popular, people are tending to access and manipulate increasing amounts of geospatial information on the web. However, seldom current GIS systems support bringing numerous geospatial information on the web into location analysis automatically.

The purpose of this paper is to develop a geospatial analysis platform for solving the static and mobile facility location problem conveniently and efficiently by combining a facility location model and an optimizing algorithm with an interactive map.

The contributions of our work can be summarized as follows:

First, this paper formalizes the SMFL problem as a bi-objective facility location model and then solves the model by using a novel heuristic algorithm named Static and Mobile Facility Location Searching (SMFLS). The algorithm splits the location decision into two steps: static facility location searching and mobile facility location searching. In order to solve the model for large datasets efficiently, a clustering-based heuristic method is proposed for the static facility location searching while the mobile facility location searching is implemented using a greedy heuristic method.

Second, the Geospatial Analysis Platform using Interactive Maps (GAPIM) is developed for solving facility location problems conveniently and efficiently by combining the bi-objective facility location model and the SMFLS algorithm with an interactive map. The platform creates a user-friendly web environment for customers to search useful geographic information, to input and visualize geographic information, and to specify spatial analysing parameters and constraints. The platform requires less execution time for searching for optimal facility locations because the searching is only triggered on the regions selected by users on the interactive map instead of the whole area. In addition, the platform is designed to be extensible