Efficient Identification of Geographic Restrictions in Location Modeling using GIS

Introduction

Spatial separation in located services and activities is often essential. Examples include homeland security, military asset defense, impacts on the environment, franchise outlet location, and promoting public wellbeing. When planning and management is supported by mathematical modeling, a difficulty has been efficient representation of spatial separation requirements. This paper reviews an optimization model, the anti-covering location problem, used to support planning and management problems where spatial separation must be ensured between sited services/activities. An approach is presented for the efficient and effective identification and use of spatial separation conditions in this model based upon the use of a geographic information system (GIS). Results highlight the significance of the developed methodology in terms of computational requirements, tractability and effectiveness. This research enhances capabilities for addressing important practical planning problems.

Model formulation (A hybrid ACLP)

$$\textit{Maximize} \quad \sum_i \beta_i X_i$$

Subject to

$$\sum_{i \in \Psi_k} X_i \le 1 \quad \forall k$$

$$|\Phi_i| X_i + \sum_{j \in \Phi_i} X_j \le |\Phi_i| \quad \forall i$$

$$X_i = \{0,1\} \quad \forall i$$

i = index of areas

k = index of cliques

Ψ_k = set of areas in clique k

Φ_i = set of areas in conflict with area i

β_i = benefit of selecting area i

$$X_i = \begin{cases} 1 & \text{if area } i \text{ is selected} \\ 0 & \text{otherwise} \end{cases}$$

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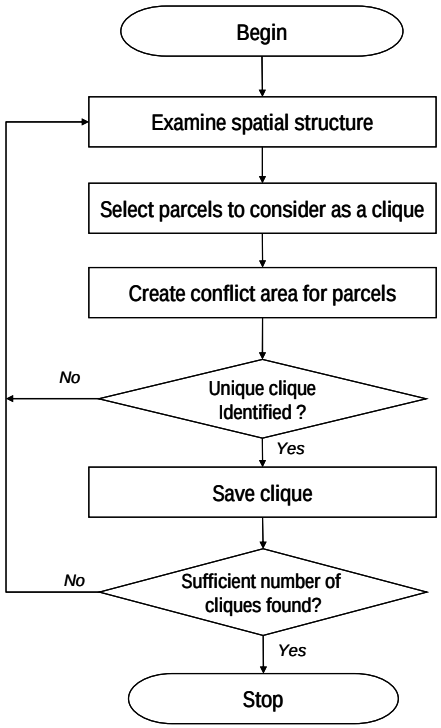
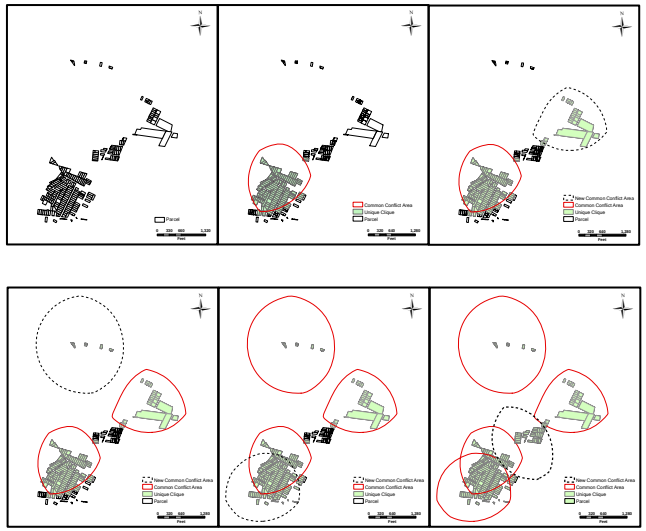
A hybrid ACLP model algorithm



Procedure of efficient identification of cliques using GIS



Comparison of results for Norwood

Constaint construct	objective	Time (sec.)	Branches	iterations	# constraints
Pairwise	32	185.83	10	7,126	1075558
Neighbors	31*	401349.53	652,000	27,328,617	3252
Hybrid	32	8.36	46	1,066	2911

Summary

The ability to identify and implement hybrid spatial separation constraints in the ACLP was shown to be possible through the use of GIS. GIS enables spatial structure to be taken into account in finding large cliques efficiently, thereby making the mathematical structure of the ACLP more amenable to exact solution using commercial optimization software. The application results highlight that the proposed GIS-based approach is computationally feasible, offering the capability to address large practical planning/policy problems. greater use and integration of GIS in spatial optimization is inevitable because of the ability to make better use of spatial information and geographic relationships.