Placement of Potential Facilities on Continuous Road Networks

Introduction

An issue of facility placement arises in that how facility locations are selected along continuous space. In this research, how public transport stop locations can be placed along continuous road network will be discussed. Many studies have involved to bus stop placements or designs (Wirasinghe and Ghoneim 1981, Demetsky and Lin 1982, Federal Transit Administration 1996, Furth and Rahbee 2000, Saka 2001) but methodologies developing stop placements along continuous road network maximizing given demand have not been discussed.

Facility placement in continuous space has been a major concern since Weber's (1909) single siting problem in pursuit of minimal transportation costs. This simple but leading work has been followed by various spatial optimization problems locating facilities in continuous space to maximize or minimize its objectives.

Church (1994) and Murray and Tong (2007) suggested planar versions of Maximal Covering Location Problem (MCLP), called Planar Maximal Covering Problem (PMC) and Extended Planar Maximal Covering Location Problem-Euclidean (EPMCE) respectively. Both approaches relax the requirement of discrete locations of facility by allowing facilities to be located across continuous space. While PMC maximizes coverage for the point-based demand, EPMCE maximizes coverage for various types of demand objects, such as not only points but also lines and polygons. EPMCE is very useful to provide unbiased and complete coverage for demand objects of lines and polygons without any point representation that possibly misleads the actual coverage.

Based on property of EPMCE (Murray and Tong 2007), this research develops such a model as maximizes coverage for polygon-based demand objects when potential facility are to be distributed along road networks. The following figures show that how those road network are discretized based on polygon-based demand obejcts.

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Figure A

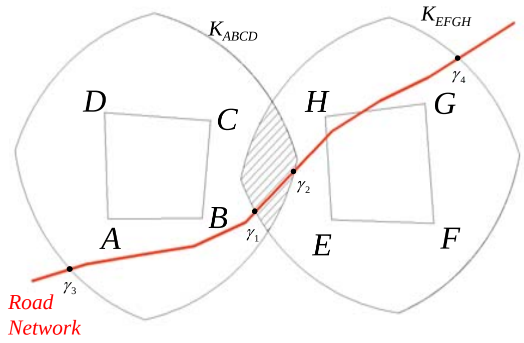
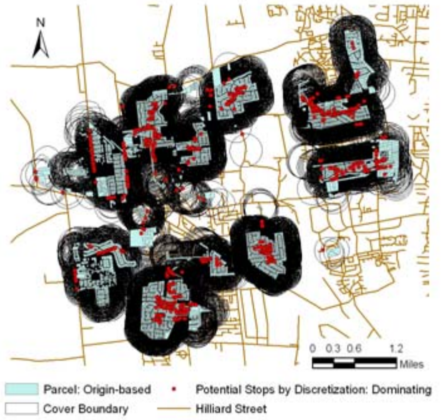


Figure B



Maximize

$$\sum_i a_i Y_i \quad (1)$$

Subject to

$$\sum_{j \in N_i} X_j - Y_i \geq 0 \quad \forall_i \quad (2)$$

$$\sum_j X_j = P \quad (3)$$

$$X_j = \{0,1\} \quad \forall_j \quad (4)$$

$$Y_i = \{0,1\} \quad \forall_i$$

Where

$i =$ index of demand parcels;

$j =$ index of potential facility locations;

$a_i =$ area for demand parcel i;

$N_i = \{ j \mid d_{ij} \leq R \}$

$p =$ number of facilities to site;

$d_{ij} =$ shortest distance from demand parcel i to potential facility j;

$R =$ the distance that could be traveled to suitably cover demand parcel;

$$Y_i = \begin{cases} 1, & \text{if demand } i \text{ is suitably covered} \\ 0, & \text{otherwise;} \end{cases}$$

$$X_j = \begin{cases} 1, & \text{if a potential facility } j \text{ located} \\ 0, & \text{otherwise.} \end{cases}$$

Summary

Figure A shows that how potential points are discreized based on covering boundaries that are derived from polygon-based demand objects.

Figure B shows potential facilities extracted from continuous road networks in research area. This potential facility points ensure complete coverage for the corresponding demand polygon.

Formulation is EPMCE based on MCLP.
This function finds the optimal locations of given number of potential locations to maximize their coverage for the demand polygons.