11-2020

A geospatial analytics approach to delineate trade areas for Quick Service Restaurants (QSR) in Singapore

Hui Ting LIM
Singapore Management University, huiting.lim.2018@mitb.smu.edu.sg

Citation

LIM, Hui Ting. A geospatial analytics approach to delineate trade areas for Quick Service Restaurants (QSR) in Singapore. (2020). *ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems 28th SIGSPATIAL GIS 2020*. 661-662.

Available at: https://ink.library.smu.edu.sg/sis_research/5918

A Geospatial Analytics Approach to Delineate Trade Areas for Quick Service Restaurants (QSR) in Singapore

Lim Hui Ting
School of Information Systems
Singapore Management University
Singapore Singapore
huiting.lim.2018@mitb.smu.edu.sg

CCS CONCEPTS
• Information systems applications → Spatial-temporal systems → Location based services

KEYWORDS
Geospatial Analytics, Spatial Lagged Sum, Spatially Constrained Clustering, Trade Area Delineation

1 INTRODUCTION

According to Huff [1], trade area is defined as "a geographically delineated region containing potential customers for whom there exists a probability greater than zero of their purchasing a given class of products or services offered for sale by a particular firm or by a particular agglomeration of firms". Several methods to delineate a store trade area have been proposed over the years. For drive-time or travel distance analysis method, the trade area is delineated according to how far or how long the customers are willing to travel to patronise the store [2]. Another commonly used method is the Huff Model which assumes that consumer decisions are probabilistic and not deterministic. This model derived the probability (p_ij) that a consumer at location j will patronize the store in location i [3]. In ArcGIS Network Analyst, the location-allocation function helped to find the optimal locations for facilities to serve a set of demand points base on the user-defined objective such as maximising market share [4].

However, many of the methods mentioned above requires users to already have the new stores location. The demand points will then be allocated to the stores according to parameters like stores capacity and driving distance. Many of the decision makers will not know the new stores location and hope that a model can propose to them a new location based on the data inputs. Thus, we would like to propose an alternative approach using a QSR chain in Singapore as a case study to delineate the trade area of their delivery stores as well as proposing new stores locations. The methodology could also be extended to other food and beverage establishments which offered delivery services.

SIGSPATIAL '20, November 3–6, 2020, Seattle, WA, USA

ACM ISBN 978-1-4503-8019-5/20/11…$15.00
https://doi.org/10.1145/3397536.3428352

2 METHODOLOGY

The study area is first be binned into regular sized hexagons of 500m to ensure that the resulting trade areas become more consistent and regular. Hexagon grids are often preferred as they are the most circular-shaped polygon that can tessellate to form an evenly spaced grid. Hexagon grids not only ensured that there are no gaps in between the market areas, it also prevented the overlapping influences from occurring (Figure 1). These hexagons will then be enriched with existing QSR sales data. After which, three approaches, spatial lagged sum, spatially constrained clustering, and hybrid, will be explored to reallocate and identify new potential areas that met the monthly sales target to build new stores. These approaches will then be compared to see if one method is better than the other.

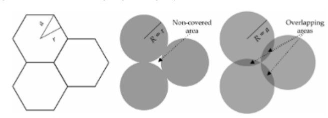

Figure 1 Hexagonal cell layout (a) and circular coverage areas (b), (c). [5]

2.1 Spatial Lagged Sum. A spatially lagged variable is a weighted sum or a weighted average of the neighboring values for that variable [6]. The formula can be seen below

$$[W_y]_i = \sum_{j=1}^{n} w_{ij} y_i$$

where:
$[W_y]_i$= spatial lagged sales value for location i
w_{ij} = spatial weight for location j to i
y_i= sales value for location j

Spatial weights, w_{ij}, was used to calibrate the spatially lagged sales variable. In this study, the spatial weights matrix was based on the adaptive distance criteria where the target hexagon and its neighbours were selected based on K nearest neighbours. The K nearest neighbour algorithm had been modified to not just based on distance but also based on sales value of the neighbours for tie breakers. Spatial lagged sum will first be applied on existing stores locations followed by remaining hexagons.

2.2 Spatially constrained clustering. Spatial 'K'luster Analysis by Tree Edge Removal (SKATER) helps to group contiguous objects that have similar observations into new cluster by employing both hierarchical clustering and connectivity graph using minimum spanning tree (MST). In this study, SKATER was implemented with not just spatial constraint but also non-spatial constraints such as monthly sales target.

2.3 Hybrid. In the hybrid approach, spatial lagged sum approach was first used to find groups of hexagons that were able to meet the minimum sales target based on existing stores location. After which, spatially constrained clustering was performed on the remaining hexagons.

3 CASE STUDY: SINGAPORE

In this case study, we are using a QSR chain in Singapore as a proof of concept. The store delivery sales data and store locations were obtained from the QSR chain. Currently, there are 38 delivery outlets covering the entire Singapore. The trade areas of their delivery outlets are determined based on road network. This had introduced some level of subjectivity to the delineation of trade area resulting in several trade areas that were not compact. Thus, our proposed methodology aimed to reorganize the trade areas such that they were more compact and identify infill opportunities for the QSR chain to build new stores.

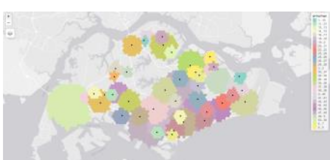

Figure 2 Spatial lagged sum results

Results of the spatially lagged sum as shown in Figure 2. Each trade area should only have one black dot representing existing store locations. Trade areas with more than 1 meant that these existing stores were located too near to each other and thus require relocation. Trade areas without any black dots represent location for new stores.

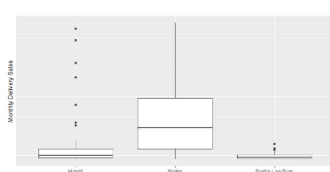

Figure 3 Delivery sales distribution across approaches

Comparing the 3 approaches, total sales for each trade area had lesser variability when using spatial lagged sum as compared to the skater and hybrid approach. This meant that the trade areas for skater and hybrid approach were not concise enough. As clustering is an unsupervised technique, we were unable to restrict the size of each clusters. This resulted in the large sales variation with some clusters in the skater and hybrid approach as observed in the box plot. On the other hand, spatial lagged sum gave us more control by defining the size of the hexagons and ensuring sales were evenly distributed. In terms of identifying potential areas for new stores, spatial lagged sum, skater and hybrid were able to identify 49, 39 and 47 stores potential respectively. It seemed that the spatial lagged approach gave the highest possible estimates whereas the skater approach tends to underestimate the number of store potentials in Singapore.

4 CONCLUSION

In conclusion, we have explored 3 approaches to reallocate trade area and identify potential areas to build new stores. Although spatially constrained clustering was based on the natural trade area, it was not appropriate for markets where the company already had existing stores as it was not possible to relocate all stores to align with the cluster results. The spatial lagged sum approach was more appropriate as it results in more compact trade areas and smaller variation in sales across the stores. The resulting trade areas and proposed new locations were then validated by human experts in the QSR chain. Using their real estate knowledge, they assessed the feasibility of the newly proposed trade areas and new stores. Finding new stores location and delineating of trade areas can now be performed faster and more efficiently. The QSR chain had since extended this approach to their Korea market thus further validating the viability of the proposed approach in this study.

ACKNOWLEDGMENTS

The author would like to thank Professor Kam Tin Seong from Singapore Management University, for his guidance.

REFERENCES

[1] Huff, D. (1964). Defining and Estimating a Trading Area. Journal of Marketing, 28(3), 34–. https://doi.org/10.2307/1249154

[2] Cui, C., Wang, J., Pu, Y., Ma, J., & Chen, G. (2012). GIS-based method of delimitating trade area for retail chains. International Journal of Geographical Information Science, 26(10), 1863–1879. https://doi.org/10.1080/13658816.2012.661058

[3] Huff, D. (2018). Defining and Estimating a Trading Area. Journal of Marketing, 28(3), 34–38. https://doi.org/10.1177/002224296402800307

[4] Esri. (n.d.). Algorithms Used by the ArcGIS Network Analyst Extension.https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/algorithms-used-by-network-analyst

[5] Baltzis, K. B. (2011). Hexagonal vs circular cell shape: A comparative analysis and evaluation of the two popular modeling approximations. Cellular Networks - Positioning, Performance Analysis, Reliability. https://doi.org/10.5772/14851

[6] Anselin, L. (2018, March 17). Applications of spatial weights. GeoDa on Github. https://geodacenter.github.io/workbook/4d_weights_applicatio ns/lab4d.html#spatial-window-sum