Application of Spatial Analysis and Network Analysis Technology in Supermarket Location

Spatial and Network Analysis

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Introduction

Supermarket shopping plays an indispensable part in people's life. How do people go to the supermarket? Different people have different choices, like as driving, biking, walking, riding public transportation or delivery. The location of the supermarket can determine the priority order of customers selecting where to shop. It can be said that the selection of location is very important for the long-term development of a supermarket

In general, supermarkets mainly provide two services for online shopping, including collection (pick-up) and delivery. These two methods are especially prevalent after the pandemic. These two operations directly contact parts of customers where most of the service quality is experienced. Therefore, it is essential to manage the collection and delivery operations for competitive advantage effectively. From consumers' perspective, how to pick-up goods more conveniently and quickly and save transportation costs will become the primary problem. The locations of stores are in the high-density population community which will be more popular. From supermarkets' standpoint, choosing more densely populated areas to increase sales and reasonably plan the coverage radius of transportation services have become the key points to be considered. There are some problems: How to confirm the geographic scope of supermarkets that can be served in order to making market plans? Is the store close to public transport stations? How to choose the best new supermarket address? These problems are addressed that will improve the competitiveness of the company. Especially during these difficult times in the industry, it is very important to improve competitiveness. In these cases, finding the right location strategy has the potential to become a critical solution. It is increasingly appreciated due to the critical role of geography in understanding business success.

Supporting Research

As we all know, good geographical location is an essential factor to attract customers. A well-located store also makes supply and distribution easier. Geographical location will affect the marketing ability of retailers and cope with competition from other enterprises (Nazir, S., 2019).

ArcGIS Spatial analysis can measure distances and shapes, track routes, establish correlations between variables and explore the locations according to users' needs. Armando and Margarida (2006) utilized three regression algorithm methods to prove

how important of spatial analysis technology in selecting sites, and applying spatial analysis with relative algorithms to set up a model to predict sales.

Network analysis is a powerful extension that provides network-based spatial analysis, including routing, travel direction, proximity, and service area analysis. Users can find servant regions anywhere on the network. Many companies widely use these technologies to conduct market analysis. For example, all supermarkets have property teams, who sift locations according to many factors, such as population density, the proximity of public transportation stations and etc. Service area can directly present the stores service distribution according to the cutoff drive time or length (Jim H., 2022). This technology can provide one intelligent monitoring and controlling system for delivery service (Jung et al., 2020).

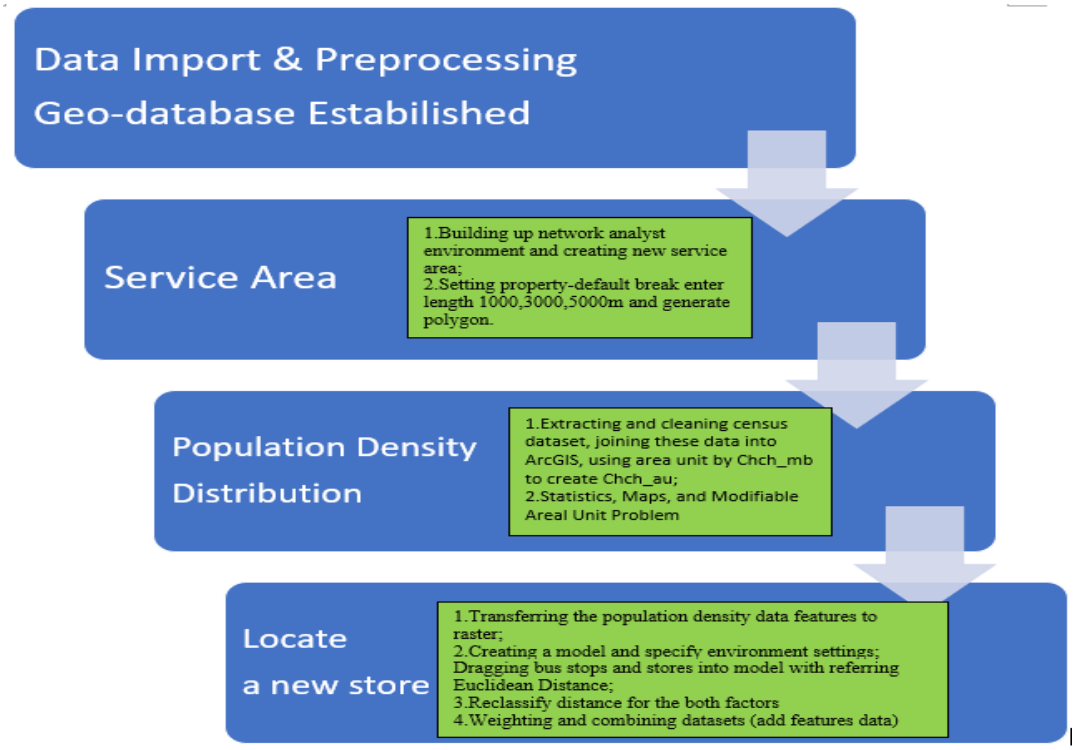
This project aims to explore the applications of network analysis and spatial analysis (modelling) in the real world and try to take some improving suggestions about the process of grocery delivery from the aspect of geographic data analysis. Some data about the locations of Countdown Supermarket stores will be one example of analyzing targets in this project. Although there are many relevant materials and many successful predictions using analytical methods, there are few relevant studies on Christchurch, New Zealand. I hope this project can provide some theoretical suggestions for the supermarket development in Christchurch.

Data and Methods

In order to using network analysis and modelling by spatial analysis, the original data sources have:

- 2013 census Canterbury Region (STATs New Zealand);
- Location informative datasets of stores and bus stops (Google Earth Pro);
- Base Map (Open Street Map - OSM);
- Christchurch road datasets (Land Information New Zealand - LINZ);
- Orbiter and MetroStar Bus routes (Retrieved from GeoG205-Lab6).

The detail data process is shown in the below diagram:



There are several things to keep in mind during the entire project operation, including:
1. In the collecting and preprocessing datasets, location datasets about stores and bus stops are collected from Google Earth Pro as KML. Files and ArcGIS can convert the files into Layers. Note that the road datasets collected from LINZ have only x-y coordinate but the stores and bus stop location datasets are x-y-z coordinate. The tool of 'Conversion tools> Feature Class to Geodatabase' is used to change coordinates, and finally all datasets keep in the x-y coordinate under Network Analysis layer. The preprocessing datasets are necessary for running a later network analysis model.

2. During operating Service Area, the default breaks are defined as 1000, 3000, and 5000 meters from delivery cost and shopping portability considerations. Also, the five kilometres service area ensures that there won't happen overlapping problems among stores in the real world.

3. As mentioned before, population density is one of the critical factors for supermarket operations. In this section, a distribution map of population density (the number of people in each district divided by the area of the community) can be obtained by importing census data and visualizing it. The first step is to convert the population density to five levels (the data range can be obtained from the previous distribution map) and insert the new Named 'features' column in the Chch-mb (Christchurch Census Meshblock geography) data table. In the table content, use the Feature to Raster tool to

convert the feature data into raster data because the weighted overlap can only be input as raster data when the model is built later.

Results

In this project, the relevant network and spatial analysis knowledge is mainly applied. First, from Figure 1, it is evident that the existing store services cover most of the Christchurch area by establishing a service area. Still, some relatively densely populated areas such as Wigram and Halswell are not directly covered. Fortunately, five stores cover orbiter and metro bus lines, and all bus stops are within three to five kilometres. Although the stores near the airport cannot protect the nearest bus stop, they can take care of the residents around the airport. The lack of service in the southwest part of the city is found. A new store needs to be opened there to ensure coverage of the entire urban.

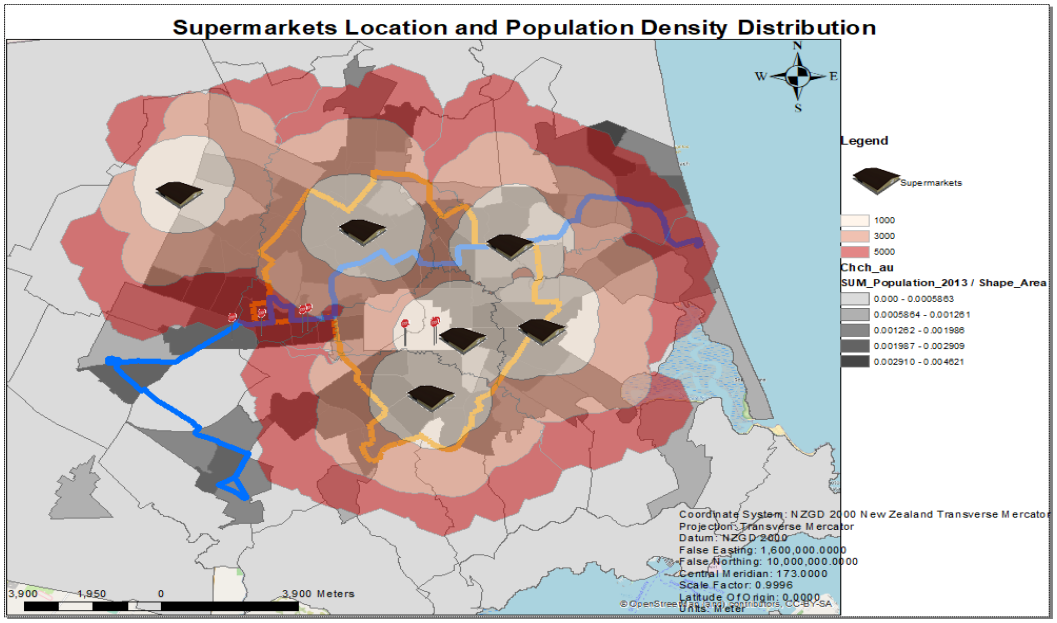


Figure1. Supermarkets Location and Population Density Distribution

In the model building process, population density and the distance from the store to the station are used as proportional variables, and the distance from other stores is used as an inverse variable. The constructed model also has a 32%:34%:34% influence on the prediction model. Each variable is divided into ten levels ranging from low to high, indicating the model predicted location and moderate from low to high. Finally, as shown in Figure 3, it is found that there is a higher level of location prediction in the geographic range, including densely populated areas such as Wigram and Halswell. This result is what the project expects.

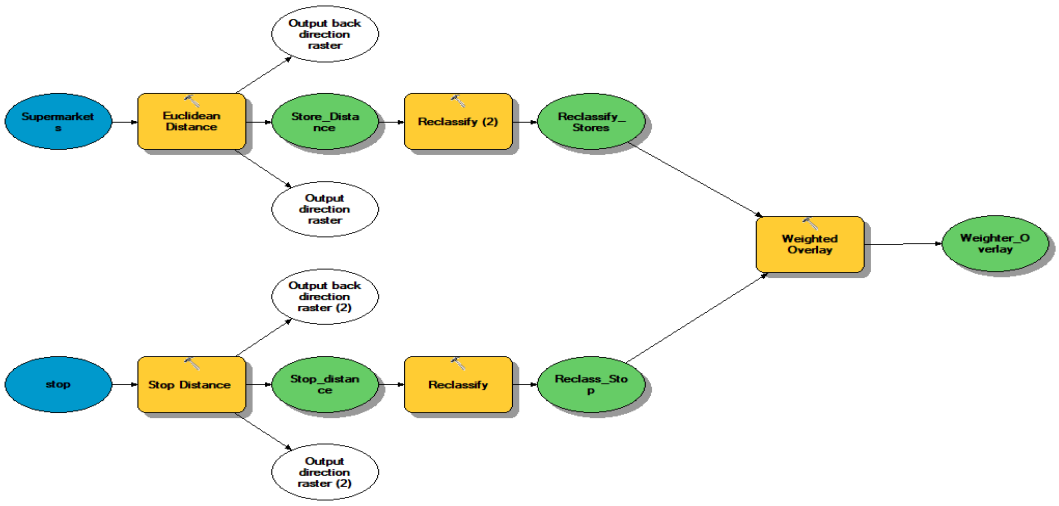


Figure 2. Model workflow for locating new store

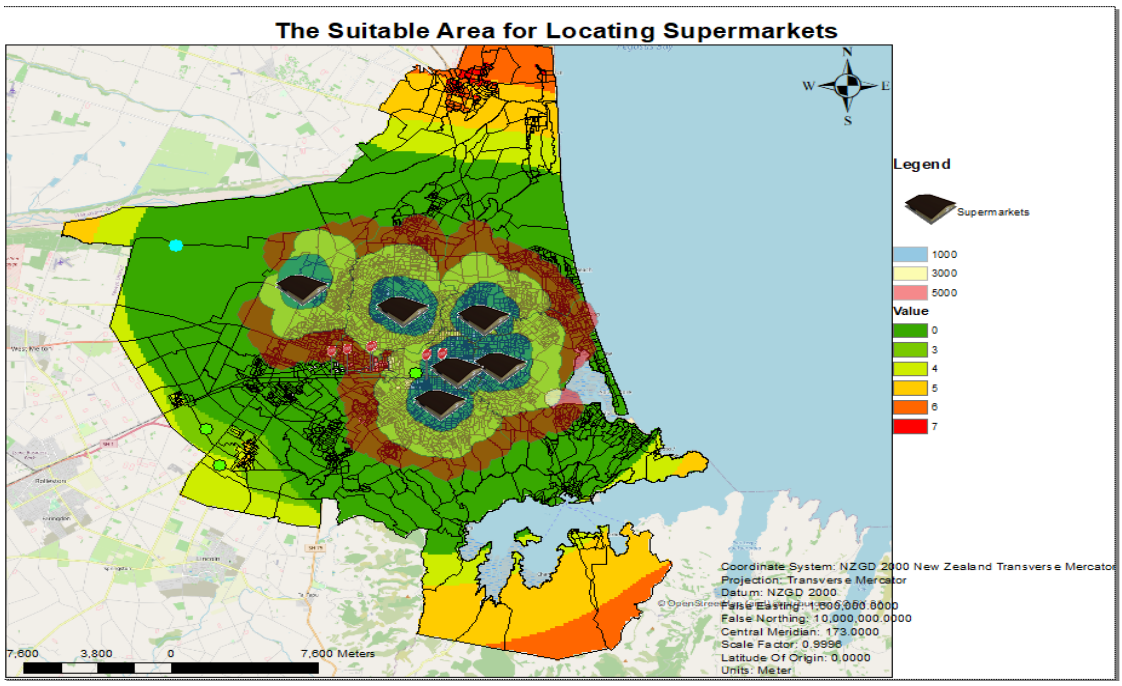


Figure 3. the suitable area for locating stores

Limitations of the Approach

This project mainly explores network and spatial analysis in determining supermarket location and service area. Two main parts take a long time; one part is processing data. Because data needs to be used for network analysis, all data needs to be reduced to one dimension. This condition may cause the data to retain singular values and cause inaccurate later models. Meanwhile, because the data is only from the 2013 census, the data may not be accurate enough to use in the current forecasting model. Therefore, the

result can show only a single display of the impact of population density on the location of supermarkets. Factors such as different age groups and different genders can also be considered. However, due to the limited data collected, the existing results can only be roughly simulated. Second, with little knowledge about ArcGIS, it took a long time to convert feature data to raster data. Although the data is successfully restored, it only needs simple tools to transfer it. Therefore, if there is an opportunity in the future, it is essential to improve the technical knowledge of ArcGIS.

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