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Centroid-Amenities: An Interactive Visual Analytical Tool for Exploring and Analyzing Amenities in Singapore

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ABSTRACT

Planning for civic amenities in a fast-changing urban setting such as Singapore is never an easy task. And as urban planners look toward more data-driven approaches toward urban planning, so grows the demand for more flexible geospatial analytics tools to facilitate a more iterative and granular approach toward urban planning [1].

Such specific tools however, are not always readily available as plugins for traditional desktop GIS software, as numerous customizations must be made to model specific temporal planning scenarios for quick analysis, which could prove both costly and time-consuming. Hence, to address this need, open-source tools such as R Shiny could be used to rapidly prototype and test urban planning models, in an iterative fashion.

To demonstrate how this could be done, we developed a proof-of-concept that aims to provide urban planners with an open-source, interactive geospatial analytics tool to help optimize the placement of amenities and services through K-means clustering, making them as accessible as possible to the city residents they serve. The platform also allows planners to compare the accessibility of the existing amenities and services, against a suggested set of optimized amenity locations, using the Hansen Accessibility Score as a measure of accessibility. This allows planners a tangible grasp on how much of an impact and improvement a relocation of amenities could make for the residents served.

This paper details our research and development efforts to design and implement an open-source web-based geospatial tool for supporting the analysis of the accessibility of amenities and services.

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CCS CONCEPTS

• Information Systems applications → Decision support systems → Data analytics

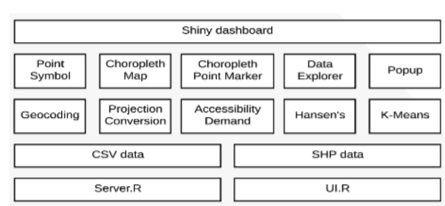
KEYWORDS

Amenities, Geospatial Analytics, K-Means Clustering, R Shiny, Urban Planning

1 APPROACH

Our sources of planning data include publicly available census data obtained though the Department of Statistics (Singapore), from a nationwide census taken in 2014[2]. Data on the locations of existing amenities were obtained from data.gov.sg[1].

1.1 Application Overview



1 Data.gov.sg, the government's one-stop portal to its publicly-available datasets.

Figure 1: Application Architecture Diagram

The application[2] is developed using R with R Shiny platforms. Users will be using a Shiny dashboard which come with features available in the standard leaflet.js library functions. At the backend, CSV and SHP data are processed via geocoding, projection conversion, Hansen Accessibility Index and weighted K-Means clustering

1.1.1 Site Selection via K-Means Clustering. In the context of our amenities location optimization model, our 'optimal location' of any amenity would be the centroid location of each cluster of its beneficiaries, as it is the location of the least distance from their beneficiaries' residence.

K-Means clustering algorithm assigns each item to a cluster having the nearest centroid.

1.1.2 Hansen Accessibility Index. This index measures the accessibility of an area, by the sum of opportunities to reach the destination from other areas, weighted by a cost function. Where i is the index of Origin Zones, j is the index of Destination Zones, and $f\left(C_{ij}\right)$ is a function of the generalized cost of travel, where heavier weights are placed nearer places or less expansive places than further or more expansive places, and vice versa.

$$Accessibility_i = \sum_j Opportunities_j \left(C_{ij}\right)$$

For our application, the origin zones will be the public housing blocks and the destination zones will be the amenities. A higher Hansen Accessibility Index will indicate that the amenities within the planning zone are more accessible.

2 RESULTS

Planners first interact with our dashboard by selecting a planning subzone and by specifying an input number of amenities. The results will be displayed in an info panel and an interactive map layer for the ease of analysis.

To compare results of current accessibility index versus the suggested accessibility index, we chose two different subzones namely, Punggol and Pasir Ris, of similar population and area size with the same amenities category selection.

Figure 2: Clustering of Childcare facilities in Subzone of Punggol Field

The analysis is shown in multiple map layers. The kernel density map layer shows the density of the demand for childcare facilities in Punggol are much denser in at the left of the area. A high concentration of the target population will be displayed in blue whereas a low concentration of the target population will be displayed in red. Yellow pins represent the current locations of childcare facilities while red pins represent the suggested locations of amenities that are optimally placed based on the weighted k-means clustering. Based on the improved accessibility index, it shows a higher number of HDB blocks having better accessibility index with highest frequency of 40 and 259.0 index compared to the current accessibility index with highest frequency of 20 and 257.7 index. Visually from the map layers, it displays the suggested childcare facilities location are placed near the denser clusters to fill the demand of childcare facilities.

Figure 3: Clustering of Childcare facilities in Subzone of Pasir Ris Drive

Next, looking at the subzone of Pasir Ris Drive, the kernel density map layer shows the density of the demand for childcare facilities in Pasir Ris Drive are much well spread across its area. Even with such clustering pattern, the improved accessibility index, shows a higher number of HDB blocks having better accessibility index with more frequency of HDB Blocks have higher accessibility index of 217 compared to the current accessibility index with fewer frequency of HDB block having the same accessibility index of 217. par

In both cases, with different demand patterns, results show a better accessibility index in the suggested k-means optimized amenities locations. With the map layers of both current and

2 The application code can be found in https://github.com/jazzywessy/Centroid-Amenities

suggested childcare facilities location displayed on the same map, it gives the urban planner a visual comparison of the difference in location. The same method could be applied to other amenities where the target population of beneficiaries can be clearly identified.

4 DISCUSSION AND FUTURE WORKS

We demonstrated how open-source platforms, can be used to rapidly prototype highly customized urban planning decision support tools, allowing for a more iterative approach towards spatial analysis. Some avenues for future works include using projected population trends and General Transit Feed Specification data to improve our k-means optimized amenities placement algorithm, and allowing users define their chosen area of analysis.

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