Quantitative Identification of Urban Functional Areas in Downtown Area of Changchun Based on POI Data

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Abstract. In the information era, the distribution pattern of point of interest (POI) data points in urban space is of great reference significance in urban infrastructure planning and urban spatial analysis, providing a basis for studying the identification of urban functional areas. With the downtown area of Changchun as the research object, the POI data was quantified according to the classification of the urban functional areas, identifying the urban functional areas in the downtown area of Changchun. The experimental results were compared with the current urban land use maps in Changchun to demonstrate the feasibility of the experimental method. Compared with traditional methods, this method features fast analysis speed and digital attributes, which is of certain value for urban geospatial planning.

1. Introduction
With the rapid development of information technology, researches on urban issues currently face the transformation of research methods and innovation in content. Big data provides a new direction for studying urban spatial organization, resident behavior and urban functional positioning. Understanding and processing data using effective data mining and analysis methods is of great significance for guiding urban planning and construction. During development of a city, to meet various needs of urban residents, different functional areas have been formed, e.g. residential areas, commercial areas, industrial areas and mixed functional areas. To control the urban spatial structure and to meet scientific and rational urban planning, urban planning researchers must divide the city into various functional areas. Although on-site investigation can understand the layout of different functional areas of a city more clearly and accurately, yet this process often involves the consumption of a large amount of human and material resources, and comprehensive survey results cannot be obtained, resulting in a low cost performance. The large amount of data generated by citizens in the process of urban life is the main object to be analyzed. Through the analysis and research of such data, a more rapid and effective research method has been produced, i.e. POI data analysis. This method can save a lot of manpower and material resources, which is of high practical value. Therefore, focusing on the concept of “functional area”, the urban functional areas were identified based on POI data, by analyzing which the functional areas in the downtown area of Changchun were identified.

2. Data Source and Data Processing
2.1. Data Source.
The POI data used in this study comes from the 2018 Amap and the Open Street Map (OSM). About 50,596 pieces of data was obtained from Amap and 18,055 pieces of data came from OSM. The data
covers 13 categories of information, i.e. business, residence, life services, restaurants, tourist attractions, public facilities, finance, sports, medical care, transportation facilities, shopping, education, government office and accommodation services, with each category containing several subcategories. Data labels include information such as name, location, type, contact information, administrative area, longitude and latitude.

2.2. Processing of POI Data.
First of all, the original data in the EXCEL was screened and sorted one by one. Repeated data was eliminated and data with incomplete information was removed; then, the data was corrected using the coordinate correction plug-in provided by the research institute to convert the latitude and longitude of the POI data into a coordinate system: the Mars coordinate system was converted into the WGS1984 coordinates; in the end, the EXCEL data was imported into Arc GIS and converted into the SHP format for data cleaning in the next step, mainly to delete the POI data of other urban areas except the downtown area in Changchun.

2.3. Processing of POI Data.
Six types of land use were mainly analyzed and researched in this study, namely residential land, land for commercial services, land for public management and public service, industrial land, land for road and traffic facilities, greenbelt and land for squares. Then, each type was divided into secondary types and small types, and the POI data was then reclassified based on relevant content. For instance, the POI data representing the land for commercial services was divided into five categories: shopping service, catering service, business residence, accommodation service and financial insurance service, each of which contains several POI facilities. For example, the shopping service category includes shopping centers, supermarkets and commercial streets. Banks, securities companies and insurance companies belong to the category of financial insurance service.

After the classification, the POI data was further counted, the results of which show that most POI data is about the land for commercial service facilities, accounting for more than half of the total data volume; there is a large proportion of POI data about land for public management and public service, land for roads and traffic facilities and residential land; POI data about industrial land, greenbelt and land for squares takes up a relatively small proportion.

3. Division of Research Units
Through a definition of the research scope, the research object, i.e. the downtown area of Changchun, includes Lvyuan District, Chaoyang District, Kuancheng District, Erdao District, Nanguan District, Economic and Technological Development Zone, National High-tech Industrial Development Zone, Jingyue Tourism Development Zone and Changchun Automobile Industrial Development Area.

4. Data Calculation
The calculation equation is as follows:

\[ F_i = \frac{n_i}{N_i} (i = 1, 2, \ldots, 6) \]
\[ C_i = \frac{F_i}{\left( \sum_{i=1}^{6} F_i \right)} \quad (i = 1, 2, \ldots, 6) \]

Notes: “\( i \)” represents the POI data of various land use types; \( n_i \) denotes the number of the \( i \)th type of POI in the fishnet unit; \( N_i \) represents the total number of the \( i \)th type of POI; \( F_i \) stands for the frequency density of the \( i \)th type of POI in the total number of POI of this type; \( C_i \) represents the ratio of the frequency density of the \( i \)th type of POI to the frequency density of all types of POI in the unit.

5. Identification of Functional Areas in the Downtown Area of Changchun
The kernel density tool in the ArcGIS software grid analysis was applied for analysis in this study. The main idea is to make a circle with the grid center as the center at an optional radius, and then calculate the density value of the points inside the circle. The points closer to the grid center occupy a larger weight, and the vice versa. The downtown area was divided into areas with a size of 200m pixels and then reclassified. The main idea of reclassification is that the regional density is positively correlated with the score. The area with a lower density will get a lower score, and vice versa.

As clearly shown in the above two figures, shops and restaurants are highly clustered in Lvyuan District, Erdao District and Chaoyang District. From an overall perspective with the main urban area viewed as a whole, there are few areas with the cluster degree reaching its peak, while secondary cluster areas are more densely distributed. The cluster degree decreases radially outward from the center of the urban area.

6. Conclusion
The rapid development of cities has brought new challenges to the planning and management of cities. Dividing the city into different functional areas and then managing them separately provides a new approach for urban planning managers and researchers. Based on the POI data, this study quantitatively identified and visualized the functional areas of the downtown area of Changchun, presenting the spatial function structure of a complex city to the citizens in a simpler way and
providing certain reference for urban planning researchers. Moreover, the different urban functional areas planned based on the POI data are of specific reference value for urban planning, providing important theoretical basis and support for decision-making with regard to specific practical planning such as site selection of different types of land use. In addition, the methods used in this study are also of reference significance for researches on smart cities and the spatial structures of future cities.

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