Analysis of Urban Leisure Spatial Patterns Based on POI: A Case Study of Urumqi City (Postprint)

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Abstract

Based on Baidu POI data, this study employs Ripley' s K-function, nearest neighbor hierarchical clustering, spatial autocorrelation, and other methods to investigate the spatial layout of public leisure facilities in Urumqi, summarize the pattern characteristics of urban leisure space, and explore the influencing factors of leisure space. The results indicate: (1) The spatial distribution of leisure facilities in Urumqi demonstrates significant centripetal agglomeration characteristics. (2) The hotspot distributions of various leisure facility types exhibit distinct agglomeration tendencies. Hotspots of entertainment, shopping, and fitness facilities are primarily located near major transportation hubs and commercial centers within the main urban area; dining facility hotspots display pronounced population-oriented characteristics; tourism facility hotspots are all distributed in proximity to popular tourist attractions; and cultural facility hotspots are situated in science, education, and cultural bases or multi-ethnic mixed residential areas. (3) The leisure space pattern of Urumqi follows a "circle-sector-cluster" model, featuring a planar comprehensive leisure center at the core, surrounded by sector-shaped sparse leisure facility areas, clustered multi-functional leisure areas, and clustered dining leisure areas, with the outermost periphery comprising suburbs with minimal leisure facilities and clustered tourism leisure areas. (4) A strong positive spatial correlation exists between leisure space and population distribution in Urumqi.

Full Text

Urban Recreation Space Patterns Based on POI Data: A Case Study of Urumqi City

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Abstract: Urban recreation space is an important organic component of a city, and its development reflects not only urban socio-economic culture but also the evolution of urban spatial structure. Based on Baidu POI data and using Ripley' s K function, spatial autocorrelation, and nearest neighbor hierarchical clustering analysis methods, this paper examines the spatial characteristics of public recreational facilities in Urumqi City, Xinjiang, China, summarizes the patterns of urban recreation space, and explores the influencing factors of urban recreation space. The results show: (1) The spatial distribution of leisure facilities in Urumqi exhibits marked centrality and agglomeration. (2) The hotspots of the six types of recreational facilities show different agglomeration tendencies. Entertainment facilities, shopping facilities, and sports facilities tend to cluster near important transport hubs and commercial centers. The hotspots of catering facilities show obvious population orientation. The hotspots of tourism facilities are located near scenic spots. The hotspots of cultural facilities are located in mixed ethnic areas. (3) The recreation space pattern in Urumqi displays a "layer + sector + group" mode. The city center is the planar comprehensive leisure center, and the periphery of the city center is the fan-shaped leisure facilities area with low density, grouped multifunctional leisure area, and grouped catering leisure area. The suburbs have few leisure facilities but are grouped tourism leisure areas. (4) It is proven that the recreation space of Urumqi is positively correlated with the spatial distribution of population.

Keywords: recreation space; POI data; recreational facilities; hotspots; Urumqi

2.1 Ripley' s K Function Analysis

Ripley's K function was used to analyze the spatial agglomeration characteristics of leisure facilities in Urumqi. The calculation formula is as follows: . L(t) was used for result analysis. When $L(t) > 0$, it indicates that leisure facilities exhibit agglomeration distribution within the distance t; when $L(t) < 0$, it indicates dispersion distribution; when $L(t) = 0$, it indicates random distribution.

The results show that the L(t) values of all leisure facilities in Urumqi are greater than 0 within the range of 0–18.47 km, indicating that leisure facilities exhibit significant agglomeration characteristics within this distance range. When the distance exceeds 18.47 km, the L(t) values become less than 0, indicating dispersion distribution. The maximum agglomeration intensity occurs at 13.12 km.

For different categories of leisure facilities, the Ripley' s K function results show that the agglomeration distances vary. Entertainment facilities, shopping facilities, and sports facilities show the strongest agglomeration within 10 km, while catering facilities show the strongest agglomeration within 5 km. Cultural facil-

ities and tourism facilities show relatively weaker agglomeration, with their L(t) values remaining positive within 15 km.

2.2 Hotspot Analysis

The hotspot analysis of different categories of leisure facilities in Urumqi reveals distinct spatial patterns. Entertainment facilities hotspots are primarily concentrated in the city center and major commercial districts, showing clear transport hub orientation. Shopping facilities hotspots are distributed along major traffic arteries, forming a fan-shaped pattern from the city center outward. Sports facilities hotspots are relatively dispersed, mainly located in areas with good accessibility.

Catering facilities hotspots show obvious population orientation, with high-density areas corresponding to population concentration zones. Tourism facilities hotspots are concentrated near major scenic spots and in the southern suburbs. Cultural facilities hotspots are primarily located in the mixed ethnic areas of the southern part of the city, reflecting the characteristics of multi-ethnic cultural integration.

The spatial distribution of hotspots shows a hierarchical pattern: the city center forms a comprehensive leisure center, the periphery forms sectoral distribution areas, and the suburbs form grouped distribution patterns.

2.3 Spatial Correlation with Population Density

The bivariate Moran' s I analysis was conducted to examine the spatial correlation between leisure facility density and population density in Urumqi. The results show a significant positive correlation between the spatial distribution of leisure facilities and population density ($P < 0.05$).

The Moran' s I values for different types of leisure facilities are: entertainment facilities 0.597, shopping facilities 0.548, sports facilities 0.606, catering facilities 0.595, tourism facilities 0.350, and cultural facilities 0.450. All values are positive, indicating that leisure facilities tend to be located in areas with higher population density. Catering facilities show the strongest correlation with population distribution, while tourism facilities show the weakest correlation, as they are more influenced by natural and cultural resources than by population distribution.

3 Recreation Space Pattern

The recreation space in Urumqi exhibits a "layer + sector + group" composite pattern. The city center (within 5 km) forms a high-density planar comprehensive leisure center, with all six types of facilities highly concentrated. The intermediate zone (5–15 km) forms a fan-shaped area of leisure facilities with medium density, where different types of facilities show sectoral distribution along major traffic arteries. The outer zone (beyond 15 km) forms grouped

leisure areas with low density, mainly consisting of tourism facilities and a few sports facilities.

This pattern reflects the combined influences of urban spatial structure, transport network, population distribution, and resource endowment. The layered structure corresponds to the urban ring-road system, the sectoral distribution aligns with major traffic corridors, and the grouped pattern matches the distribution of scenic resources and suburban residential areas.

4 Conclusions

This study demonstrates that POI data can effectively reveal the spatial characteristics of urban recreation space. The spatial distribution of leisure facilities in Urumqi shows significant agglomeration characteristics, with clear centrality and hierarchical structure. Different types of leisure facilities exhibit distinct location preferences: entertainment, shopping, and sports facilities are transport-oriented; catering facilities are population-oriented; tourism facilities are resource-oriented; and cultural facilities are ethnicity-oriented.

The "layer + sector + group"pattern reflects the unique natural environment, urban form, and socio-cultural characteristics of Urumqi. The positive correlation between recreation space and population distribution provides important reference for urban planning and leisure facility layout optimization. Future research should consider dynamic changes and the impact of new urban development on recreation space patterns.

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Note: Figure translations are in progress. See original paper for figures.