Extraction and analysis of spatial divergence features of residence space

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Abstract. Reasonable planning of urban residential spaces is important for urban development. This article used the population spatial distribution data and house price data to extract and analyze the characteristics of urban residential space differentiation in Shenyang and Wuhan. The results showed that: (1) There was a phenomenon of residential space differentiation in Shenyang and Wuhan. Compared with Shenyang, the phenomenon of residential space differentiation in Wuhan was more serious. (2) The proportion of people living in low, medium and high housing price areas in Shenyang and Wuhan showed the primary form of olive structure. Research conclusions: Combined with the data of population spatial distribution and house price, the study of urban social space was conducive to building a fair, just and harmonious urban social space, which was valuable not only in theory but also in practice.

1. Introduction
The urban residential space differentiation problem is one of the important research issues in urban social geography, it is an evolving process of urban social space, which from less to more, from simple to complex, and from the whole to the individual [1]. Residential space differentiation is an inevitable phenomenon in urban update and expansion. The essence is the reflection of the social class differentiation in the urban spatial pattern [2]. Foreign scholars began to study the differentiation of residential spaces earlier. Since the 1920s, they started from the three classic models of Chicago School in the United States [3], and gradually formed a relatively mature theoretical and practical system of ecological school [4], behavioral school [5], and positivist school [6] after a hundred years of development Domestic scholars began to study the differentiation of residential spaces earlier. Since the 1920s, they started from the three classic models of Chicago School in the United States [3], and gradually formed a relatively mature theoretical and practical system of ecological school [4], behavioral school [5], and positivist school [6] after a hundred years of development Domestic scholars began to study the differentiation of residential space in the 1980s [7], after more than 30 years of development, relevant research results are constantly emerging, for example, we can study urban residential differentiation from different perspectives, such as Household Registration and Occupational Dual Dimensions [8], supply and demand factors [9], residential price perspective [10], ecological perspective[11], etc. The research areas are mainly some important cities, such as Beijing, Shanghai, Wuhan, Xi’an, Shijiazhuang, and so on [12-18]. Although it has obtained good results, the research perspective is mostly concentrated at the microscopic level, lacking macroscopic analysis.

Therefore, this article is based on the Population spatial distribution data and house price data, Using spatial autocorrelation, spatial interpolation and overlay analysis, taking Shenyang and Wuhan as examples, to analyze their living space differentiation characteristics from a macro perspective.
2. The research methods

2.1. Flowchart of research technology

The technical process is shown in Figure 1. First of all, we need to make the spatial self-correlation analysis of house price data, Judging whether the data meets the prerequisites for making spatial interpolation (Having high spatial autocorrelation); and then, house price data are spatially interpolated to attain the interpolation surface diagram. Finally, superpose the population spatial distribution data with interpolation diagram, Statistics and analyze the number of distributions in different housing prices.

![Flowchart](image)

**Figure 1.** Research technology flowchart.

2.2. The research methods

2.2.1. Space self-correlation analysis. This article uses the global Moran’s I index for spatial self-correlation analysis, and its calculation principles are as follows.

\[
I = \frac{n}{S_0} \sum_{i=1}^{n} \sum_{j=1}^{n} \omega_{i,j} z_i z_j
\]

\[
S_0 = \sum_{i=1}^{n} Z_i^2
\]

Among them: \( z_i \) is the deviation between the attribute of feature i and its average value \((x_i - \bar{X})\); \( \omega_{i,j} \) is the spatial weight between feature i and j; \( n \) equals the total number of elements, and \( S_0 \) is the aggregation of all spatial weights.

2.2.2. Kriging space interpolation. The Kriging interpolation method is based on the measured sample data, through spherical, Gaussian, exponential function model to predict the approximate values of other unmeasured area sample points. The calculation principle is as follows:

\[
Z(x_0) = \sum_{i=1}^{n} \lambda_i Z(x_i)
\]
Among them: \( Z(x_0) \) is the house price of sample points to be predicted; \( Z(x_i) \) is the known sample points of house price; \( \lambda_i \) is the weight of house price of the ith sample point; \( n \) is the number of house prices of sample points.

3. Experiment and analysis

3.1. Research area and data source

3.1.1. Research area. This paper chooses Shenyang and Wuhan as the research areas. Shenyang is located in the middle of Liaoning Province, adjacent to the Liaodong Peninsula in the South and Changbai Mountain in the north, it is the central city of the three northeast provinces, and also an important heavy industrial city in China. The landform is mainly plain, belonging to the temperate semi-moist continental climate, and the resident population is 75.64 million in 2019, the region's total output value is 647.03 billion yuan.

Wuhan is located in the east of Jianghan Plain. The Yangtze River, the third-largest river in the world, and its largest tributary, the Han River, run through the center of the city, and it belongs to the subtropical monsoon humid climate zone. Wuhan city is rich in water resources, and it is not only the thoroughfare of nine provinces but also an important Scientific research base in China. The resident population is 11.212 million in 2019, the region's total output value is 1.622321 trillion yuan. The two cities’ economic development is rapid, the geographical location characteristics are obvious, the development level and the urban positioning are different, it is very representative to study the residential space differentiation characteristics of the two cities.

3.1.2. Research data. The price data selected in this study comes from the house price website(http://www.fangjia.com/cpdb/index), which is a domestic real estate data service provider with a real estate database. This article gets the house price data through the official API interface in December 2018. After cleaning, removing duplication, and other pretreatment, the sample distribution data of housing prices in the two cities are shown in figure 2.

![Figure 2. The sample distribution data of housing prices in Shenyang and Wuhan.](image)

The data of population spatial distribution come from GeoQ, whose population spatial distribution data is generated based on the data of the sixth national population census, with high accuracy, and it was captured in December 2018. The population spatial distribution data of the two cities are shown in figure 3.
3.2. Experiment and analysis

3.2.1. Spatial autocorrelation analysis and interpolation calculation. After standardization, the global Moran's I index range is [-1, 1], under the given significant level, the Moran's I index is greater than 0 indicates a closing trend, and the Moran's I index is less than 0 is discrete distribution, and the Moran's I index is equal to 0 indicates that it is randomly distributed, and there is no spatial self-correlation. Table 1 is the result of the spatial self-correlation analysis of the house price data. The change in the overall Moran's I index indicates that the house price of two cities in Shenyang and Wuhan has a strong spatial agglomeration. Therefore, spatial interpolation can be performed.

Table 1. Moran's I index results.

|          | Shenyang | Wuhan   |
|----------|----------|---------|
| Moran Index | 0.515809 | 0.396420 |
| Moran Index | 29.513650 | 17.278904 |

Under the condition that the house prices of Shenyang and Wuhan meet the spatial autocorrelation, the Kriging method is used to interpolate the rooms, and the spherical function model is selected as the interpolation model. The results are shown in Figure 4. It can be seen from the spatial interpolation of housing prices in Shenyang and Wuhan that there is spatial differentiation of housing prices in both cities.
3.2.2. Differentiation feature extraction of residential space

![Scatter plot of housing price and population in Shenyang and Wuhan.](image)

Figure 5. Scatter plot of housing price and population in Shenyang and Wuhan.

To superimpose the spatial distribution data of population onto the spatial interpolation map of house price, we can establish the internal relationship between housing price data and population data in geographical space. The population of statistics in different housing prices is shown in Figure 5. It can be analysed from the figure that in Shenyang and Wuhan, the population distribution of different housing prices is different, that is, housing price has a strong screening effect on the spatial distribution of population. Based on the screening effect of house price on population, the house price is divided into three grades: low, medium and high by relative comparison method. Access to the residential space differentiation characteristics of the research area (as shown in figure 6).

Table 2. Classification standard of low, medium and high housing prices in Shenyang and Wuhan.

|                | Shenyang               | Wuhan                  |
|----------------|------------------------|------------------------|
| High housing prices | More than 8,000 RMB    | More than 16,000 RMB  |
| Medium housing price | 6,000 yuan to 8,000 RMB| 11,000 yuan to 16,000 RMB |
| Low housing price   | Less than 6,000 RMB    | Less than 11,000 RMB   |

![Differentiation characteristics of residential space in Shenyang and Wuhan.](image)

Figure 6. Differentiation characteristics of residential space in Shenyang and Wuhan.
The residential space differentiation characteristics of Shenyang and Wuhan are shown in Figure 6. According to the survey, the high housing price area of Shenyang is mainly distributed in the central area of the city, while the medium housing price and low housing price are mainly distributed in the ring with a different radius around the city center; The high housing price area of Wuhan is mainly located in the west of East Lake and five blocks of Dazhi, Yiyuan, Chezhan, Yongqing and Siwei in Jiangan district. The medium housing price area is located in the northwest, southeast and northwest of East Lake, while the low housing price area is mainly located at the edge of the city.

3.2.3. Analysis on differentiation characteristics of residential space. Through the above research, it is confirmed that there is a phenomenon of residential space differentiation in Shenyang and Wuhan. Then I make statistics on the population distribution of spatial differentiation, and the results are shown in table 3.

According to the data in Table 3, it can be found that in the research area: First, the proportion of people living in medium housing prices in Shenyang and Wuhan is more than 60%, and the proportion of people living in medium housing prices in Wuhan is as high as 76.8%; That is to say, people living in medium housing prices have become the main part of society in the two cities; Second, by calculating the difference between the proportion of people with high housing prices and those with low housing prices in the two cities, and it can be found that the difference is 7.0% in Wuhan and 0.8% in Shenyang. It is concluded that the differentiation of residential space in Wuhan is more serious than that in Shenyang. Third, through the macro analysis of the proportion of people living in low, medium and high housing prices in the two cities, the results show that the groups living in different housing prices in the two cities present the primary form of olive structure.

| Table 3. Proportion of population living in low, medium and high housing price in Shenyang and Wuhan. |
|-------------------------------------------------|------------------|------------------|
| Proportion of people with high housing prices   | 17.4%            | 15.1%            |
| Proportion of people with medium housing prices | 66.0%            | 76.8%            |
| Proportion of people with low housing prices    | 16.6%            | 8.1%             |
| The difference between the proportion of people with high and low housing prices | 0.8%             | 7.0%             |

4. Conclusion and discussion
Based on the data of population spatial distribution and house prices, this paper studied the residential spatial differentiation between Shenyang and Wuhan, and the phenomenon of residential spatial differentiation in Shenyang and Wuhan. The main conclusions were as follows:

(1) There was a phenomenon of residential space differentiation in Shenyang and Wuhan. Compared with Shenyang, the phenomenon of residential space differentiation in Wuhan was more serious;

(2) The proportion of people living in medium housing prices in Shenyang and Wuhan was more than 60%, and the proportion of people living in low, medium and high housing price areas in Shenyang and Wuhan showed the primary form of olive structure.

There were also some deficiencies in this study: The data of house price and population was used to study the residential space differentiation; the size of housing price samples was small, and the interpolation effect was poor; The division of low, middle and high-income groups was not scientific and rigorous enough. In the future, I hope to choose more kinds of data, sufficient housing price samples, more scientific and rigorous division methods to further study the problem of residential space differentiation.
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