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Identification of Urban Functional Areas and Governance Measures Based on Point of Interest Data: A Case Study of the Shenyang Railway Station Area in Shenyang City

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Abstract: Inventory extraction and governance measures in urban land use have become important topics in urban regeneration research. This study aimed to inform design governance in urban regeneration through a point of interest (POI) data-based case study. An approximately 15 km^2 rectangular development area was assessed for its characteristics and deficiencies. Frequency density analysis was conducted based on data identification of urban built environments and governance from an integrated planning perspective, using field research, spatial autocorrelation, Getis–Ord Gi* analysis, and SPSS. We (1) applied POI data to assess the frequency ratios of the function types for the 6008 buildings in the study area; (2) analysed layouts of POI densities in hotspots for different formats; and (3) applied an evidence-based approach and overlay analysis to identify the area's functional morphological zones. Finally, the urban physical and morphological properties were identified and compared with the identification result of the urban functional areas to qualitatively evaluate the differences. Global Moran's I of the POI density of Retail Business (B11), Restaurants (B13), Hotels (B14), Entertainment and Recreation (B3), and Residential Services (R22) were 0.35, 0.35, 0.06, 0.20, and 0.15, respectively, displaying a significant spatial clustering feature. However, for land types including Administrative Offices (A1), Finance and Insurance (B21), and Other Business Facilities (B29), the *p*-values between the POI density and the random pattern were 0.23, 0.71, 0.56, respectively, showing no significant difference. Our study provides recommendations for governance and integrated urban redevelopment planning to coordinate and guide further regeneration.

Keywords: POI; morphological identification; zones; land use; design governance

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1. Introduction

1.1. Research Background

Inventory extractions and governance measures in urban land use at the inventory planning stage have become important topics for research on urban regeneration. Further, urban land use functions are characterised by morphological zoning and classification, which is a fundamental principle of urban city planning and reflects the comprehensive results of socio-economic drivers and human use patterns. In the governance of urban regeneration design, the principles embedded in policy and guidance have dovetailed with substantive thinking within urban design and can be recognised in significant projects. However, in many cities, providing services to urban residents is no longer the focus of urban governance. Today, the focus is on the city's prosperity and its ability to attract job and investment opportunities [1]. Accordingly, design governance requires the scientific identification and evaluation of urban morphology, through research on zone integration, to reveal the inherent patterns and deficiencies in an area's development and facilitate the adoption of correct measures to 'provide a high-quality public realm and promote the design' [2]. In addition, considering that land users acquire rights to the land they use and invest in development via land concessions, identification, and evaluation of actual urban land use functions is essential, as it has practical implications for the 'planning, implementation, and assessment' that promote 'urban health examination' [3–5]. In summary, analysis and identification of urban area environments for systematic assessment of inherent patterns and deficiencies in area development are critical for further urban regeneration and 'urban physical examination'.

1.2. Literature Review

Classification by zoning types and functions are two of the traditional methods used in architecture and urban planning research. Urban functional areas are geographic units composed of various interrelated elements within a city [6–8]. Scientific, rational, and consistent functional zone planning is crucial to the implementation of long-term urban development goals [9]. In urban planning, the selection of urban lands and functional urban zoning are inseparable. In urban regeneration, the concept of regeneration includes the reallocation and adjustment of urban functional areas. Through detailed research on urban morphology, a theory of typical morphology has been generated from studies targeting key urban morphology and architecture [10,11].

Cities are complex systems whose functional zoning extends beyond the four basic functions mentioned in the Athens Charter. As the methods of zoning gradually developed, the classification of urban areas did not remain limited to their physical attributes but included the social and economic functions driven by human activities [12,13]. Xing and Meng [14] found that the classification of urban functional regions plays an important role in urban planning, resource management, and sustainable development. Earlier studies have focused solely on delineating regions by urban morphology or deriving functional types on the basis of human activities, but few sufficiently depict these characteristics and discuss integrating them. The descriptions of the specific social and economic functions of urban land are not detailed enough to satisfy the practical needs of urban planning and management. To solve the increasingly complex urban problems, an urgent need has arisen in urban planning and management to ensure the timely and accurate acquisition of urban land use information.

After the 1960s, given the development and maturity of geographic metrology, the method of functional area identification and division has gradually become quantitative [15]. The emergence of the Internet and big data provides new possibilities for the identification of urban functional areas [16]. Data identification methods in urban morphology research can be classified along two scales, micro- and meso-scale research, and macro-scale research. In urban design research, traditional morphological perceptions and quantitative data analysis dimensions should be combined to form data-informed, algorithm-driven, evidence-based approaches [17] in meso/micro-scale perspective studies, although detailed urban morphology is often strongly correlated with the functional type [18].

Three types of data commonly used in the identification of urban functional areas include points of interest (POI) data, positioning data, and social media check-in data. Using taxi trajectory data, Liu et al. [19] verified the classification of the functions of the different areas of a city by using a model-based analysis and a classification tree, completing the identification of urban functional areas in Beijing. Pei et al. [20] used mobile phone data to determine the attributes of the residents' activities, and applied a c-means clustering approach to infer the land use types. Zhou et al. [21] used the kernel density approach to conduct temporal data mining of the taxi GPS data in Shenzhen, analysing and validating the discipline of attraction of the transportation between two commercial centres. Wang et al. [22] used the check-in data on Sina web to recognise the daily behavioural characteristics of people in different periods, for the functional zoning of cities. However, obtaining positioning data and social media check-in data is not easy. Moreover, these studies have difficulties in achieving detailed functional zoning from an urban micro-perspective, while the urban geospatial distribution is uneven. For example, the accuracy of using mobile phone data to identify urban functions is limited by the density of mobile phone signal towers; when the density is higher, the accuracy is also higher. POI data have the advantages of high accessibility and being able to provide a huge amount of data; thus, the use of building and POI data to identify urban functional features has attracted much attention from researchers, with many of them focusing on the identification of urban functional features through building and POI data.

POI generally refers to point data containing geographic information on electronic online maps. POI data are static data that can reflect the spatial distribution of facilities in a given area [23]. Numerous studies have employed POI data and human mobility data to infer functional regions by identifying mobility pattern distributions [24]. Kernel density of the POI data for each function type is calculated, and land use type is determined according to the nuclear density threshold [25]. POI category ratio methods are usually used to identify functional areas [26,27]. For example, methods for the classification of building functions have been investigated by classifying the types through POI-weighted frequency density (FD) ratios. It was hypothesised that the distribution of functional areas in cities could be reflected in the classification of building functions [9,28,29].

This study argues that in the literature on building function classification that uses POI-weighted FD, the POI data on industry formats cannot properly identify the target buildings' residential functions for the following reasons. First, statistical inconsistencies exist between the POI-based classifications for industry management and the POI-based classifications for urban land. Second, differences in functional industry formats can also exist among the different land use categories. Third, classification errors have been identified in the research; for example, many office buildings and business buildings were misclassified as having residential functions. Studies from a macro analysis perspective present another example. Such studies, which are based on remotely sensed images, can reveal the morphology of urban regions to some extent. Analyses that integrate remote sensing data and socio-economic information enable the transition of land cover and urban structures into detailed functional models of urban land use [18,30,31]. By comparison, macro-level research has simply extracted and fused a variety of natural features from remote sensing images and has failed to quantitatively measure the landscape so as to describe the urban morphology in detail [14].

In summary, the literature review suggests that in identifying spatial clustering or patterns in old urban areas, morphological methods of describing and evaluating the spatial frequency densities of POIs in different service area formats and for assessing the spatial distribution characteristics of the clusters can better reflect the spatial scaling classifications and functional zoning of streets and blocks [32–36]. However, there are still limitations in the literature [37]. For example, many studies directly link POIs with block functions, while in reality, because of the excessive differences between the density of various types of POIs and the differences in block scales, researchers have to subjectively design constant parameters for specific identification work; therefore, the accuracy of large-scale block identification is insufficient. Further, because of different POI distributions in various types of cities, these constant parameters have to be adjusted accordingly, leading to poorer applicability. The inverse distance weighted method is used to measure the distance between the POIs and buildings to connect the POIs with specific buildings. Next, the methods of category ratio and FD are used to determine the actual functional properties of specific blocks, to realise the rapid identification of urban functions, and construct a method for the identification of urban functional areas based on POI identification at the scale of blocks.

1.3. Research Aims

In view of the problems in the existing studies on urban function identification, including using a scale that is at an inappropriate macro-level, poor accuracy of identification, and the complications that arise in directly applying the same research results to different cities, this study attempts to address the issue at the district level and utilise the spatial adjacent relations, to connect the POIs with the plots where the buildings are located, realise the rapid identification of the land use functions of urban districts, identify and evaluate the functional clustering of the urban built environment, and summarise the characteristic rules of the land use planning in the high-speed railway station districts by examining real-life cases. Compared with the traditional methods, this study makes improvements in the following areas: (1) examines the issue with spatial adjacent relations of the POIs, to lower the influences of the excessive clustering of POI data on the identification of plot functions, in order to provide a more accurate identification; (2) eliminates the subjective design of the bandwidth parameters and weighting parameters in traditional POI kernel density studies, so that the research results can be directly applied to other urban designs; (3) considers the actual conditions in zones with mixed functions, as well as the zoning management and control of the units to be regenerated, and takes into account the contradictions and conflicts between historical elements and modern elements, physical elements and industrial format elements, and functional elements and structural elements in an integrated manner, so that the study can provide suggestions to the upper-level planning of the regeneration management of the study district [38–42].

2. Materials and Methods

2.1. Study Area

A 15 km^2 rectangular area in front of the Shenyang Railway Station in the Heping District of Shenyang City was selected as the study area. This area has high economic, cultural, and historical value. It includes Shenyang Railway Station, Zhonghua Road, Taiyuan Street, Zhongshan Road, Zhongshan Square, Heping Square, and other important places. These places have integrated urban functions, such as being historically and culturally relevant while also incorporating commercial services, administration, healthcare, accommodations and leisure, and history and culture. Shenyang Railway Station is a modern, integrated passenger transport hub that connects various modes of transportation, including railways, metros, and buses. The station was originally built in 1899 and was transformed into a high-speed railway hub in 2014. The history of Taiyuan Street dates back to 1898. Zhongshan Road and its neighbouring areas represent most of the 'South Manchuria Railway Zone'. The zone was developed by Japanese invaders in the last century and gradually became a prosperous district with numerous types of merchants and businesses. With continuous historical changes over time, especially in modern society, the evolution of urban regeneration has drastically changed the historical morphology, making this district highly representative of the economic development, historic preservation, and modern construction in Shenyang [43,44] (Figure 1).

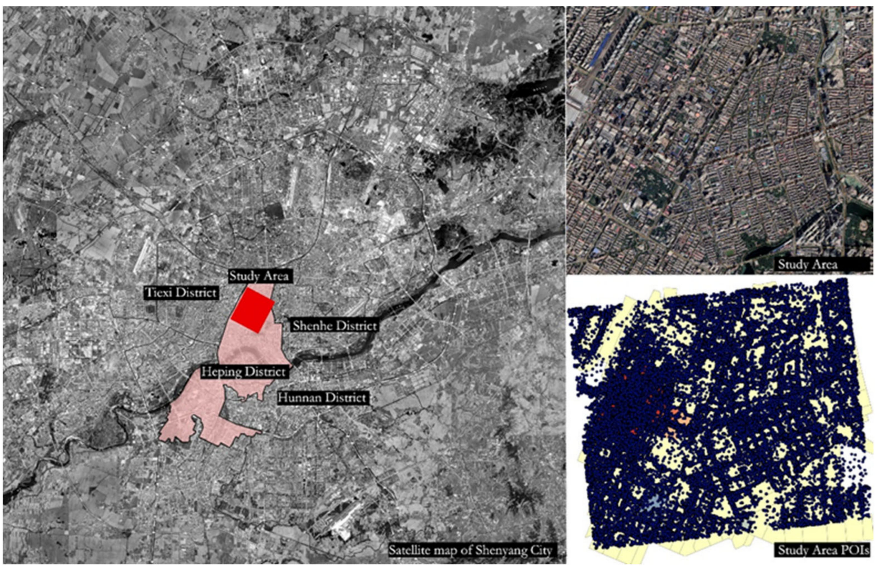

Figure 1. Study area. Source: Baidu Maps.

2.2. Data and Pre-Processing

2.2.1. Data Sources

POI data were obtained from Baidu Maps using the Shuijingzhu Universal Map Downloader; the map showed 97,238 POIs, which were mainly classified as Shopping Services, Catering Services, Life Services, Businesses & Enterprises, Scientific, Educational, and Cultural Services, Sports and Leisure Services, Medical Services, Financial and Insurance Services, Transportation Services, Accommodation Services, Business and Residential Services, Government Agencies, and Social Organisations. A total of 6008 buildings were shown in the study area, and the data source was the Baidu Building Vector Data 3.0.

2.2.2. Data Pre-Processing

To reflect the correspondence between POI classification and urban land use functions, the obtained POI data were classified and sorted with reference to the Land Use Classification section of the Classification of Urban Land Use and Planning Standards of Development Land (GB50137-2011) Code; the POI classification categories corresponded to broad and major land use categories. It is important to note the differences in land use patterns even when the industry format is of the same type. For example, shopping services POIs may exist on commercial and residential land. For statistical simplicity, certain types of POIs were classified collectively and represented with specific classification symbols. Further, the vast majority of healthcare POIs fall within the community medical service category; thus, major errors could occur if they were broadly classified as Category A (Administration and Public Services) Land. To avoid such errors, this study categorised Medical Services as R22 Residential Services under Category R (Residential). In another example, small and medium-sized training agencies dominated Scientific, Educational, and Cultural services POIs. Accordingly, they were categorised as B29—Other Business Facilities (Table 1) in this study. In addition, the broken surfaces in the downloaded building shapefiles were merged using a manual geoprocessing function to ensure that the buildings' centres of mass can truly reflect the relationships among these buildings.

Table 1. Classification of POI types in the study area.

Format Index	A1	B11	B13	B14	B21	B29	B3	R22
General category	A			B				R
Affiliated land	Administrative offices	Retail businesses	Restaurants	Hotels	Finance & insurance	Other business facilities	Entertainment & recreation	Residential services
POI format category	Government agencies & social organisations	Shopping services	Dining services	Accommodation, business & residential services	Companies & enterprise and financial & insurance services	Scientific, educational, and cultural services, automobile repair, other	Sports and leisure services	Life and medical services

2.3. Methods

The analysis process was divided into two levels. First, the urban functions and their patterns and characteristics, as well as the urban physical and morphological properties, were identified. The analysis results of the two were compared, to examine whether consistency existed between urban functions and urban morphology and to provide suggestions for the direction of planning (Figure 2). The urban functions and their patterns and characteristics were identified using FD analysis, spatial autocorrelation analysis, and Getis–Ord Gi* analysis; the urban physical and morphological properties were identified through methods including spatial intensity analysis. The analyses were conducted with arcGIS10.4 and SPSS28.

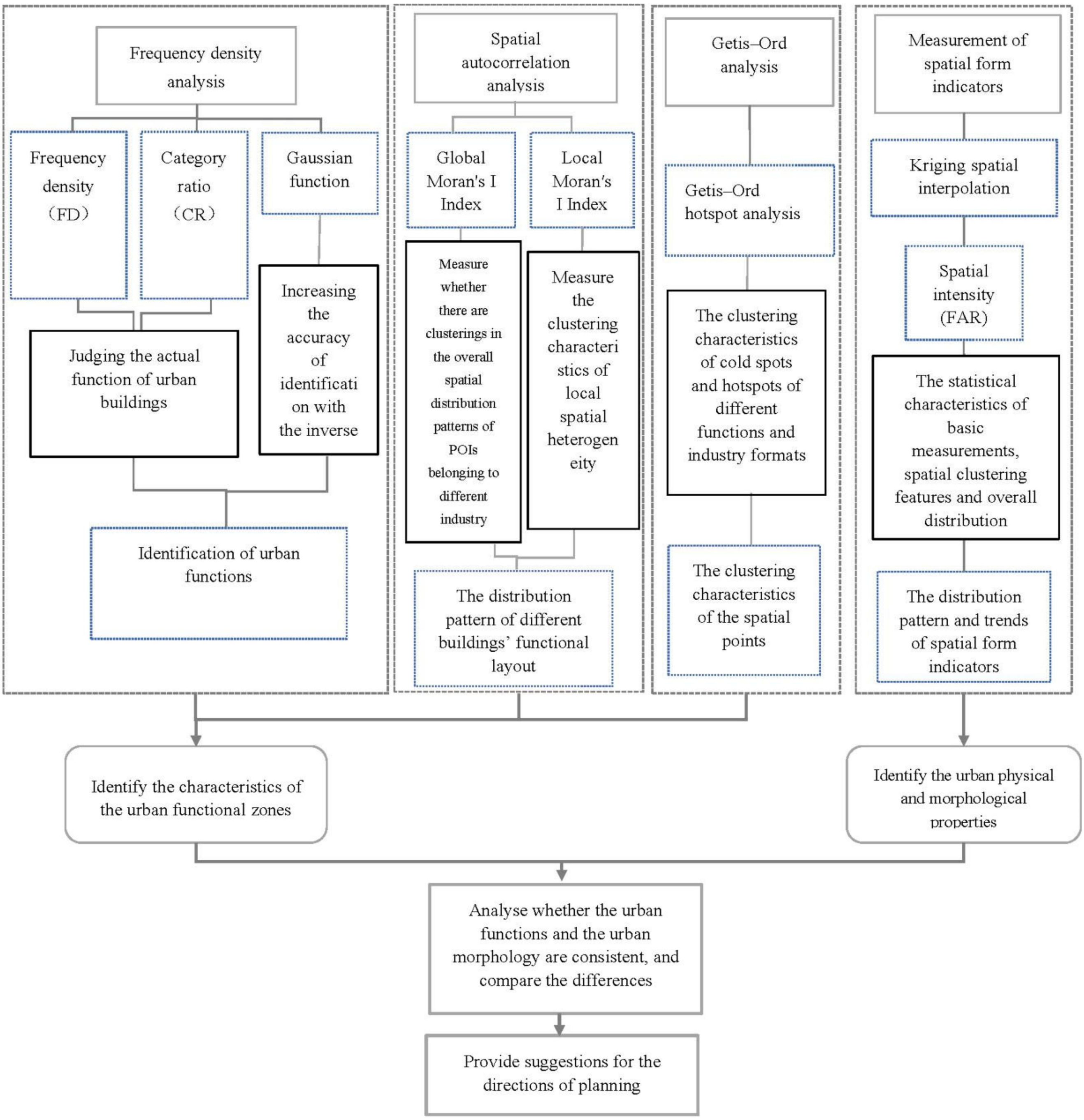

Figure 2. Flow chart of the research approach.

2.3.1. Frequency Density Analysis

POIs are point data that represent real geographical entities and include spatial information (e.g., latitude and longitude), address, and property information (e.g., name and category). In the present study, the buildings' actual use functions were measured by geotagged POIs in Baidu Maps. For each urban building in the study area, the POIs that fell within the building area were screened and selected using the building function classification method as a reference, and the FD (Equation (1)) and ratio category of indicators were constructed according to the POI types to assess the actual urban building use functions (Equation (2)):

$$F_i = \frac{n_i}{N_i}(i = 1, 2, 3, \ldots, n) \quad (1)$$

$$C_i = \frac{F_i}{\sum_i^n F_i} (i = 1, 2, 3, \ldots, n) \tag{2}$$

where i denotes the type; n denotes the number of types; n_i denotes the number of POIs of type i in the building; N_i denotes the total number of POIs of type i in the POI dataset; F_i is the FD of type i POIs as the percentage of the FD of that type of POIs; C_i is the FD of type i POIs as a percentage of the FD of all types of POIs in the building. After the FD ratio of each type was calculated, it was concluded that most previous studies used 0.5 as the threshold [45,46].

As POIs obtained from the Internet are prone to problems such as data loss, location deviation, and irregularity in attributes, and as the range is associated with probability, it was necessary to extend the number of POIs connected to the land in the present study to more POIs within a certain range around the land: the closer a POI is to a piece of land, the higher the probability that it belongs to that land, as approximated according to Gaussian distribution [28]. In this paper, a 100 m search radius was selected for the POIs adjacent to the building, and the distance (x) between the POI and the buildings' centre of mass was the inverse distance weighted using a Gaussian function (Equation (3)).

$$fx = ae^{\frac{(x-b)^2}{2c^2}} \tag{3}$$

2.3.2. Spatial Autocorrelation Analysis

Spatial autocorrelation analysis can reflect the degree of correlation between an element in a regional unit and its neighbouring elements, including global spatial autocorrelation and local spatial autocorrelation. In this study, Global Moran's I was used to determine whether the overall spatial distribution patterns of POIs of different formats were clustered. Local Moran's I was used to measure the clustering characteristics of local spatial heterogeneity to determine the distribution pattern of the function layouts of different buildings.

Global Moran's I index is as follows:

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} (x_i - x)(x_j - x)}{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} \sum_{i=1}^{n} (x_i - x)^2} \tag{4}$$

where x_i denotes the observed value of region I and W_{ij} denotes the spatial weights matrix. The range of values of Moran's I index is between [−1, 1], with less than 0 indicating negative correlation and more than 0 indicating positive correlation. The closer the I value is to 1, the more significant the cluster effect, and the closer the I value is to −1, the more significant the convergence of the spatial distribution.

2.3.3. Getis–Ord Gi* Analysis

To determine the clustering characteristics of the spatial points, according to one of its attributes, a hotspot analysis was conducted using Getis–Ord Gi*. The final visualisation results clearly showed the distribution of hot and cool spots. In this study, the POI point densities of urban lands were used as the analytical field to analyse the clustering characteristics of cold spots and hotspots in different functional formats.

2.3.4. Spatial Intensity Analysis

Spatial intensity is chosen as the indicator to measure urban morphology. The equation to measure the intensity of the spatial indicator is:

$$FAR = \sum_{1}^{n} AiFi/S \tag{5}$$

where *FAR* denotes the spatial intensity, *A* denotes the projected area of buildings, *F* denotes the number of floors of buildings, *S* denotes the area of the plot, and *i* denotes the plot number.

After completing the statistics of spatial intensity, the statistical data were processed using the kriging spatial interpolation method to convert the statistical data of the discrete points into a continuous curved surface of data as an intuitive display of the distribution trend and degree of clustering of the spatial intensity indicators.

3. Results

In the present study, POIs adjacent to the buildings were included in the calculation of the building's function types, which effectively improved the low rate of recognition of POIs that can result from location deviations and semantic irregularities. Considering the complex functions that service buildings must fulfil to meet market demand, the refined POI classification method presented in this paper could improve POI recognition accuracy and scientifically reflect the mixed land uses intended by planning and management. In addition, as noted in the introduction, among the POIs obtained, Commercial Services (Category B) functions were more applicable to cluster analysis. Furthermore, the research method was unable to identify Public Administration and Public Services (Category A) POIs, which are of larger scale but have fewer facility configurations. Using hospital buildings as an example, according to the Guidelines for Planning for the Establishment of Medical Institutions (2021–2025) issued by the National Health Commission of the People's Republic of China, public hospitals have a built-in three-tier medical emergency service system at the provincial, municipal, and county levels with a balanced layout and established branches. Although there are no planning restrictions on the total number and space of private hospitals in an area in the guidelines, there were very few hospital buildings in the area relative to the total number of POIs, and the FD of those POIs could be easily ignored. Therefore, the results of this study are more relevant in terms of conducting cluster analysis for business services (Class B) functions.

According to the careful study of the building functions (Table 2), results on the proportions of C_i building types showed no significant differences in frequency percentages among A1 Administrative Office, B11 Retail Business, B13 Restaurants, B14 Hotels, B21 Finance and Insurance, B29 Other Business Facilities, B3 Entertainment and Recreation, and R22 Residential Services. Further, the total number of POIs for each type of service was relatively balanced, while the broad category results for Commerce and Services (Category B = B11 + B13 + B14 + B21 + B29 + B3) were significantly different from those for Categories A and R (Figure 3). The results indicate that Business and Services (Category B) absolutely dominated the percentage of POI frequencies in the study area, and that there were no significant differences in proportions among the subcategories in Public Administration and Public Services (Category A), Residential Services (R22), and the subcategories in Category B, which indicates a more balanced format distribution. However, the spatial patterns of industry formats of the same type were clearly different. For instance, relatively high-end commercial formats were usually clustered in large commercial buildings, whereas the relatively low-end commercial formats tended to cluster along residential streets (Figures 3–5).

When studying the format layouts, the researchers observed clear clustering characteristics in the spatial layouts for the main format types. Among them, the layout hotspots for B11 Commercial Retail displayed three main hotspot areas: the area in front of the railway station, the intersection of Heping North Street and Zhongshan Road, and the area of the Shiyi Wei Road block; and four cold spot areas, the main one being the Heping Square area, and the other three located near the border of the study area. The hotspots and cold spots in the layout for B13 Restaurants were essentially the same as for B11. This analysis is consistent with a business model wherein retail businesses are combined with restaurants. There was only one hotspot in the layout for B14 hotels: the area in front of the railway station. The layout of the hotspots for B21 Finance and Insurance were significantly different from other commercial categories, but a small number of hotspots overlapped with those from B11 and B13. The B29 Other Business layout was rather different, having relatively scattered hotspots. There was only one layout hotspot for R22 Residential Services, again the area in front of the railway station.

Table 2. Proportions of building function types.

		C_i**A**1	C_i**B**11	C_i**B**13	C_i**B**14	C_i**B**21	C_i**B**29	C_i**B**3	C_i**R**22	C_i**B**
No. of cases	Valid data	6008	6008	6008	6008	6008	6008	6008	6008	6008
	Missing data	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean		9.906	13.784	15.677	12.925	11.958	12.129	10.047	12.129	76.519
Standard deviation		11.658	8.206	12.401	11.160	9.382	9.216	10.379	9.216	12.569
Variance		135.912	67.335	153.781	124.546	88.021	84.926	107.718	84.926	157.968
Skewness		1.660	1.726	2.030	1.439	1.401	1.333	1.471	1.333	(0.929)
Standard error of skewness		0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Kurtosis		3.575	6.270	6.462	3.004	3.275	3.418	2.952	3.418	1.565
Standard error of kurtosis		0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Min. value		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.664
Max. value		98.336	85.889	100.00	81.395	76.316	86.472	86.616	86.472	100.00

The comprehensive layout of all Category B Business formats showed the general characteristics of having one hotspot and one cold spot, with the hotspot being the area in front of the railway station and the cold spot being the Heping Square area. Compared with the layout hotspots for Commercial Services, the hotspots in the layout for Public Administration and Public Services Category A show significant differences, revealing differences in the distribution characteristics between this format type and Commercial Services. There was only one layout hotspot for R22 Living Services, the area in front of the railway station. This indicates Shenyang Railway Station's strong capacity as a catalyst for service functions, and the layout pattern was clearly visible. The layout of the living service function in the residential land was scattered and balanced, and no hot or cold spots were visible. By contrast, cold spots appeared in the layout of Administrative Offices and Non-Service Areas in Heping Square (Figure 6).

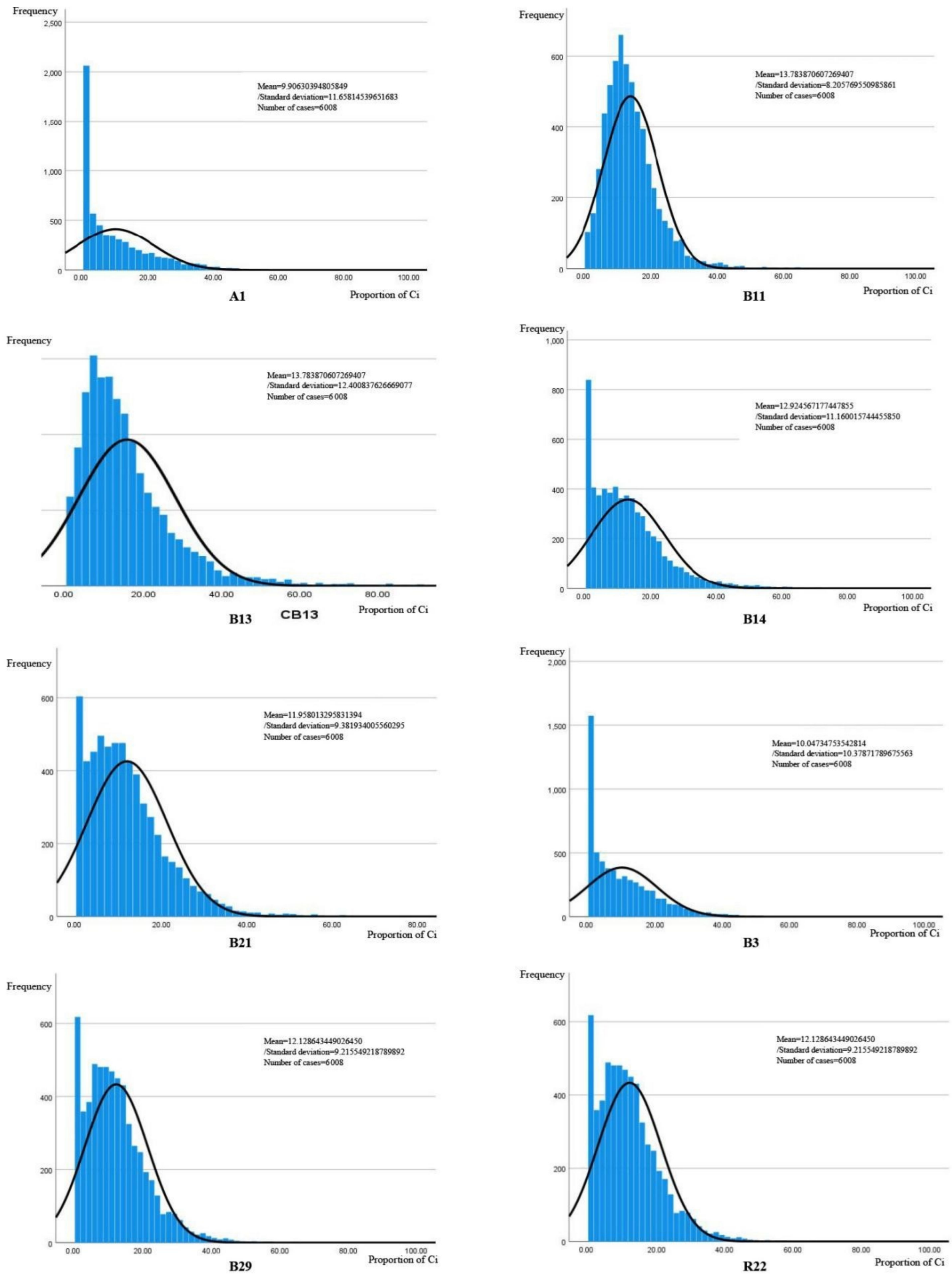

Figure 3. Frequency histogram of the proportion of C_i building function types for Categories A1, B11, B13, B14, B21, B3, B29, R22.

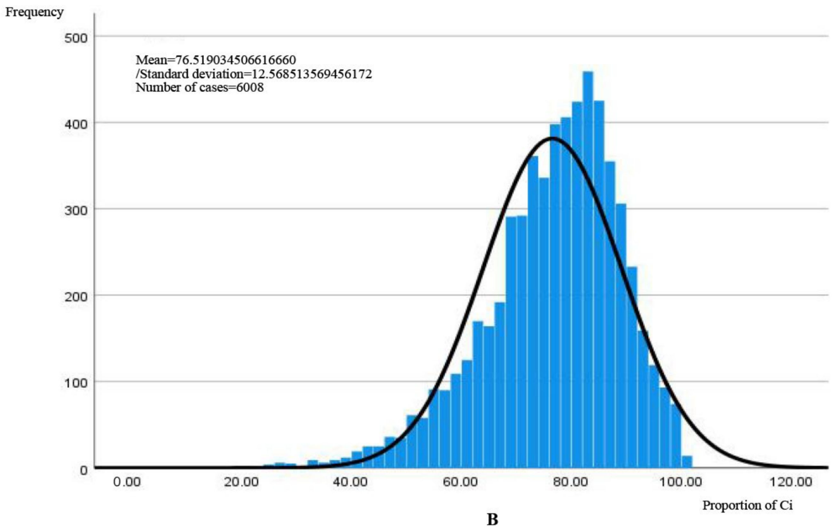

Figure 4. Frequency histogram of proportion of *Ci* B building function types.

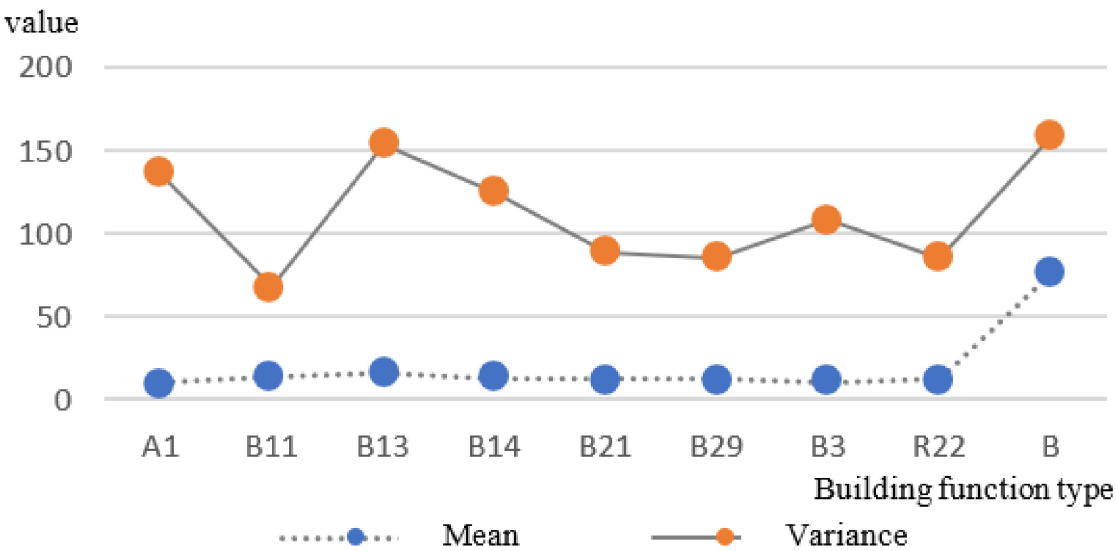

Figure 5. The relationship between the mean and variance of the category ratio, *Ci*, of the building functions.

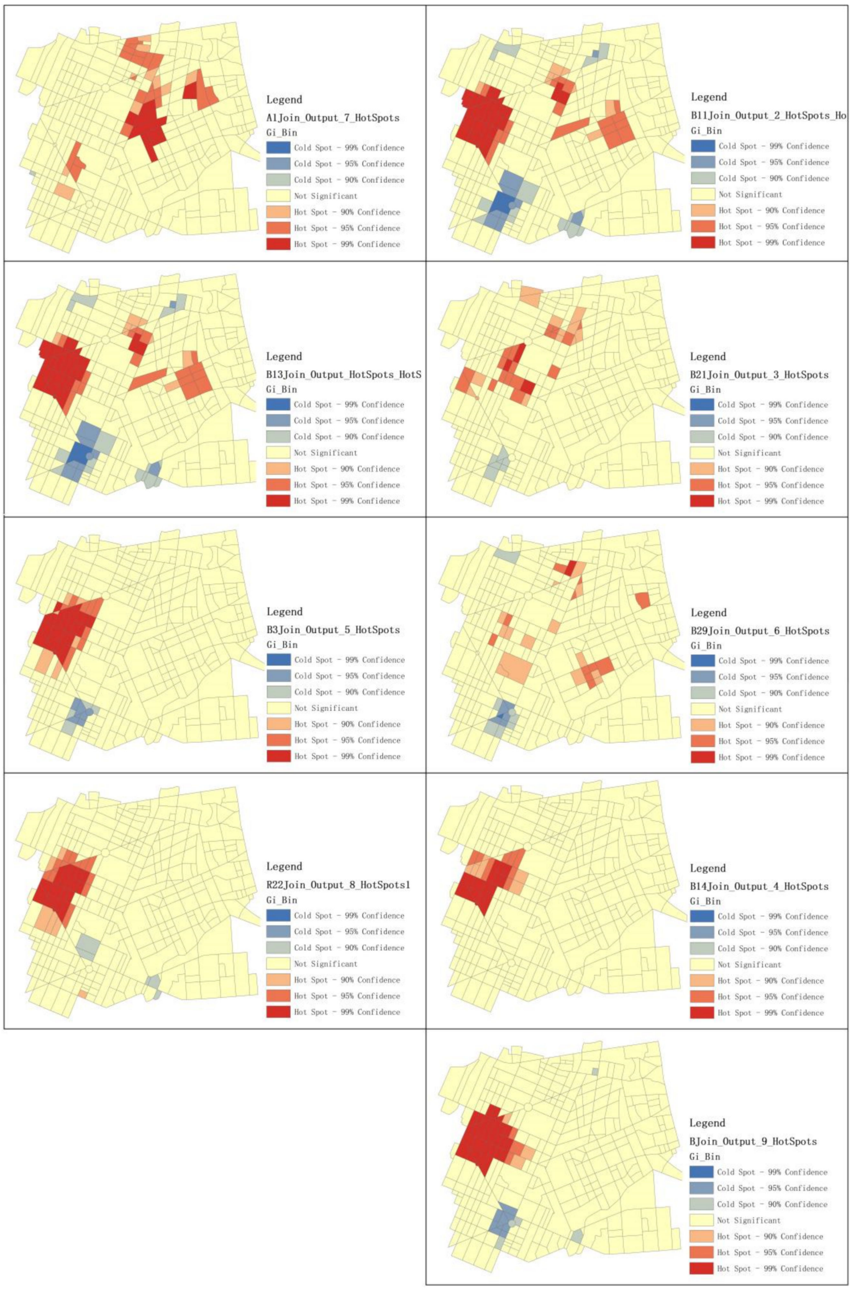

Figure 6. Categories A1, B11, B13, B14, B21, B3, B29, R2, category B.

4. Discussion

4.1. The Adoption of Holistic and Comprehensive Governance Mindsets

The identification results of the functional zoning indicate that a holistic mindset is necessary for district regeneration. Integrated planning of a district is needed to systematically solve the problems in design governance and redevelopment. This paper argues that, based on the identification of functional units, different governance units to be regenerated should first be set up, while a systematic assessment of the built environment in the area of each unit should be conducted according to different governance strategies, in order to implement systematic measures of protection, comprehensive renovation, as well as demolition and reconstruction [47,48]. Compared with the functional zoning categories applied in the relevant literature, the more clearly determined functional zoning at the land scale allowed for policy recommendations for area regeneration and redevelopment to be proposed in this study (Figure 7). Theoretically, there should be a fair amount of similarity in physical spatial forms within the same functional zone. However, in reality, the diverse characteristics of land use in the functional areas demonstrate the spatial competition between historical blocks, old blocks, and new blocks, the cultural conflicts between protection and development, and the stark contrast in spatial scales between the new blocks and original blocks, due to economic interests.

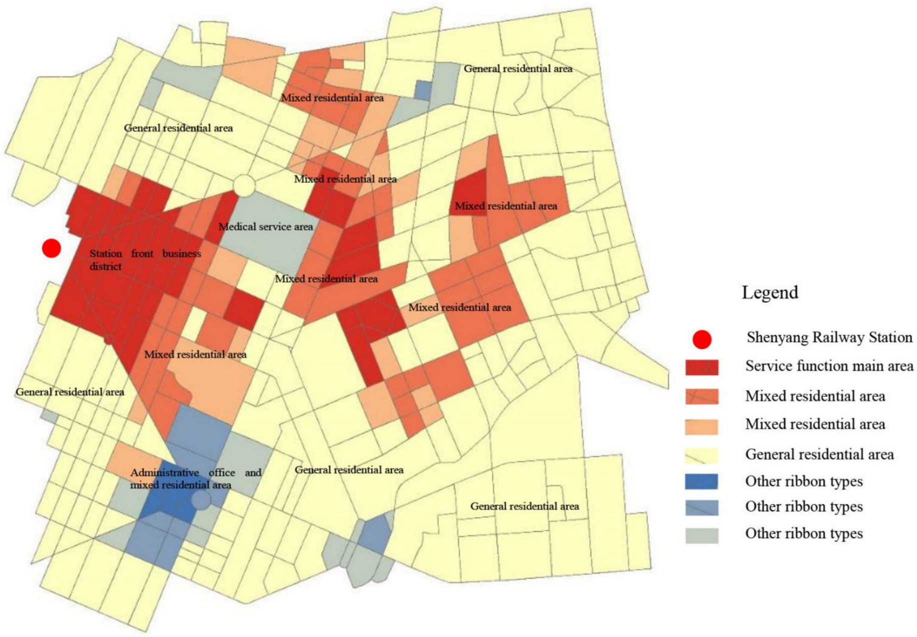

Figure 7. Functional area overlay analysis diagram.

In the continuous regeneration and evolution of cities, spatial forms have become gentrified, and the needs of the original residents, along with the need for inclusive spaces in the area, have been ignored. Ground-floor activities are absent in many tall buildings close to open public spaces and streets, and the integrity of the original districts has been undermined. Meanwhile, plot ratios are overly pursued in some development projects, and many spaces have been left unused due to the poor operation of new businesses. This paper argues that further regeneration and governance of districts should be based on the identification results of functional zoning, while also considering the specific problems in the actual spaces, adhering to the goal of serving the public interest and using urban governance methods to systematically solve the various problems in design governance and redevelopment.

4.2. Typological Characteristics of the District's Spatial Structure

The results show that the spatial structure in the district has clear distinctions between categories, which is conducive to looking for an overall positioning of the district's regeneration, and the planning and control of micro-projects. The land use and regeneration planning of the district in front of the high-speed railway station is currently the focus of the planning industry [49–52]. The significance of the high-speed railway station as an important catalyst in the city was reflected in the study results. The results clearly show the impact of Shenyang Railway Station on the urban structure and format functions. Analysis of the spatial distance layout patterns provides evidence that the functional format distribution characteristics of this area are highly correlated with the distance from the high-speed railway station, although it is impossible to rule out the potential impact of other catalysts in approximating concentric layout characteristics.

Further, different functional areas form different morphological patterns, and these patterns are the main basis for identifying functional areas in this study. The land-use patterns in the functional areas comprise predominantly mixed district layouts (e.g., combinations of residential and commercial buildings, administrative offices, and residential areas). Land use is also mixed; that is, it features a balance of residential, commercial, office, and other functions or mixtures of different forms of spatial combinations of the same nature within small plots [53,54]: for example, a vertical, high-intensity development layout. In short, the mixed land uses in the study area reflect complex spatial use needs. Therefore, while planning an urban space with a need to include mixed functions, like the district in front of the high-speed railway station, it is necessary to comprehensively consider the needs for different functions and balance the relationship between land functions, architectural styles, and land usage.

4.3. Strategies for Design Governance

The research shows that there are certain differences between the original plan and the functions in actual use. Such differences will have a stronger influence on the direction of design governance. The differences in the functional areas represent the diversity of the city. While implementing the strategies of design governance, such differences should be addressed by using different types of governance tools for different categories of areas. Over the course of history, the study area has come to comprise a mixture of historical buildings and modern construction. This is especially true of the area in front of the Shenyang Railway Station, which features historically protected buildings and historic districts, as well as various new shopping centres and office buildings. Taiyuan Street, a famous commercial pedestrian street, is also located in this area. As a result of development driven by commercial interests, many original historical buildings have been replaced by large-scale projects, and the street format has also changed drastically, effectively resulting in transfers of the spatial development rights between the existing historic district and the new district, with a strong contract in spatial scale. In new buildings, the functions of the original formats are continued and strengthened to a certain extent. However, as noted, 'the focus of much urban governance is no longer the provision of services to city residents, but a concern with the prosperity of the city and its ability to attract jobs and investment' [55]. Therefore, in the governance of further regeneration, it is necessary to effectively identify the internal contradictions between the differences, and maintain the balance between the right to development and the right to protection, between economic value and social value, and between the functions and diversity of spaces, in a proactive way.

4.4. Limitations

This study has certain limitations. Although the study results shed light on the intrinsic trends of business clustering in urban space, they also demonstrate that functional clustering can result in static characteristics and is lacking in terms of capturing the area's dynamic evolution through its historical changes. The purpose of this study was not to evaluate the history of the urban regeneration process but to reflect on the gains and losses accrued from previous planning actions by studying the dynamic evolution of the area; in this way, the laws of urban regeneration can be followed to achieve organic regeneration and effective urban governance. It is recommended that detailed research be conducted on site properties and building functions and with residential populations, so that a more precise picture of urban regeneration needs and governance approaches can be obtained. Urban regeneration units should be prepared from an area integration perspective to formulate comprehensive and precise policies for integration and area regeneration.

5. Conclusions and Recommendations

5.1. Conclusions

From an analysis of the FD ratios of building functions in the study area and identification of functional urban areas, the following conclusions have been reached:

First, the study area presents the characteristics of the clustering of different industry formats and clear distribution of functional blocks. Based on the Getis–Ord Gi* analysis, clear layout hotspots can be formed; moreover, although the density clustering of POI

Categories in A1, B21, and B29 is not significant, specific areas can be identified through the analysis of hotspots in the layout. In the present study, the study area was divided into the following functional areas: main service function areas, mixed residential areas, and general residential areas. Among them, the front of the Shenyang Railway Station has become the most significant commercial district area, while most of the other districts are residential and mixed with varying degrees of various types of land use functions. Finally, the functional identification zoning map of the study area was derived through overlay analysis. In addition, identification of some of the functional areas within the border of this study area involves identification of urban functions outside the border (Figure 6). The analysis results of the other areas are for reference only. They are not to be taken as the main study conclusion.

Second, this study demonstrates the scattering feature of the distance circles with the high-speed railway station as the core in the planning of land use layout. By combining the urban land use classification standards and refining the POI classification types, the commercial service category (Category B) functions of 6008 buildings in the study area were effectively identified to demonstrate the clustering characteristics; if the Global Moran's I for the plot density of Category B POIs is 0.289477 and the Z-score is 6.019681, the possibility of this clustering pattern being randomly generated is less than 1%. In addition, the Global Moran's I of POI density of Categories B11, B13, B14, B3, and R22 all show certain clustering characteristics. However, the differences between the POI density for Categories A1, B21, and B29 and the random pattern are not significant (Table 3). It follows that the layout of urban commercial service areas and building functions is related to the circle distance from the core catalyst, and the layout of public administration and public service lands is related to the scope of their service areas.

Table 3. Global autocorrelation analysis of plot density for POIs in different categories.

		A1	**B11**	**B13**	**B14**	**B21**	**B29**	**B3**	**R22**	**B**
Global Moran's I	Index	0.057265	0.349522	0.349522	0.065379	0.014452	0.024536	0.200207	0.150106	0.289477
	Z-score	1.199865	7.110324	7.110324	2.510486	0.367017	0.568939	4.547237	3.60044	6.019681
	p-value	0.230192	0	0	0.012057	0.713607	0.569397	0.000005	0.000318	0

Third, the inconsistency between functional zoning, land use classification, and form-based zoning will be a key point of reference for design governance. Urban design is a technical means for regeneration. As cities undergo sustainable development, urban design coordinates the economic, social, and environmental benefits, and optimises function and form, from the perspective of planning and the visualised expression through the design of spaces. In urban computing, quantifying the use intensity and degree of mixed use of functional areas can help uncover problems left behind in the history of urban planning [56]. As we qualify urban morphology with urban construction intensity as the indicator, the results in Figures 8 and 9 show that there are strong differences in urban morphology within the district in front of Shenyang Station. Compared with the identification results of urban functional areas, a large number of service industry functions concentrate in this district, forming functional areas that are more holistic. The differences in urban morphology are caused by multiple factors such as the aggregation characteristics of the high-speed railway station as an urban catalyst, the dilemma faced by the regeneration of historical blocks, and the influence of economic benefits. In summary, many conflicting urban spaces with significant differences in morphological characteristics appear in the process of regeneration of old urban areas, and the contradiction between old and new buildings is prominent. In the governance of urban regeneration, the refining of functional zoning and the identification of form-based zoning is of considerable practical import. Researchers should focus more on the urban regeneration techniques based on integrated planning of a district, such as the transfer of spatial development rights, joint development of districts, and rewards for spatial contribution rates, to pursue more scientific and effective urban design governance.

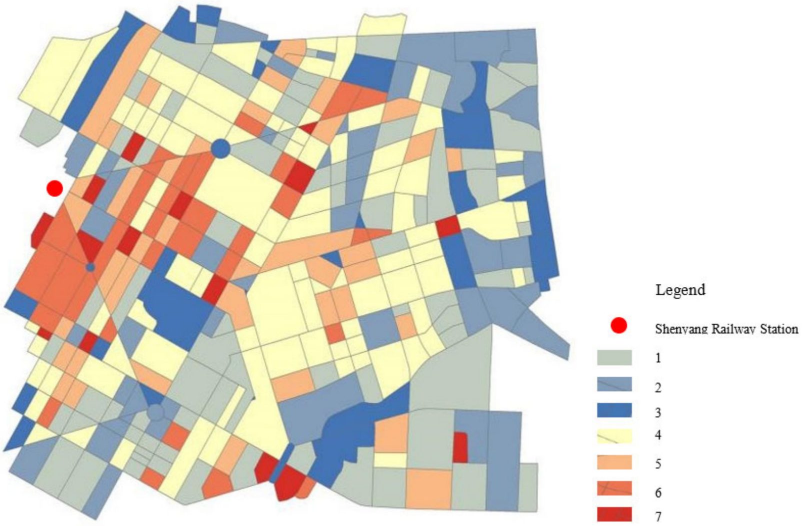

Figure 8. Statistical map of spatial construction intensity by plot.

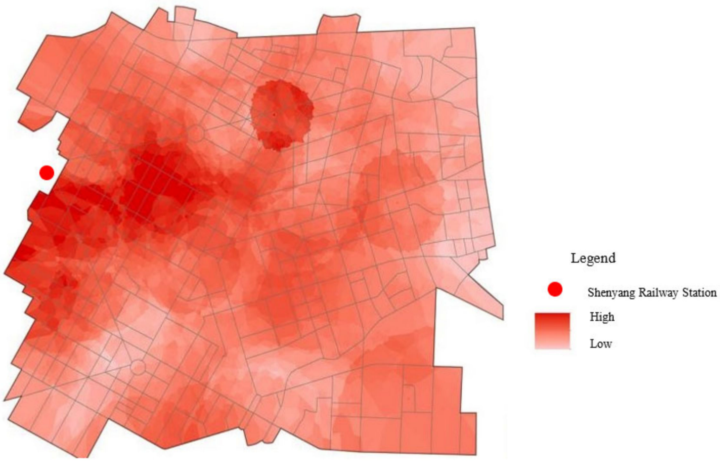

Figure 9. Analysis spatial intensity using the kriging interpolation method.

5.2. Recommendations

At the level of urban design, the combination of data identification and evidence-based methods allows for the scientific and effective identification of various features and patterns within a regenerated area and the formulation of control guidelines for integrated planning of the area. This is one of the most important technical tools for avoiding the overlay of individual units in urban regeneration. Although the scope of this paper did not allow for a thorough focus on the following ideas, it is contended here that areas should be planned from the integrated area planning perspective, summarising historical experience and lessons learned, avoiding the fallacious overlap of individual developments, reasonably delineating urban regeneration units, preparing urban regeneration governance guidelines, and scientifically guiding urban regeneration governance and redevelopment. For the spaces in cities whose functions need to be changed or for buildings that need to be demolished and reconstructed, urban designers should come up with a comprehensive plan that considers multiple aspects, including urban morphology, functions, protection of historical legacy, and economic development and sustainability, with integrated consideration of the development of urban space, and prevent significant conflicts between spaces or the destruction of the cultural legacy of the cities. In conclusion, the effective identification of urban functions, morphology, and historical value is essential in urban regeneration, while spaces with problems of unmatched features and imbalance should be improved under the guidance of refined strategies of urban governance and urban redevelopment.

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