Spatial Coupling Analysis between Color Steel Buildings, Urban Hot Spot and Fire Point —a Case Study of Lanzhou

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Abstract. As a typical product of the transitional stage of urban development, the color steel buildings (CSBs) are easy to cause fire, which is difficult to be extinguished effectively and quickly. This paper aims at the particularity of the geographic location of the CSBs and the lack of joint application with Point of Interest (POI) and fire points in the study of urban fire risk., this paper investigated the fire risk of Lanzhou city based on above three types of data acquired in 2017. The involved data were meshed by kernel density analysis and superposition analysis. Afterward, the pairwise spatial coupling relationship of the data were visualized by two-factor cartography, through which the condition of spatial coupling were obtained. The relationship between the obtained regions and urban fire risk was further compared. The research results show that CSBs and the POI Point are highly coupled with the fire locations of Lanzhou spatially. Thus, the joint application of the two factors can be effectively utilized to evaluate the fire risk in Lanzhou. The phenomena that the CSBs outnumbered the POI Points indicates that the corresponding areas are not well urbanized and have high incidence of fire.

1. Introduction
With the accelerated development of urbanization, the continuous expansion of urban areas and the increasingly complex spatial structure, the number and scale of fires, economic losses and casualties have become increasingly serious. Therefore, the reliable and effective assessment of urban fire risk has become one of the hot issues in academic research. Scholars have done a lot of effective research, and put forward many research methods and application models. Such as Xia [1] people such as the conventional method of calculation results as the training sample of neural network (NN) model, set up various combined NN model; Hongsen Luo [2] and others through the AHP method to build a fire risk assessment system, and set index score criterion; xue-peng Jiang [3] and others from the risk theory, combining macroscopic urban regional characteristics, microscopic to build urban fire risk evaluation index system of the typical places; Ye-tomahawk Liu [4] and others based on various spatial analysis methods, index system of city fire risk -formative factors and eliminate the evil factors, an independent evaluation. The above methods have made beneficial exploration for fire analysis and evaluation, but they are all based on the establishment of multiple indexes to determine the weight of each index, and the uncertainty of the weight of each index will make it difficult to guarantee the evaluation result.

For this, Therefore, Mingming Zhu [5] et al took the Person of Interest (POI) big data as the research object.; Zhibang Xu [6] and others use POI nuclear density analysis to identify the center of
Beijing urban fire risk distribution. These methods all using big data POI cities can only be interested in some local dense area were studied, and in view of the city of POI scarce, lack of infrastructure, and there is a big fire safety problems of urban villages, industrial park, are unable to reflect, thus has certain limitations.

Aiming at urban POI scarce land, Pengyuan Li [7][8], Jijing Ma [9], Jinmei Wang[10] such as per capita found along with the development of the city, choi steel buildings widely appeared in the villages, the edge of the city. In addition, choi steel building collapsed due to poor material fire resistance and easy, difficult to save, easily happened major fire accident[11]. Therefore, the particularity of its spatial distribution and the vulnerability of its materials have a very good data support and guidance effect on the assessment of urban fire risk level.

2. Data Origin
This paper takes the main urban area of Lanzhou city as the research area. The experimental data include the city CSBs, POI and fire disaster statistics. Among them, the data of the CSBs is extracted based on GF-2 fusion image, with the minimum extraction precision of 0.8m and acquisition time of 2017-8(see Figure 1). The POI data was from OpenStreetMap, updated on 2017-6-2, and a total of 3547 pieces were obtained. The fire disaster data was provided by The Lanzhou Fire and Rescue Corps on July 1-12, 2017, with a total of 1030 fire information.

![Lanzhou city CSBs distribution map](image)

Figure 1. Lanzhou city CSBs distribution map

3. Research Technique

3.1. Data Pre-processing
Through early fusion, correction and human-computer interactive interpretation of GF-2 remote sensing images, vector data of the 2017 CSBs in Lanzhou city, a total of 15025 pieces, are obtained.

The original POI data were stored in different layers and categories, covering public service facilities such as government agencies, hospital pharmacies, cultural leisure facilities, restaurants and bars, hotels and supermarkets, tourist attractions, etc. Besides, churches and mosques unrelated to the study were excluded and merged into the same layer.

The location data of each fire information was accurately obtained through the Aude map coordinate picker, and the object-ID field was added. After coordinate transformation, it was imported into ArcMap and converted into vector data, and was uniformly set as the WGS-84 spatial reference coordinate system.

3.2. Vector Data Grid
In order to better demonstrate the coupling relationship among the CSBs, POI and fire point data, a
honeycomb hexagonal grid with close circular and rich topological relationship was created, and the generated Lanzhou city grid is shown in Figure 3.

The CSBs data were converted into elements, and then superimposed with the grid after the kernel density analysis and processing, the regular grid diagram of the CSBs was obtained. In the same way, POI regular grid diagram and fire point regular grid diagram can be obtained (see Figure 3, 4, 5).

![Figure 2. Lanzhou honeycomb grid](image2)

![Figure 3. CSBs Fire point density rule grid](image3)

![Figure 4. POI point density rule grid](image4)

![Figure 5. Fire point density rule grid](image5)

3.3. Unified Disposal

Min-max normalization, also known as deviation standardization, was performed on multiple variables. The conversion function was shown in formula (1).

\[
N^* = \frac{n - n_{\text{min}}}{n_{\text{max}} - n_{\text{min}}}
\]

The density values of CSBs, POI and fire point are normalized and normalized to the interval [1,150] by using the above formula. The normalized point density values were graded according to the standard method, and were divided into three levels: high, medium and low, as shown in Table 1. The spatial connection is used to link the point density grading fields, and nine combinations of high-high, medium-middle, low-low, high-middle, high-low, medium-high, low-low, low-high, low-high, low-low can be obtained by combining the two (see Figure 6, 7, 8).

| CSBs density | POI density | Fire point density |
|--------------|-------------|--------------------|
| low          | middle      | high               |
| <15          | 15-110      | >110               |
| low          | 3-35        | 35                 |
| <3           | 4-60        | >60                |

Table 1. CSBs, POI and fire point density classification
4. Space Coupling Analysis

Space coupling first appeared in 1954 when Elliott, R. J studied the spin orbit coupling of "double" space groups[12]. In 2001, Criminal Weiqin et al. began to study the coupling relationship of geographic space and obtained a series of research results[13]. In view of the existence environment and material of the CSBs, there is a high risk of fire, so there must be some coupling relationship between the CSBs, POI and the spatial location of the fire points. The same and different coupling regions represent the difference of urban spatial structure and fire risk to some extent.

4.1. Coupled Spatial Analysis of Heterogeneous Regions

4.1.1. Spatial coupling analysis of CSBs and POI

![Figure 6. CSBs higher than POI density area](image1)

![Figure 7. CSBs lower than POI density area](image2)

(1) The regional analysis of CSBs complex higher than POI density value.

Most of the urban areas with the coupling relationship between the CSBs and POI are distributed in the southwest of Anning District (see Figure 6). The appearance of CSBs is the result of economic stimulus, and POI point is the appearance of economic development, so it shows that these urban areas are in the initial state of economic development and there are few urban service facilities, which are the key areas to be planned and transformed in urban construction. The “mid-low” area is mainly distributed in the city periphery of Anning district and Qilihe District. This area is mainly a transition area from urban to suburban development, which represents the human activity scope reflected by the CSBs, part of which is the spillover effect of the city and the development scope of the future expansion of the city. Therefore, reasonable planning should be made in advance.

(2) The regional analysis of the POI density value of the CSBs.

The area where the CSBs is lower than the POI density value is shown in Figure 7. It can be seen from the figure that the area where the CSBs is lower than the POI density value is mainly the core urban area. It shows that the city has fast economic development and complete infrastructure, and its regional characteristics are dense population and concentrated service facilities.
4.1.2. Spatial coupling analysis of CSBs and fire sit

![Figure 8. CSBs higher than fire point density area](image1)

![Figure 9. CSBs lower than fire point density area](image2)

(1) The regional analysis of the CSBs higher than the fire point density value.

The CSBs is higher than the density value of fire point, as shown in Figure 8. The coupling area of "high-middle" is small, mainly exists in Yintan Road street, Shajingyi Street and Chenping Street, Xigu District, and takes the shanty town of the village in the city as the typical urban building. According to the investigation, small CSBs in urban villages are densely built, with large population flow and serious aging of lines, crowded roads, and complex urban spatial structure. In case of fire rescue, it is difficult. "Medium-low" coupling area is mainly distributed in the township area, the CSBs is mostly built by civil temporary, scattered distribution, the possibility of fire and the consequences of the fire is small.

(2) The regional analysis of the density value of CSBs below the fire point.

The area where the CSBs is lower than the fire point density value is shown in Figure 9. It can be seen from the figure that "low-high" coupling areas are concentrated in the urban center of chengguan district, where commerce and service industry are prosperous, urban planning and construction are relatively complete, and CSBs are inevitably rare. With dense population and many disaster causing factors, it is easy to cause inflammable and explosive disasters and cause serious consequences. The "medium-high" coupling zone is also a relatively prosperous urban area. In addition to the old urban area, the Xigu District also has a large area of rapid economic development of the urban area, building materials factories, factories, a large area of CSBs for industrial park construction. Although the number of fires in this area is less, the fire of large CSBs will cause serious economic losses and casualties, so it is also the key reconstruction area for disaster prevention and reduction.

4.1.3. Spatial coupling analysis of POI and fire points

![Figure 10. POI higher than fire point density area](image3)

![Figure 11. POI lower than fire point density area](image4)
(1) Regional analysis of POI higher than fire point density value.

The distribution range of POI above the fire point density value is very small, as shown in Figure 10. It can be found that the "high-middle" coupling area is characterized by tourism service agencies, with open spatial structure, small population density, less disaster-causing factors and less risk of fire. (2) Its "medium-low" coupling area is scattered, mainly located in the park, art gallery, research institute administration, the probability of fire in this area is low.

(3) Regional analysis of POI lower than fire point density value.

As shown in Figure 11, POI has a large and scattered distribution range below the fire point density value. The "medium-high" coupling area is mainly located around the central city. The infrastructure in this area is relatively weak compared with the central city. The residential population is dense and the fire is prone to occur. In the east of Xigu District, there are large-scale CSBs. The urban villages are densely populated, and the infrastructure is backward and the probability of fire is large. Therefore, further planning and construction is urgently needed in this area. "Low-middle" coupling area is mainly distributed in the suburban area of the city.

5. TAG

By studying the spatial coupling relationship of fire spots, CSBs and POI data in Lanzhou city in 2017, and analyzing and discussing the coupling characteristics, causes and urban spatial structure relationship of the above three groups of data, the following conclusions are drawn:

(1) The combined application of Lanzhou CSBs and POI can comprehensively map the overall fire risk situation of the city and provide reference for the assessment of urban fire risk.

(2) CSBs in Lanzhou gather in urban villages and industrial parks, such as Yintan Road street, Shajingyi Street, Chenping Street, Xigu District, etc. Urban villages are densely populated, frequently hit by fires, and rescue roads are narrow, making post-disaster rescue very difficult and prone to cause secondary disasters and casualties. Once the industrial park causes fire, it will cause serious economic loss. The characteristics of these areas are that POI points are rare, and they are all urban fire planning blind areas, which should be paid attention to.

(3) The spatial coupling of the steel plate buildings, POI and fire sites in different areas reflects the differences of urban spatial structure to a certain extent, and also reflects regional social problems. Taking Anning district and Xigu District as the key areas to be renovated, the solution of these problems will help reduce the risk of urban fire and promote the healthy development of the city.

6. Acknowledgments

The work was financially supported by the National Natural Science Foundation of China (No. 41761082), the National Key R&D Program of China (2017YFB0504201) and LZJTU EP 201806.

I would like to express my gratitude to my teacher's instruction, the elder brothers' guidance and the help of fellows. I would also like to express my gratitude to the excellent platform of Lanzhou Jiaotong University for its support, which enabled me to finish my thesis successfully.

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