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Research on renewal and transformation of urban negative space based on AI spatial identification technology

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Abstract: This paper aims to study the renewal and transformation of urban negative space based on AI spatial identification technology, and takes Deya Road in Changsha as a typical case for field investigation. On the basis of data analysis based on the establishment of the standard model, through the feature analysis of Deya Road negative space and the data analysis of the standard model, combined with AI image space recognition technology and algorithm-based logical thinking, the paper summarizes the spatial feature points of the negative space for digital translation, providing data sources and evaluation criteria for AI machine learning. At the same time, the probability of success of spatial identification and spatial model library are established. Combining with the record of quantitative data, the positive countermeasures are put forward for the negative spatial remodeling of streets.

1. Introduction

In recent years, with the acceleration of urbanization, the spatial contradictions inside urban streets are also intensifying, resulting in negative Spaces such as "imperfect space utilization, poor space quality, chaotic functional layout and lack of crowd attraction". Such Spaces will not only damage the overall appearance of the city, but also affect residents' healthy and comfortable life experience. Therefore, the renovation and utilization of negative space is gradually becoming the focus of urban renewal. However, due to the large number and complex types of negative Spaces in the city, traditional renewal and reconstruction strategies cannot cover the reconstruction of a variety of negative Spaces. Therefore, it is the focus of the current renewal and reconstruction of negative Spaces to formulate a reasonable identification and classification procedure and put forward renewal and reconstruction strategies one by one.

From the perspective of the needs of space users, this paper combines the needs of space users with the characteristics of space environment, deeply analyzes the scoring situation of space users on each part of the space, and converts the scoring situation into a qualitative and quantitative index of space [1]. Based on AI spatial recognition algorithm technology, the negative spatial image data obtained from the investigation of Deya Road, Kaifu District, Changsha City was identified and classified by AI space, and then different negative space renovation strategies were proposed according to different classification results.

2. An overview of AI spatial recognition technology

2.1 The development history of AI technology

From 1943 to 1960s, the concept of artificial intelligence was proposed for the first time, and then symbolism and connectionism (neural network) were developed, and numerous research achievements such as checkers program and man-machine dialogue were made. In the early years of AI development in the 1970s, people had high expectations for AI, but after the level of computing research, the practical application of AI was impossible. In the 1980s, artificial intelligence began to be widely used in practice, and its research direction shifted from general reasoning strategies to the application of professional knowledge. From 1990s to 2010, the rapid development of Internet technology facilitated the application and innovation of artificial intelligence technology, and the research focus of artificial intelligence gradually shifted to machine learning. Since 2011, in the Internet era, new concepts such as big data, cloud computing and the Internet of Things have been put forward constantly. Artificial intelligence technology represented by deep neural network has developed rapidly, and major technical breakthroughs have been made in image classification, speech recognition and unmanned driving.

2.2 Principle and application of AI spatial recognition technology

Principle of AI spatial recognition technology: (1) discriminating problem type (classification problem or regression problem); (2) Data collection, processing and feature extraction; (3) Screening the corresponding learning algorithm program; (4) Construct training model and corresponding training and test data set; (5) Model evaluation; (6) Get the calculation results.

Application of AI spatial identification technology: The current application of AI in the space field mainly includes two aspects: spatial discrimination problems (including spatial image and model classification, evaluation and optimization of spatial indicators) and spatial generation problems (including spatial arrangement problems, spatial image generation problems and spatial form generation problems). The techniques involved in this study are mainly spatial discriminant problems.

3. The characteristics and influence of urban negative space

The concept of negative space

Negative space refers to a naturally occurring, unplanned, and expanding space from the inside to the outside, which is disordered, unorganized and isolated.

The characteristics of negative space

(1) Poor internal landscape environment, low ornamental degree, less green coverage area.

(2) Poor traffic accessibility, often blocked by debris, inconvenient traffic.

(3) Infrastructure construction lags behind, usually with problems such as old and damaged infrastructure.

(4) Lack of security, negative space usually lack of prevention and safety supervision.

(5) The function of negative space is relatively simple and the construction is not perfect, which lacks characteristics.

(6) The spatial scale of negative space is not suitable for human activities.

Negative space disadvantages

Negative space will not only damage the integrity and aesthetics of urban streets, but also affect residents' living experience, which is reflected in four aspects:

(1) Low safety: lack of prevention and supervision facilities in the negative space, less personnel exchanges, prone to danger. In disasters and accidents, the safety of the population cannot be

guaranteed.

(2) Environmental damage: Negative Spaces are mostly deserted and hidden places, which are often ignored and affect the overall urban style.

(3) Lack of attraction: negative space scale is not suitable for human activities, easy to produce negative effects and not suitable for rest and stay.

(4) Low utilization rate of space: although the area of negative space is small, there are a large number of negative Spaces, which occupy urban space but have no function. Intensive use of land resources cannot be realized, resulting in waste of urban construction space.

4. Taking Deya Road in Changsha City as an example, urban negative space research and data collection

4.1 Overview of Deya Road and negative spatial data acquisition

(1) Overview of Deya Road

Deya Road, located in Kaifu District, Changsha City, Hunan Province, is a north-south main road, starting from Dongfeng Road and ending in Sany Avenue, with a total length of about 4.2 kilometers, as shown in Figure 1. This research mainly selects the section from Simao Chong to Yaque Lake at the north end of Deya Road for investigation and research. The stretch is surrounded by clusters of residential and industrial buildings, most built in the 1980s and 1990s and some abandoned. The road within the street is relatively narrow, and there are problems such as indiscriminate parking of private cars and random stacking of debris and garbage. The supporting public service facilities around the road are old and badly damaged. There are many street shops on the road, and the traffic flow is larger. During the investigation, it is found that the residents here have low satisfaction with the streets, and the existence of a large number of negative Spaces in the streets has caused great inconvenience to the residents' daily life. Therefore, it is necessary to preserve the basic pattern of the streets and the urban texture at the same time to transform and update the streets, and it is necessary to consider many aspects, including traffic dredging, space use, environmental governance, function allocation, safety requirements and supporting facilities.

(2) Negative spatial sample data acquisition and basic spatial simulation

We made a blanket visit to the target area. On the one hand, we visited the subjective feelings of residents in different blocks on some typical negative Spaces. On the other hand, we used 3D scanner infrared scanning technology to scan the real space to form 3D models and measure basic data. A total of 31 negative Spaces were collected to extract spatial features.

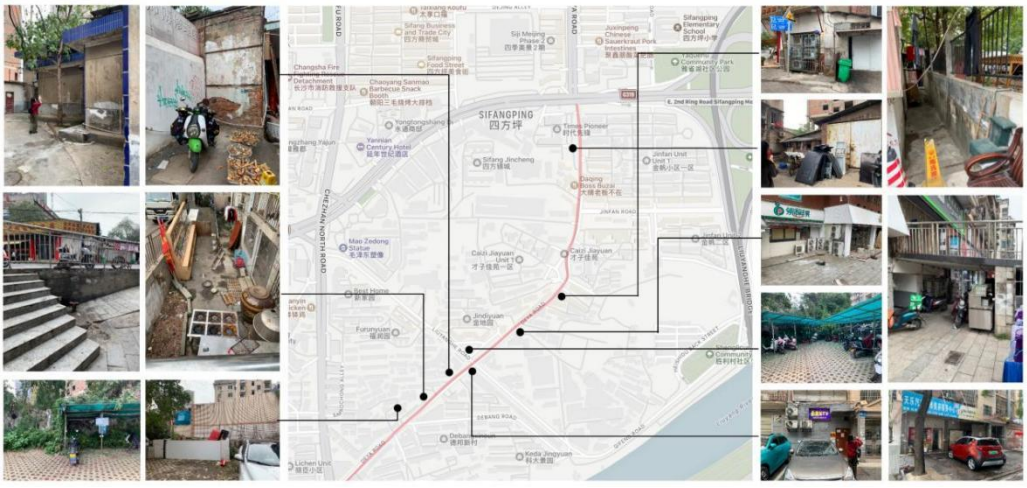

Figure 1: Investigate the road section plan and the existing negative space status chart

4.2 The establishment of the standard model of negative space

Indicator Settings

In the process of investigation, we found that different negative Spaces have different feelings for users, and they also have different physical properties. Based on the above two aspects, we set the following two indicators:

(1) Class A data analysis

Category A data are statistically analyzed from depth, surface width, aspect ratio, aspect ratio, projection area and underside Angle, etc., so as to judge their distribution rules. The standard model cannot be established without the support of statistical data, and its parameters are related to the number of sample occurrences.

Physical data of more than 30 negative Spaces that have been framed in the survey were recorded, and statistics were carried out from six indicators, namely depth, surface width, aspect ratio, aspect ratio, projection area and underside Angle.

(2) Type B data analysis

Class B data takes into account the large space area of the whole block, and the space experience varies with different regions. Therefore, firstly, multiple photos of each space area are projected to let the evaluators have a comprehensive understanding of all kinds of Spaces. Then select a typical photo of each regional space and ask the evaluator to rate the space. According to the research theory of Oswald, when formulating an evaluation system for the whole space, it should be evaluated from at least three dimensions: evaluation (good and bad), action (active and passive) and power (strong and weak).

The establishment of the standard model

According to the above statistical results, it is not difficult to find that under the existing sample data, the projection area is concentrated in $2m^2$ to $4m^2$, the depth data is mainly 2m to 4m, and the surface width data is mainly distributed in 1000mm to 1500mm. Therefore, we set up a simple standard model as shown in Figure 2

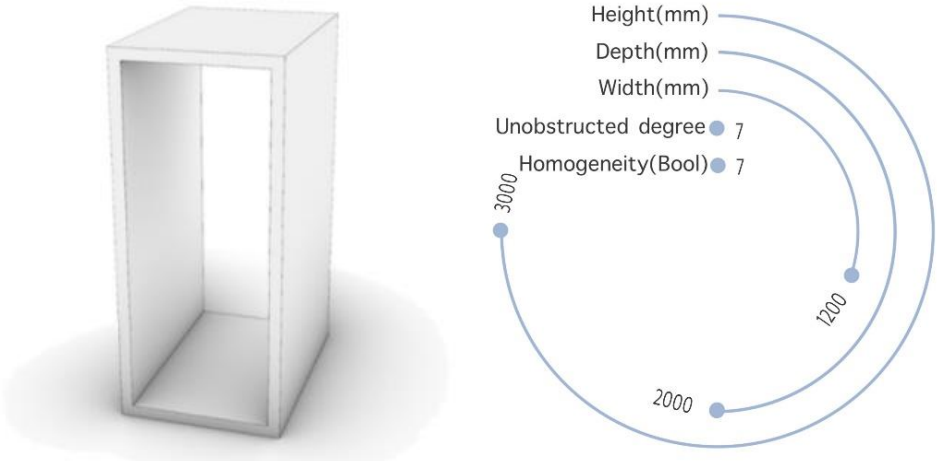

Figure 2: Negative space standard model and data

4.3 Data analysis and results display of negative space

The establishment of database according to standard model

This approach builds a simple monitoring application that looks at a series of images and looks for Spaces in them, which the AI compares to the model's understanding of what humans are (and aren't), and then returns a probability value for each input metric provided. The detected object is the

probability of the actual suggested category, and this probability is the core concern of almost every object detection application. Each region defined by an object detection algorithm usually has a probability score assigned to it, the average of which is obtained by various methods.

Data analysis and summary

After detecting the indicators of the object space, the program will compare with the database in the standard model, and give the standard evaluation of the target negative space according to the indicators, and provide the corresponding updating strategy.

(1) The space whose length, width and height do not conform to the human body size (the space width of a single person should be more than 800mm and the height should be more than 2100mm[2]) the poor experience of people can only be used as the installation place of mandatory functional devices, such as garbage cans and fire-fighting equipment.

(2) The evaluation of space atmosphere feeling with patency ≥1 is neutral, < The depth of space the atmosphere ＜1 feeling towards cold and quiet, and the space feeling becomes claustrophobic and intimate.

(3) If the space with a projection area of $\approx 2m^2$ is free of debris, the privacy evaluation is poor, but the group activity place is better. Projected area > The privacy of the negative space of 5m ²is rated well, and the degree of attractiveness varies from person to person.

(4) The negative space with aspect ratio =1~2 is the most comfortable. An aspect ratio greater than 3 and less than 4 can make some people feel uncomfortable and small. Four is even stronger.

(5) The claustrophobia of the negative space with a depth greater than 2m is gradually strengthened. The space with a depth greater than 6m is mostly used as the back door of the store or the corridor leading to the warehouse. The subjective feelings vary with the location and natural light.

(6) The corner Angle of acute Angle space is too small to form a sense of pressure, which is suitable for the placement of functional devices, and the sense of experience is poor.

5. Urban negative space renewal and transformation strategy based on AI spatial identification technology

5.1 AI identification and classification of urban negative space

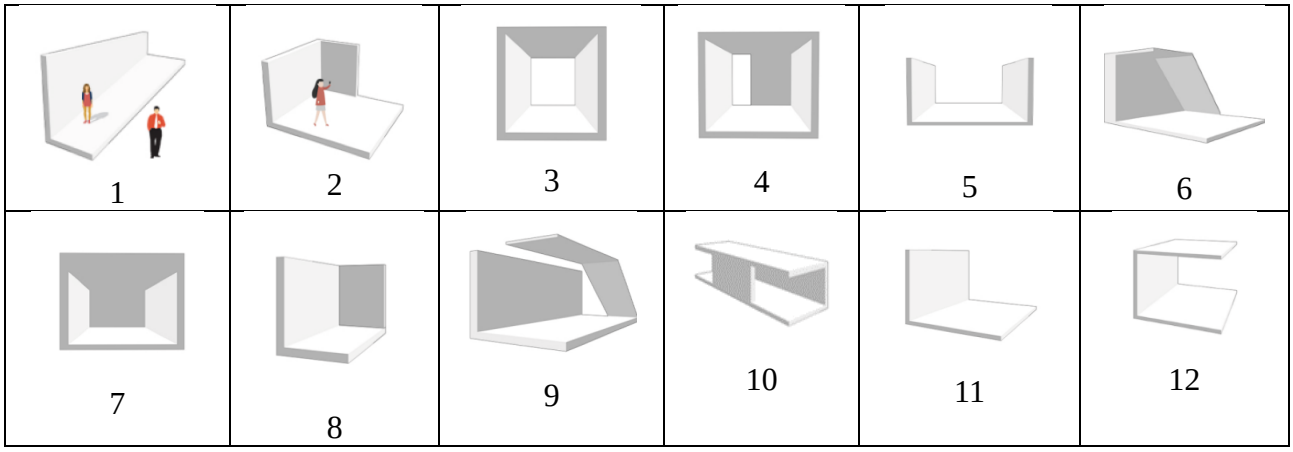

Figure 3: 12 basic models of negative space

In this study, a specific space type is defined as the standard model, a database is established according to the standard model and the survey results, and an AI recognition system is formed. The negative space of different levels is rated and the characteristics of different levels of negative space are summarized. Then, by analyzing the specific scale, existing facilities, surrounding functions and crowd activities of the negative space, appropriate functions are allocated to the negative space and

corresponding renewal strategies are proposed.

Based on the above system introduction and the previous research on urban negative space, the following 12 types of negative space are summarized and classified according to different analysis indicators (in Figure 3).

5.2 Put forward the reconstruction and renewal strategy of urban negative space according to classification

The root cause of negative space is that this kind of teratoid space form greatly reduces the possibility of people's activities here. Space needs vitality, and the source of space vitality is the development of crowd behavior. Human beings are the measure of everything, and human activities are often planned and purposeful. A space with good quality can stimulate the vitality of people, while a disorderly space is rarely used and experienced. Whether the space vitality can be activated requires designers to intentionally create and establish the sense of order in the space environment. [4]

The transformation and renewal strategies corresponding to different types and degrees of negative space are adapted to local conditions. If the transformation and renewal of negative space are generalized, it will not only fail to achieve good transformation and renewal effects, but also waste a lot of human and material resources. Grade different types of space according to AI technology. For negative Spaces with similar information such as enclosure mode, patency, depth, surface width, height and evenness, similar reconstruction and renewal techniques can be adopted to improve reconstruction efficiency and fitness.

The function distribution direction of negative space includes traffic space, user experience space, life function space and so on.[5] Taking the above three directions as an example, traffic space -- traffic function is the core of connecting urban space. On the one hand, route optimization and management should be strengthened, and on the other hand, spatial guidance system design should be strengthened. Delimit the business scope of shops along the street, remove sundries piled up at will, and ensure traffic efficiency. Crowd experience space -- public art installations can be used to increase interaction and retain pedestrians, or flexible temporary installations can be used to increase street vitality. Living function space -- according to the functional activity needs of people around the space, the corresponding missing facilities are configured, such as safety facilities (such as fire appliances), street furniture, sanitation facilities, commercial facilities (such as takeout cabinets), etc., and the facilities are regularly updated and maintained to ensure their normal use [3].

6. Conclusion

The negative space in the city is often disorderly, small, not easy to be paid attention to and idle for a long time. The transformation and renewal of negative space can not only rely on government departments to find one by one. When the AI recognition system is established, the recognition system can be connected with the network platform to quickly identify the spatial rating of the location of pictures in various web pages and apps and identify whether it is a negative space. Or open the system directly to the public, where citizens can upload photos to the system to facilitate the discovery of negative Spaces. The ultimate goal is to establish an intelligent recognition system for negative space, and on this basis, formulate a negative space transformation strategy, so as to build a bridge between AI recognition technology and space transformation technology for users, enterprises and governments, provide technical and strategic support for the discovery and transformation of negative space, and contribute to the improvement of urban space utilization rate.

The identification and transformation of small-scale negative space is an effective measure to find and solve a large number of urban Spaces to be improved, and an important means to meet the needs of contemporary social development and urban residents' requirements for the quality of human

settlements. On the basis of field investigation and sample data collection of old blocks in Changsha, this study puts forward a standard model and uses AI space recognition technology for qualitative analysis to identify the typical types of negative Spaces that can be transformed, summarizes the characteristics of different types of negative Spaces, and puts forward operational strategies for urban negative space transformation from the perspective of practical application. It is hoped to provide reference for the discovery and activation of negative space in different regions.

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