International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 2353-2372

https://doi.org/10.70517/ijhsa464200

The influence of landscape visual sensitivity based on GIS on identifiability

Xingyuan Fu[1] and Siqi Feng[1,*]
[1] Landscape Architecture, Northeast Agricultural University, Harbin, Heilongjiang, 150006, China
Corresponding authors: (e-mail: 17804146336@163.com).

Abstract Based on GIS technology, this study conducted 3D modeling of the core urban area of Harbin and constructed a landscape visual sensitivity evaluation model, thereby achieving the quantitative analysis of visual features. Eye-tracking experiments were then conducted on streets within the study area to measure their identifiability. Further, SPSS and other software were used to analyze the relationship between landscape visual sensitivity and identifiability, upon which a three-dimensional street identifiability model was constructed to provide theoretical support and design strategies for urban spatial optimization.

Index Terms GIS, Landscape visual sensitivity, Identifiability, Eye-tracking experiment

I. Introduction

In the ongoing development of China's cities, urban characteristics have increasingly homogenized, and streets have become indistinguishable, leading to the gradual erosion or even disappearance of people's sense of orientation and belonging. In such urban spaces, the public struggles to recognize physical environments or perceive cultural identities tied to their existence, ultimately resulting in disorientation and alienation. Street identifiability enables the public to distinguish between places and evokes cognitive associations with specific locations. The regional characteristic elements embedded in streets not only serve as dynamic visual components shaping urban public space identities but also act as cultural symbols and cognitive anchors in public consciousness. Therefore, urban street design and renovation should respect and leverage regional information to create spaces with distinctive local cultural identities. Only through this approach can cities foster a sense of belonging and identity among residents amid rapid urbanization.

Existing research on identifiability predominantly relies on space syntax and cognitive mapping. However, current methodologies exhibit two key limitations. First, space syntax—a two-dimensional tool—emphasizes spatial accessibility and connectivity but offers overly simplistic evaluation metrics for studying identifiability in complex three-dimensional urban environments. Second, methods like questionnaires and cognitive mapping are highly subjective, with studies demonstrating discrepancies between cognitive maps and actual spatial configurations. Additionally, due to the vast scale of cities, identifying priority areas for identifiability enhancement in built environments remains unresolved in existing research.

Given these limitations, this study introduces landscape visual sensitivity as an analytical framework. The concept of landscape visual sensitivity was first proposed by Bacon in 1979, defined as a measure of how likely a landscape is to be noticed, integrating factors like visibility, clarity, and conspicuousness [1]. It comprehensively reflects the visual prominence and significance of landscapes within a given visual range. By evaluating the visual sensitivity of landscapes, the most visually critical areas in urban streets can be identified as priority conservation zones [2].

Yu applied GIS to assess landscape visual sensitivity in Wangxiangyan Scenic Area using four indicators: relative slope, relative distance, appearance probability, and landscape conspicuity [3]. Wang (2018) employed Yu’s four factors combined with an Urban Digital Elevation Model (UDEM) to analyze visual sensitivity in Zhongshan District, Dalian City [4]. YaNan F (2021) integrated relative slope, relative distance, appearance probability, historical building kernel density, bus stop kernel density, and commercial kernel density to evaluate visual sensitivity in Tianjin’s Five Avenues Historic District across three dimensions: visibility, potential user volume, and prominence [5]. Yang X (2023) further expanded this framework by incorporating traffic accessibility, streetscape features, and random viewpoint analysis to calculate visual sensitivity for Beishan Street in Hangzhou, while also exploring correlations among evaluation factors [6].

Visual cognitive psychology posits that cognitive processes involve attention, recognition, and memory to reflect and interpret the existence, significance, and value of objective entities. These processes fall under the domain of visual perception and represent higher-level mental activities. The theory highlights that attentional behavior is the primary step in human information cognition. During “attention,” individuals selectively focus on specific stimuli, and only selected information proceeds to subsequent recognition stages. The recognition process typically involves receiving sensory inputs, perceptual organization by the brain, information processing and extraction, and matching against stored memories to assign meaning and trigger responses.

A systematic review of literature reveals that while landscape visual sensitivity and identifiability differ in research objectives and applications, they share profound conceptual and mechanistic connections. This relationship stems from the bidirectional interaction between visual information filtering and spatial meaning construction within human cognitive systems, mediated by both landscape attributes and subjective perceptual capacities. Conceptually, landscape visual sensitivity emphasizes the probability of a landscape being noticed due to its objective attributes (e.g., elevation) and spatial positioning (e.g., visibility coverage). Here, “attention” constitutes the initial stage of cognitive processing, involving low-level visual signal handling. In contrast, identifiability belongs to higher-order cognition, requiring observers to match noticed landscape features with memorized spatial patterns to assign functional or cultural “sign value.” Together, they form a cognitive continuum from “being seen” to “being recognized.”

Second, the quantitative parameters of the two concepts exhibit potential spatial coupling. Landscape visual sensitivity primarily focuses on the physical attributes and spatial distribution of landscape elements. These attributes determine the visibility and visual prominence of landscape elements. Commonly used evaluation indicators for landscape visual sensitivity—such as visibility and conspicuity—essentially shape the material foundation for identifiability, which emerges through cognitive processing based on visual sensitivity. Consequently, enhancing landscape visual sensitivity likely elevates its identifiability.

In summary, areas with high visual sensitivity attract greater attentional investment, prompting observers to extract and store their forms, textual features, and other characteristics into memory templates, thereby strengthening their role as cognitive anchors. Landscape visual sensitivity and identifiability form a dialectical unity between material manifestation and cognitive interpretation, establishing a complete chain from visual perception to meaning recognition. Traditional identifiability research, constrained by the complex characteristics of built environments, fails to intuitively reflect holistic environmental features at a macro scale. In contrast, landscape visual sensitivity quantifies visual resource environments from a macroscopic perspective. Validating the correlation between these two concepts clarifies key elements influencing street identifiability and proposes corresponding design strategies.

II. Experimental data

II. A. Overview of the Research Area

The study area of this paper is located in the western middle area of Harbin City, in the southern part of the section from Songhua River Highway Bridge to Songpu Avenue in the Songhua River Basin. It is the area connected by the Songhua River Highway Bridge, Friendship Road, Shanghai Street, Anfa Street, Jiaohua Street, Xidazhi Street, Dongdazhi Street, Yiman Street, Nantong Street, Dongzhi Road, Songpu Avenue and the banks of the Songhua River. It connects the three districts of Nangang District, Daoli District and Daowai District on the south bank of the Songhua River. It includes four historical and cultural blocks: the Central Street Historical Block, the Laodaowai Chinese Baroque Historical and Cultural Block, the Stalin Street Historical and Cultural Block, and the Jile Temple Historical and Cultural Block. The total area of this region is 17.077 square kilometers. This area is not only the most representative city card of Harbin, but also an important functional zone for the residents of Harbin. As the core urban area of Harbin City, it has extremely high urban development and cultural value.

II. B. Data Sources and Data Preparation

The data used in this study were obtained through the following three methods.

(1) The data obtained from the government's official website and relevant planning documents include the administrative divisions of Harbin City and the scope of the protection plan for historical districts.

(2) The data obtained from the software include DEM data with an accuracy of 8m in the study area from the Bigemap software; Road network data obtained from OpenStreetMap (OSM) : Landsat8 remote sensing image data of Harbin City in July 2024 obtained from the United States Geological Survey (USGS); The Point of Interest (POI) data of Harbin City in August 2024 obtained from Autonavi Maps; The location of buildings obtained from Baidu Maps data.

(3) The building floor data obtained through on-site investigation is calculated by multiplying the number of floors by 3 meters to obtain the building height data.

Convert the floor plan to a 3D model through ArcGIS Pro. Attach 3D building blocks to the surface of the 3D DEM model to draw the UDEM superimposed by DEM and building blocks [7]. During the calculation process, the resolution of the raster map is uniformly set at 1m×1m(Figure 1).

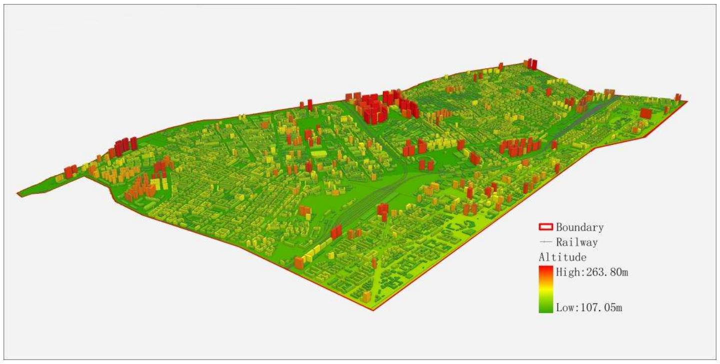

Figure 1: The urban digital elevation model (UDEM) of the study area

III. Research Process

III. A. Measurement of Landscape Visual Sensitivity

At present, the research objects on landscape visual sensitivity have gradually expanded from natural landscapes to urban landscapes. In the research related to the visual sensitivity of urban landscapes, although each study has constructed targeted index systems and analysis methods due to the differences in evaluation goals, there are still three core contents that have been widely mentioned and focused on in most literatures, namely: visibility, usage types and quantities, and saliency. In this study, seven indicators, namely relative slope, relative distance, occurrence probability, POI kernel density, SHDI based on POI diversity, historical building kernel density, and NVDI, were selected as standards to construct an evaluation model of landscape visual sensitivity.

III. A. 1) Relative slope

Relative slope is an important topographic factor that affects the visibility of the landscape in the field of view. During the viewing activity, as the slope of the landscape surface relative to the observer's line of sight direction increases, the probability of the landscape being noticed and recognized also increases accordingly [8], the visual impact is stronger, and thereby the visual sensitivity is enhanced. Therefore, the slope value can be used as an important parameter to measure the visual sensitivity of the landscape.

In the specific measurement process, based on the ArcGIS Pro platform, the slope analysis tool was used to extract the slope of the study area, obtain the slope distribution data along the line of sight direction, and take it as the spatial quantitative index of the relative slope [9]. Subsequently, the Jenks Natural Breaks classification method was applied to divide the calculation results into six levels (Figure 2).

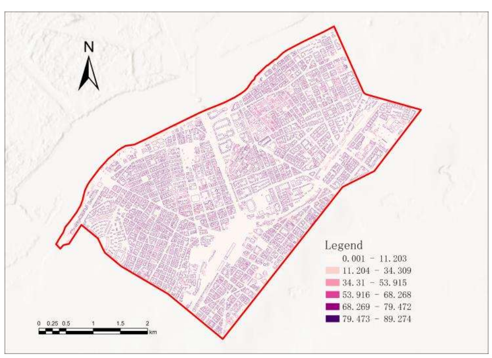

Figure 2: Landscape visual sensitivity-relative slope grading map

III. A. 2) Relative Distance

Relative distance is one of the spatial factors for measuring whether a landscape is easy to observe [10]. This study takes the road network in the urban built environment as the main viewing path and holds that viewers are usually located in the roads and their adjacent areas. The closer the landscape is to the road, the higher its visibility and visual clarity are, and it is more likely to be noticed, thus having a higher visual sensitivity to the landscape.

In the specific measurement process, based on the ArcGIS Pro platform, the straight-line distances from each landscape unit to the nearest road are calculated using the Euclidean distance tool, which is used as the spatial quantitative index of the relative distance. Subsequently, the Jenks natural discontinuity point classification method was used to divide the calculation results into six grades (Figure 3).

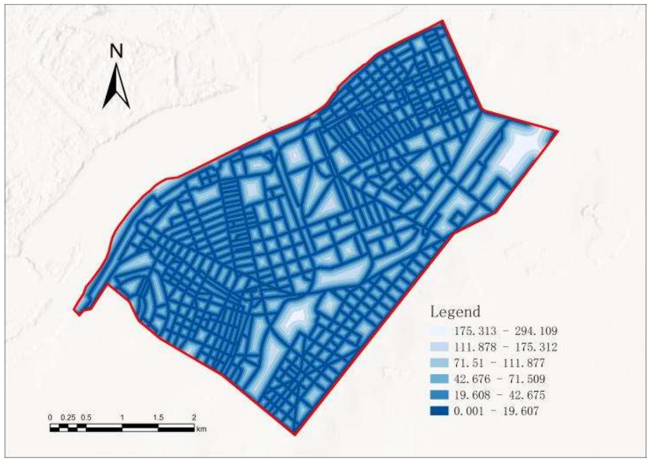

Figure 3: Landscape visual sensitivity-relative distance grading map

III. A. 3) Occurrence Rate

The occurrence probability reflects the probability that a landscape unit is seen in the observer's field of vision and is an important indicator for measuring visual sensitivity. The higher the frequency of a landscape's appearance in the field of vision, the more likely it is to attract attention, and thus its visual sensitivity to the landscape is correspondingly stronger [11].

During the specific measurement process, a viewpoint was set every 100 meters along the main roads within the study area, and a total of 1,136 viewpoint samples were obtained. Based on the ArcGIS Pro platform, with the aid of the field of view analysis tool, the number of pixels that can be observed within the visible range of each viewpoint is calculated, and the total number of times each pixel is seen by the viewpoint is counted as a quantitative indicator of its occurrence probability [12]. The minimum visible frequency of the landscape unit is 0 times (completely invisible), and the maximum visible frequency is 105 times. Subsequently, the Jenks natural discontinuity point classification method was used to divide the calculation results into six grades (Figure 4).

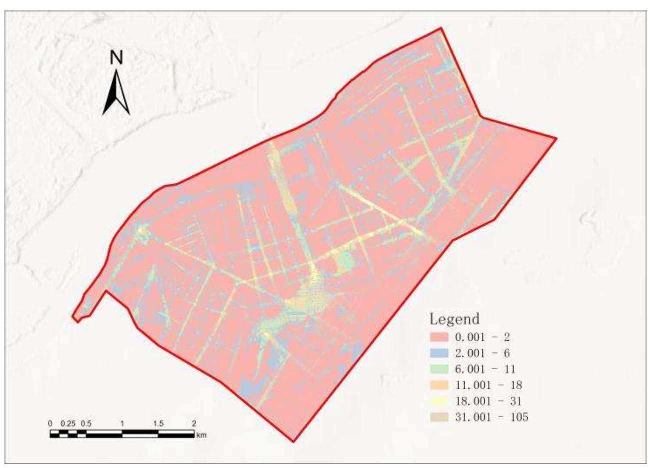

Figure 4: Landscape visual sensitivity-graded map of occurrence probability

III. A. 4) POI kernel density

POI (Point of Interest) kernel density is used to measure the degree of spatial agglomeration of urban functional elements and is one of the important indicators reflecting the vitality of a block and the attractiveness of pedestrian flow. Areas with dense public service facilities and commercial resources usually have a higher usage frequency and spatial utilization intensity, which can form a more active urban interface, thereby enhancing their landscape appeal and public participation level.

In the specific measurement process, this paper selects the POI data of Harbin City in August 2024 based on the ArcGIS Pro platform.

The spatial distribution of points of interest in the study area is measured by using the kernel density analysis tool. This method quantifies the agglomeration degree of POI in the urban space by spatially processing the point data and reflects its spatial density level. Subsequently, the Jenks natural discontinuity point classification method was used to divide the calculation results into six grades (Figure 5).

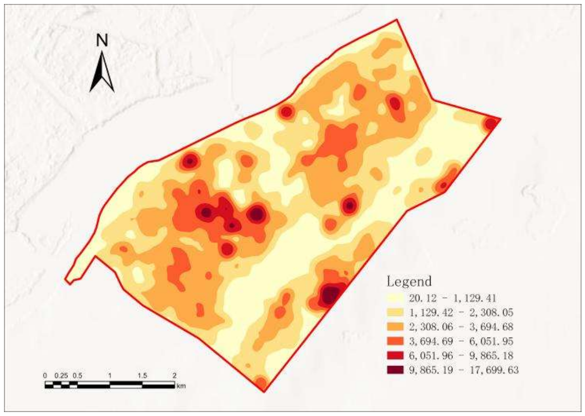

Figure 5: Landscape visual sensitivity-graded map of occurrence probability

III. A. 5) Shannon Diversity Index (SHDI) Based on POI Diversity

The Shannon Diversity Index (SHDI) reflects the diversity and heterogeneity of landscapes and can quantitatively reveal the complexity of elemental composition within a region. The higher the SHDI value is, the more complex the landscape composition is and the stronger the heterogeneity. POI diversity is an important indicator for measuring the complexity of functional element allocation in urban space, reflecting the combination and distribution characteristics of different urban functions within the region. Areas with diverse functions usually have stronger spatial appeal. They not only help enrich the visual layers of urban landscapes but also are more likely to stimulate public participation behaviors and spatial usage frequencies, thereby having a significant impact on the visual sensitivity of the landscape. Based on this, POI diversity can be quantitatively expressed through SHDI.

In the specific measurement process, the study area was divided into 50m×50m grid data through the fishing net tool of the ArcGIS Pro platform. Then, the SHDI value of each grid is calculated through the SHDI formula. The calculation formula is as follows:

$$\text{SHDI} = -\sum_{i=1}^{m} p_i \ln p_i \tag{1}$$

In the formula, the ratio occupied by type i of pi - POI; The number of M-POI types.

After completing the SHDI calculations of all grids, the Jenks natural discontinuity point classification method was used to divide the calculation results into six grades (Figure 6).

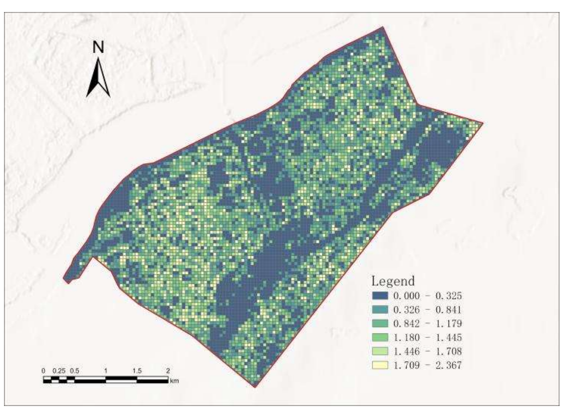

Figure 6: Landscape visual sensitivity-SHDI grading map

III. A. 6) Core density of Historical buildings

Historical buildings are important material carriers that carry the historical memory and cultural genes of a city, and they possess irreplaceable cultural value and historical significance. Its spatial distribution density not only reflects the historical and cultural accumulation of the region, but also visually enhances the prominence of the urban landscape, thereby having a positive impact on the visual sensitivity of the landscape [13].

In the specific measurement process, based on the "Notice of the Harbin Municipal People's Government on Publishing the List of Historical Buildings in Our City" and the "Notice of the Harbin Municipal People's Government on Publishing the List of the Sixth Batch of Historical Buildings in Harbin City", this study collected and sorted out a total of 247 historical buildings within the research area. And convert its location information into point feature data on the ArcGIS Pro platform. Subsequently, the spatial distribution of historical buildings was calculated using the kernel density analysis tool to obtain the kernel density value of historical buildings, which was used as a spatial quantitative indicator of the aggregation degree of historical and cultural elements. Subsequently, the Jenks natural discontinuity point classification method was used to divide the calculation results into six grades (Figure 7).

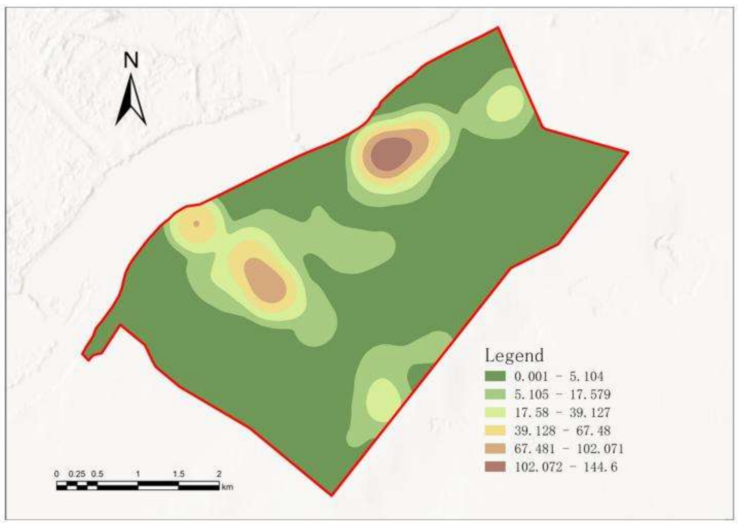

Figure 7: Landscape visual sensitivity-Core density grading map of historic buildings

III. A. 7) Normalized Vegetation Index (NDVI)

In urban space, green vegetation not only has important ecological functions, but also, compared with hard landscapes, is more variable in visual expression and spatial hierarchy, and is more likely to become the visual focus, thereby enhancing its saliency in the field of view and having a positive impact on the visual sensitivity of the landscape [14]. Normalized Vegetation Index (NDVI), as a commonly used remote sensing indicator, can be used to quantify the vegetation coverage level in urban areas. Its calculation formula is as follows:

$$NDVI=\frac{(NIR-RED)}{(NIR+RED)} \tag{2}$$

In the formula, NIR represents the reflectance in the near-infrared band, and RED represents the reflectance in the red band.

In the specific measurement process, this paper obtains the remote sensing image data of Harbin City in August 2024. Firstly, cloud removal processing and atmospheric correction are carried out on the ENVI 5.3 platform, and then it is imported into the ArcGIS Pro platform for NDVI operation to obtain the vegetation coverage index data in the study area. The NDVI value is taken as the spatial quantification index to reflect the green space coverage level in different areas. Subsequently, the Jenks natural discontinuity point classification method was used to divide the calculation results into six grades (Figure 8).

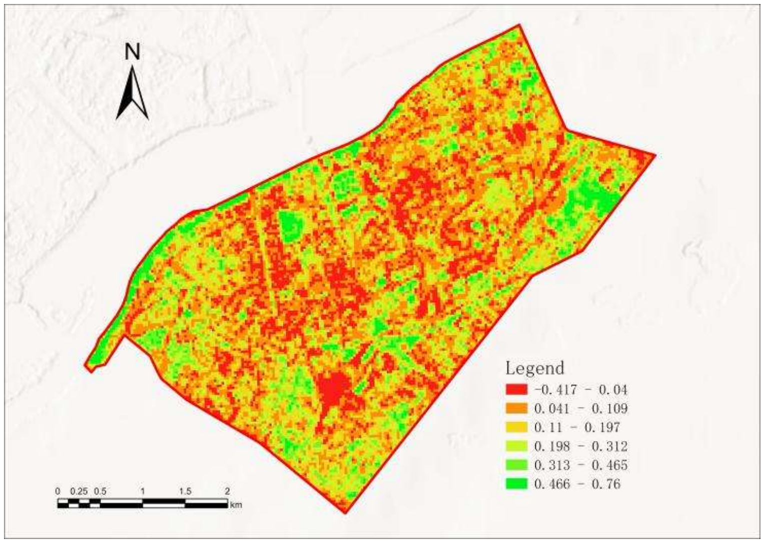

Figure 8: Landscape visual sensitivity-NDVI grading map

III. B. Factor Weight Calculation

III. B. 1) Tyson Polygon

Tyson polygons can present the influence range of spatial elements, their interrelationships, and the boundary characteristics between them and the surrounding areas, presenting the distribution pattern of point sets in the planar space in a relatively intuitive way. In spatial analysis, Tyson polygons can effectively visualize data and facilitate weight calculation.

In the urban built environment, buildings, as the most core spatial constituent elements, not only undertake the dual roles of urban functional organization and image expression, but also often become important symbols of people's visual attention and regional identification. However, in the actual urban space, there is usually a lack of clear plot boundaries between buildings. If only the outline of the building itself is adopted as the unit boundary, it is easy to ignore the surrounding environmental elements, thereby affecting the accuracy of the evaluation results. To solve this problem, this study introduces the Tyson polygon method to divide the urban space. The specific approach is: Abstract the building as a center point through ArcGIS Pro software, and use Tyson polygons to separate plots of different sizes. For example, in areas such as along railway lines or around green Spaces, due to the sparse buildings and wide views, the area of the generated Tyson polygon plots is relatively larger. This differentiated spatial division can better reflect the actual control range of the building over the surrounding landscape and is conducive to conducting a more accurate assessment of landscape visual sensitivity, as shown in Figure 9.

Finally, based on the generated 6,605 Tyson polygons, the values of 7 influencing factors of landscape visual sensitivity in each polygon were extracted, and then the subsequent weight analysis was carried out. This method not only overcomes the limitation of blurred plot boundaries, but also reveals the differences in spatial patterns of different urban areas based on the density characteristics of building distribution, providing a stable and physically significant spatial division basis for the evaluation of landscape visual sensitivity.

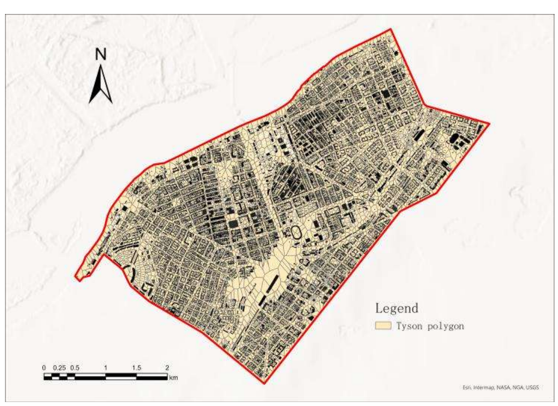

Figure 9: Tyson polygon result diagram

III. B. 2) Determine the weights by the entropy weight method

(1) Data standardization processing

Since indicators of different natures can have a significant impact on the results, the influence of dimensions should be removed during the calculation process, and the data should be standardized. The processing procedure is as follows:

The processing of positive indicators is as follows:

$$y_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{3}$$

The processing of negative indicators is as follows:

$$y_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)} \tag{4}$$

(2) Define standardized values

Calculate the proportion of the JTH indicator in the i-th sample: As shown below:

$$P_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \tag{5}$$

(3) Calculate the entropy value

The information entropy e_j of the JTH index is calculated based on the information entropy theory as follows:

$$e_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \tag{6}$$

(4) Calculate the degree of variation of the indicators

Calculate the degree of variation of the JTH indicator as follows:

$$g_j = 1 - e_j \tag{7}$$

(5) Calculate the index weights

Calculate the weight of the JTH indicator as follows:

$$w_j = \frac{g_j}{\sum_{i=1}^{m} g_j} \tag{8}$$

The results are as follows (Figure 10):

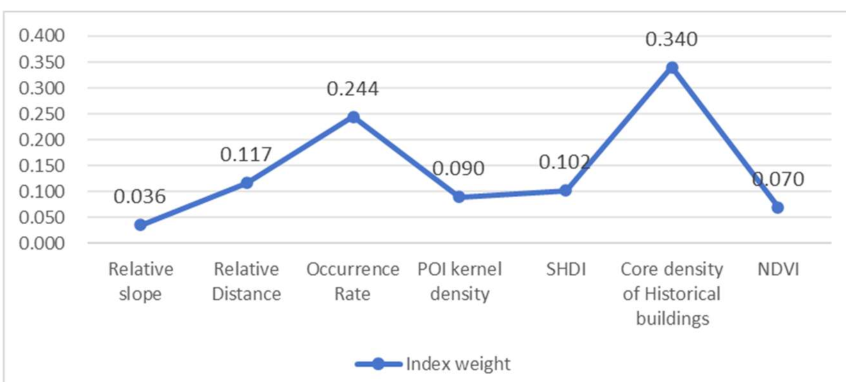

Figure 10: Landscape visual sensitivity index weight

III. C. Evaluation Results of Landscape Visual sensitivity

After superimposing the weights, the final result of landscape visual sensitivity is shown in the figure (Figure 11, Figure 12).

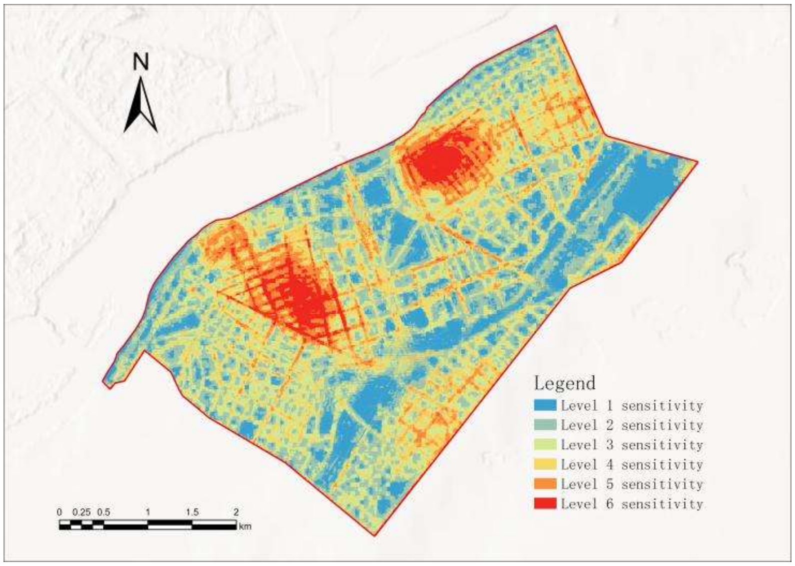

Figure 11: Landscape visual sensitivity plan

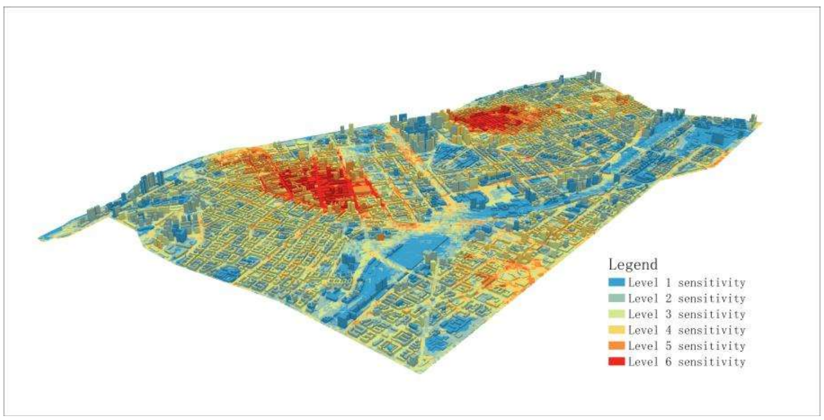

Figure 12: Landscape visual sensitivity 3D model diagram

IV. Research on Recognizable Visual Features of Urban Streets

When exploring landscape identifiability, traditional research methods usually rely on subjective methods such as questionnaires and cognitive maps, emphasizing the subjective assessment of the spatial environment by individuals. However, identifiability involves not only the objective dimension of material composition but is also influenced by human psychological perception, emotional response and cognitive processes [15]. Therefore, simple subjective assessment may be difficult to reveal the recognition and cognitive processes of human beings in the actual environment.

In recent years, eye-tracking technology, as a more intuitive and objective research tool, has been widely applied in exploring spatial information processing and human spatial cognition. Eye tracking can not only provide precise visual focus points and fixation patterns, but also reveal the attention allocation, perceptual processing and information processing methods of individuals when exploring complex spatial information. Existing studies have shown that the processing of spatial information depends on and is influenced by gaze behavior. Therefore, through eye-tracking technology, the cognitive responses of individuals in landscape recognizability can be effectively captured, thereby providing a more scientific and detailed basis for spatial design and recognizability assessment.

IV. A. Eye Movement Experiment

IV. A. 1) Experimental Process

1) Picture preparation

The selected scenes were shot on the spot from 8 o 'clock to 11 o 'clock on a sunny day in September. After screening, a total of 28 photos were obtained. The photos were finally uniformly made into 16:9 PPT files for the subjects to view.

2) Preparation of the subjects

To ensure the consistency of the professional level and the influence of past experience of all the subjects, 38 current students of Northeast Agricultural University were selected. The uncorrected visual acuity and corrected visual acuity (within 200 degrees) of the subjects were both normal, including 15 males and 23 females.

3) Instrument preparation

In this experiment, the tobii pro fusion screen eye tracker was adopted as the eye movement tracking device, and the sampling frequency of eye movement was 120Hz. ErgoLAB is adopted as the data analysis platform.

4) Selection of eye movement indicators

In the cognitive process, people mainly rely on fixation to obtain the processing of information. Fixation behavior is related to visual interest. Analyzing fixation behavior can obtain people's cognitive characteristics of the scene within the line of sight area.

AOI (Area of Interest) refers to the eye movement interest area. The AOI zoning of eye movement reflects the areas that the subjects are interested in in the scene and the duration of stay in each area [16]. The analysis elements of the region of interest in eye movement experiment photos are generally classified into 4 to 8 types. By analyzing the selected 28 samples, the following five areas of interest were summarized: text signs, buildings, plants, ground and facilities [17]. The division of the regions of interest is carried out by using the built-in AOI function of the Tobii software. During the division, efforts should be made to avoid overlapping regions as much as possible.

In order to analyze the visual behavior characteristics of the subjects when observing each AOI, and in combination with the results of previous studies, three eye movement indicators, namely the time before the first entry, the total fixation time, and the number of fixations, were selected as the analysis indicators for the visual behavior characteristics. The specific meanings of eye movement indicators are shown in the Table 1.

Table 1: The specific meanings of eye movement indicators

Eye movement index	Abbreviation	Basic meaning
The time before the first fixation	FFT	The time experienced by the subjects before they first enter each element of interest can reflect the subjects' recognition and prominence (in seconds) of the empty element.
Total fixation time	FT	The total time of all fixation points within the area of interest, reflecting the visual appeal (in seconds) of the elements in that area of interest [18];
Number of gazes	FC	The total number of glances within the area of interest. It reflects the degree of attention paid to the area. A high frequency indicates that the interest is more likely to be noticed by the subjects and has a high degree of recognition [19].

IV. A. 2) Experimental Process

Guide the subjects to sit directly in front of the table 700cm away from the desktop computer, and at the same time, the experimenter explains the entire purpose, process and requirements of the experiment to the subjects. After the explanation is completed, calibrate the eye movement instrument. Once the instrument is adjusted properly, stabilize the subject.

At the start of the experiment, the blank picture (5 seconds) and the experimental picture (10 seconds) are played alternately. The eye tracker tracks and records the eye movement data of the experimental picture in real time until the playback is completed. The entire experimental process takes approximately 7 minutes and 30 seconds.

IV. B. Analysis of Eye Movement Experiment Results

IV. B. 1) Time before the first fixation

The time before first fixation (FFT) refers to the period of time that the subject experiences before the first fixation on the area of interest, which to a certain extent reflects the degree of prominence and recognizability of the spatial elements. As shown in the Table 2, buildings (1.05 seconds), plants (2.76 seconds), and text signs (2.78 seconds) have shorter durations before the first gaze, indicating that these elements attract people's attention more quickly and have a stronger degree of recognisability. The time before the first gaze of the ground (3.26s) and facility (3.57s) elements is relatively long, and their identifiability is relatively weak. This data, on the whole, reflects the degree of contrast and prominence of identifiable elements in the scene.

Table 2: Statistics of mean first fixation time

Area of Interest	Average value (s)
Text identification	2.78
Architecture	1.05
Plant	2.76
Ground	3.26
Facilities	3.57

IV. B. 2) Total Fixation time

Total fixation time (FT) is the sum of The Times of all fixation points within the region of interest, reflecting the complexity of the elements in that region of interest and the sensitivity of cognitive processing. As shown in the Table 3, the total gaze time of elements such as buildings (3.21 seconds), text signs (1.62 seconds), and plants (1.07 seconds) is relatively long, indicating that the visual attraction of the above elements is high and the recognisability is relatively high. The total fixation time of the facilities (0.46s) and ground (0.39s) elements is relatively short, and the identifiability is relatively low. This data, on the whole, reflects the visual appeal of the test subjects to the identifiable elements in the scene.

Table 3: Statistics of mean fixation time

Area of Interest	Average value (s)
Text identification	1.62
Architecture	3.21
Plant	1.07
Ground	0.39
Facilities	0.46

IV. B. 3) Number of gazes

The number of gazes (FC) reflects the degree of attention paid to the area. A high FC indicates that the interest is more likely to be noticed by the subjects and has a high degree of recognition. As shown in the Table 4, the elements of architecture (11.10t), text signs (4.70t), and plants (3.77t) have more gaze counts, indicating that the above elements receive more attention from the subjects and have higher recognizability. The total fixation time of the facilities (1.49t) and ground (1.27t) elements is relatively short, and the identifiability is relatively low. This data generally reflects the degree of attention that the test subjects pay to the identifiable elements in the scene.

Table 4: Statistics of mean fixation count

Area of Interest	Average value (t)
Text identification	4.70
Architecture	11.10
Plant	3.77
Ground	1.27
Facilities	1.49

To sum up, among the indicators that affect the time before first gaze (FFT), the element with the smallest FFT value is the building. This indicates that the building element is the first to receive attention, and it maintains the highest values in both the total duration of gaze (FT) and the number of gazes (FC), suggesting that the building is the primary visual focus of street recognizability. The text signs FT and FC follow the buildings closely, and the plant elements also show a relatively high gaze duration and frequency, indicating that they are also important landscape elements for identifying the streets. Analyzing the reasons, this result is in line with the prospect avoidance theory formulated by Appleton, which states that all living beings, including humans, instinctively perceive the environment and can quickly retrieve it when needed to ensure survival. This means that observers classify landscapes based on potential prospects and shelters, and the most common shelters for modern people are buildings. Meanwhile, the amount of information of artificial landscape elements (including material information such as forms and materials, as well as textual information such as plaques and couplets) is greater than that of natural landscape elements. They are more likely to create a greater visual contrast with the surrounding environment, thereby arousing the visual attention and cognitive desire of the test population. Among them, the detailed structure and textual information of the building are more abundant compared to other landscape elements, and thus have stronger recognizability.

IV. C. Analysis of Street Identifiability Results under Eye Movement Data

The CRITIC analysis method is a commonly used objective weighting approach. It can effectively reduce subjective human intervention, enabling the obtained weights to better reflect the amount of information contained in the indicators themselves. Thus, it enhances the objectivity and rationality of weight distribution, and the calculation results are more practically representative.

This method performs weight assignment according to the following steps. First, suppose there are a total of m evaluation objects and n evaluation indicators. Let the original observed value of the i-th evaluation object under the j-th indicator be x_{ij} (where $i=1,2,\dots$) m; $j=1,2,\dots,n$), the evaluation formula is as follows.

(1) The dimensionless processing of positive indicators (total fixation time, fixation frequency) is as follows:

$$y_{ij}=\frac{x_{ij}-\min(x_j)}{\max(x_j)-\min(x_j)} \tag{9}$$

The dimensionless processing of the negative index (the time before the first fixation) is:

$$y_{ij}=\frac{\max(x_j)-x_{ij}}{\max(x_j)-\min(x_j)} \tag{10}$$

(2) Volatility:

$$S_j=\sqrt{\frac{\sum_{i=1}^{m}(y_{ij}-\overline{y}_j)^2}{m=1}} \tag{11}$$

(3) Relevance:

$$R=\frac{\sum_{j,k=1}^{m}(y_{ij}-\overline{y}_j)^2(y_{ik}-\overline{y}_k)}{\sqrt{\sum_{j=1}^{m}(y_{ij}-\overline{y}_j)^2\sum_{k=1}^{n}(y_{ik}-\overline{y}_k)^2}} \tag{12}$$

(4) Conflicting:

$$A_j=\sum_{i=1}^{n}(1-r_{ij}) \tag{13}$$

(5) Information quantity

$$C_j=S_j*A_j \tag{14}$$

(6) Weight

$$W_j=\frac{C_j}{\sqrt{\sum_{j=1}^{n}C_j}} \tag{15}$$

The final weight results are shown in the figure as follows (Figure 13):

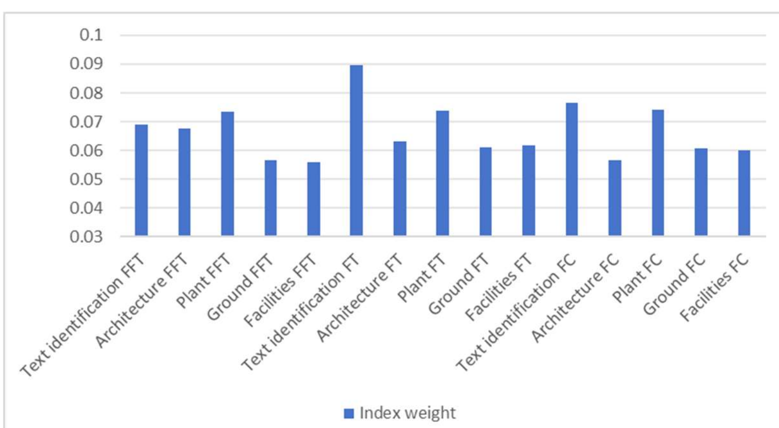

Figure 13: Street recognizability index weights under eye movement data

Text Identifier FT (0.0897) > Text Identifier FC (0.0767) > Plant FC (0.0741) > Plant FT (0.0738) > Plant FFT (0.0734) > Text Identifier FFT (0.0690) > Building FFT (0.0676) > Building FT (0.0631) > Facility FT (0.0619) > Ground FT (0.0609) > Ground FC (0.0608) > Facility FC (0.0599) > Ground FFT (0.0567) > Building FC (0.0566) > Facility FFT (0.0559)

The weights of FT (total gaze duration) and FC (gaze count) of text identifiers rank first and second respectively, indicating that their content attractiveness (such as text and color) has a significant impact on recognizability.

The FT and FC weights of plant elements rank third and fourth respectively, reflecting their enhancement of street memory points through features such as color changes and morphological rhythms.

Although the FC weight of the building is not high, its FFT and FT weights are both relatively high, indicating that the rapid recognition and continuous attraction of the building coexist. The building achieves rapid positioning through contour, facade style, etc., and maintains visual interest through detailed design at the same time.

By superimposing the weights, it can be known that the ranking of the influencing factors of street recognisability is as follows: text identification (0.2353) > plants (0.2213) > buildings (0.1873) > ground (0.1784) > facilities (0.1777). This indicates that in the process of visual recognition of streets, text signs have the greatest impact on recognizability, followed by plants and buildings, while the ground and facilities have a relatively small impact.

Therefore, the identifiability results of each street are obtained. And calculate the recognisability scores of the text signs, plants, buildings, facilities and ground of the selected 28 streets respectively.

Street identifiability=0.0690* y_{ij} ,Text identification FFT+0.0676 y_{ij} *,Architecture FFT+0.0734* y_{ij} ,Plant FFT+0.0567* y_{ij} ,Ground FFT++0.0559* y_{ij} ,Facilities FFT+0.0897* y_{ij} ,Text identification FT+0.0631* y_{ij} ,Architecture FT+0.0738* y_{ij} ,Plant FT+0.0609* y_{ij} ,Ground FT+0.0619* y_{ij} ,Facilities FT+0.0767* y_{ij} ,Text identification FC+0.0566* y_{ij} ,Architecture FC+0.0741* y_{ij} ,Plant FC+0.0608* y_{ij} ,Ground FC+0.0599* y_{ij} ,Facilities FC

The recognizability of text identifiers=0.0690* y_{ij} ,Text identification FFT+0.0897* y_{ij} ,Text identification FT+0.0767* y_{ij} ,Text identification FC

Building identifiability=0.0676* y_{ij} ,Architecture FFT+0.0631* y_{ij} ,Architecture FT+0.0566* y_{ij} ,Architecture FC

Plant identifiability=0.0734* y_{ij} ,Plant FFT+0.0738* y_{ij} ,Plant FT+0.0741* y_{ij} ,Plant FC

Ground identifiability=0.0567* y_{ij} ,Plant FFT+0.0609* y_{ij} ,Ground FT+0.0608* y_{ij} ,Plant FC

Facility identifiability=0.0559* y_{ij} ,Facilities FFT+0.0619* y_{ij} ,Facilities FT+0.0599* y_{ij} ,Facilities FC

V. Results and Analysis

V. A. The Correlation between landscape visual sensitivity and street recognizability

The landscape visual sensitivity and identifiability of 28 street scenes were imported into SPSS for Pearson correlation analysis (Table 5). According to the analysis results, $p < 0.001$, which proves that there is a significant correlation between landscape visual sensitivity and recognizability.

Table 5: Correlation analysis of landscape visual sensitivity and identifiability

	Pearson correlation	Identifiability
Landscape visual sensitivity	Correlation coefficient	0.729**
	p value	0
	Sample size	28

To further explore the influence relationship of landscape visual sensitivity on street identifiability, a linear regression analysis was conducted with landscape visual sensitivity as the independent variable and identifiability as the dependent variable. The results of the regression model are shown in the table as follows (Table 6).

Table 6: Regression analysis of landscape visual sensitivity and identifiability

Results of linear regression analysis (n=28)							
	Non-standardized coefficient		Standardized coefficient	t	p	Collinearity diagnosis	
	B	Standard	Beta			VIF	Tolerance
Constant	0.204	0.043	-	4.783	0.000**	-	-
Landscape visual sensitivity	0.089	0.016	0.729	5.435	0.000**	1	1

R^2	0.532
Adjustment R^2	0.514
F	F (1,26) = 29.541, p = 0.000
D-W value	1.73

The regression analysis results of landscape visual sensitivity and identifiability showed that B=0.189, $p < 0.001$. It can be judged that there is a regression relationship between landscape visual sensitivity and identifiability, and landscape visual sensitivity has a significant positive impact on identifiability. R^2= 0.532, indicating that the explanatory degree of the independent variable for the dependent variable is 53.2%. This result shows that the fitting degree of the model is relatively high, and the landscape visual sensitivity occupies a relatively high explanatory power in the change of recognizability.

V. B. The Influence Mechanism of Landscape Visual Sensitivity on Street Identifiability

In order to deeply explore the relationship between each index of landscape visual sensitivity and street identifiability, each factor of landscape visual sensitivity and identifiability were introduced into SPSS for Pearson correlation analysis. The results show (Table 7): Street identifiability was significantly correlated with the nuclear density of historical buildings ($p < 0.001$) and the nuclear density of POI (p=0.004), and showed a positive correlation.

Table 7: Regression analysis of landscape visual sensitivity indicators and identifiability

Pearson Correlation								
		Relative slope	Relative distance	Occurrence rate	POI kernel density	SHDI	Core density of historical buildings	NDVI
Identifiability	Correlation coefficient	-0.109	-0.246	0.095	0.531**	0.155	0.665**	-0.327
	p value	0.582	0.208	0.629	0.004	0.432	0	0.09
	Sample size	28	28	28	28	28	28	28

In order to further clarify the influence degree of each factor of landscape visual sensitivity on street identifiability, each index in landscape visual sensitivity was taken as the independent variable, and a linear regression analysis was conducted with street identifiability as the dependent variable. The results show (Table 8): R^2= 0.655, and all VIF is less than 5. In the regression results, the p values of POI kernel density, SHDI index based on POI diversity, and historical building kernel density are all less than 0.1, indicating that these three indicators have a significant impact on street identifability. Among them, the regression coefficients of the POI kernel density and the historical building kernel density are positive, meaning that these two factors have a positive promoting effect on the recognizability of street space. However, the regression coefficient of SHDI is negative, indicating that the excessive diversification of POI types may interfere with street recognition and thereby have an inhibitory effect on recognizability. Based on the results of the regression analysis, the following identifiability regression model can be established:

Recognizability =0.000026*POI core density -0.055* SHDI based on POI diversity +0.0011* Historical building core density +0.465.

Table 8: Regression analysis of landscape visual sensitivity indicators and identifiability

Results of linear regression analysis (*n*=28)							
	Non-standardized coefficient		Standardized coefficient	*t*	*p*	Collinearity diagnosis	
	B	Standard error	*Beta*			VIF	Tolerance
Constant	0.465	0.096	-	4.864	0.000**	-	-
Relative slope	-0.004	0.005	-0.205	-0.787	0.44	3.923	0.255
Relative distance	-0.001	0.001	-0.25	-1.32	0.202	2.083	0.48
Occurrence rate	0.002	0.006	0.095	0.404	0.691	3.185	0.314
POI kernel density	0	0	0.535	2.27	0.034*	3.224	0.31
SHDI	-0.055	0.03	-0.407	-1.809	0.086	2.937	0.34

Core density of historical buildings	0.001	0	0.42	2.549	0.019*	1.578	0.634
NDVI	-0.133	0.156	-0.19	-0.853	0.404	2.869	0.349
R^2	0.655						
Adjustment R^2	0.534						
F	F (7,20) = 5.427, p=0.001						
D-Wvalue	1.936						

V. C. Analysis of the Recognizable Distribution Characteristics of Streets in the Core Urban Area of Harbin City

To deeply explore the distribution characteristics of street identifiability in the core urban area of Harbin City, this paper is based on the previously constructed multiple linear regression model of identifiability: Recognizability =0.000026*POI kernel density -0.055* SHDI based on POI diversity +0.0011* Historical building kernel density +0.465. After inputting the model formula into the ArcGIS Pro platform, the spatial distribution map of street recognizability in the core urban area of Harbin City was obtained. To present the differences of streets in terms of recognisability more clearly, the Jenks natural discontinuity point classification method was adopted to divide the calculation results into six grades, and the corresponding classification diagrams were drawn (Figure 14, Figure 15).

This result visually reflects the spatial performance characteristics of the street in terms of the distribution of cultural resources, functional configuration structure, and visual perception potential, providing data support for the refined renovation and spatial optimization of the street.

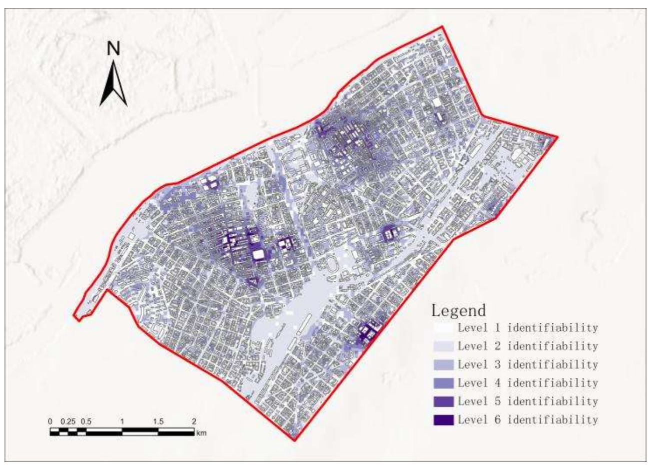

Figure 14: Identifiability results of streets in the core urban area of Harbin-plan view

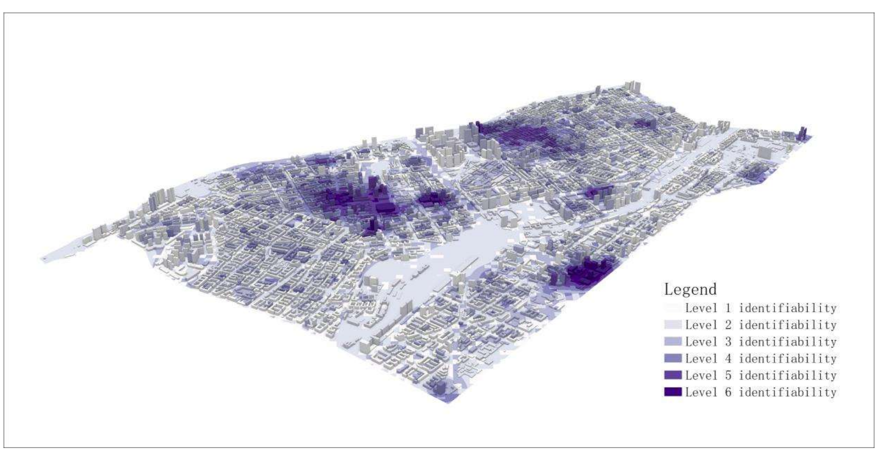

Figure 15: Identifiability results of streets in the core urban area of Harbin-3D model diagram

From the perspective of the spatial distribution characteristics of the GIS analysis results, the street identifiability presents a distribution feature of "high in the northwest and low in the southeast - sheet-like distribution". The street identifiability presents a significant "patchy" distribution pattern, highlighting several areas with higher identifiability. In terms of the patchy distribution, the street identifiability shows a typical "center-edge" circular layer spatial diminishing feature, that is, expanding outward from several core street areas, the identifiability level gradually weakens. The identifiability score within the study area ranged from 0.35 to 0.88, with an average of 0.49. The streets within the study area as a whole presented a relatively low level of identifiability.

The results show that the streets with higher and higher recognizability at level five and level six are mainly concentrated in the core areas of Daoli District, Daowai District and Nangang District. It is mainly divided into the following three types of areas.

The first category is highly recognizable clusters located within historical districts, such as the Chinese Baroque Historical and cultural District with Beisandao Street and Beisidao Street as its peaks. The Central Street Historical and cultural Block, with West Ninth Street and West Eleventh Street as its peaks; The Nanji Street, Mosque Street and other areas around the Western Mosque of the Qing Dynasty; Stalin Street with the Friendship Palace as its peak. This type of street is mainly characterized by the aggregation of historical buildings, complete street texture and prominent cultural symbols. It has distinct locality and cognitive stability, and is highly recognizable.

The second category is commercial clusters, such as the streets near the Markway Mall business district and the streets near the Taipingqiao Lesong Shopping Plaza business district. Such streets are characterized by high-density consumption functions, high pedestrian flow intensity and active commercial interfaces, and often radiate outward around large business districts or shopping plazas. This type of street is an important functional area for residents' daily life, a high-frequency cognitive area, and has a high degree of social interactivity. Therefore, it has a relatively high recognizability.

The third type is the functional complex area guided by landmarks, such as the Sophia Cathedral - New 100 Shopping Plaza area; Museum - Hongbo Square Area Flood Control Memorial Tower - Parkson Shopping Plaza area. Such streets are usually lined with urban landmark buildings, such as churches and memorial halls, which often constitute the dominant elements of regional spatial identification and possess a strong sense of direction and spatial recognition. The street structure is clear and the landscape elements are complete. It has both static cognition and dynamic guidance functions and is an important intersection area of urban cognition and traffic flow lines. Therefore, it has high recognisability.

The results show that the distribution of moderately identifiable streets at levels three and four is mainly in the northeastern and central-eastern areas of Daoli District, as well as the central and western areas of Daowai District. A small portion is distributed in a dotted pattern at the junction of Daoli District and Nangang District, mainly divided into the following two types of areas.

The first type is the main urban roads, such as Yifang Street and Jingyang Street. Most of these streets have convenient transportation, with sufficient subway and public transportation stations, and they are the main Spaces for the daily life of urban residents. The surrounding POI business types of these streets are relatively diverse, but these facilities often present a fragmented layout, resulting in the functions of these areas being relatively comprehensive but lacking high coherence and distinctiveness. As a result, from an overall perspective, the recognizability of these streets is relatively low. Meanwhile, the architectural style of such streets tends to be consistent, and the street structure is relatively regular. However, it lacks distinct regional characteristics or personalized visual landmarks, resulting in a medium level of recognizability.

The second category includes streets distributed within and around newly-built residential areas, such as Jinyuan Road Residential Area and Zeyuan Road Residential Area in the west of the study area, and Baoyu Tianyi Lanwan Residential Area in the northeast of the study area, etc. The building heights in these areas are generally high, with strong distinctiveness, a high density of POI, and the street structures are usually quite regular, featuring certain planning characteristics, giving people an impression of being orderly but monotonous. Therefore, although the block planning is relatively clear, due to the lack of distinctive landscape elements or landmark buildings, it is difficult to generate strong spatial recognition and memory points visually, and thus its recognizability is at a medium level.

The results show that the distribution of low and relatively low identifiable streets at the first and second levels presents a trend of large area distribution with high identifiable street clusters as the core, mainly divided into the following two types of areas.

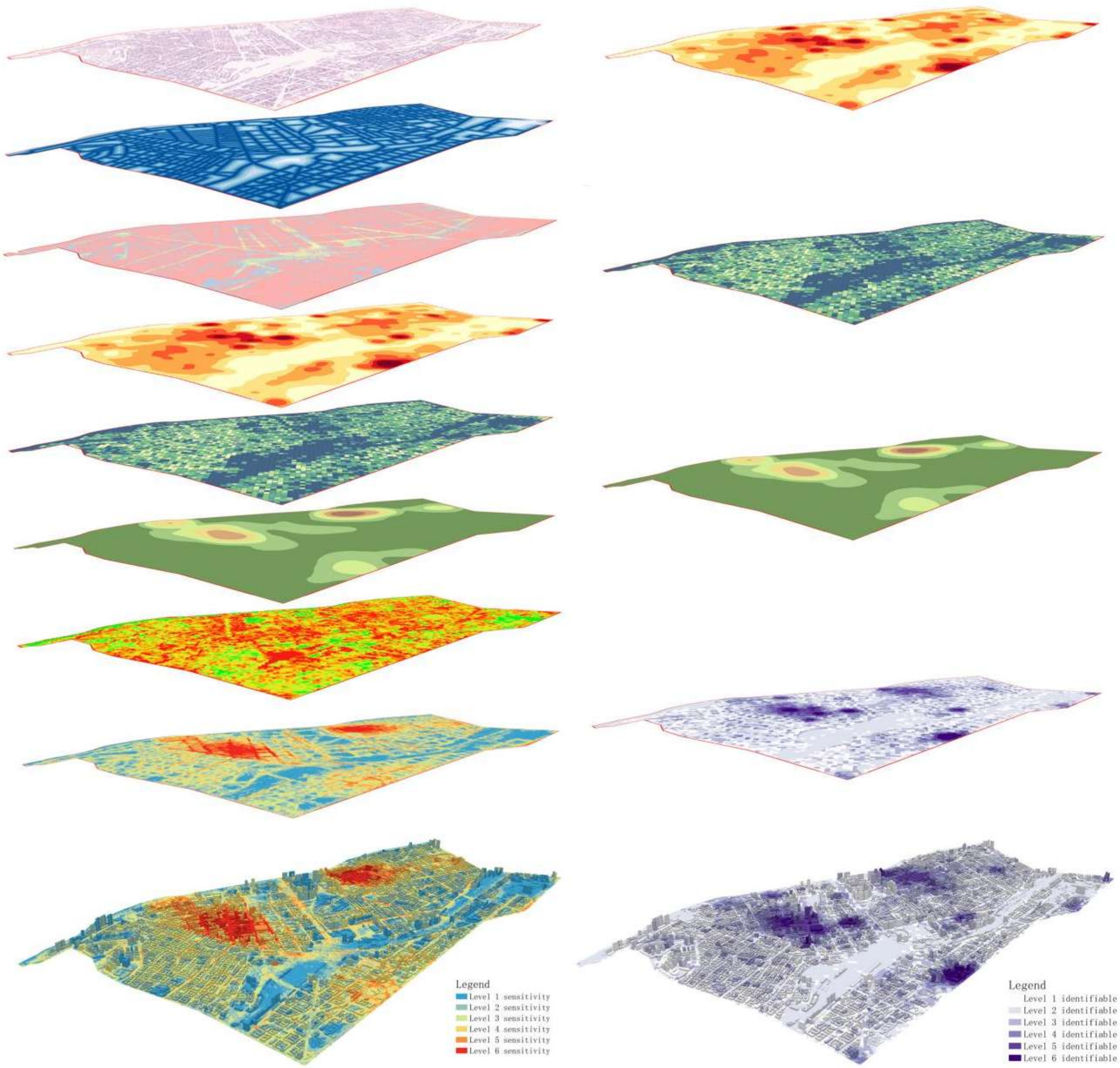

Figure 16: Comparison map of landscape visual sensitivity and identifiability in the core urban area of Harbin

The first type is the streets located within and around the old residential areas. Most of the buildings in old residential areas are old residential buildings or low-rise buildings, and their designs and styles mostly lack modernity. These buildings generally lack iconic and unique design elements, making the entire area visually unrecognizable. Meanwhile, the POI density of the streets in this type of area is relatively low, the infrastructure is generally aging, and the greening is relatively monotonous, resulting in low street identifiability.

The second is the streets near the railway line. The areas near railways often mainly undertake transportation or industrial functions. Public facilities, commercial facilities, etc. around the streets are relatively scarce, and the POI density is low. This makes the social and economic vitality of these streets weak, and they cannot form rich social interaction and spatial cognition like the urban core area. It is difficult to form distinct street characteristics through the integration of vision and function. This has thus affected the recognizability of the streets in this area.

To sum up, the street identifiability in the core urban area of Harbin shows a distribution feature of "high in the northwest and low in the southeast - sheet-like distribution". The overall recognizability score of the street is relatively low. Streets with high recognizability are mostly concentrated in historical and cultural blocks, commercial clusters, and functional complex areas guided by landmarks, as well as other places for leisure, entertainment and daily life.

V. D. Analysis of the Differences between Landscape Visual Sensitivity and Street recognizability Results

It has been proved in the previous study that landscape visual sensitivity has a significant positive impact on street recognizability. As an important visual feature of the urban built environment, landscape visual sensitivity can effectively affect the recognisability performance of street landscapes to a certain extent. However, although the two show a strong correlation at the statistical level, from the perspective of spatial expression results, there are still certain differences between them. This section aims to further analyze the differences in the spatial distribution characteristics of landscape visual sensitivity and recognizability, and deeply reveal the relationship between visual perception and spatial cognition.

From the comparison between the GIS classification map of landscape visual sensitivity and the GIS classification map of identifiability (Figure 16), it can be observed that the two have a great similarity in spatial distribution, but there are also some differences. Specifically, some landmark buildings or structures, such as the Revolutionary Leader's Inspection of Heilongjiang Memorial Hall, the West Mosque, are at a relatively low level on the landscape visual sensitivity grading map, indicating that their visual saliency is not high and they may be located in relatively concealed or unobtrusive positions. However, in the identifiability grading map, the identifiability scores of these markers are relatively high, reaching level four, level five or even level six. This phenomenon reflects two important cognitive psychological phenomena.

First of all, although some landscape elements are not prominent in the physical space, due to their unique historical significance and social and cultural value, they occupy an important position in people's cognitive memory and have strong recognisability. Historical buildings, cultural heritages and other landmark objects often form a deep memory impression in people's cognition. Even if they are not visually prominent, people can quickly identify them and endow them with higher cultural and symbolic meanings through their previous cognitive experiences and understanding of the historical background, thereby enhancing the recognizability of these landscape elements. This further proves that identifiability is not only determined by the physical visual features of the landscape, but also influenced by culture, history and individual memory [20].

Secondly, this analysis also verifies that landscape visual sensitivity constitutes the physical basis for the formation of recognizability to a certain extent. Landscape visual sensitivity mainly focuses on the physical attributes of landscape elements, such as visibility, saliency and spatial layout features, which determine the probability of the landscape being noticed. In areas with higher visual sensitivity, landscape elements are more easily captured by observers. However, landscape visual sensitivity is only a prerequisite for recognizability. The latter requires a more complex cognitive processing procedure, including the memory matching of landscape elements and the assignment of cultural symbols. At this level, the visual sensitivity of the landscape can be regarded as the "input" or basis of identifiability, and identifiability is the in-depth processing and meaning interpretation of landscape information on this basis. Therefore, the identifiability of a landscape is not only a continuation of its visual sensitivity, but also jointly influenced by higher-order cognitive factors such as an individual's cultural background and historical memory.

VI. Conclusion

This article takes the identifiability issue of the city as the starting point of the research. It evaluates the landscape visual sensitivity of the core urban area of Harbin through GIS, quantitatively analyzes the identifiability elements in combination with eye movement experiments, explores the correlation between landscape visual sensitivity and identifiability, and on this basis, constructs a three-dimensional evaluation model of street identifiability. This model clearly shows the weak identifiable areas within the study area, providing a theoretical basis and design strategy for urban space optimization. The main research conclusions are summarized as follows:

(1) Explore the constituent dimensional characteristics of the visual sensitivity of the urban built environment landscape.

Based on the coordination of the original constituent dimensions of landscape visual sensitivity and the landscape characteristics of the built environment, and in accordance with the inherent characteristics of identifiability, the constituent factors and evaluation system of visual sensitivity suitable for urban landscape research are constructed. An evaluation model based on seven indicators, namely relative slope, relative distance, occurrence probability, POI core density, historical building core density, SHDI and NVDI, is proposed. And explore the ranking of the influencing factors of landscape visual sensitivity based on the built environment: core density of historical buildings > occurrence probability > relative distance > SHDI > POI core density > NDVI > relative slope.

(2) To enhance the recognizability of streets, discussions should be conducted from both macro and micro perspectives

1) In terms of macro regions, landscape visual sensitivity has a significant positive impact on street identifiability. The evaluation model of street identifiability based on landscape visual sensitivity is constructed as follows:

Recognizability =0.000026*POI core density -0.055* SHDI based on POI diversity +0.0011* Historical building core density +0.465. This indicates that in urban planning and design, to enhance the recognizability of streets, the spatial agglomeration degree of historical buildings and the number of POIs should be moderately increased. To enhance the expression of cultural characteristics and functional agglomeration in the street environment [21]; Meanwhile, the diversity of POI types should be reasonably controlled to avoid weakening the overall cognitive clarity and visual focus of the street due to overly dispersed functions.

2) In terms of the micro aspects of street landscape elements, the main landscape elements that affect the recognizability of the street include five categories: text signs, buildings, plants, ground and facilities. Among them, the influence of text signs is the most prominent and is the main factor in enhancing the recognition of the street. This might be because they have a direct information transmission function. Secondly, there are plants and buildings. The former enhances the sense of spatial memory through color and form, while the latter provides stable visual landmarks by relying on volume and facade features. Finally, there are the ground and facilities. Although they have a relatively weak visual impact, they still play a certain role in spatial guidance and detail recognition.

(3) Explore the recognizable distribution characteristics of streets in the core urban area of Harbin

By constructing a three-dimensional model of the core urban area of Harbin, the weak points of street identifiability are identified, and the priority streets for identifiability regression and construction are clearly pointed out. The street identifiability in the core urban area of Harbin shows a distribution characteristic of "high in the northwest and low in the southeast - sheet-like distribution". The overall recognizability score of the streets in the study area is relatively low. Streets with high recognizability are mostly concentrated in historical and cultural blocks, commercial clusters, and functional complex areas guided by landmarks, as well as other places for leisure, entertainment and daily life.

Taking the Central Street Historical Block as an example, the analysis results show that the recognizability scores of Huapu Street and Xitoudao Street in the Central Street Historical Block are the lowest. This indicates that in the process of planning and renovating the Central Street Historical District, priority should be given to enhancing the landscape recognizability of these two streets. Specifically, its recognition among residents and tourists can be effectively enhanced by measures such as adding facilities with local characteristics, plant landscapes, cultural symbols or historical element signs.

(4) Analysis of the differences and causes between the results of landscape visual sensitivity and identifiability

The visual sensitivity and identifiability of the landscape have a high consistency, but show significant differences in local areas. For example, historical landmarks such as the Sophia Cathedral, the Flood Control Monument, and the museum have a lower grade in the landscape visual sensitivity classification map, but a higher score in the identifiability classification map, reflecting their strong cognitive significance. This phenomenon is further verified from the perspective of cognitive psychology: Although identifiability is based on the physical foundation of landscape visual sensitivity, it is simultaneously influenced by multi-dimensional cognitive factors such as urban memory, emotional connection, and historical culture. Landscape visual sensitivity determines the potential of a landscape to be noticed, while identifiability is the result of deep processing based on individual experience and collective memory. Based on this, in urban design practice, the combination of visual distinctiveness and cultural symbolism should be taken into account. By setting elements with cultural identification and strengthening spatial memory points, the overall recognizability of the city and the quality of spatial perception can be enhanced.

References

[1] Bacon W R. The visual management system of forest service, USDA.In: Proceedings of Our National Landscape.G Elsner and R.C Snardon, eds.USDA Forest service General Technical Report PSW-35.1979.

[2] Liu,B.Y. Visual Quality Evaluationon Landscape Environment.J.Tongji Univ.1990,18,24–29.

[3] Yu,K.J.Research on Landscape Sensitivity and Threshold Evaluation[J]. Geographical Research,1991,10(2): 38-51.

[4] Wang F, Qu X. The study of urban landscape visual sensitivity assessments: A case study in the Zhongshan District of Dalian[J]. Journal of Spatial Science, 2018, 63(2): 325-340.

[5] YaNan F, Jian Z, Aihemaiti N. Landscape Visual Sensitivity Assessment of Historic Districts—A Case Study of Wudadao Historic District in Tianjin, China[J].ISPRS International Journal of Geo-Information, 2021, 10(3): 175-175.

[6] Yang X, Shen J. Landscape Sensitivity Assessment of Historic Districts Using a GIS-Based Method: A Case Study of Beishan Street in Hangzhou, China[J].ISPRS International Journal of Geo-Information, 2023, 12(11): 462-.

[7] Wan, W., Hu, J., and Liu, X., 2011. Three-demensional GIS visility analysis based on urban DEM.Computer Engineering, 37 (s1), 376–379.

[8] Tian, J. and Lu, J., 2017. Study on the form design strategy of Hilly Cities based on slope analysis.Value Engineering, 36 (33), 184–186.

[9] Janc, K., 2016. Visibility and connections among cities in digital space. Journal of Urban Technology,22 (4), 1–19

[10] Miller, P. and Jiang, S., 2012. Scenery management in the United States: claytor lake scenery management study. Chinese Landscape Architecture, 28 (3), 15–21.

[11] Kuang, L.Z., 2015. Research of Canyon Scenic Spot's landscape visual sensitivity evaluation. Thesis.Southwest University.

[12] Qiu, Y.S., 2013. The study of landscape visual quality assessments based on GIS technology — a case study on Jiuzhaigou in Sichuan Province. Thesis. Shanghai Normal University.
[13] Luo, X.; Huang, Y.; Bi,J. Study on methods of evaluating visual landscapes in historic and cultural districts. J. Landsc. Res. 2011, 3, 21–24.
[14] Zheng,Y.; Lan, S.; Chen,W.Y.; Chen, X.; Xu, X.; Chen,Y.; Dong,J.W. Visual sensitivity versus ecological sensitivity: An application of gis in urban forest park planning. Urban Green. 2019, 41, 139–149.
[15] Lynch, K., 1984. Good City Form. Cambridge: The MIT Press.
[16] Zhang G, Yuan B, Hua H, et al. Individual differences in first-pass fixation duration in reading are related to resting-state functional connectivity[J].Brain and Language, 2021, 213: 104893.
[17] Hao S, Hou R, Zhang J, Shi Y, Zhang Y. & Wang C. Visual behavior characteristics of historical landscapes based on eye-tracking technology.Journal of Asian Architecture and Building Engineering, 2024, 24(2), 487–506.
[18] Li J, Zhang Z, Jing F, et al. An evaluation of urban green space in Shanghai, China, using eye tracking[J]. Urban Forestry & Urban Greening, 2020, 56: 126903.
[19] Kim Juyeon and Park Junsu. The region of interest of horizontal spatial elements was analyzed by eye tracking experiments. Journal of the Korean Institute of Interior Design, 2017, 26(5), 65-74.
[20] Koseoglu E, Onder D E. Subjective and objective dimensions of spatial legibility[J]. Procedia-Social and Behavioral Sciences, 2011, 30: 1191-1195.
[21] Askarizad R, He J, Khotbehsara E.M. The Legibility Efficacy of Historical Neighborhoods in Creating a Cognitive Map for Citizens. Sustainability 2022, 14, 9010.