An Analysis of Aesthetic Perception of Karst Landscapes Based on Social Media UGC Data: A Case Study of Huangguoshu Scenic Area

Xi Zhao[1,a], Kangning Xiong[1,b,*], Meng Zhang[1,2,c]

[1]School of Karst Science, State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University, Guiyang, 550001, China
[2]Guizhou University of Finance and Economics, Guiyang, 550025, China
[a]1049933910@qq.com, [b]xiongkn@163.com, [c]357382793@qq.com
[*]Corresponding author

Abstract: Karst terrain has become a tourism hotspot due to its unique natural landscape and aesthetic value. However, research on the aesthetic perception of tourists in karst scenic areas is still insufficient. This study selected Huangguoshu Scenic Area as a case study, using User Generated Content (UGC) data from tourism social media to capture tourist photos of the scenic area as analysis samples. By extracting points of interest (POI) from photos, ArcGIS 10.2 was used for kernel density analysis, NVivo 11 was used for encoding analysis of photo content, and UCINET 6 software was used for social network analysis of node data to explore tourists' aesthetic perception of the Huangguoshu landscape. The study revealed the following findings: (1) Tourists' aesthetic attention mainly focuses on the combination of "mountain water (waterfall) vegetation" landscape elements formed by special terrain and landforms, while the attention to cultural and cultural landscapes is relatively low; (2) There are differences in the popularity of different scenic spots within Huangguoshu Scenic Area, with the Great Waterfall Scenic Area being the most popular, followed by Tianxing Bridge Scenic Area and Doupotang Scenic Area. The range of tourists shows a clear pattern of seasonal distribution, with the most concentrated tourists in summer and the most scattered in autumn. (3) The overall emotional tendency of tourists towards the Huangguoshu landscape is positive, and the amount and intensity of positive emotions exceed negative emotions. Negative emotions mainly stem from overcrowding during flood season and dissatisfaction during dry season. The conclusion of this study has practical guiding significance for optimizing resource allocation and improving tourist experience in Huangguoshu Scenic Area, and provides valuable reference information for the protection and development of other karst scenic areas.

1. Introduction

The global karst distribution area reaches 22 million km2, of which 5.1 million km2 is exposed

to the surface[1]. Karst areas have characteristics such as high sensitivity to ecosystem variation, low environmental capacity, and low resilience to disasters [2], but they also possess special material, energy, structure, and function [3], thus forming a unique karst landscape. Karst landscapes represent an important aspect of the Earth's geographical diversity, providing unique economic, scientific, educational, entertainment, and aesthetic values with significant management significance [4]. The unique artistic landscape of karst provides support for the development of tourism. Tourism is a unique visual experience, and tourists often experience their destination through "visual gaze" [5]. In recent years, with the tourism boom as the background, research on landscape aesthetic preferences has been increasing, with a trend of interdisciplinary and multi domain intersection. Neuroaesthetics [6] and big data [7-9] are increasingly being used in landscape preference research. Expanding the collection of landscape aesthetic preference data is one of the future development directions for natural beauty and aesthetic value [10]. If the landscape perception evaluation is limited to a certain social group, the perception evaluation results obtained are difficult to be widely applied. User Generated Content (UGC) provides a "thematic" perspective for exploring the aesthetic perception image of tourists, with the characteristics of intuitiveness, authenticity, and reliability. The large amount of data breaks through the time and space limitations of traditional questionnaire surveys. UGC contains a large amount of audio, video, images, text content, etc., providing a large amount of reliable non structural research data for the study of perceptual image. The most mainstream of these are text and image data, which are tangible manifestations of tourist gaze. Analyzing the content of photos can provide a very detailed depiction of the landscape that tourists appreciate [11]. The interpretation of photos depends on the content captured in the photos [12]. Encoding is a way of interpreting photos, with the aim of breaking down sample data into units of different meanings, converting them into multiple labels or codes, and then reclassifying them to facilitate comparison between similar things[13]. Therefore, the aesthetic perception and experience of the photographer can be explored by analyzing their photos[14]. Tourists are not only perceivers of tourist destination images, but also projectors of tourist destination images. The online word-of-mouth effect formed by tourists in the dissemination of tourism information [15]. Therefore, the photos taken during the journey are not only objective evidence of the real scenery, but also a carrier for tourists to visually represent their aesthetic preferences for the destination terrain. The framing form, content expression, and spatial distribution of photos to some extent reflect people's subjective landscape preferences and aesthetic needs.

At present, there is little research by domestic scholars on the visual symbol of tourism images, and most of them analyze the visual image representation of tourism destinations from the perspective of the destination subject [16-18], while the research objects of aesthetic preferences are mainly urban landscapes [19-21] and forest landscapes[20,22,23], with few studies combining photos with karst landscapes. Therefore, in order to fill this gap, the Huangguoshu Scenic Area in the tentative list of World Heritage Sites was selected as a representative. Based on the images and texts in UGC data, methods such as Nvivo encoding and text analysis (cluster analysis and sentiment analysis) were used to expand the data source, improve the openness of the aesthetic evaluation system, explore the relationship between natural beauty elements and overall emotional bias in UGC data, and provide reference for optimizing resource allocation and enhancing tourist experience in scenic areas.

2. Data sources and research methods

2.1. Study area

Williams identified the "South China Karst" and "Dinar Karst" as two of the most important

karst regions in the world[24]. Huangguoshu Scenic Area is one of the representative areas of karst contiguous distribution in southern China, which is composed of two distinct but closely related environmental regional units, the plateau area and the canyon area, which is a completely different but closely related plateau area and canyon area of natural geography, landform type, development and evolution, landscape characteristics, living environment, human habitation and land use, which contain rare natural landscapes and beautiful natural environments in the world. It is an outstanding representative of the natural landscape of the plateau and mountains in southern China, and even in the world, and has an irreplaceable position. In January 2019, the National Forestry and Grassland Administration of China accepted the application of Huangguoshu Scenic Area for a World Natural and Cultural Heritage Project (Figure 1). Huangguoshu Landscape is located in Zhenning County and Guanling Buyi and Miao Autonomous County of Anshun City, Guizhou Province, most of which are located in the Huangguoshu National Scenic Area, which is composed of three areas: the Great Waterfall Area (E105°40′05″,N25°57′08″), the Dishuitan Area (E105°36′21″,N25°59′29″), and the Gaodang Area (E105°40′25″,N26°04′02″), with a heritage area of 34.70 km2. The buffer zone covers an area of 112.30 km2. The natural landscape of Huangguoshu is represented by waterfalls, which belong to the erosion crack waterfall in the karst landform, showing the harmonious beauty of man and nature. Huangguoshu Waterfall is one of the rare karst waterfalls in the world, with a height of 77.8 meters and a width of 101 meters, it is one of the largest waterfalls in the nine-level and eighteen waterfalls, and is known as the "Karst Waterfall Museum" that integrates the waterfall landscape in the world, and is also one of the five major waterfalls in the world, with extremely high aesthetic, ecological and scientific value.
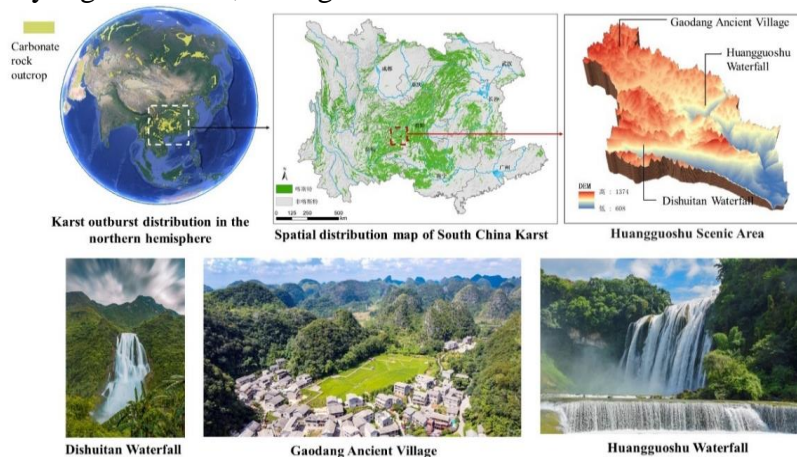

Figure 1: Location map of research areas Huangguoshu landscape

2.2. Research method

This study primarily employs qualitative research methods supplemented by quantitative analysis. Grounded in theories such as Grounded Theory, Landscape Visual Preference, and Gaze Theory, the research utilized Python 3.6 to extract user-generated content, including comments and photographs, from the Huangguoshu Scenic Area between 2015 and 2022. The data were sourced from Ctrip, a representative Chinese online travel platform, and 2bulu.com, China's largest outdoor self-guided tour platform, resulting in a collection of 7,965 comments and 6,133 geotagged photos. Spatial distribution patterns of visitors were determined using Kernel Density Analysis in GIS 10.2. Content coding of photographs was conducted with Nvivo 11, and visual analysis of landscape elements aligning with tourist aesthetic preferences was performed using Ucinet and its integrated Netdraw module. Finally, sentiment analysis was carried out through Micro Word Cloud to discern

patterns in tourist emotional responses.

All data used in this study are publicly available and collected according to the terms and conditions of the data provider. These data are anonymous and we have not collected any personal information. These data allow researchers to download and analyze them for scientific purposes, and therefore do not require ethical approval. The data analysis model used in the article is constructed based on existing and publicly available deep learning models.

3. Research results and analysis

3.1. Kernel density analysis based on photo POI

The collected photographs were named according to the dates they were taken to facilitate seasonal categorization (Table 1). The Huangguoshu Scenic Area consists of seven distinct attractions. As indicated in Table 1, the majority of photos were taken during the summer, accounting for 56.45% of the total, while the winter season had the least, at only 7.04%, suggesting a preference for visiting during the summer flood season. According to Figure 2, the Great Waterfall area is the most popular among all attractions year-round, followed by the Tianxing Bridge area, with the Steep Slope Pond area ranking third and receiving significantly fewer visitors. The Great Waterfall's impressive height and width contribute to its popularity, surpassing the Steep Slope Pond falls, while the Tianxing Bridge area, with its karst landscape and diverse natural features, is highly attractive to tourists. Other areas like the Dripping Beach, Dragon Cave, Stone Village, and Lang Palace see much lower visitation compared to the top three sites.

Table 1: Seasonal distribution of photos in Huangguoshu scenic area

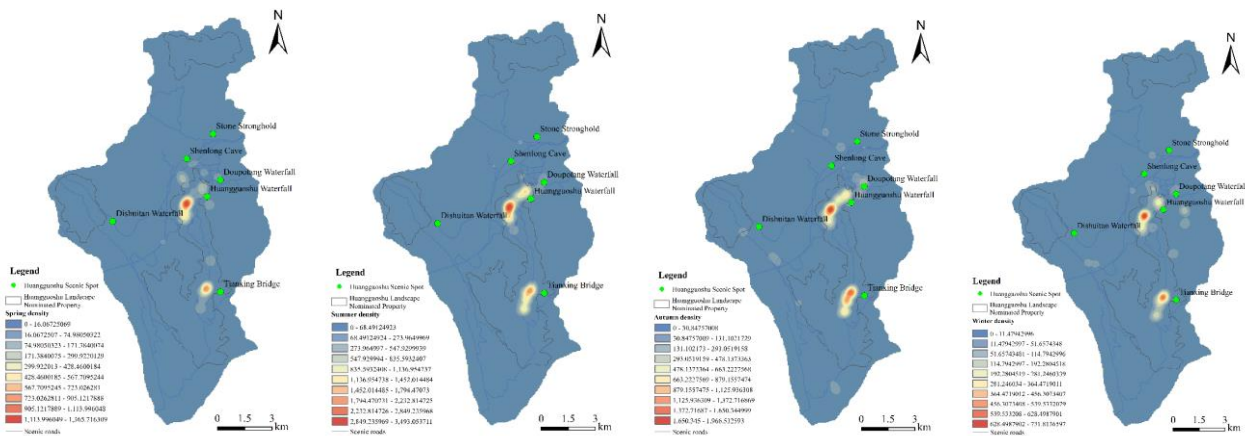| Season	Spring	Summer	Autumn	Winter
Photos	644	3462	1595	432
Proportion	10.50%	56.45%	26.01%	7.04%

Figure 2: Distribution of core density in Huangguoshu Scenic Spot in four seasons (a: Spring, b: Summer, c: Autumn, d: Winter).

To specifically analyze the seasonal changes in tourist behavior characteristics, photo POIs were extracted and divided according to seasons. Arcgis10.2 was imported for kernel density analysis. Although the overall consistency of tourist photos showed "Great Waterfall Scenic Area>Tianxing Bridge Scenic Area>Doupotang Scenic Area ", they also showed changes due to seasons (Figure 2). The summer kernel density distribution in Figure 2b is highly concentrated compared to other seasons, mainly concentrated in the three scenic spots of the Great Waterfall, Tianxing Bridge, and

Doupotang Scenic Area. Starting from autumn, the pedestrian flow begins to decrease, and the flood season gradually ends. The water flow gradually decreases, and the attractiveness of the waterfall landscape decreases. Tourists show a phenomenon of spreading everywhere. The autumn tourist volume in scenic spots such as Dishuitan and Shenlong Cave is higher than that in summer (Figure 2c), and from winter to spring, the pedestrian flow decreases sharply. The diffusion range of tourist attractions is lower than that in autumn, but still higher than in summer. Subsequently, the flood season is approaching, and tourist areas are once again concentrated in the Great Waterfall and Tianxing Bridge scenic spots. The amount and scope of sightseeing in the Huangguoshu landscape show a regular variation with the seasons.

3.2. Qualitative analysis based on tourist photos

3.2.1. Overall analysis of nodes in photo encoding

Table 2: Description of node categories

Tree node	Free nodes	Explain
Road	1path;2 Scenic area roads;	Road is one of the main focuses
Animal	1 fish;2 bird	One of the main focuses is on animals
Build	1 Modern housing; 2 pavilions; 3 characteristic residential buildings; 4 suspension bridges; 5 observation platforms; 6 Huangguoshu Courtyard; 7 exhibition halls	One of the main focuses is on buildings
Scenery	1 close-up; 2 close-up shots; 3 medium shots; 4 Vision; 5 Panorama	It is possible to clearly distinguish the photos of the shooting subject and divide them based on the shooting distance
Infrastructure	1 Graphic and textual signage; 2 raincoats; 3 tickets; 4 fences; 5 colored lights; 6 buses; 7 elevators; 8 cable cars; 9 rafts; 10 Inscriptions	Photos related to tourism service facilities and tourism infrastructure
Meteorological scenery	1 Dark clouds; 2 Blue skies; 3 Clouds and Mists; 4 Rainbows;	One of the main focuses is the meteorological landscape that appears due to weather changes
Humanities and Culture	1 Mural; 2 drums; 3 specialty restaurants; 4 ethnic costumes; 5 ethnic activities; 6 handicrafts; 7 mythological figures; 8 Sculptures by Xu Xiake	One of the main focuses is on items, activities, etc. that represent the local culture and culture
Landscape Architecture	1 Dry season; 2. Flood season; 3 water mist; 4 waterfalls; 5 still water; 6 rivers; 7 cave stone scenes; 8 River Stone Scenery; 9 stone bridges; 10 stone pillars; 11 Water Stone Forest; 12 water stone roads; 13 Stone scenery along the road; 14 three-dimensional levels; 15 River valleys and channels; 16 Mountains with continuous terrain	One of the main focuses is on landscape architecture
Life scene	1 Take a nap; 2 Selling	Refers to the filming of daily life scenes of local people in scenic areas
tourist	1 Take photos as a souvenir; 2 Crowded Crowds	Tourists are one of the main focuses
Plant landscape	1 Single vegetation; 2 groups of vegetation	One of the main focuses is on vegetation, where single vegetation refers to the subject of the shoot being a single plant (such as beautiful banyan trees and ancient trees), and group vegetation refers to the distribution of vegetation in patches as one of the focuses
Other	Other	Photos that cannot be classified into the above nodes

Upon preliminary analysis of the 6,133 photographs, high similarity and redundancy were observed due to the delimited scope of the study. To enhance the scientific validity of the results, simple random sampling was employed, and it was determined that a 10% sample size was sufficient with low redundancy after multiple sampling analyses. After excluding blurry, duplicate, and irrelevant photos, 598 valid images were obtained. Using Nvivo 11 and grounded in Grounded Theory, an open coding process was applied to the photo content, adopting a neutral and objective stance to allow content elements to emerge, categorizing them into free nodes such as "tourist facilities," "division of attractions," and "landscape scenery." Given the diversity and complexity of the photo content, different elements were coded into separate nodes, resulting in 2,000 encodings and 61 free nodes. After completing the initial coding, an in-depth examination of the intrinsic connections between nodes was conducted, followed by axial coding to consolidate the free nodes into 12 tree nodes (Table 2), thereby refining the thematic essence.

3.2.2. Analysis of Tree Nodes in Photo Encoding

The diversity of photo content elements resulted in varying proportions of tree nodes (Figure 3). The landscape category was the most prevalent, accounting for 46.5%, with waterfall elements being the most frequent at 251 codings, representing 12.55% of the total. Flood season and mist followed with 184 (9.20%) and 106 (5.30%) codings, respectively, indicating that the impressive water volume and mist of the waterfalls during the flood season are the most captured elements by tourists. Photos with identifiable shooting subjects were categorized into "shot types" based on distance, comprising 19.4% of the total codings, ranking second, with medium shots being the most coded at 144 times. Vegetation-focused photos, labeled as "vegetation landscapes," accounted for 12.7% of all tree nodes, ranking third. Group vegetation was coded 212 times (10.62%), significantly outpacing individual vegetation at 42 codings (2.09%), suggesting a preference for widespread vegetation scenes, which also reflects the recognition of Huangguoshu's natural conservation and greening efforts by tourists. Other nodes included meteorological scenery (7.88%), tourists (4.48%), tourist facilities (2.94%), architectural forms (2.44%), cultural elements (1.60%), roads (1.25%), daily life scenes (0.35%), animals (0.25%), and others (0.15%).

Figure 3: Proportional distribution of tree nodes
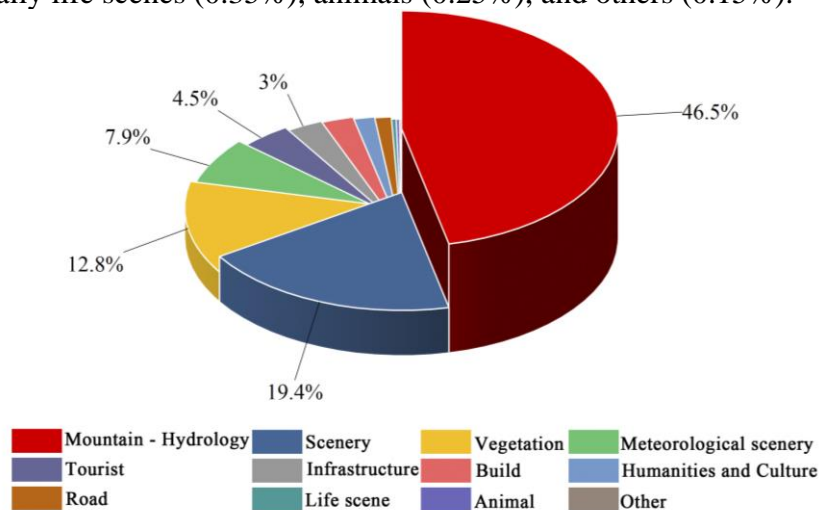
Figure 4 reveals that shot types, landscape scenery, plant landscapes, and meteorological conditions are the elements with the highest co-occurrence, forming the fundamental aesthetic preferences within Huangguoshu's landscape. The most frequent co-occurrence is between shot types and landscape scenery, with 352 instances, indicating that landscape is the most photographed

scenery by visitors. 58% of tourists adjust their shot types when capturing landscapes to obtain images that best meet their aesthetic preferences. Co-occurrences of shot types with plant landscapes were noted 162 times, landscape with plant landscapes 152 times, shot types with meteorological conditions 104 times, and landscape with meteorological conditions 92 times. Further analysis using NetDraw in UCINET6 software visualized the co-occurrence network. The size of the nodes in the network represents the number of nodes directly related to each node, with larger nodes indicating more connections. The thickness of the lines between nodes signifies the strength of the association, with thicker lines indicating more frequent co-occurrences and stronger relationships. Therefore, shot types and landscape scenery have the most direct connections with other nodes, followed by tourists, while animals and daily life scenes have fewer connections. The strongest association is between shot types and landscape scenery, suggesting that the natural beauty of Huangguoshu's attractions is highly appealing to tourists, whereas there is less focus on animals and local daily life scenes.
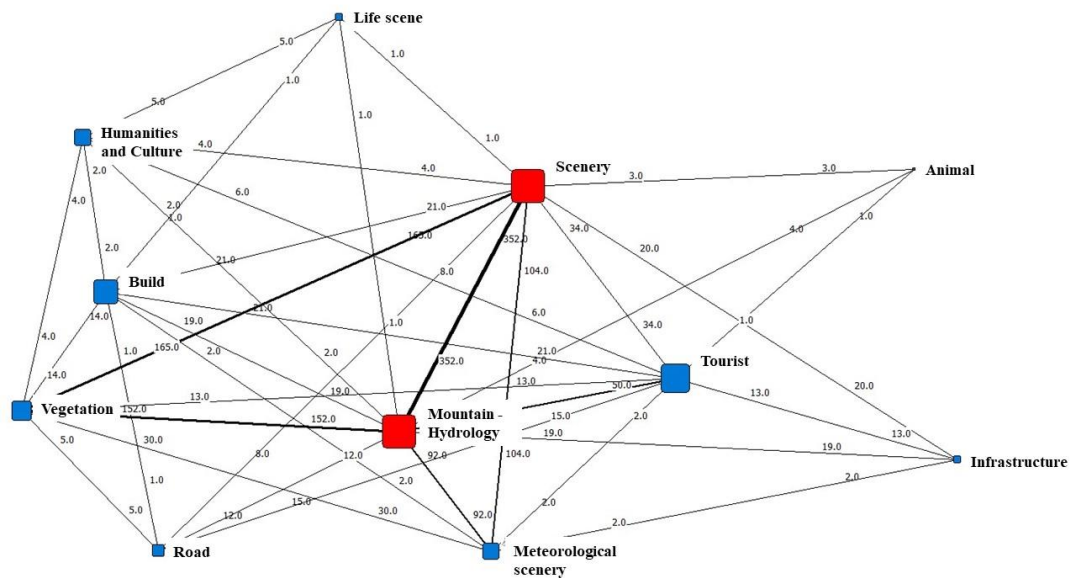

Figure 4: Proportional distribution of tree nodes

3.2.3. Analysis of Free Nodes in Photo Encoding

Further analysis of the co-occurrence network of free nodes revealed 1,126 connections, indicating the presence of 1,126 co-occurrence relationships. To clearly demonstrate the spatial relationships between image elements, a principal component analysis of the free node co-occurrence network was conducted, with the results displayed in Figure 5. Nodes of the same color represent the codings under the same tree node. When taking photos, tourists typically have a clear subject preference, resulting in close-up and medium shots having the most connections with other nodes, followed by long shots and close-ups. Close-ups and medium shots are strongly associated with waterfalls during the flood season, but more tourists opt for medium shots over close-ups when capturing this phenomenon. In addition to flood season waterfalls, group vegetation and clear skies also rank high in medium shot co-occurrences, indicating that tourists prefer to combine waterfalls, vegetation, and meteorological conditions at an appropriate distance, but avoid too distant shots to maintain focus on the main landscape, hence long shots have fewer connections than close-ups and medium shots. In vegetation landscapes, group vegetation has the strongest connections with other nodes, suggesting its ubiquitous presence across various sites in Huangguoshu, indicative of effective natural conservation in the karst environment and a clear aesthetic preference for lush

group vegetation over just waterfall scenes among tourists. Consequently, many photos include lush group vegetation. Additionally, the act of tourists taking souvenir photos is highly associated with other nodes, indicating that Huangguoshu's overall landscape image aligns with tourist aesthetics, leading to photo-taking behaviors at different attractions.
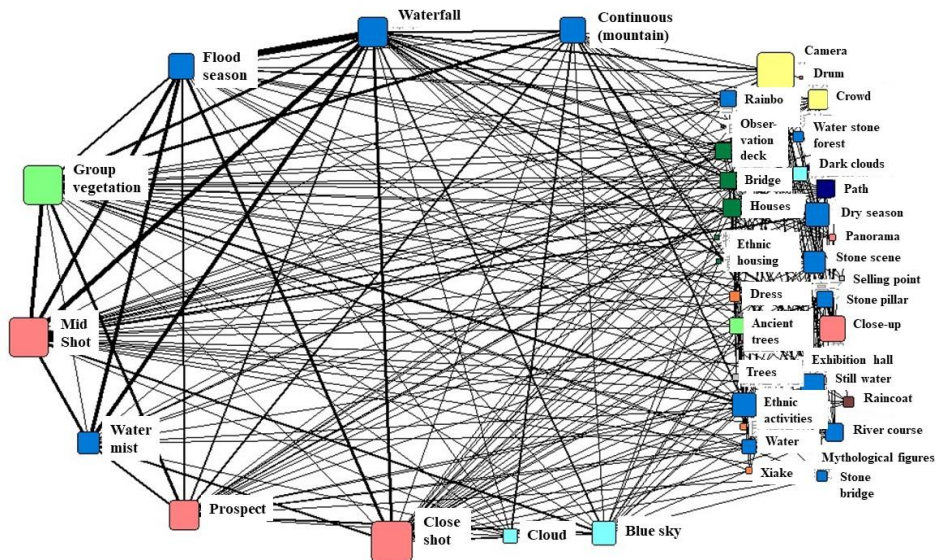

Figure 5: Free node co-occurrence network

3.2.4. Emotional Analysis of Tourists in Huangguoshu Landscape

In photographs where tourists are one of the main focal points, a dendritic node named "Tourist" includes two free nodes: "Photo Souvenir" and "Crowded Scenes." "Photo Souvenir" implies that tourists are highly satisfied with the landscape they are in, leading them to take selfies there. This act is an essential clue for analyzing tourist gaze and self-presentation, reflecting their attention focus and selective memory of landscape elements. Landscape elements in photos often carry unique attributive meanings. Firstly, there is an aesthetic preference stemming from the locality or uniqueness of the landscape, where tourists take selfies to share on social platforms, signifying a strong identification with the natural beauty of the current landscape. Secondly, it represents the subject-object relationship between tourists and the photographed subject; tourists believe not only that the natural beauty of the current landscape surpasses others but also that using such landscapes as a backdrop or setting can enhance their own beauty, thereby generating aesthetic emotions from the outside in and bottom-up, such as openness, melancholy, and exhilaration.

Analyzing the landscape elements in such photos helps destinations identify their unique resources and uncover tourists' aesthetic inclinations and emotional sentiments. This study further analyzed tourist photo souvenir pictures and generated a co-occurrence network (Figure 6). There are a total of 54 tourist photo souvenir pictures, with waterfalls, flood season, mist, and group vegetation being the most co-occurring nodes, with respective occurrences of 17, 11, 7, and 4 times. In terms of shot types, medium shots are the main choice followed by close-ups, with 13 and 4 co-occurrences, respectively. This indicates that waterfall landscapes during the flood season are most attractive to tourists; the rushing waterfalls, the slowly rising mist, and the lush vegetation in the background create a fairy-tale-like scene. Tourists prefer to take medium shots of themselves with such landscapes to satisfy their aesthetic needs and emotional experiences.
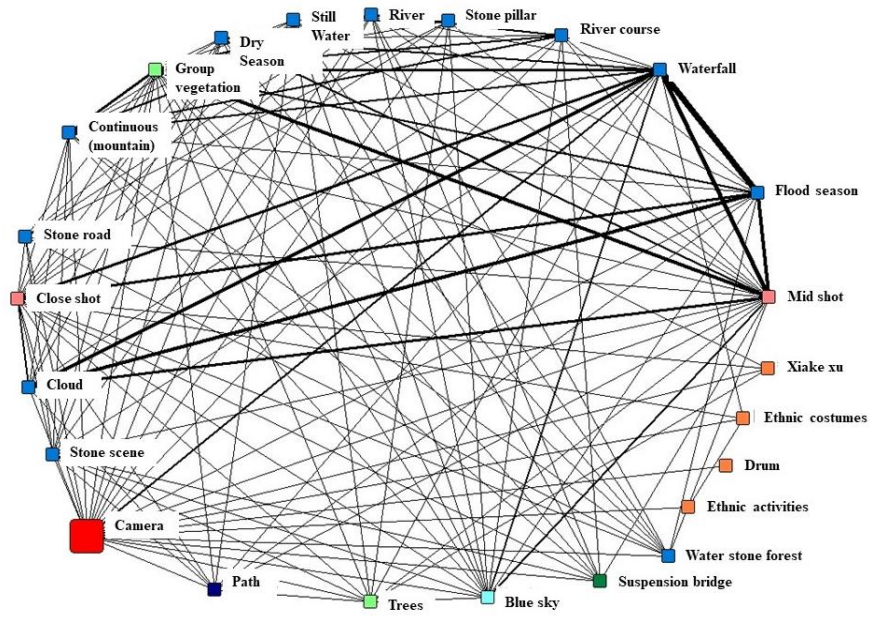
Figure 6: Take pictures of the memory node co-display network

Analyzing sentiment bias solely based on images has limitations, therefore text data is also used for analysis. In the data preprocessing stage, it is necessary to clean the UGC text data, remove irrelevant characters and stop words, and perform stem extraction or word shape reduction, followed by feature extraction, convert the text into a model recognizable format (TF-IDF), and then use the microword cloud to identify and learn the emotional tendencies in the text. The results are shown in the figure 7-8. Research has found that overall, the number of positive emotions among tourists towards the Huangguoshu landscape is greater than that of negative emotions. Negative emotions are generally based on scores between 0-20, with a relatively uniform distribution around -10, while positive emotions are most concentrated between 20-40, with an extreme value of over 40 points and an average emotional score of 14.65, indicating that tourists generally have positive emotions towards the yellow fruit tree landscape. The negative emotions are often due to feeling regretful during the flood season, or feeling like a waterfall landscape due to overcrowding during the flood season, resulting in a psychological characteristic of low cost-effectiveness and high ticket prices. In the analysis of positive emotional words, people believe that the scenic area is large, spectacular, and cost-effective, making it a worthwhile trip.
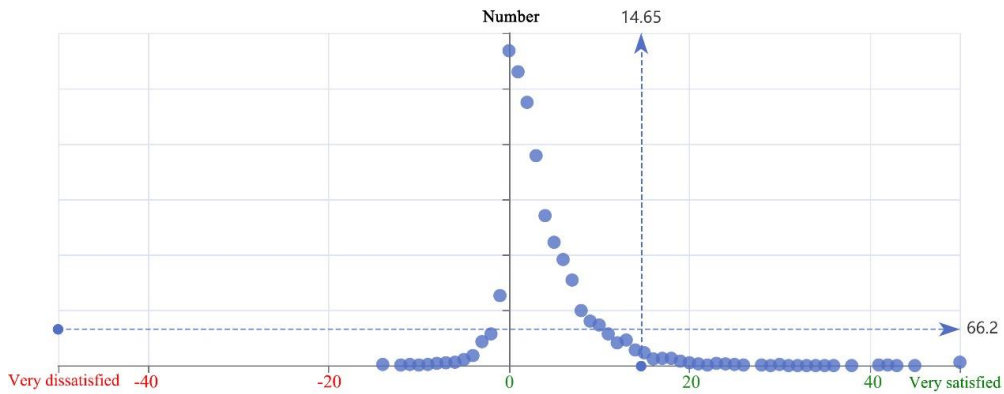

Figure 7: The distribution of emotional values and quantities

Figure 8: Cloud Map of Positive and Negative Emotion Words (a: Positive Emotion, b: Negative Emotion)

4. Conclusion and Discussion

This study investigates the aesthetic preferences of tourists at Huangguoshu Waterfall using social network UGC data and POI photos, aiming to understand the aesthetic tendencies towards waterfall landscapes in karst regions. The findings are as follows:

1) The combination of "mountain-water (waterfall)-vegetation" elements, shaped by karst topography, is a focal point of tourist aesthetic attention. In Huangguoshu's waterfall-centric landscape, tourists seek more than just the waterfalls; they control distance and angle to capture the synergy of "rolling hills-waterfalls in full flow-lush vegetation" in medium shots, resulting in the most frequent co-occurrence of "water and mountain landscapes" and "vegetation landscapes" in photos. Cultural nodes appear less frequently, indicating a tourist focus on natural rather than cultural landscapes in Huangguoshu. The site should enhance its cultural landscape offerings to showcase not only the unique natural beauty fostered by Guizhou's karst environment but also its distinct karst culture.

2) Tourist congregation at various Huangguoshu scenic spots exhibits seasonal cyclical changes. Across the seasons, the stability of tourist viewing preferences is evident, with hotspot popularity ranking from the Great Waterfall area to Tianxing Bridge, then to Steep Slope Pond, and finally other areas. Tourist concentration peaks in summer and disperses in autumn.

3) Tourists generally display positive emotions towards the Huangguoshu landscape, with an average sentiment score of 14.65. Sentiment analysis combining photos and textual reviews reveals that positive emotions are more frequently and intensely expressed than negative ones. Negative sentiments peak in the high season, primarily due to crowding caused by high visitor volumes, while in the off-season, they result from missing the flood season, leading to regret.

In the future, landscape aesthetic preferences should also incorporate multidimensional aesthetic perception. This study only uses images and texts from UGC data, leaning towards perspective cognition. However, natural aesthetics and artistic aesthetics are not the same. Natural aesthetics emphasize wholehearted participation, so aesthetic perception should not only come from perspective, but also be further studied by integrating multiple senses. Meanwhile, the data in this study comes from online evaluations and images. Tourists who upload relevant content on social platforms are mainly middle-aged, young, and highly educated groups. Therefore, although the research data has achieved a breakthrough in scale, the aesthetic preferences of the elderly

population are still ignored. Moreover, tourists cannot represent the public's attitude. In addition to tourists, research on the evaluation of natural beauty in scenic areas also needs to consider the aesthetic preferences of different stakeholders such as scenic area managers and indigenous people, in order to assist in the protection and development of subsequent scenic areas.

Acknowledgements

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