Targets of “Constant-holistic Shadow” Space Based on the Features of Different Requirements of Activities in Hot Summer Regions

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Abstract: When participating in the outdoor activities during the sunny and hot days in the regions with a hot summer, people are looking forward to staying in the “constant-holistic shadow” space which is always in shadow during the period of activities. It is necessary to set the targets of “constant-holistic shadow” space differently based on the different temporal-spatial feature requirements of varied types of activities. This paper has qualitatively compared the coupling degree of the three main factors of crowd outdoor activities in summer, analyzed the varied feature requirements of different activity types for the “constant-holistic shadow” space, and discussed the targets and setting methods of “constant-holistic shadow” space of the three typical activity requirements, so as to provide a basis for setting rational targets of the “constant-holistic shadow” space.

1 Introduction
Shadow space during outdoor activities in hot summer regions is popular among crowds because of its light and heat comfort, and also attracts the attention of domestic researchers in planning and architectural design, who have made some preliminary explorations[1]. Based on the relationship between sun shadow and the thermal environment of living areas, the concept of shadow rate of the proportion of shadow occupied area is put forward, and its characteristics and calculation methods are expounded[2], involving the preliminary quantitative analysis of shadow in residential area planning. From the perspective of improving comfort, microclimate and building energy efficiency, a preliminary method of using the shadow formed by buildings for outdoor activity space in the southern architectural environment is proposed, and the design is verified[3]. After comparing and summarizing the shading effects of several commonly used shading measures in urban outdoor public space, it is proposed to make full use of the shadow formed by high-rise buildings and combine them with other shading measures in a reasonable way[4]. Although planting can make up for the lack of shade, because massive planting is often not feasible, reasonable plant distribution is crucial[5].

Explorations on sunshine requirement involving shadows have been reported from time to time, such as the balanced utilization of sunshine resources in buildings, the idea of “all-day shadow detection line” proposed to coordinate the allocation of sunshine resources among plots by controlling the shadow rate of the detection line, the construction time sequence of first south and then north applied to planning and design conditions or regulatory detailed planning, and the establishment of concept of all-day sphere of influence and all-day shadow area related to time and time period[6]. In order to protect the residents’

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sunshine right, the article discusses the influence of the subject building on the sunshine of the object building, puts forward four methods to determine the scope of the objects, including the building shadow capture method, or clarifies the use conditions and scope of different subject and object determination methods based on the software simulation analysis of the case[7]. Based on the relevant simulation method to avoid the sunshine requirement of excessive shadow, the article explores the optimal layout method of buildings in urban grid[8]. In terms of spatio-temporal dynamics, some researchers have carried out temporal simulation of single building and single-day building shadow, and established the extraction tool of building shadow duration[9]. And some scholars have put emphasis on energy-saving simulation optimization in the early stage of building design, and developed the optimization algorithm of sunshine shadow[10].

At present, the preliminary exploration concerning outdoor shadow utilization mostly considers the influence of direct sunlight reflection at the peripheral surfaces of outdoor shadow space and micro-terrain of the shadow bearing surfaces (hereinafter referred to as “shadow forming conditions”) and designs responses, but little attention is paid to different requirement type features of crowds in outdoor shadow space during the target period. Based on different types of outdoor activities, through the coupling degree relationship, this paper discusses the significant differences in size of crowd gathering, psychological state of crowds and crowd displacement, etc., and expounds how to construct the “constant-holistic shadow” space that is always in the shadow during the activity period more reasonably and economically according to the requirement features of different activity types.

2 Crowd Outdoor Activity Attribute and Classification Features of Requirements of “Constant-holistic Shadow” Space

2.1 Main Factors of Outdoor Activities Affecting the Requirements of “Constant-holistic Shadow” Space
The main factors of common outdoor activities under the requirement of “constant-holistic shadow” space mainly include: size of crowd gathering (the representative value set as ‘α’), the psychological state of crowds (the representative value set as ‘β’) and the crowd displacement (the representative value set as ‘γ’). The three factors have a direct impact on the quality of requirement degrees of “constant-holistic shadow” space (the representative value set as ‘F’).

2.2 Types and Features of Requirement Degree of “Constant-holistic Shadow” Space Based on Main Factors
Influenced by the coupling of three main factors, there are mainly three typical types of activity requirements: global ordinary-quality requirement, global high-quality requirement and local high-quality requirement.

2.2.1. Global ordinary-quality requirement of “constant-holistic shadow” space
When the value $F_1$ is relatively large, which means, all three values $\alpha$, $\beta$ and $\gamma$ are large: big size of crowd gathering, the troubled psychological state of the crowd, and the long crowd displacement. Such occasions are represented by large-scale sports competitions, large-scale parades, etc. Such outdoor activities often have less requirements for the construction of “constant-holistic shadow” space, and their global “constant-holistic shadow” space have ordinary requirement for the quality.

2.2.2. Global high-quality requirement of “constant-holistic shadow” space
When the value $F_3$ is relatively small, which means, among the three values $\alpha$, $\beta$ and $\gamma$, one of them is large and the other two are relatively small:
   a. In case of big size of crowd gathering (the calm psychological state of the crowd and the short crowd displacement), such outdoor activities are represented by group picnics on weekends, etc.
   b. In case of troubled psychological state of the crowd (small size of crowd gathering and short
crowd displacement), such outdoor activities are represented by outdoor chess and cards activities, etc.

c. In case of long crowd displacement (small size of crowd gathering and calm psychological state of the crowd), such outdoor activities are represented by family leisure walking, etc.

In general, the outdoor activities similar to those mentioned above have high requirement for “constant-holistic shadow” space, and the global “constant-holistic shadow” space has high requirements for the quality.

2.2.3. Local high-quality requirement of “constant-holistic shadow” space

When \( F_2 \) is between \( F_1 \) and \( F_3 \), two of the three values among \( \alpha \), \( \beta \) and \( \gamma \) are large and the rest is small:

a. In case of a big size of crowd gathering, the troubled psychological state of the crowd, and the short crowd displacement, such outdoor activities are represented by large-scale keynote speeches, etc.

b. In case of a big size of crowd gathering, calm psychological state of the crowd, and the long crowd displacement, such outdoor activities are represented by large-scale outdoor exhibitions, etc.

c. In case of a small size of crowd gathering, the troubled psychological state of the crowd, and long crowd displacement, such outdoor activities are represented by cycling in greenways of relatives and friends, etc.

In general, the outdoor activities similar to those mentioned above have certain requirement for “constant-holistic shadow” space, and the local “constant-holistic shadow” space has high requirements for the quality.

![Venn diagram](image)

**Figure 1.** Venn diagram of the coupling relationship of main factors of outdoor activities under the requirement of “constant-holistic shadow” space

2.3. Relationship between Requirement Degree and Main Factors of “Constant-holistic Shadow” Space

From the above, it can be seen that there is significant interplay between quality and construction requirement (F) of “constant-holistic shadow” space have an obvious interaction relationship and the main factors of outdoor activities: as the sum of \( \alpha + \beta + \gamma \) increases, the value F becomes smaller. Venn diagrams are used to qualitatively express the relationship between F and \( \alpha + \beta + \gamma \) (as shown in Figure 1), defining the graphic area as F (\( F_3 > F_2 > F_1 \)), and \( \alpha + \beta + \gamma \) as \( \forall \alpha, \beta, \gamma \in (0, 1) \). The greater the value \( \alpha \) (or closer to 1), the bigger size of the crowd gathering, and vice versa. The greater the value \( \beta \) (or closer to 1), the more troubled the psychological state of the crowd, and vice versa. The greater the value \( \gamma \) (or closer to 1), the longer the crowd displacement, and vice versa. Although \( F_1 \) is
the smallest, it is the overlap area jointly controlled by \((\alpha, \beta, \gamma)\), and the quality and construction requirement of “constant-holistic shadow” space are the lowest at this time. Although \(F_3\) is the largest, it is only controlled by one factor and the quality and construction requirement of “constant-holistic shadow” space are the highest at this time. \(F_2\) which is between \(F_1\) and \(F_3\), is a pairwise overlapping area, and its quality and construction requirement of “constant-holistic shadow” space is also between \(F_1\) and \(F_3\), which is global ordinary quality. The qualitative relationship is as the following formula (1):

\[
F = f^{-1} = (\alpha + \beta + \gamma)^{-1}
\]

As can be seen from the above, \(F\) and \(f\) are reciprocal and are inversely proportional to each other. When there are more active factors at the same time or \(f\) approaches “3”, quality and construction requirement of “constant-holistic shadow” space is lower, and vice versa. Through the pre-judgment of the coupling degree of the three main factors including size of crowd gathering, psychological state of the crowd and crowd displacement, the quality and requirement of “constant-holistic shadow” space in different outdoor activities can be qualitatively analyzed, which can help to capture the necessary and suitable targets of “constant-holistic shadow” space with high matching degree in the dynamic temporal and spatial changes under the macro visual threshold.

3 Analysis of the Targets of “Constant-holistic shadow” Space Based on the Requirement Type Features

3.1 Temporal Analysis of the Targets of “Constant-holistic Shadow” Space

The dynamic process of the “constant-holistic shadow” space should be measured according to the outdoor activity time (or time period), including the start and end time as well as the duration of the activity. When the size of crowd gathering and the required space change during the outdoor activity period, for example, all positions are occupied during the waiting period before the start of the competition and the closing period, the temporal (duration) target of “constant-holistic shadow” space should be set according to the official start and end time period of the activity.

3.2 Spatial Analysis of the Targets of “Constant-holistic Shadow” Space

Based on the temporal and spatial differentiation of people’s stay, the target area of “constant-holistic shadow” space is determined to ensure the range of places where people stay for a relatively long time. Taking family greenway cycling as an example, when it is impossible to guarantee the global construction of “constant-holistic shadow” space in the greenway, the “constant-holistic shadow” space can be set in places where people stay for a long time such as rest sites for riders or midway sites for sightseeing. For another example, in the process of outdoor volleyball competition, the service area has higher quality and requirement of “constant-holistic shadow” space than that of the non-service area.

3.3 Analysis of the Target Groups of “Constant-holistic Shadow” Space

Different target groups have different qualities and requirements of “constant-holistic shadow” space. For example, from the perspective of age, young children have lower quality and requirement of shadow space than that of adults. From the perspective of occupation, outdoor sports professional groups have lower quality and requirement of shadow space than that of non-professional groups. In terms of the degree of crowd gathering, gathering of single person or several people has lower quality and requirement of shadow space than that of groups of many people.

4 Targets and Setting Methods of “Constant-holistic Shadow” Space of Typical Activity Requirement Types

Based on the coupling degree of the three main factors of outdoor activity type requirements, the targets of “constant-holistic shadow” space is analyzed, and then its emphasis aspects are determined, so as to set and lay out differentiated spatio-temporal dynamic space and improve the thermal environment of people’s outdoor activities in hot summer regions (as shown in Figure 2).
4.1. Targets of “Constant-holistic Shadow” Space of Global Ordinary-quality Activity Requirement Types

Jointly controlled by the three main factors, the global high-quality activities are characterized by high density or large scale of crowd gathering, active or noisy psychological state of the crowd and long-distance crowd displacement. The “constant-holistic shadow” space under the requirement of such activities has obvious constraints in objective factors such as economy and land for construction, and it is difficult to guarantee high-quality or continuous “constant-holistic shadow” space when setting the “constant-holistic shadow” space globally. When it is impossible to guarantee a continuous and full-time “constant-holistic shadow” space, we should strictly control the target period. When it is impossible to guarantee the global high quality of the “constant-holistic shadow” space, we should compare the target groups with higher requirement of shadow space. For example, in outdoor fields of large-scale competition in high-speed running, the official start and end time periods of the competition is the target time period, and the spectator seats and even the guest seats are the target groups.

4.2. Targets of “Constant-holistic Shadow” Space of Local High-quality Activity Requirement Types

Outdoor activities under the control of pairwise factors have higher requirements for the quality of “constant-holistic shadow” space as the coverage scale is reduced. The main purpose of creating the “constant-holistic shadow” space is to improve the thermal environment of outdoor activities in hot summer regions, and its quality measurement indicators are mainly the thermal comfort and psychological subjective feelings of humans inside the “constant-holistic shadow” space. Different types of shadow former can be selected to improve the apparent temperature in the “constant-holistic shadow” space (as shown in Figure 3), different shapes of shadow former can be set to optimize the necessary range of shadow coverage, and different layout modes of shadow former can be determined to obtain better full shadow period and space enclosure (as shown in Figure 4).

Figure 3. Temperature contrast of “constant-holistic Shadow” space with different shadow formers in hot summer regions[11]
4.3. Targets of “Constant-holistic Shadow” Space of Global High-quality Activity Requirement Types

Different from the previous two, with the decrease of the control surface of the main factors, the global high-quality activities have the least limitation and the highest requirement for the quality of “constant-holistic shadow” space. When the main factor of outdoor activities is the size of crowd gathering, such as group picnics during weekends, it is necessary to focus on the convenience of communication between people in the “constant-holistic shadow” space covering widespread groups during the start and end time periods of activities, and use the patches of plants for irregular interspersed or linear layout. When the main factor of outdoor activities is the psychological state of the crowd, such as outdoor chess and cards activities, efforts should be made to take care of the active psychological state of the crowd in the “constant-holistic shadow” space and set the layout mode of the shadow formers with weak enclosure. When the main factor of outdoor activities is the crowd displacement, efforts should be made to focus on crowd activities during the start and end time periods of activities, and select linear, aggregated or interspersed layout mode of “constant-holistic shadow” space according to the displacement path to build a global high-quality “constant-holistic shadow” space at the same time of spatial and temporal differentiation (as shown in Figure 5).

5 Conclusions

Different types of crowd activities have different requirements for “constant-holistic shadow” space, which are reflected in the requirement time (or time period), space size, shape, direction and quality, etc. The difference in requirements can be classified into different various types, and it is highly correlated with the type of activities. At the same time, the targets of “constant-holistic shadow” space should be appropriately, qualitatively and temporal-spatially matched with the coupling of three main control factors including size of crowd gathering, psychological state of the crowd and crowd displacement as differentiated settings, so as to scientifically, effectively and economically construct the “constant-holistic shadow” space during outdoor activities periods in hot summer regions.
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