

Research on the Impact Mechanism of Leisure Environment Quality on Spatial Vitality from the Perspective of Image-Text Fusion Perception: A Case Study of Nanjing

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Abstract:

The quality of the leisure environment is a critical factor influencing residents' leisure experiences and participation, and is closely tied to urban vitality and economic development (Štreimikienė, 2015; Janpavle et al., 2022). Understanding how environmental quality affects leisure space vitality is essential for promoting urban growth (Van et al., 2018). Current approaches to identifying the influencing factors of spatial vitality exhibit several limitations: (1) Many rely on expert knowledge to construct indicator systems (Tu et al., 2022; Gao et al., 2023), such as the 5D framework for the built environment. However, as urban spaces evolve rapidly and people's demands for environmental quality continue to change, these methods fail to offer timely and dynamic adaptability. (2) Spatial vitality is not only shaped by external factors like transportation systems and surrounding land use, but also by the intrinsic characteristics of the space (Liu et al., 2023). As Norberg-Schulz's (Norberg, 1979) theory of place suggests, both natural and built environments form a spatial place, and the distinctive features of a space can provide diverse experiences for individuals. Therefore, when exploring the factors influencing spatial vitality, it is crucial to consider both the intrinsic environmental attributes of the space and the subjective perceptual feedback from individuals.

This study adopts a human-centered approach to construct a research framework for exploring the relationship between leisure environment quality, as perceived through image-text fusion, and leisure space vitality. Online review texts from Dianping (<https://www.dianping.com>) and street view images from Baidu Street View (<https://ditu.baidu.com>) are employed to comprehensively assess the quality of the city's leisure environment. Natural language processing and semantic segmentation techniques are used to evaluate leisure environment quality, while mobile signalling data allows for the quantitative measurement of leisure space vitality through user trajectory semantic modeling. Finally, using an optimal parameter-based geographical detector (OPGD), an in-depth analysis is conducted to examine the impact mechanisms of individual environmental quality factors and their interactions on the vitality of leisure spaces, both at global and local spatial scales in Nanjing.

The findings reveal the following: (1) Leisure space vitality in Nanjing follows a "single-core, multi-center" distribution pattern. The vitality of the main urban area is concentrated around the Xinjiekou commercial district, while Jiangbei District exhibits a "three-point" pattern with interactions between the two ends and the center. In the Xianlin area, high-vitality zones are concentrated around the university town, and in the Dongshan area, they are distributed along the Shuanglong Avenue corridor. (2) On a macro scale, leisure space vitality in Nanjing is indirectly influenced by economic factors. On a local scale, the influence of 14 leisure environment quality factors on space vitality shows significant regional heterogeneity. However, in core areas at both the municipal and district levels with high leisure space vitality, the effects of these factors are all significant. (3) The formation mechanisms of leisure space vitality in Nanjing are closely related to regional geographical location, population density and composition, as well as economic income levels.

This study has significant theoretical and practical value in the field of urban spatial vitality. Theoretically, it confirms the significant impact of leisure environment quality—based on image-text fusion perception—on leisure space vitality. This research contributes to a more systematic and comprehensive understanding of the factors and mechanisms that influence leisure space vitality, and enhances the research framework for spatial vitality formation. Methodologically,

the study breaks from traditional factor selection approaches based on expert knowledge, uncovering the complex relationships between human-perceived environmental factors and leisure behaviour from a human-centered perspective. It provides a scientific basis for understanding how urban environments can better meet people's leisure needs, offering more humanized decision support for the optimization and planning of urban leisure spaces.

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