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A Machine Learning–Driven Study of the Impact of Pedestrian-View Street Spatial Form on Aesthetic Judgements: Commonalities and Differences in Judgements between Local and Non-Local Visitors and Their Implications for Urban Design
— A Case Study of a Tourist Pedestrian District in Luoyang, China

（歩行者視点の街路空間形態が美的判断に与える影響に関する機械学習を用いた研究：地元訪問者と非地元訪問者の判断の共通点と相違点、および都市設計への示唆――中国・洛陽の観光歩行者地区を事例として）

To support the effective reuse of ageing buildings in tourism-oriented urban street regeneration, this study investigates the influence of street spatial form on tourists' aesthetic judgments, aiming to maximise aesthetic perception while fulfilling the requirements of circularity and economic viability. It further provides a theoretical foundation and practical guidance for enhancing aesthetic experience in urban design. Building on this, the study establishes a theoretical framework and design recommendations for urban regeneration that prioritise aesthetics, circularity, and economic efficiency, while accounting for both differences and commonalities in aesthetic preferences between local and non-local tourists.

Taking the historic cultural district of Lijingmen in Luoyang, China—a typical pedestrian street with a strong tourism function—as the empirical case, the study systematically explores the influence of street spatial form on aesthetic perception from the pedestrian's perspective, with a focus on developing a corresponding evaluation framework. The research addresses the following key areas: (1) theoretical clarification of the concept and value orientation of the pedestrian perspective; (2) methodology for constructing street spatial form indicators; (3) empirical analysis of the relationship between spatial form and aesthetic evaluation; (4) development of a spatial form-based aesthetic value judgment model using street view data; and (5) design recommendations for urban regeneration informed by the findings. Additionally, by comparing survey data from tourists in Luoyang and Xi'an, the study analyses the aesthetic consensus and divergences between local and non-local tourists regarding street spatial form.

Methodologically, this study employs machine learning as a core approach. It integrates the ViT-Adapter semantic segmentation model trained on the ADE20K dataset and the MiDaS DPT depth estimation model to quantify spatial form indicators. Street view photographs and their corresponding sketch outlines were used as stimuli, and participants were asked to rate their aesthetic preferences based on these images. The aesthetic ratings and spatial indicators were then analysed using a Generalised Additive Model (GAM) to capture the complex, nonlinear relationships. The resulting aesthetic evaluation model was applied to systematically assess the aesthetic quality of all streets within the study area.

Through a comprehensive inductive research process, the study yields four main findings:

1)Establishment of a street regeneration theoretical framework based on the pedestrian perspective

This study is the first to clearly define the concept of the pedestrian perspective and use it as a theoretical foundation to build a design framework for the regeneration of tourism-oriented pedestrian streets. This framework proposes a systematic approach to enhancing aesthetic quality through spatial form, including: establishing the fundamental value of the pedestrian perspective in urban design; constructing a pedestrian-based spatial form–aesthetic evaluation index system; developing multidimensional predictive models to assess the combined influence of spatial elements on aesthetic perception; and enabling the quantitative evaluation of existing streetscapes' aesthetic effects.

2) Independent aesthetic effects of spatial form and its interaction with non-structural visual elements

The findings demonstrate that street spatial form possesses intrinsic aesthetic value, which can be identified and evaluated independently of non-structural visual elements (e.g., advertisements, people). However, interactions between spatial form and such elements also influence aesthetic judgments—positively or negatively—depending on the visual prominence of spatial features within the field of view.

3) Commonalities and differences in aesthetic judgments between local and non-local tourists

While aesthetic evaluations by local and non-local tourists share some common tendencies, notable differences also exist. Commonalities include the significant impact of three key spatial variables—street depth, sky visibility, and ground proportion—on aesthetic judgments, with nonlinear and interactive effects observed across both groups. However, in terms of differences, the stability of aesthetic ratings related to ground proportion varies significantly between local and non-local tourists.

4) Disparities between street-level and point-level aesthetic evaluations

Street-level aesthetic value (SAV) is generally higher than point-level aesthetic value (PAV), suggesting that holistic assessments more effectively capture the continuity and stability of spatial form. In contrast, point-level evaluations are more susceptible to local fluctuations and lack a consistent aesthetic foundation. As such, comprehensive assessments offer greater representativeness and applicability for evaluating streetscape aesthetics.

The findings of this study underscore the irreplaceable aesthetic value of street spatial form from a pedestrian perspective and its substantial potential in supporting urban regeneration goals that align with sustainability, economic viability, and visual quality. Moreover, integrating the interaction between spatial form and non-structural visual elements, acknowledging the aesthetic differences and convergences between local and non-local tourists, and balancing street-wide and point-specific spatial characteristics are all critical to improving the quality of tourism-oriented street regeneration. These insights provide a theoretical basis and evaluative framework for urban design practice, while expanding the research horizon for aesthetic-driven strategies in the renewal of tourism streetscapes.