Studies in Art and Architecture
ISSN 2958-1540
www.paradigmpress.org/SAA
Volume 4 Number 4 December 2025

# Research on the Perception of Community Public Space Vitality and Renewal Strategies Based on Deep Learning and Street View Data

**Tinghui You**[1]

[1] Gold Mantis School of Architecture, Soochow University, Suzhou 215009, China
Correspondence: Tinghui You, Gold Mantis School of Architecture, Soochow University, Suzhou 215009, China.

doi:10.63593/SAA.2025.12.01

**Abstract**

Community public spaces serve as essential venues for the daily activities of urban residents, and their level of vitality directly affects the quality of the living environment and the sustainability of urban development. To scientifically evaluate the vitality of community public spaces and propose targeted optimization strategies, this study integrates deep learning techniques with multi-source street view data to construct a vitality perception evaluation framework focusing on five core dimensions: aesthetics, recognizability, functionality, comfort, and safety. Taking two representative neighborhoods in Shanghai—one in the city center and one in the suburban area—as case studies, the research employs visual semantic segmentation to perform pixel-level analysis of street view samples, quantifying the proportions of spatial elements such as buildings, greenery, roads, and public facilities. These data are then combined with Point of Interest (POI) information for kernel density and diversity analyses. The results show that central urban neighborhoods perform better in pedestrian paving, street furniture, POI density, and road accessibility, indicating a higher overall vitality perception level. In contrast, suburban neighborhoods exhibit slight advantages in traffic signage but generally suffer from lower green visibility, encroached pedestrian spaces, and insufficient green and environmental facilities, which constrain spatial vitality. The findings suggest that both types of neighborhoods insufficiently address user experience. Accordingly, this study proposes four renewal strategies—enhancing walkability, improving environmental attractiveness, enriching functional services, and strengthening safety perception—to maximize the effectiveness of public space use and provide a scientific basis for the optimization of urban living environments.

**Keywords:** deep learning, street view data, community public space, spatial vitality, perception evaluation, renewal strategies

---

## 1. Introduction

As China's urban development shifts from incremental expansion to stock optimization, public demand for high-quality and vibrant community environments continues to grow. As essential venues for social interaction, leisure, and physical activity, community public spaces have become key indicators of urban livability and governance efficiency. Traditional methods for assessing spatial vitality—such as surveys and field observations—are often constrained by subjectivity, high cost, and limited spatial coverage. In recent years, the emergence of new forms of geospatial big data, represented by street view imagery, combined with artificial intelligence technologies, has provided a revolutionary means to objectively and extensively perceive urban spatial quality from a human-centered perspective.

Existing research based on street view data has achieved substantial progress, including the construction of multidimensional evaluation systems integrating POI and street view information to assess spatial quality around metro stations and commercial streets, as well as the application of semantic segmentation techniques for quantitative comparison of street space characteristics across cities. However, most studies have focused on macro-scale urban districts or transportation nodes, while research on the micro-scale vitality of community public spaces—particularly those employing deep learning for fine-grained perception—remains limited. (Durand J N L., 1986) As the fundamental unit of urban life, the vitality of community public spaces bears more direct relevance to residents' everyday experiences.

This study selects two representative neighborhoods in Shanghai—one located in the central urban area and the other in the suburban periphery—as case studies. It innovatively applies visual semantic segmentation, a deep learning technique, to analyze large-scale street view imagery, accurately extracting key physical elements that influence spatial vitality. Combined with POI and other functional data, a comprehensive evaluation framework is established to identify spatial vitality differences across neighborhood types, diagnose existing problems, and propose human-centered renewal strategies. (Weise G., 1953) The findings aim to provide data-driven insights and decision support for refined urban governance and community quality enhancement.

## 2. Research Subjects and Data Processing

### *2.1 Overview of Research Objects*

This study selects two types of representative neighborhoods in Shanghai with distinct characteristics as comparative samples.

Central Urban Sample:

Located in the core area of Shanghai, this district is a highly built-up zone characterized by high population density and mature mixed-use development. It integrates commercial, office, and residential functions, with intense use of public spaces. It serves as a typical example of a high-density community in the urban core.

Suburban Sample:

Situated in the suburban area of Shanghai, this district has developed along major transportation corridors, surrounded by large residential areas or university campuses. It forms a new community serving specific population groups. The area has relatively lower development intensity and a newer road network structure, representing the typical pattern of suburban community development under urban expansion.

The two neighborhoods exhibit significant differences in spatial morphology, functional composition, construction period, and population characteristics, offering strong comparative research value. Their total areas are approximately 190 hectares and 240 hectares, respectively.

### *2.2 Data Sources and Processing*

The study integrates three categories of core data:

Street View Image Data:

Based on the OSM road network, street view sampling points were set at 80-meter intervals within the study areas. A total of 447 panoramic street view images were initially collected. After removing redundant points caused by excessively wide roads, 383 valid sampling points were retained for deep learning analysis.

Spatial Base Data:

Urban road network and building footprint data were obtained from OpenStreetMap (OSM). After topological processing, they were used for grid partitioning and spatial analysis.

Functional Attribute Data:

Points of Interest (POI) data were collected via online map APIs, covering 13 categories such as catering, shopping, healthcare, and education. After data cleaning, 3,462 valid records were obtained, which were used to analyze the functional density and diversity of the neighborhoods. (Jia Qi Shen, Chuan Liu, Yue Ren & Hao Zheng, 2020)

## 3. Research Methods

### *3.1 Deep Learning-Driven Visual Semantic Segmentation*

This study employs advanced deep convolutional neural networks (CNNs), such as DeepLabv3+ and U-Net, to perform pixel-level semantic segmentation on street view images. (Chan, Yick Hin Edwin & Spaeth, A. Benjamin, 2020) After being pre-trained on large-scale street view datasets, the models were fine-tuned using image data from the study areas to ensure high segmentation accuracy. Each pixel in the image was classified into semantic categories including buildings, roads, sky, greenery, vehicles, street furniture, and traffic signs.

By calculating the proportion of pixels belonging to each category relative to the total pixel count, the method enables the automated and quantitative extraction of spatial elements. This provides an objective data foundation for subsequent analyses of urban spatial vitality and perceptual evaluation.

### *3.2 Construction of a Multidimensional Urban Vitality Perception Evaluation System*

Drawing on the analytical framework proposed a five-dimensional evaluation system for assessing the vitality of community public spaces. The framework integrates visual, functional, and environmental dimensions to comprehensively capture spatial perception:

- Aesthetic Quality: Reflects the visual attractiveness of the space, characterized by the pedestrian paving rate and street furniture installation rate.
- Legibility: Represents the spatial sense of orientation and readability, measured by the traffic signage installation rate, including signals and directional signs.
- Functionality: Evaluates the accessibility and richness of service facilities, quantified by POI density (number per hectare) and POI diversity (number of primary POI categories).
- Comfort: Relates to users' physical and psychological comfort, assessed through green view index (vegetation proportion), sky visibility ratio (sky proportion), and spatial enclosure degree (building wall proportion).
- Safety: Ensures the security and comfort of pedestrian movement, represented by pedestrian accessibility (sidewalk width to total road width ratio) and motorization level (carriageway width to total road width ratio).

This multi-criteria framework allows for a balanced assessment of both the physical and perceptual qualities of urban public spaces, bridging environmental design with human experience.

### *3.3 Spatial Analysis Methods*

Using a GIS-based analytical framework, kernel density analysis, overlay analysis, and buffer analysis were conducted to integrate spatial and visual datasets. (Wu J, Guo X, Zhu Q et al., 2022) The spatial distribution patterns of POIs were spatially coupled with the quantitative results derived from street view segmentation, revealing the clustering, dispersion, and differentiation characteristics of vitality-related elements across the study areas.

This spatial coupling analysis provides a clear and intuitive representation of how different environmental components interact to shape urban vitality, offering valuable insights for evidence-based urban renewal and design optimization. (Hillier, B., Yang, T. & Turner, A., 2012)

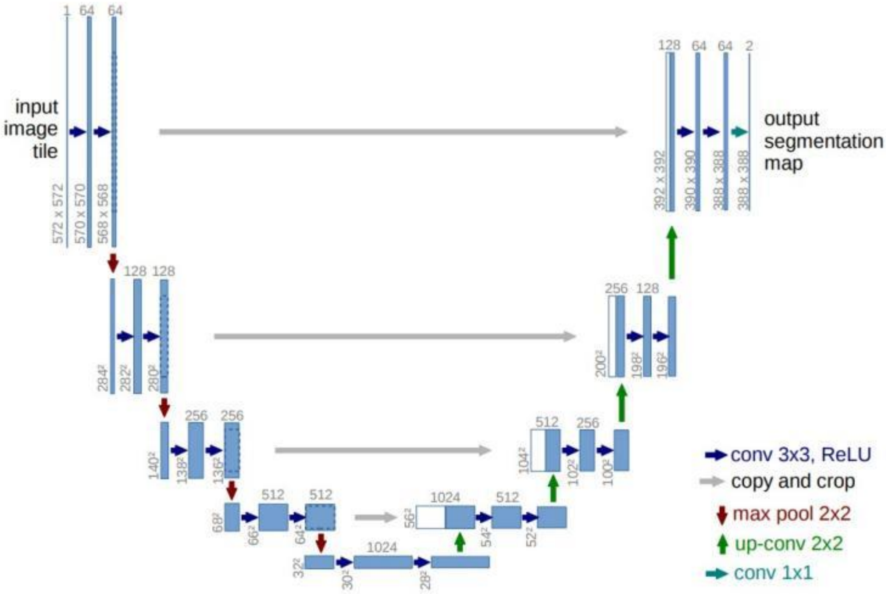


**Figure 1.** Deep Convolutional Neural Networks (U-net)

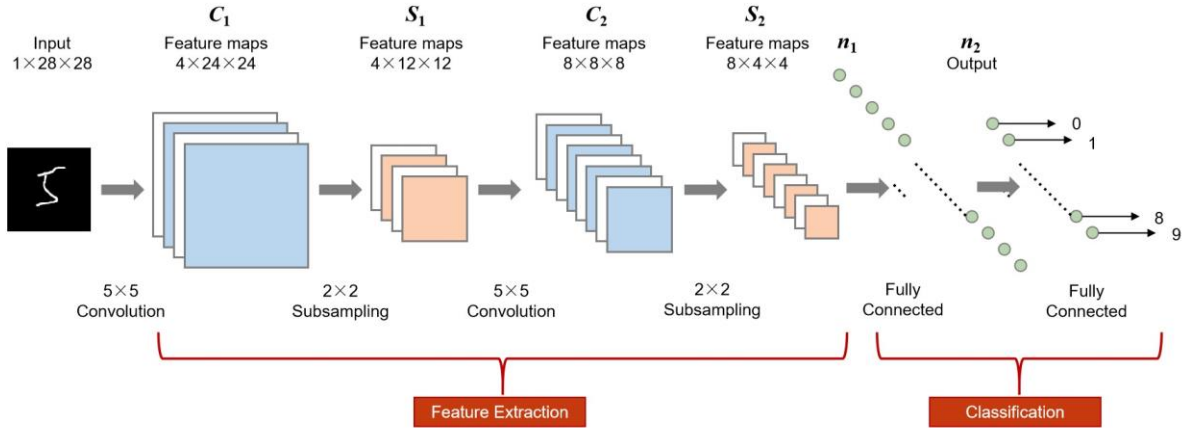


**Figure 2.** Deep Convolutional Neural Networks (CNNs)

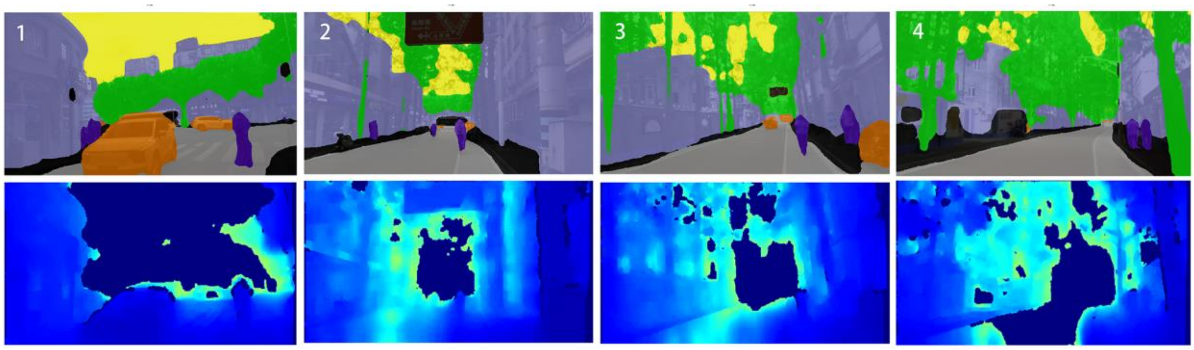


**Figure 3.** Semantic Analysis Results of Street View Images

## 4. Results

### *4.1 Overall Characteristics of Community Public Space Vitality*

Integrating the multidimensional indicators reveals a clear contrast in the vitality of public spaces between central urban and suburban communities in Shanghai.

The central urban area, supported by a high density of functional facilities and a well-developed pedestrian network, demonstrates a stronger overall vitality perception. However, both urban types exhibit notable weaknesses: the green view index is generally low (mean value of 4.15%), and traffic signage coverage is severely insufficient (mean value of 0.005%). These results reflect an overall lack of attention to spatial aesthetics, legibility, and ecological comfort in current community design.

*4.2 Comparative Analysis*

- Aesthetic Quality:

The central urban area shows a significantly higher proportion of pedestrian paving (4.25%) and street furniture (2.15%) than the suburban area (2.30% and 1.45%, respectively). This indicates a stronger investment in environmental details and human-centered facilities, contributing to greater spatial cleanliness and visual appeal.

- Legibility:

The traffic signage rate in suburban communities (0.006%) is slightly higher than in the central area (0.003%). This may be due to the simpler road network in suburban districts, where way finding systems are clearer, whereas the complex, dense street patterns in central areas may reduce signage visibility and effectiveness.

- Functionality:

The POI density in the central area (15.20 per ha) far exceeds that of the suburban area (2.30 per ha), with a more even spatial distribution, resulting in superior accessibility and convenience. In contrast, suburban POIs are clustered and unevenly distributed, leaving distinct service blind spots within the community.

- Comfort:

The sky visibility ratio in suburban communities (39.50%) is higher than in central areas (28.60%), offering a stronger sense of openness due to lower building enclosure. However, the green view index in suburbs (3.70%) remains lower than in the central area (4.60%), indicating room for improvement in ecological comfort and landscape quality.

- Safety:

The pedestrian accessibility ratio in the central area (20.40%) surpasses that of the suburban area (13.80%), while the motorization level is lower (14.50% vs. 18.40%). This suggests stricter control over vehicular traffic in central districts and better protection of pedestrian spaces. In suburban areas, sidewalk encroachment by parked vehicles remains a common issue, posing safety risks for pedestrians.

*4.3 Renewal Strategies for Community Public Spaces*

Based on the above analysis, this study proposes four strategic directions for enhancing community public space vitality:

- Enhance Walkability:

Optimize road cross-section design, widen sidewalks, and improve accessibility through barrier-free facilities. Enforce stricter control over roadside parking to ensure continuous pedestrian paths. Introduce rest areas, benches, and shading structures to enrich the walking experience.

- Strengthen Environmental Appeal:

Promote vertical greening and pocket park construction to increase the green view index. Improve paving materials and color coordination to create visually distinctive nodes. Enhance street cleanliness and maintenance to maintain a high-quality urban environment.

- Improve Functional Services:

Based on POI density analysis, fill service gaps by adding convenience stores, community canteens, and outdoor fitness facilities. Encourage diversified street-level commerce to stimulate local vitality and social interaction.

- Reinforce Safety and Legibility:

Install clear and visible traffic signage and wayfinding systems to improve spatial readability. Strengthen nighttime safety through improved lighting and open sightlines. Deploy smart surveillance and emergency response facilities to build a resilient and safe public environment.

**5. Conclusion**

This study demonstrates that integrating deep learning techniques with street view data enables a refined and objective assessment of community public space vitality. The findings reveal that while the central urban areas generally exhibit higher vitality, suburban neighborhoods possess certain advantages in terms of spatial openness. (Shibo Zeng, Gui Jin, Kaiyuan Tan & Xuan Liu, 2023) However, both types of communities require significant improvements in greening, safety, and aesthetic quality.

Future community renewal should abandon the traditional focus on construction over experience, and instead prioritize residents' daily use and psychological perception. By employing scientific diagnosis and precise interventions, cities can continuously enhance the quality of public spaces and ultimately achieve the development vision of "a people's city built for the people." The methodological framework proposed in this study offers valuable insights for community evaluation and renewal planning in other urban contexts.

**References**

Chan, Yick Hin Edwin and Spaeth, A. Benjamin. (2020, September 16-18). Understanding and Visualizing Generative Adversarial Networks in Architectural Drawings. *Architecture and Fabrication in the cognitive age–Proceedings of the 38th eCAADe Conference – Volume 2*, TU Berlin, Berlin, Germany, pp. 299-308.

Durand J N L. (1986). *Recueil et parallèle des édifices en tout genre, anciens et modernes*. Uhl.

Hillier, B., Yang, T., Turner, A. (2012). Advancing Depth-map to Advance Our Understanding of Cities: Com-paring Streets and Cities and Streets with Cities. In M. Greene, J. Reyes, & A. Castro (Eds.), *Proceedings of the Eighth International Space Syntax Symposium* (pp. K001:1–15). Santiago de Chile: PUC.

Jia Qi Shen, Chuan Liu, Yue Ren, Hao Zheng. (2020). Machine Learning Assisted Urban Filling. *Proceedings of the 25th International Conference on Computer-Aided Architectural Design Research*.

Shibo Zeng, Gui Jin, Kaiyuan Tan, Xuan Liu. (2023). Can low-carbon city construction reduce carbon intensity? Empirical evidence from low-carbon city pilot policy in China. *Journal of Environmental Management*, *332*, 117363.

Weise G. (1953). *Die Spanischen Hallenkirchen der Spaetgotik und der Renaissance*. I. Alt-und Neukastilien. Tuebingen.

Wu J, Guo X, Zhu Q et al. (2022). Threshold effects and supply-demand ratios should be considered in the mechanisms driving ecosystem services. *Ecological Indicators*, *142*, 109281.