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EXPLORING URBAN STREETScape DESIGN: COMPREHENSIVE REVIEW OF SCIENTIFIC RESEARCH

The purpose: to analyse and synthesize research on urban street space and the evolution of urban streetscape design concepts, tracing their origins, development, classifications, and design practices.

Methodology. The study conducts a historical and theoretical review of scientific and literary sources, employing methods of analysis, systematization, classification, and summarization of the obtained results.

Results. Classical theories of designing public spaces, as well as the development of concepts related to spatial perception and a human-centric approach in design, have been examined and analysed. The interaction of these theories with big data and artificial intelligence in the research and design of urban public spaces has been identified, revealing that such collaboration accelerates the emergence of cutting-edge theoretical and practical innovations.

Scientific novelty. Based on the analysis conducted, three main research directions in street space are identified and systematized: macro-level research, micro-level research, and research in urban design practices.

Practical significance: The results of this research establish theoretical foundations and outline directions for the future development of studies in the field of street space design. They can be utilized by architects and urban designers in the process of planning and design.

Keywords: street space, urban design, spatial perception, public space, streetscape design, environmental design.

Introduction. In the face of global urbanisation and the proliferation of cars, trams and other motorised vehicles, the attributes and characteristics of the original public space of the city have changed considerably. This phenomenon, known as "urban sprawl", is reflected in Chinese urban design as the suburbanisation of the urban core, closed urban transit traffic, large commercial complexes that destroy the original mechanism of the city, extended high-density residential environments, and large closed communities [1]. This logic of urban planning, with its emphasis on clear functional differentiation and motor-orientation, has resulted in public space being fragmented by numerous wide streets, and pedestrian space being divided into a multitude of fragmented corners by motor lanes and parking spaces. At the same time, on a microscale, residents are increasingly feeling the lack of living space, and foreign tourists are tired of the homogeneous landscape of the city. There is a growing demand for pleasant and vibrant spaces in traditional neighbourhoods. Since the 20th century, academics and local

governments have begun to gradually realise the various problems in urban construction, and design theories and methods for creating and renewing street space have been proposed, practised, validated and critiqued. By summarising the theoretical research and practical methods of street design worldwide, this paper is a compendium of the classical research theories, the latest research developments and practical case studies in academia and the design community.

Analysis of previous researches. In recent years, research on streetscape design has mainly focused on street measurement and evaluation, summarising street design practice cases, etc. There are relatively few studies on the system of combining the theory and practice of streetscape design in terms of temporal and spatial scales. W. Xiong and B. Liu [2] classified the research on environmental evaluation theory and index system of street space in recent years accordingly. Yi. Long, J. Tang [3] sorted out the progress of quantitative research methods of global street space quality through the measurement methods and evaluation methods

of street space quality. R. R. Jayakody, K. Keraminiyage, M. Alston & M. Dias [4] summarised the design elements, design methods and paths of shared-space streets through three streetscape design case studies in the UK. Yi. Wang, Q. Zhou, X. Yang et al. [5] classified urban streetscape types into six types based on pedestrians' subjective perspectives. Wenzhi Wu et al. made a comparative study of street design guidelines of ten cities in China and western countries, listing the differences and focuses of street space design principles and concepts in different countries. W. Wu, J. Lu, B. Zhao [6] made a comparative study of street design guidelines of ten cities in China and western countries, listing the differences and focuses of street space design principles and concepts in different countries. L. Bertolini [7] analysed different types of urban street space transformation experiments and developed an assessment framework for these space types.

Statement of the problem. Literature review studies of street space and streetscape design have focussed on case studies, comparative studies and quantitative methods. This paper hopes to make use of the macroscale and micro-scale of spatial observation, combined with the discourse and practice of streetscape design, to sort out and summarise the theories and methods of urban streetscape design after the 20th century. At a time when the living space of the street is disappearing, and the traditional cultural lineage and imagery of the city are dying, the spatial transformation of street space from "design for traffic" to "design for people" is an important issue now. The street design for people is not only for the residents, but also for the people. People-oriented street design not only provides basic communication space for residents, but also further develops more spatial functions, such as revitalising community commerce and enriching urban imagery. Therefore, it is necessary to compare and summarise the concepts, research methods and practice cases of streetscape design under different systems in Eastern and Western countries, so as to provide

a theoretical and methodological framework for the subsequent sustainable development of street space.

The results of the research and their discussion. Streets are a primary component of the urban public space system, forming the backbone of urban spatial morphology. They are also vital places where residents perceive the city's character and vitality. In the process of rapid urban development, the deterioration of the urban street environment due to urban sprawl and the development of motorised transport networks has been a concern for scholars from various disciplines. Scholars in different fields have studied strategies to maintain the vitality of urban spaces, seeking mechanisms to create pedestrian-friendly street spaces from multiple perspectives, and exploring theoretical breakthroughs and practical deepening of urban streetscape design.

1. Macro Research Approaches to Urban Space in the 20th Century. As an essential linear component of urban space, streets serve as the primary conduits for pedestrian traffic and interpersonal interaction. They are also a significant focus of study in fields such as design, architecture, landscape architecture, and urban planning, while simultaneously drawing attention from urban management processes.

Systematic theoretical research on streets can generally be traced back to the first half of the 19th century, when scholars from disciplines like architecture, sociology, and geography introduced morphological concepts into the realm of urban space research, forming the foundation for urban morphology theory. In the 1960s, Western scholars in the field of urban design began discussing the social effects, human-environment relationships, spatial aesthetics, and other aspects of street space. For instance, Kevin Lynch, in his 1959 book "The Image of the City", proposed the concept of "legibility" by observing five elements of the city: paths, edges, districts, nodes, and landmarks, which collectively create a graphic representation of the city's form [8]. Jane

Jacobs, in her work "The Death and Life of Great American Cities", emphasized that streets not only bear the responsibility for the safe operation of urban transportation but also serve as public and communal spaces for residents to engage in social activities [9].

Subsequently, the design field began to focus on the spatial organization of urban public streets, design techniques, and how to enhance the quality and vitality of cities through this fundamental element. For example, Jan Gehl introduced the theory that the quality of social activity spaces influences people's interactions and activities. William Whyte, in "The Social Life of Small Urban

Spaces", employed street filming methods to systematically record the activities of people on streets over time, comparing and analysing the gathering patterns in different public spaces to study the relationship between street quality and public space vitality [10]. Ashihara Yoshinobu, in "The Aesthetic Townscape", applied Gestalt psychology to introduce the concepts of positive and negative spaces and discussed the appropriate scale of street space using the height-to-width ratio [11].

These scholars recognized the significant impact of street quality on urban vitality and conducted qualitative research on street spaces from various theoretical perspectives (Tab. 1).

Table 1

Review of Macro Research of Streetscape in the 20th Century

Researcher	Time	Research object	Constituent elements/viewpoints
Kevin Lynch	1960	The image of the city	Path, boundary, node, area, landmark
Jane Jacobs	1961	Street vitality	Short streets, sufficient pedestrian density, mixing of main functions, and mixing of building ages
Jan Gehl	1971	Street vitality	Integration rather than separation, convergence rather than dispersion, openness rather than closure, invitation rather than exclusion
Yoshinobu Ashihara	1979	Street aspect ratio (D/H)	When D/H=1, the street ratio is appropriate When D/H>1, the street gives people a sense of alienation When D/H<1, the street gives people a sense of oppression
Kevin Lynch	1981	Street form evaluation	Vitality, sensation, suitability, accessibility, controllability, efficiency, and fairness
Allen B Jacobs	1993	Street spatial form	Clear street boundaries, continuous street landscape, street accessibility, building coordination and diversity, transparency, diversity of activities, pedestrian density, etc.
Montgomery	1998	Street vitality	Appropriate urban texture, humanized scale, urban blocks and permeability, public areas, green spaces and water features, street connections, appropriate density, mixed use, landmarks and visual stimuli and details, architectural style as imagery

2. Micro-Level Research Advances in Street space. In the latter half of the 20th century, research methods in urban public space often relied on researchers' subjective judgments and theoretical summaries, lacking a strong empirical foundation. This was mainly due to several factors: First, at the time,

information technology was not sufficiently advanced to explore crowd activities and spatial data indicators within neighbourhoods from a big data perspective, resulting in a lack of effective quantitative tools. Second, the spatial scale of the research objects, such as interior building spaces, exterior street spaces, and

connecting grey spaces, was quite micro, making data collection and observation challenging. Third, due to the extensive development of urban construction during specific historical periods, designers and researchers did not pay enough attention to the micro-perspective of street environments. Studies in this context often focused on larger-scale urban communities, emphasizing technical and social aspects of space. Consequently, research from a human-centric perspective on street space at the micro-level was lacking, underestimating the crucial role of different types of public spaces in urban vitality and quality.

With the rise of quantitative thinking in various disciplines, the field of street space research also began to focus on micro-level studies. Street spaces typically have some level of enclosure and are often defined by buildings or structures on both sides, creating linear public open spaces primarily divided into pedestrian and vehicular spaces, interspersed with trees, shrubs, and small public amenities. Existing quantitative research on public spaces generally uses the spatial elements of streets for data collection and measurement. Recent advancements in quantifying physical street space include four main categories:

Streetscape Research Based on Neighbourhood Survey Data. Traditional studies on spatial quality often rely on common methods such as statistical and sociological surveys and field investigations to collect information about street space elements and their characteristics. Field surveys and questionnaires, by conveying information from respondents, can summarize the physical features of different streets as well as the usage patterns and spatial perceptions of different groups of people. These methods are widely applicable and have high effectiveness. However, they are limited by their relatively small data collection scope. For instance, Yong Chen and Xinghua Zhao focused on commercial street spaces, particularly Huaihai Road, and collected data on pedestrian activities in

ground-floor commercial spaces to explore the relationships between variables affecting interactions between people and commercial interfaces [12].

Streetscape Research Based on Geographic Information Data. The widespread use of Geographic Information Systems (GIS) across various disciplines has created conditions for the quantitative study of block space characteristics and its environment at the city scale. Platforms like «Baidu Maps» and «Amap» in China, as well as «OpenStreetMap» globally, provide valuable geographical data for urban research. With the increasing availability of digital information on these platforms, the feasibility of studying street space in various dimensions using GIS has grown. Researchers use GIS to study street vitality by measuring aspects such as block density, accessibility, street width, and more, based on different types of points of interest. For example, researchers like Ying Long conducted large-scale block measurements in cities like Beijing and Shanghai using points of interest, covering data indicators related to block density, block accessibility, street width, and more [13].

Streetscape Research Based on Live Street Pictures. Street view images, forming image databases based on human visual perception, have become a new research method for obtaining street space data. They offer advantages such as convenient data collection in large quantities and independence from natural conditions like location, time, and weather. Internet-based map services have also introduced urban street view features, providing researchers with easier access to information. Today, street view maps are widely used as effective means of measuring street space.

Moreover, the advent of the big data and artificial intelligence era has introduced new trends, including the application of intelligent recognition, image segmentation, and machine learning to street space environment research. Researchers can automatically identify and

classify numerous image data with computers, creating databases of street elements that can be used for further research. For instance, by analysing the visual elements of street images (vegetation, sky, fast and slow road surfaces, motorized and non-motorized vehicles, pedestrians, public furniture and other elements of urban design etc.), researchers can calculate their proportional distribution and quantitatively analyse the spatial quality and vitality of linear streets.

Streetscape Research Based on Three-Dimensional Building Data. As a linear enclosed spatial form, streets are influenced by various factors, including the proportion, scale, colour, shape, texture, and real-virtual relationships of buildings and structures on both sides. These factors affect visual perception and human perception. Researchers like C. Harvey used three-dimensional scale data of these buildings and structures, employing computer algorithms to automatically identify road centrelines, road boundaries, and boundary facades. This allowed for the quantitative measurement of 12 street space element variables related to building morphology and street space. These variables included street width, continuity of the building skyline on both sides, the number and height of buildings on both sides, the width-to-height ratio of street space to surrounding buildings, and the visual curvature of the street [14].

3. Research on Street Design Practices.

During the period of extensive development of urban construction, streets mainly adopted the red line management model in upper-level planning. This management model was often considered a bottom-line logic planning method. Its purpose was mainly to avoid the "worst design" rather than pursue the "best design" and "good planning". As China's urban construction enters a new development process, higher-level planning levels have gradually become aware of some problems with planning methods, and the "people-oriented" urban development concept has

received attention. Therefore, urban design represented by streets and acupuncture-style urban renewal based on microscale observation have gradually become an important issue in urban construction.

The concept of Shared Streets Space (SSS) first appeared in the concept of "Inclusive Multi-functional Road Design" first proposed by Buchanan in his 1963 book "Urban Transportation", and was applied to urban traffic. It laid the foundation for the later street sharing model [15]. Complete Streets was proposed by David Goldberg, head of the Smart Growth Alliance, which advocates improving pedestrian and bicycle facilities and encouraging people to walk, bike or take public transportation.

In 2002, San Diego in the United States released the first guidelines for the "Complete Streets" concept. In 2004, London, England released the "Streetscape Design Guide – Better Streets", which is generally considered by academic circles to be the first mature, complete and influential guideline and proposed an initiative to build London into the world's leading pedestrian-friendly city. In terms of the overall strategy and design update method, the guideline proposes six attributes, liveability, accessibility, safety, durability, openness, and sustainability [16]. In 2005, the National Complete Streets Alliance was established, and the Complete Streets movement spread rapidly across the United States; by 2012, 125 communities across the United States had adopted Complete Streets policies. Complete streets fully consider the needs of walking and non-motorized vehicles encourage walking and public transportation to give priority, and make the distribution of urban road rights more balanced.

The Active Streets movement, which grew out of the Complete Streets movement, is even more visionary. It regards street space as a kind of urban public space, improves the quality of the urban environment in many ways, and enhances economic vitality and social cohesion. Vibrant Streets combines public space creation

and cultural preservation with the participation of people in street design and construction. The spatial environment design of the street focuses on forming characteristics to enhance the recognition of the street. Vibrant streets focus on improving street functions, facilities and pedestrian environment, improving walking convenience and comfort, thereby increasing the proportion of walking trips on the street, increasing the attractiveness of street space and activities, and increasing the diversity of people's activities.

In Western countries, improving the vitality and liveability of neighbourhoods has also been an ongoing urban issue, with governments, parliaments, NGOs and residents involved in proposing and improving strategies for urban design and regeneration. Numerous famous cities have put forward and improved initiatives, declarations and strategies for friendly street spaces.

Copenhagen, the capital of Denmark, launched the "Copenhagen Bicycle Policy" (2002–2012) and "Copenhagen Bicycle Strategy" (2011–2025) in 2001 and 2010 respectively, with the aim of promoting the use of street-friendly spaces. The aim is to promote low-carbon mobility, while at the same time introducing policies to limit the development of small cars. Copenhagen has also been adhering to the public Transport-Oriented Development (TOD) mode, so the "Finger Plan" model was created in this context, five radial rail corridors and urban development along the land and green space between the corridors, and continues to be interlocked with the neighbourhood bicycle system, forming the famous bicycle-friendly low-carbon city. The city is known as a bicycle-friendly, low-carbon city. Another example is the Tokyo Bay Area, a metropolitan area with more developed public transport, whose street design guidelines emphasise the importance of prioritising the construction of pedestrian and cycling zones in streets, while at the same time developing public transport. For example, New York issued the New York Vibrant Streets Design Guidelines

in 2009, proposing the construction of more vibrant, green and attractive streets to improve the quality of life of the people; the guidelines are divided into five major parts: user manuals, geometry, materials, lighting, and furniture [17].

In China, street design guidelines have also been issued to guide streetscape design, and in October 2016, the Shanghai Street Design Guidelines were issued, with "complete streets" as the core concept and "people-centred" as the primary goal, with highlights such as convenience, efficiency and attention to vulnerable groups, while focusing on local culture [18]. In September 2018, the Beijing Urban Design Guidelines for Street Renewal and Governance were released to the public, highlighting the local architectural and spatial characteristics, protecting the city's cultural lineage, and enhancing the aesthetics of the environment in the design guidelines for Beijing as an important historical city (Fig. 1).

In summary, since the beginning of the 21st century, urban planners, users, and regulators have collectively shifted their focus to human-centred urban development. They have advocated and implemented numerous declarations and examples of resident-friendly streets. Simultaneously, excellent street design and renewal projects require not only the expertise and aspirations of managers and designers but also precise scientific data, analytical methods, and measurement techniques. These theories, analyses, and design experiences combined can better implement construction concepts such as green, innovative, open, and shared, promoting the creation of safe, liveable, and sustainable friendly living environments in cities with different backgrounds and at different times.

Conclusion. In the era transitioning from extensive urban development to meticulous design and renewal of urban spaces, streets have evolved beyond being mere passageways. They have become pedestrian-friendly neighbourhood spaces grounded in human-centred thinking, or become a spiritual place for tourists to learn about the city culture. Thanks

to urban design, streets now need to serve as places for conversation, entertainment, relaxation, and social interaction for people of different age groups and professions.

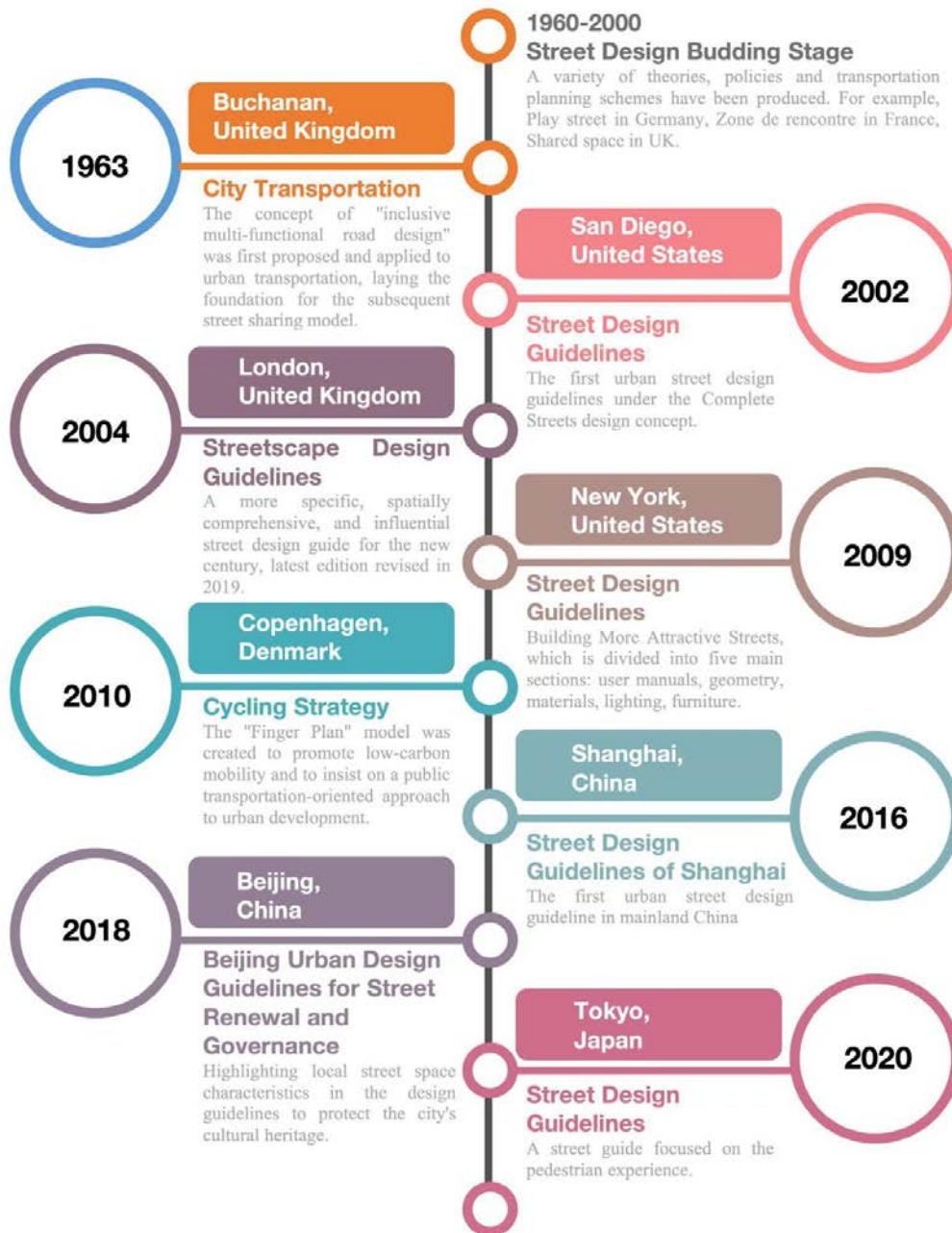


Fig. 1. Timeline of Global Urban Street Design: Guidelines and Practice

Existing research encompasses multifaceted qualitative studies that arise from interdisciplinary collaboration. For instance, early social scientists, architects, and urban researchers interpreted the classic theories of street space from various perspectives during the Industrial Revolution and the era of humanism. Urban designers and social practitioners, from that period to the present

day, have developed diverse theoretical frameworks related to street design through the implementation and review of design projects. These theoretical frameworks continue to evolve.

As the field of data processing and artificial intelligence continues to advance, there is an increasing variety of methods for acquiring streetscape research data. These

methods include live street pictures, three-dimensional spatial data, or geographic information data. At the same time, starting from the United States and the United Kingdom, streetscape design guidelines have been compiled based on different street design concepts. These systematic guidance frameworks have been continuously practised

and verified in street spaces in cities around the world, and different types of design cases have been accumulated. These techniques and practices help to enrich research methods aimed at improving the quality of streetscapes and contribute to the creation of comfortable, functional and aesthetically pleasing designs for street spaces.

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ВИВЧЕННЯ ДИЗАЙНУ АРХІТЕКТУРНОГО СЕРЕДОВИЩА МІСЬКИХ ВУЛИЦЬ: КОМПЛЕКСНИЙ ОГЛЯД НАУКОВИХ ДОСЛІДЖЕНЬ

Мета: проаналізувати та узагальнити дослідження міського вуличного простору та еволюцію концепцій міського вуличного дизайну, відстежити їх походження, розвиток, класифікації та дизайн-практики.

Методологія. У дослідженні проведено історико-теоретичний огляд наукових та літературних джерел із застосуванням методів аналізу, систематизації, класифікації та узагальнення отриманих результатів.

Результати. Розглянуто та проаналізовано класичні теорії проектування громадських просторів, а також розвиток концепцій просторового сприйняття і людиноцентричного підходу в дизайні у поєднанні з великими даними та штучним інтелектом. Виявлено, що така взаємодія у сфері дослідження та дизайну міських громадських просторів прискорює появу передових теоретичних та практичних інновацій.

Наукова новизна. На основі проведеного аналізу виділено та систематизовано три основні напрями дослідження вуличного простору: дослідження на макрорівні, дослідження на мікрорівні та дослідження міської дизайн-практики.

Практичне значення. Результати цього дослідження створюють теоретичні основи та окреслюють напрями розвитку подальших досліджень у сфері дизайну вуличного простору і можуть бути використані архітекторами та міськими дизайнерами у процесі планування та дизайну.

Ключові слова: вуличний простір, міський дизайн, просторове сприйняття, громадський простір, вуличний ландшафтний дизайн, дизайн середовища.

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