Seeing the Built Environment and People: Urban Design through Digital Profiling of City Dwellers

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Abstract: China's large-scale urbanization has made the recurring urban-design demand to understand both the built environment and its users increasingly important, while multiple digital technologies have advanced in parallel. This interaction is a major line in the contemporary evolution of urban-design science and supports a more human-centered discipline. This paper reviews theoretical changes in urban design and urban-population research, traces the multidisciplinary origins of profiling, and explains the role of digital population profiles in recognizing individuals as subjects, reconstructing the human-city community, and linking large and small data. Planning projects demonstrate multiscale applications and their operational challenges. The paper concludes by identifying future directions in population profiling, intelligent prediction, and digital urban design for human-city symbiosis.

Keywords: urban design; digital population profiling; human-city community; big data; human-centered planning

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1 Why Profile Urban Populations?

1.1 A New Urban-design Demand to "See the Built Environment and People"

Urban design historically concentrated on physical form. Classical aesthetics, ideas of harmony between people and nature, axial order, geometry, and dimensional control shaped Chinese and Western practice, from the Zhou Li and Vitruvius to the Forbidden City and the Acropolis [1]. Nineteenth-century plans for Berlin, Paris, and other cities continued to emphasize architectural form. Rapid industrial urbanization later exposed the limitations of this object-centered approach. Large-scale disorder, high-vacancy new towns, traffic congestion, environmental decline, and unequal services require urban design to explain how diverse people actually use space.

Contemporary urbanization also intensifies the recursive relationship between people and cities. Human activity produces urban space, while urban environments condition behavior, perception, opportunity, and social relations. Network society [2], smart-city research [3], and the historical evolution of design technologies [4] have widened the scope of urban design. The discipline now needs methods that connect physical form with individual and group needs without reducing users to a single average resident.

1.2 New Trends in Research on "Urban People"

Research on urban people has moved from aggregate social categories toward the dynamic patterns of individuals and groups. Sociology interprets division of labor and social organization [5], complexity science views cities as adaptive systems [6], and planning has reconsidered its contemporary mission [7]. Historical household registration provided an early administrative portrait of urban populations [8], while current research emphasizes civilization, diversity, and communities with a shared future [9]. Digital methods can now connect demographic attributes with activity, mobility, emotion, and spatial preference [10-12].

2 From Population Portraits to Digital Profiles

2.1 Multidisciplinary Origins

Population profiling draws on demography, sociology, geography, psychology, behavioral science, planning, and computer science. The cognitive revolution redirected attention toward perception and decision processes [13-15]. Urban analysis subsequently combined surveys, observation, interviews, registration data, spatial syntax, and environmental measurement [16-19]. Each method captures a different relationship between people and place, but conventional studies often remain limited in sample size, temporal coverage, or their ability to represent repeated everyday behavior.

2.2 Technological Change under New Urban Science

Mobile positioning, points of interest, social media, sensors, remote sensing, street-view images, and platform records have enabled continuous observation of large populations. Data-adaptive urban design demonstrates how large datasets can support pedestrian systems and public-space networks [20]. Scientific paradigms also change when new instruments make previously invisible relationships measurable [21]. In urban design, big data can describe dynamic, static, explicit, and latent dimensions of urban life [22].

2.3 Digital Profiling as a Lens on Human-city Relations

A digital profile is a structured representation of population attributes and behavior. It links natural attributes such as age and sex, social attributes such as family, education, occupation, and income, territorial attributes such as residence and mobility, and activity dimensions including type, frequency, duration, distance, time, and travel mode. Subjective measures of satisfaction, well-being, and preference complement observed behavior. This framework identifies heterogeneous needs and translates them into spatial requirements for residence, employment, daily services, and transport [23-24].

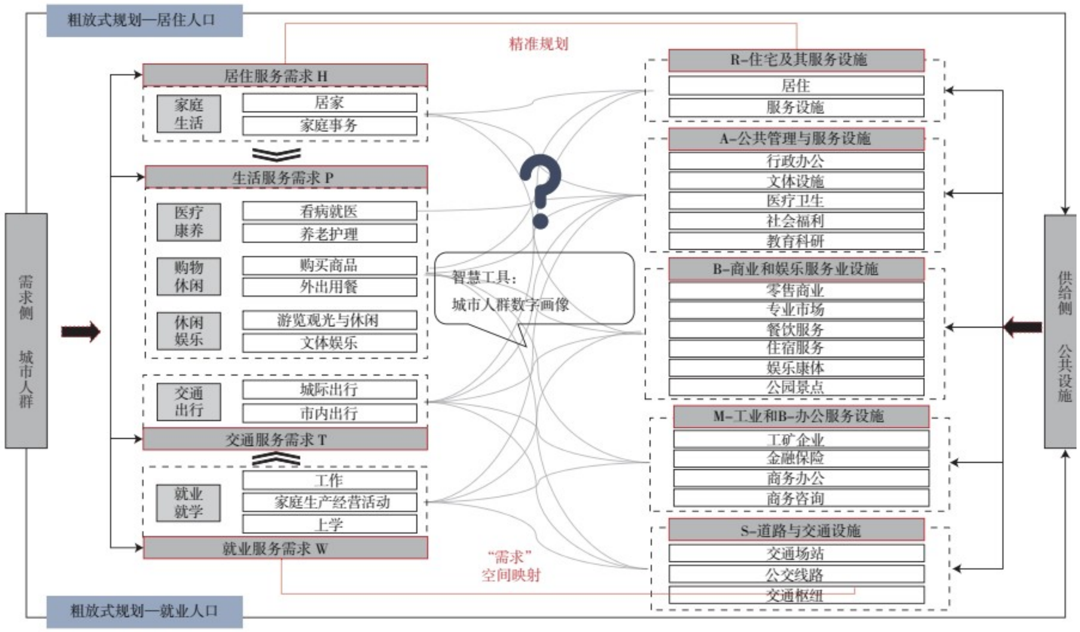

Fig. 1 Supply and demand elements in the "human-city" community

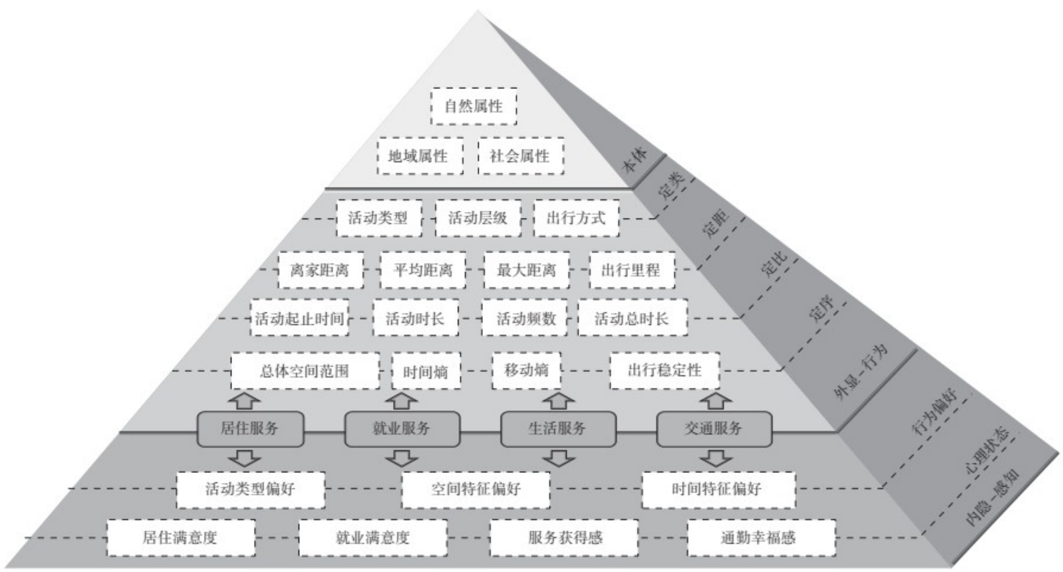

Fig. 2 Attribute system of digital population profiles

3 Scientific Mechanisms for Digital-profile-based Urban Design

3.1 Recognizing the Individual as the Subject

Traditional planning converts heterogeneous populations into broad residential or employment totals. Digital profiles retain differences in daily schedules, destinations, mobility capacity, life stage, and service dependence. They therefore reveal why similar built environments produce different experiences and why equal quantities of facilities do not necessarily generate equal accessibility. Urban design can use these distinctions to move from generalized provision toward population-specific spatial responses.

3.2 Reconstructing the "Human-city Community"

People and space interact through residence, work, services, transport, and leisure. Profiles connect population demand with the quantity, accessibility, functional mix, and spatial arrangement of facilities. Residential and employment behavior describes stable daily anchors; shopping, recreation, and public-space use reveal flexible preferences; commuting indicates the strength of connections among anchors. Joint analysis explains whether the urban supply system supports actual patterns of life and helps form an ordered, mutually supportive human-city community.

3.3 Linking Observation and Iterative Design through "Large-small Data Feedback"

Large datasets provide broad temporal and spatial coverage but may omit intentions, informal behavior, and vulnerable groups. Surveys, interviews, observation, and participatory design provide depth but cover fewer people. Combining the two enables large-data pattern discovery, small-data interpretation, design generation, simulation, post-implementation observation, and renewed adjustment. This feedback process supports evidence-based iteration while retaining multiple subjects and local knowledge [25-28].

4 Applications in Urban Design

4.1 From Fine-grained Behavior Simulation to Street Design

At street scale, digital profiles combine pedestrian counts, activity purposes, travel routes, stay duration, and temporal peaks. Simulation can compare existing and proposed conditions, identify bottlenecks and inactive edges, and test how entrances, public-space widths, ground-floor uses, crossing facilities, and waiting areas redistribute footfall. A project around Nanjing's Drum Tower used this process to compare pedestrian density before and after design and to refine street-space allocation.

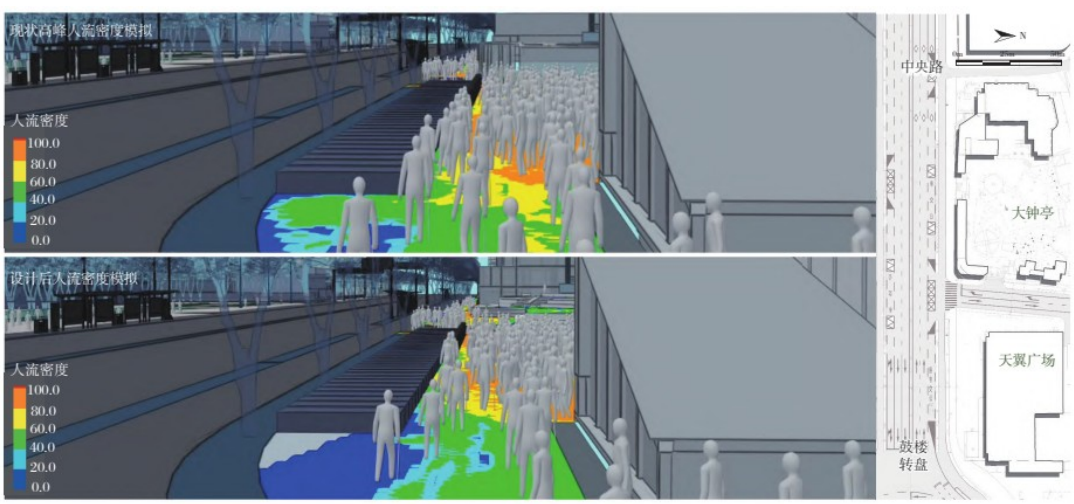

Fig. 3 Pedestrian-flow simulation at street scale before and after design

4.2 From Heterogeneous Everyday Needs to District-scale Design

At district scale, profiles distinguish workers, residents, visitors, older people, children, and service users. Their daily chains reveal when and where public spaces, commercial facilities, community services, and transport connections are needed. Overlaying activity radii with facility distribution helps locate missing links and supports coordinated design across neighborhoods instead of isolated site improvements.

4.3 Community Courtyard Modules Based on Typical Population Needs

Community projects can translate typical profiles into modular interventions. Public courtyards may be connected to support group activities; open courtyards can provide continuous movement routes and flexible facilities; enclosed courtyards can improve privacy and everyday services. Digital portraits clarify which combinations respond to time-specific and group-specific needs and help align detailed design with local behavior.

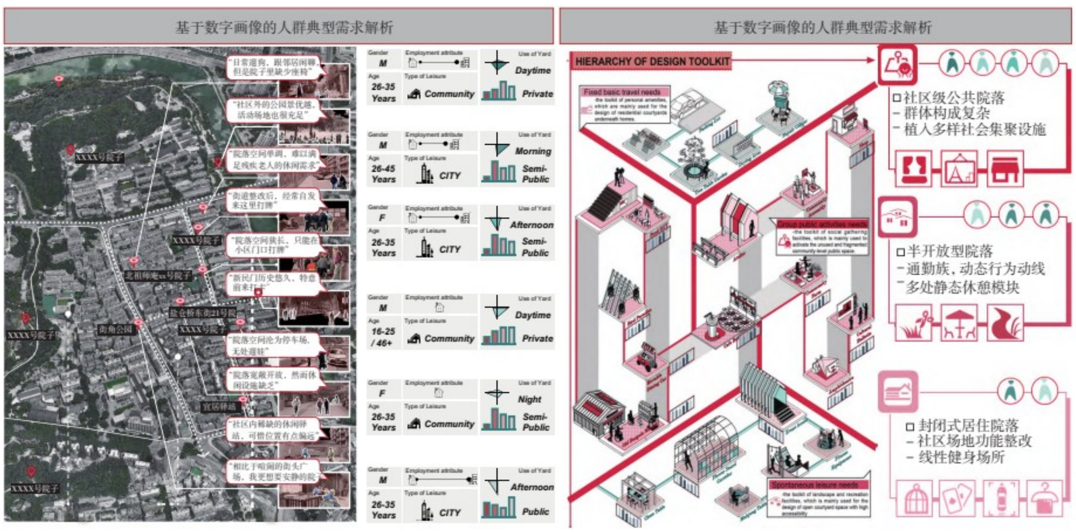

Fig. 4 Community courtyard design modules based on digital population profiles

4.4 Deconstructing Living-circle Behavior for Citywide Design

A citywide project used six months of mobile location-based service data covering about two million people and 18,752,065 daily records, together with land-use and POI data. Residence, employment, and leisure anchors were identified in a three-dimensional time-space-behavior framework. Clustering 147 profile results produced fourteen typical groups. Their activity radii and destination patterns revealed mixed, aging, weakly commercial, and single-function areas, as well as mismatches between neighborhood edges and actual mobility. The analysis supported differentiated public transport, commercial, recreational, and community-service strategies.

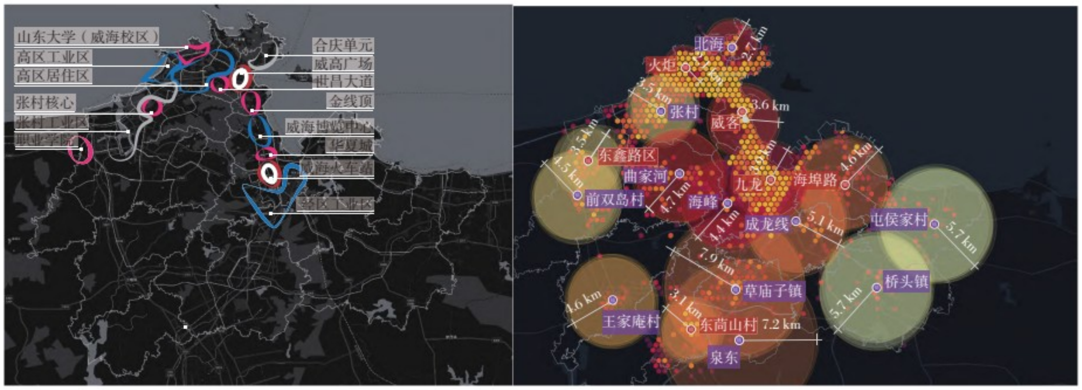

Fig. 5 Deconstruction of living-circle behavior based on digital population profiles

5 Prospects

5.1 Personalized Spatial Customization

Future urban design should coordinate population needs with spatial supply at the level of individuals and groups. Digital profiles can combine broad behavioral data with questionnaires and expert interpretation to identify dynamic networks and spatial requirements. Personalized provision does not imply designing separately for every person. It means recognizing recurring differences and creating adaptable environments that accommodate multiple life courses and temporal patterns.

5.2 Artificial Intelligence and Rapid Profile Evolution

Complex measurement models, multi-agent systems, and artificial intelligence can extend profiling across larger populations and improve prediction. Machine learning may reveal relationships between group attributes and material space, simulate future behavior, and evaluate design scenarios. The priority is transparent modeling, careful validation, and protection against biases in platform data. Used responsibly, these tools can improve the digital, precise, systematic, and personalized character of urban design.

5.3 Digital Urban Design for Human-city Symbiosis

Digital profiling supports a full-process urban-design approach from diagnosis and co-design to implementation and evaluation. It can help explain urban problems, match facilities with behavior, and create feedback between spatial change and social response. The method remains under development, but it offers a practical route toward urban environments that recognize individuals, sustain diverse communities, and improve the quality and vitality of cities.

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