Modelling human movement and access to greenspace in x-minute cities requires holistic, interdisciplinary approaches

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Abstract:

1. Introduction

Urban development since the industrial revolution has often prioritized productivity over liveability, leading to sprawling cities with limited focus on pedestrian networks and green spaces. Recent research, however, underscores the importance of these elements in urban environments. Urban ecosystems, including green and blue spaces, provide essential ecosystem services that contribute to positive health outcomes. Despite their benefits, there is a noticeable lack of equal access to these greenspaces, especially in the context of income inequality and historical planning cultures. The concept of the 'x-minute city' has emerged as a solution to improve urban living, advocating for essential services and amenities, including greenspaces, to be accessible within a short walk or bike ride from every household. This concept encompasses four dimensions: proximity, density, diversity, and digitalization, and calls for a holistic approach in urban planning that integrates greenspace accessibility within this framework. Previous studies that have attempted to model the x-minute city have relied heavily on proximity-based and density-based analysis—measuring the number of amenities within a distance threshold, or density—to quantify the accessibility of services in the city. However, these methods often overlook the complex systems associated with urban movement and its variation between demographic groups and areas of the built environment. We propose Multi-context Inclusive City (MIC) models which combine elements from spatial interaction models, human mobility networks, and movement ecology to provide a comprehensive understanding of human movement within the x-minute city.

2. From Minimal to Comprehensive Interactions: Connecting People and Nature

2.1 Spatial Proximity-Based Approaches

These approaches are foundational in defining the x-minute city, utilizing geographic information science (GIS) techniques to map and define spatial accessibility. Examples include defining '15-minute walk zones' for greenspace accessibility and 'service areas' around buildings. While straightforward, these methods often lack temporal elements and overlook individual preferences and behaviours.

2.2 Behavioural Ecology Approaches

These approaches examine the motivations behind movement choices in urban environments, drawing parallels with animal foraging behaviours. Models like the optimal foraging theory and marginal value theorem can provide insights into how individuals choose destinations based on benefits like greenspace quality and crowding.

2.3 Population Mobility Models

These models study movement patterns at a broader level, incorporating concepts like the gravity model and intervening opportunities law. These models help understand how proximity and availability of amenities influence people's decisions to visit certain locations, balancing quality against distance.

2.4 Individual Mobility Models

Individual mobility models delve into more personalized movement patterns, emphasizing individual preferences and constraints. The Exploration and Preferential Return (EPR) model, for example, balances exploring new locations and returning to familiar ones, capturing a more nuanced picture of urban mobility.

3. Building a Holistic Framework: The Multi-context Inclusive City Model

Each of the models in these groups, in isolation, offer urban planners and policymakers valuable perspectives on distinct aspects of human mobility and spatial accessibility, allowing them to focus on specific dimensions of urban environments. However, while a standalone model might cater to certain scenarios, the combination of these models into what we define as Multi-context Inclusive City (MIC) models not only enriches our grasp of urban dynamics but also ensures an insight into the intricacies of urban systems and the multifaceted nature of human behaviours. This comprehensive approach is instrumental in modelling the complex interplay between various elements of urban life, creating a more nuanced understanding of urban systems, allowing us to better capture the four key dimensions of the x-minute city. In this context, various approaches could be merged, leading to the creation of four distinct categories of MIC model: GIS-Behavioral Ecology, Human Mobility-Behavioral Ecology, GIS-Human Mobility, and a combined GIS-Human Mobility-Behavioral Ecology model. Each MIC model category enhances our understanding of city movement from different perspectives.

4.1 GIS-Behavioral Ecology Model

There are some situations in which stakeholders will be focused on understanding how environmental factors and human social behaviors influence movement in the city. In this case, an MIC model that integrates GIS with behavioral ecology models (which we refer to as GIS-BE) could be developed. For example, when planning new urban greenspaces, urban planners may aim to optimize both access and usage by residents. GIS methods could be applied for mapping potential greenspace locations incorporating urban density, existing infrastructure, and areas lacking greenspace, as well as assessing the accessibility of the current and proposed greenspace. The behavioral ecology models could then be incorporated into these structures to predict how different demographic groups might use the proposed greenspace by understanding the choices people make about which greenspace to visit, considering travel time, quality, and crowdedness.

4.2 Human Mobility-Behavioral Ecology Model

HM-BE models focus exclusively on the dynamics of individual movements within urban settings. These models provide a deeper, more nuanced understanding of the motivations behind people's movements. By integrating individual human mobility data, qualitative survey information, social media analytics, and movement ecology theory, these models can be tailored to specific urban scenarios. Predominantly relying on network analysis, HM-BE models utilize nuanced parameters extracted from the available data, ensuring an accurate reflection of urban dynamics. Leveraging real-world data, these models facilitate the construction of a synthetic representation of urban movement patterns, thereby enabling precise modelling of fine-scale movements within the city.

4.3 GIS-Human Mobility Model

The third MIC model category, known as GIS-HM, synergizes human mobility modelling with GIS-based spatial analysis. The GIS-HM model simplifies the integration of fine-scale urban movement analysis with spatial analytics and network analysis. This model is particularly suited for examining broader movement patterns of individuals in a city, as it emphasizes a data-driven approach using human mobility data and synthetic trajectory models over the qualitative, behavioural insights integral to the GIS-BE model. The GIS component enriches the model by providing an intricate understanding of the physical urban landscape, thereby enhancing the spatial context of the mobility data. This blend results in a comprehensive, quantitatively grounded perspective on urban mobility dynamics.

4.4 GIS-Human Mobility-Behavioral Ecology Model

Integrating all perspectives results in the GIS-HM-BE model, the most comprehensive of the MIC models. This model intricately combines the spatial analytics of GIS, the behavioral insights from movement ecology, and the quantitative rigor of human mobility models. Fundamentally, GIS-HM-BE adheres to the principles of the preceding MIC models: GIS maps the urban landscape, human mobility traces individual movement patterns, and behavioral ecology deciphers the underlying decision-making processes. However, GIS-HM-BE's unique strength lies in its holistic approach. It adeptly navigates the complexities of urban movement by accounting for both the spatial context—demographics, socioeconomic status, neighborhood segregation, transportation networks—and the individual behavioral context—motives for movement, personal preferences, and social interactions.

While GIS-HM-BE offers unparalleled detail and complexity, its application is contingent on computational feasibility and the specific demands of the research question or project. It is not always necessary or practical to employ all three perspectives, especially if a simpler MIC model category suffices. Nevertheless, the primary goal of these models is not to replace but to enhance existing approaches, such as contributing to the creation of an urban digital twin to test potential modifications before they are enacted.

5. Conclusion

The x-minute city concept, with its focus on proximity, density, diversity, and digitalization, requires a multifaceted approach to fully capture the dynamics of urban movement. MIC models offer this comprehensive framework, enabling urban planners to create more sustainable, inclusive, and health-promoting urban landscapes. Future efforts should focus on empirical testing, validation, and community engagement to ensure these models accurately reflect the complexities of urban living and effectively guide the development of more liveable cities.