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A novel design-based framework for enhancing the application of urban design in the CIM platform

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Abstract:. The New Urban Agenda (NUA) promotes a "smart city approach" employing digital twins and City Information Modeling (CIM) for transparent, interactive data platforms to facilitate sustainable urban development. Nevertheless, the current CIM implementation lacks the creative impetus needed for effective urban design. This study proposes two approaches to enhance CIM's urban design framework. While application integration and intelligence are focal points, data accuracy remains a challenge. Urban design, explored in tangible/spatial and intangible/non-spatial dimensions, demands precision. The study underscores the imperative for CIM to support both dimensions, enabling analytical applications and support stakeholders in the urban design process.

Keywords: framework; CIM platform; urban design; application; tangable/spacial and intangible/non-spacial

1. Introduction

As a result of the complex nature of urban systems, it has been challenging for humans to fully and methodically understand the objective patterns and rules of space [1]. NUA encourages “smart city approaches” [2] as a strategy to address the various environmental, economic, and social effects of rapidly growing cities and to achieve sustainable urban development. This approach utilizes digital and advanced technologies to create a transparent accessible and interactive data platform to facilitate the exchange and dissemination of information among various urban stakeholders and support urban planning and design [2]. The introduction of the digital twins has provided new opportunities for the advancement of smart cities. Digital twins are virtual recreations of the physical world and can be used to represent the physical structure of complex systems like cities [3,4]. The platforms of digital twin cities become more prevalent among researchers, planners, and decision-makers as novel tools for designing and managing short and medium-term plans [3–6]. The development of digital twin cities revolves around the use of city information modelling (CIM), and the CIM platform serves as a tool to access urban data and essential facility networks for urban construction and management [4,6,7]. CIM excels in city management and offers robust evidence-based decision support; however, it falls short in fostering the creative impetus necessary to drive the urban design process.

2. Method

This study aims to explore the role of CIM platforms in high-density urban areas fostering human-centred urban design. Given the diverse dimensions of urban design, ranging from the macro level of cities to the micro level of neighbourhoods, this research seeks to facilitate the advancement of knowledge in this field. In tackling the question of how a CIM can provide urban designers with relevant information to actively and efficiently engage in urban development, our investigation employs a dual strategy.Two approaches can be taken to develop the framework of the CIM for urban design in this research. The firts approach entails enhancing the current models and data factors within existing platforms to align with the demands of urban design across multiple platforms.

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The second approach entails the identification and summarization of supplementary urban design factors pertinent to the city centre by conducting a comprehensive literature review.

3. Application of Urban Design in the CIM platform

The growth (expansiosn) of CIM aligns seamlessly with the principles advocated by NUA, emphasizing the promotion of innovative digital technologies capable of significantly enhancing urban design and planning processes.Although the opinions on CIM vary among practitioners, however, the general agreement is that CIM is a valuable, indispensable idea that serves as a central focus for professionals engaged in digital urban design [8].

3.1. Outline of CIM and CIM platform

3.1.1. CIM and its platform

CIM is becoming an important base model for Smart and Digital Twin Cities, which can realise city design and management [9]. Several municipal administrations in Asia and Europe have recognized the significance of CIM in enhancing public services and elevating the overall standard of living in cities[10]. These models have been constructed and distributed (mostly) on accessible platforms to enable other cities to gain insights from their experiences.

While a definition of CIM remains elusive, the construction of platforms involves the incorporation of physical spatial components of the city. These components are represented through various tools like GIS, BIM and data gained from ICT technology.

The CIM platform is a simulation service designed to facilitate the dynamic operation of urban areas. The city structure is conventionally organized into several key layers, including the facility layer (comprising the perception and transport layer), as well as the data processing, service, and application layers.

3.1.2 Two CIM Platform Types

The platform name varies in different cities. In Singapore, it is a “Virtual Singapore”, the platform facilitates simulations and virtual testing of novel solutions for urban planning challenges. Hangzhou, China, has the “City Brain”, the software system that uses artificial intelligence and data collection for cities management.

CIM platforms can be classified into two distinct types. The first relies on a 3D geographic information model that is equipped with comprehensive city-wide data. This mode necessitates a substantial initial capital investment and demands the collaborative efforts of all relevant agencies. China's Xiong'an New Area is now being constructed using this style. The second utilizes a 2D or 3D geographic information model that incorporates domain-specific urban spatial data, like transportation, infrastructure, and greening. This model establishes the spatial governance framework for the domain, such as the London Tree Map. This particular model requires minimal funding and can be managed by a few departments. Additionally, it allows for the establishment of several avenues for public involvement.

3.1.3 CIM Platform Development Stages

The implementation of essential technologies in CIM can be categorized into three stages: data aggregation, application expansion, and application integration and intelligence [11](Table 1). As CIM advances, the data on the CIM platform becomes extensive and the model's accuracy improves. This facilitates the application of CIM in various urban construction fields and opens up opportunities for the business development of humanscale urban design.

Table 1. CIM characters in different stages

Stage	Key Technology	Main Tasks	Application
Stage 1	Big data, Cloud storage, Internet of Things technology, BIM, GIS	Aggregation of all kinds of urban data	
Stage 2	Artificial intelligence, cloud computing	Application ability exploration and research of CIM	Visualization Urban management
Stage 3	Data fusion technology, Data mining technology	integrate with each application system, realizing intelligent application	Data service support

3.2. Application of urban design in the CIM platform

3.2.1 The trends of urban design research

The interdisciplinary nature of urban design and the blurred boundaries with the disciplines of planning and architecture have made it a constant source of debate[12,13]. Through an examination of the research conducted by twelve prominent scholars in urban design, Stefano et al. [12] observe that these scholars collectively prioritize the concrete aspects of the tangible dimension of urban design, that is, its material relevance in the shaping of urban forms the city, while a minority place greater emphasis on the intangible dimension, including the social, cultural, and symbolic significance. In this perspective, Ye[14] categorizes the two elements as spacial and non-spacial, without making a distinction between them in this study.

3.2.2 Urban Design Research for CIM

The field of urban design encompasses the examination of both urban form and urban life. Within the framework of CIM, the examination of urban form focuses on explicit buildings or spaces, a domain in which designers excel. Conversely, urban life primarily pertains to the subjective spatial perceptual experiences of individuals, constituting an analysis of implicit elements. In other words, CIM can incorporate both spatial analysis of urban form and non-spatial assessment of perception and behaviour exhibited by city residents, hence facilitating the application of urban design principles. The model that represents spatial analysis is a simulation that closely resembles actual things, whereas the representation of non-spatial assessment is achieved via the interpretive analysis of diverse data.

3.3 The framework of Uran Design in the CIM platform

According to the aforementioned research, advancements in urban design discipline and technology have enabled the CIM platform to offer data service support for urban design. The CIM platform must generate both tangable/spacial and intangible/non-spacial data required for urban design.

Currently, the data on tangable-spacial in the CIM platform primarily consists of models, such as GIS and BIM. These models were originally used for urban management and planning, but their precision at the human scale is insufficient for urban design. Therefore, it is necessary to refine the data.Intangeble/non-spacial data encompasses a diverse range of inform intangeble- nonspacial ation that must be integrated with ongoing urban design research to enhance the incorporation of social, cultural, and other data. This integration will create a data pathway that facilitates analysis for urban design purposes.

Utilize the benefits of CIM information modelling to further advocate for public involvement in urban design. This is the process of articulating public opinions by analyzing extensive datasets, among other methods.

4. Conclusion

The framework of this research concept is formed by amalgamating the advantages of contemporary urban design research trends and information platforms. The use of tangible/spacial and intangible/non-spacial dimensions in urban design will provide convenience for people involved in urban design.

CIM has significantly enhanced urban research and can streamline urban design operations under modern technology circumstances. In the realm of urban design, there has been a transition from focusing on facilitating platform construction and providing data modules for these platforms, to emphasizing the acquisition of various types of information required for urban design from CIM.

Urban design research has shifted its focus from tangible/special aspects to in-tangible/non-spacial aspects to non-physical and intangible aspects. Advancements in technology have facilitated the improvement of expressing the content of physical and tangible aspects, while the data generated enriches research on the latter.

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