Research on urban architecture design based on the concept of smart city

Junwei Zhu

School of Arts, Design and Architecture, University of Plymouth, Devon, PL4 8AA, UK

Abstract: With the rapid development of information technology and the advancement of urbanization, the concept of smart city has gradually become the core element of urban planning and architectural design. This paper first introduces the basic concept and development background of smart city, and then analyzes the principles and methods of urban architecture design under the concept of smart city in detail. Through case studies, this paper discusses the application and effect of smart city building design in practical projects. Urban architectural design based on the concept of smart city should cover intelligent infrastructure, environmental protection and energy saving design, humanized interactive experience, data-driven design decisions, safety protection system, flexibility and adaptability, interdisciplinary integrated design, and the integration of culture and history. These suggestions will help build an efficient, green, humanistic and intelligent modern city and create a better living environment for residents. This study believes that the architectural design integrating the concept of smart city is not only reflected in advanced technological means, but also reflected in profound thinking about the ecological environment and human society.

Keywords: smart city; urban architecture design; sustainable development

1. Introduction

Throughout the development of human cities, architecture has always had a profound impact on the evolution of urban form. With the advent of the information age, traditional urban construction and architectural design have gradually evolved from traditional architecture dominated by materials, technology and economy to architecture in smart cities. From the concept of smart city to the present, there have been a lot of related theories and practices. Most of these are related to public administration or information technology, while traditional architectural theories have little to do with smart cities. Smart city has the characteristics of informatization, integration and globalization, in this context, the environment, the city, the building have gained new connotations, for the future architecture, this is both an opportunity and a challenge. This study uses literature research, case analysis and other methods to conduct in-depth analysis and discussion on the relevant theories and practices of smart city architectural design, aiming to explore the principles and methods of urban architectural design under the concept of smart city, analyze its application effect in practical projects, and provide useful reference and inspiration for future urban architectural design.

2. Connotation of smart city and smart building

Smart city refers to the urban development model that uses information and communication technology (ICT) and smart technology to carry out intelligent management, services and innovation in all aspects of urban operation.[1] The core of smart city is to improve the efficiency and quality of urban operation and promote the sustainable development of the city through data-driven decision-making and intelligent technology. Smart city is a complex system project, which covers information technology, government affairs, economy, environment, transportation, medical care, education and security. Only comprehensive and coordinated development of these aspects can realize the wisdom of the city, so that citizens can enjoy a more convenient, efficient and safe life. The construction of smart cities first relies on a strong information technology foundation. This includes the application of advanced technologies such as cloud computing, big data, the Internet of Things, and the mobile Internet, which provide solid data support and efficient computing and processing capabilities for the intelligence of various areas of the city.

There is no unified definition of intelligent building. The American Intelligent Building Association,

founded in 1986, defines smart buildings as: "By connecting and optimizing the four basic elements of the building structure (built environment structure), system (intelligent system), service (living, various needs of users) and management (property operation management), we can provide a reasonable, efficient, comfortable, warm and convenient building environment, and achieve the purpose of adding value."[2] American architecture scholar Jim Sinopoli said in his book Smart Buildings: "The essence of intelligent buildings is to integrate all advanced systems, including building automation, life safety and remote communication systems, and jointly serve a more comfortable and convenient living environment. (See Figure 1)"[3]
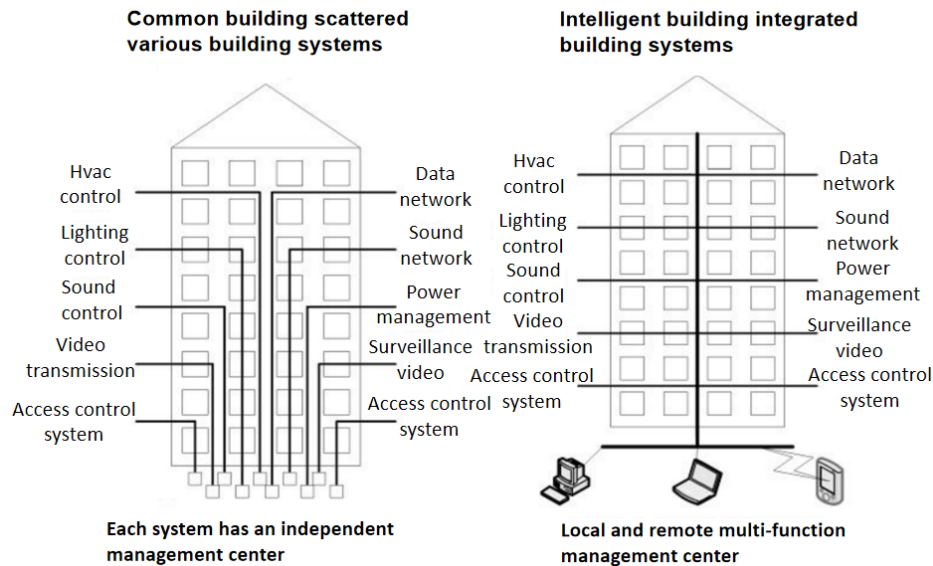

Figure 1: Comparison of the management of ordinary buildings and intelligent buildings[4]

3. Significance of urban architectural design research under the concept of smart city

At present, urban architecture design is faced with many challenges. Traditional design methods often neglect the multi-dimensional interaction between architecture and urban environment, society, culture and so on. At the same time, with the increasing problems of population growth, resource shortage and environmental deterioration, how to design buildings that not only meet the functional needs but also adapt to the future urban development trend has become an urgent problem to be solved. Introducing the concept of smart city into urban architectural design can make the architectural design more in line with the overall requirements of urban development. By integrating intelligent technology into architectural design, it can not only improve the functionality and use efficiency of buildings, but also promote the harmonious symbiosis between buildings and the surrounding environment.

3.1 Improve the level of urban intelligence

The architectural design combined with the concept of smart city can enhance the intelligent level of the city through the application of intelligent building systems, Internet of things and other technologies. The application of these technologies can make buildings better adapt to the needs of urban development and realize the optimal allocation and efficient utilization of resources. In addition, the architectural design under the concept of smart city not only focuses on the function and beauty of the building itself, but also focuses on improving the quality of life of residents. Through the application of intelligent technology, residents can be provided with a more convenient and comfortable living environment and services.

3.2 Promote sustainable urban development

The architectural design under the concept of smart city can provide strong support for the innovation of urban management mode. Through the application of intelligent technology, urban management can be refined, intelligent and efficient, and improve the level and efficiency of urban management. At the same time, the architectural design combined with the concept of smart city can enhance the overall

competitiveness and attractiveness of the city. Intelligent and green architectural design can attract more investment and talent inflow, promote the economic and social development of the city, and these buildings have become an important part of urban culture, showing the characteristics and charm of the city. Finally, the architectural design under the concept of smart city pays attention to the environmental protection, energy saving and sustainable development of buildings. By adopting green building materials and energy-saving technologies, the negative impact of buildings on the environment can be reduced and the sustainable development of cities can be promoted.

3.3 Promote the integration of technology and architecture

Introducing the concept of smart city into architectural design can promote the deep integration of technology and architecture. Through the use of advanced scientific and technological means, the innovation and breakthrough of architectural design can be achieved, and the technological progress and development of the construction industry can be promoted. In short, urban architectural design research based on the concept of smart city not only helps to promote the innovation and development of the construction industry, but also helps to enhance the overall competitiveness and attractiveness of the city, and achieve sustainable development of the city

4. Challenges and problems faced by urban architectural design

4.1 Unreasonable spatial layout planning

With the acceleration of urbanization, urban spatial layout planning is facing unprecedented challenges. How to rationally arrange various types of buildings and public Spaces in the limited urban land, ensure the functionality and aesthetics of the city, and avoid overdevelopment and the emergence of "urban disease" is the primary issue facing urban architectural design. In addition, with the increase of urban population, traffic congestion and inadequate infrastructure have become another major problem in urban architectural design. How to design a reasonable traffic network, optimize traffic flow, and ensure the perfect and efficient infrastructure is an important factor that must be considered in urban architectural design.[5]

4.2 Insufficient ecological and cultural protection

In the context of global climate change and increasingly serious environmental pollution, urban architectural design needs to pay more attention to ecological environmental protection. How to meet the urban development, reduce the negative impact on the environment as much as possible, to achieve green buildings and low-carbon life, is an important task facing urban architectural design. At the same time, with the advance of urbanization, many buildings and areas with historical and cultural value are at risk of being demolished or destroyed. How to integrate the concept of cultural and historical protection into urban architectural design and protect and inherit the cultural heritage of the city is an aspect that cannot be ignored in urban architectural design.

4.3 Challenge of sustainable energy utilization

With the intensification of energy crisis and the deepening of the concept of sustainable development, sustainable energy utilization has become an important consideration in urban architectural design. How to use renewable energy such as solar energy and wind energy to reduce building energy consumption and achieve sustainable energy utilization is the direction that urban architectural design needs to explore. At the same time, urban architectural design also needs to consider economic factors and cost issues. How to control construction cost and achieve the balance of economic and social benefits under the premise of ensuring building quality and functionality is the challenge that urban architectural design must face.[6]

4.4 Lack of technological innovation and integration

With the continuous progress and innovation of science and technology, urban architectural design needs to constantly introduce new technologies, new materials and new processes. How to integrate these technological innovations into urban architectural design effectively and improve the performance and quality of buildings is a problem that urban architectural design needs to solve.

5. Suggestions on urban architecture design based on the concept of smart city

5.1 Intelligent infrastructure

(1) Intelligent transportation system planning

Intelligent transportation system is an important part of smart city infrastructure. Through the intelligent transportation system planning, it can realize the intelligent control of traffic signals, the optimal selection of vehicle routes, the efficient scheduling of public transportation, etc., effectively alleviate traffic congestion and improve travel efficiency.

(2) Construction of information service platform

Information service platform is an indispensable part of smart city architectural design. Through the construction of a unified information service platform, the integration and sharing of various types of urban information can be realized, and the transparency and efficiency of urban management can be improved. In addition, the smart security system is an important guarantee in the design of smart city buildings, through the application of high-definition monitoring, face recognition, intelligent alarm and other technologies, can effectively enhance the city's security capabilities and protect the personal safety of citizens.

(3) Iot device integration

On the one hand, smart city architectural design needs to build an efficient data processing center to realize the collection, storage, analysis and application of various types of urban data. Through the data processing center, real-time monitoring and early warning of urban operation can be realized, providing scientific basis for urban planning and management. On the other hand, iot devices are the key to realizing smart cities. By integrating various types of sensors, actuators and other iot devices into the building design, the intelligent control and management of the building can be realized, and the comfort and convenience of the building can be improved (See Figure 2).
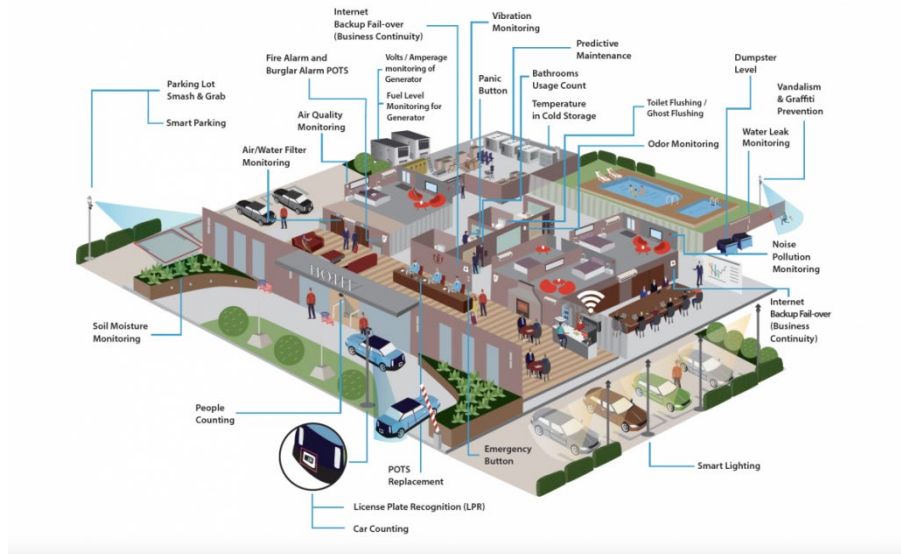

Figure 2: Iot smart building capabilities[7]

5.2 Function Layout Planning

The primary task of urban architecture design is to carry out functional layout planning. This includes the reasonable division of various functional areas, such as commercial areas, residential areas, industrial areas, public green Spaces, etc., to meet the different needs of urban residents. At the same time, it is also necessary to consider the connection and transition between various functional areas to ensure the integrity and coordination of the city. First of all, in the functional layout planning, land use and space planning is the key link. It is necessary to rationally arrange the proportion and layout of various types of land according to the city's development goals and demand analysis results. For residential land, commercial land, industrial land and other different types of land, detailed planning and layout should be carried out to ensure the rationality and efficiency of land use. At the same time, we should also

consider the spatial form and landscape style of the city, and shape the urban spatial pattern with characteristics. Secondly, according to the traffic needs of the city and the road network, reasonable planning of traffic flow lines to ensure smooth and safe traffic. At the same time, it is also necessary to consider the configuration and layout of parking Spaces to meet the parking needs of residents. By optimizing traffic flow and parking design, urban traffic efficiency can be improved and traffic congestion can be alleviated. Finally, in the functional layout planning, the layout and service radius of various supporting facilities should be fully considered to ensure that residents can easily enjoy various services. At the same time, it is necessary to establish a perfect service system, improve service quality and efficiency, and meet the diversified needs of residents.

5.3 Application of innovative technologies

Innovative technology is an important driving force for the development of smart cities. In urban architectural design, we should actively explore and apply new technology, new materials, new technology and other innovative technical means to promote the innovation and development of urban architectural design. For example, the use of BIM technology to realize the digitization, visualization and collaboration of architectural design; Using 3D printing technology to realize the rapid manufacturing and assembly of building components; Using smart home technology to realize the intelligent and comfortable living environment. For example, concrete 3D printing technology is a process method that uses 3D printing technology to build building structures layer by layer with concrete as printing material. It converts the graphic design model of the building into a 3D printing path, and uses the printing system to accurately layer the fabric, layer by layer superposition and accumulation to achieve formation-free construction. This technology has the advantages of high efficiency, flexibility and energy saving, which provides new possibilities for urban architecture design. On the one hand, concrete 3D printing technology makes the spatial layout of buildings more flexible and efficient. Designers can design a unique space layout according to the actual needs through computer modeling to achieve personalized design. On the other hand, concrete 3D printing technology can precisely divide functional areas, making the transition between various areas more natural and smooth. At the same time, the technology can also realize the design of complex space, such as curves, surfaces and other shapes, to meet diverse functional needs. Finally, concrete 3D printing technology can precisely control the distribution and density of the material, making the load-bearing structure design more reasonable and efficient. In addition, the technology can also realize complex structural forms, such as overhangs, arches, etc., to improve the overall stability of the building (See Figure 3).
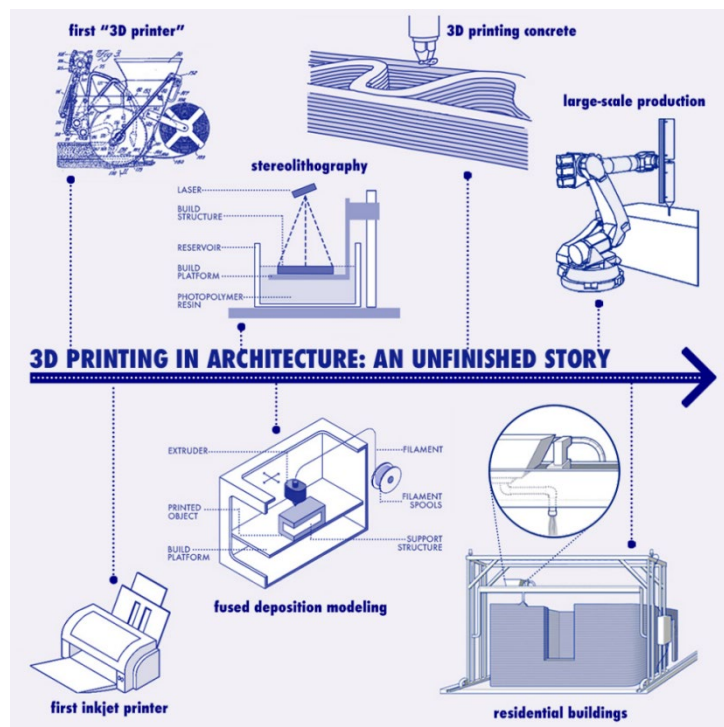

Figure 3: The Evolution of 3D Printing in Architecture[3]

5.4 Selection and application of building materials

In urban architectural design, material selection is the key factor that determines the aesthetic, functional and environmental properties of buildings. Suitable materials can not only give the building a unique style, but also achieve the purpose of energy saving and emission reduction, and protect the ecological environment. First of all, basic building materials such as glass, steel, concrete, etc. have the advantages of high strength, good durability, convenient construction, etc., can meet the needs of modern buildings for beauty, practicality, safety and other aspects, and are an indispensable part of urban architectural design. In addition, green building materials refer to those building materials that have less impact on the environment during production and use and can be recycled. For example, the use of waste production of new wall materials, low-energy thermal insulation materials, etc., are representatives of green building materials. The use of these materials helps to reduce the environmental pollution of buildings and achieve sustainable development. In addition, urban architectural design also needs to pay attention to the selection of some decorative materials, such as stone, tile, wallpaper, etc. They are important elements in the architectural appearance and interior design, these materials have rich color, texture and texture, can add unique artistic charm to the building. The structural material is the skeleton in the building, such as steel bars, concrete and so on. They need to have excellent load carrying capacity and stability to ensure the safety and durability of the building. When selecting structural materials, it is necessary to fully consider factors such as their performance, cost and construction difficulty. The use of materials in urban architectural design involves many aspects, and each material has its unique properties and application scenarios. When choosing materials, designers need to comprehensively consider the functional needs, aesthetic requirements, environmental protection and cost factors of the building to maximize the comprehensive benefits of smart city architectural design.

5.5 Energy cycle in building design

As a development model that pursues green, environmental protection and high efficiency, smart city can no longer be satisfied with the traditional means with high economic cost and ecological cost. A new method of urban waste treatment and utilization is needed to meet the severe challenges of resource utilization and energy consumption.
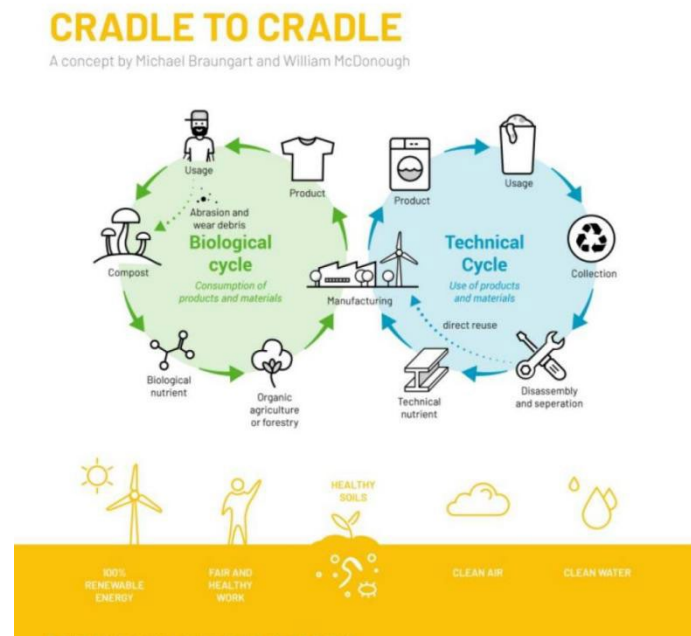

Figure 4: Cradle-to-cradle design

In the book From Cradle to cradle: Explorations in Circular Economy Design[8], the authors illustrate the existence of two material flows on Earth. Nature is constantly running in the way of metabolism, in this process there is no so-called waste, the earth's main nutrients carbon, hydrogen, oxygen and nitrogen in the cycle and recycling process, this material flow can be called ecological material flow. The emergence of industry has concentrated, transformed and synthesized material on Earth into new material that cannot be returned to the Earth's ecosphere, thus becoming a new process material flow. MacDonald

believes that the process of human development in the future is the process of the flow of industrial material to ecological material. Humans must make the process material flow can self-regulate and metabolize, discard the concept of waste, so as to perfect the entire human ecological cycle.

The "cradle to cradle" system requires a complete thinking about the outcome of the product at the beginning of the design, designing a cycle path for the energy flow and the material flow, and taking into account raw material mining, product production, product use, recycling and recycling. "Cradle to Cradle" provides revolutionary guidance for the "wisdom" of architectural design: the production, transportation, assembly, construction, demolition, and backfilling of buildings can all be used as the entry point of concept and creation in architectural design. Therefore, the energy cycle in architectural design is to realize the simulation and reproduction of the non-living built environment to the living ecological environment, so as to establish a smart and self-sufficient urban life, which is reused in the circular energy flow (See Figure 4).

6. Conclusion

In short, the architectural design based on smart city needs to fully consider the application of information technology, the requirements of ecological environmental protection and humanized design. Through reasonable planning and design, the intelligent, green and sustainable development of the city can be realized. At the same time, it is also necessary to pay attention to the technical, economic, social and other problems and challenges that may appear in practice. Smart city is one of the important directions of future urban development, and the architectural design based on smart city is a key link to achieve this goal. Through in-depth analysis and discussion, this study provides some theoretical support and practical reference for smart city architectural design. Future research can further focus on the application and effect of smart city architectural design in different regions and different cultural backgrounds.

References

[1] Zubizarreta I, Seravalli A, Arrizabalaga S. Smart city concept: What it is and what it should be[J]. Journal of Urban Planning and Development, 2016, 142(1): 04015005.

[2] Sinopoli, J., Smart Buildings[M]. Spicewood Publishing, 2006;

[3] Information on:https://www.archdaily.com/1005043/infographic-the-evolution-of-3d-printing-in-architecture-since-1939

[4] Agha R H M. The nature of intelligent system in buildings[C]//Proceedings of the International Conference on Intelligent Science and Technology. 2018: 62-66.

[5] Kang Y. Spatial Layout Analysis of Urban and Rural Buildings under Multicriteria Constraints[J]. Mathematical Problems in Engineering, 2022.

[6] Li B. Effective energy utilization through economic development for sustainable management in smart cities [J]. Energy Reports, 2022, 8: 4975-4987.

[7] Le D N, Le Tuan L, Tuan M N D. Smart-building management system: An Internet-of-Things (IoT) application business model in Vietnam[J]. Technological Forecasting and Social Change, 2019, 141: 22-35.

[8] Information on:https://en.wikipedia.org/wiki/Cradle-to-cradle_design#/media/File:Cradle_to_Cradle_concept.png