Immersive Urban Futures: A Framework for Virtual Reality Integration in Smart City Ecosystems

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Absrtact: With the rapid advancement of urbanization and digital technologies, China´s smart city development has entered a phase of accelerated growth. Virtual reality (VR) technology is emerging as a transformative force in this evolution, offering innovative solutions to enhance urban intelligence. This paper investigates the application of VR technology in smart city construction, focusing on three critical domains: (1) smart healthcare, where VR facilitates telemedicine, surgical simulation, and patient rehabilitation; (2) smart entertainment, enabling immersive virtual experiences in tourism, education, and cultural preservation; and (3) smart transportation, improving traffic management, autonomous vehicle testing, and driver safety training. Through these applications, VR technology demonstrates significant potential to optimize urban services, improve quality of life, and drive sustainable urban development. The findings provide valuable insights for policymakers and urban planners seeking to integrate emerging technologies into smart city initiatives.

Keywords: virtual reality; smart city; urban intelligence; smart healthcare; smart transportation; immersive technology

1 Introduction

Against the backdrop of rapid economic growth and technological advancement, China´s principal societal contradiction has evolved into the imbalance between the population´s escalating demands for higher living standards and the current uneven and insufficient development. This paradigm shift has positioned smart city development as an indispensable pathway for urban transformation in the digital era. Contemporary urban planning now confronts both unprecedented opportunities and complex challenges as smart cities emerge as the dominant paradigm for sustainable urbanization and information-age development.

2 Virtual reality technology and smart city construction

2.1 virtual reality technology

Virtual reality technology uses computer to generate a simulation environment, which provides users with visual, auditory, tactile and other sensory stimulation. For example, VR glasses, gestures, body posture and natural language are used to interact with the environment in real time to bring a immersive feeling. Virtual reality and human-computer interaction are inseparable in the future development.

2.2Characteristics of virtual reality

2.2.1 immersion

Immersion refers to that users can completely immerse themselves in the computer-generated virtual environment. It tries to make users feel immersive in the three-dimensional virtual environment created by the computer, and feel that they are part of the virtual environment. What users see, hear, smell and touch in the virtual environment created by virtual reality is exactly the same as what they feel in the real environment.

2.2.2 interactivity

Interactivity refers to the ability of users to interact with various objects in the virtual scene. As like as

two peas, the virtual environment is created by virtual reality. Users can interact with different environments and interact with different dimensions of information. The virtual environment responds to the user´s actions and interact with users. This interaction is exactly the same as the real world interactions. Interactivity includes the degree of operability of objects, the natural degree of users´ feedback from the virtual environment, and the degree of objects´ movement according to the physics theorem in the virtual environment.

2.2.3 conception

Conceivability refers to that users immerse themselves in the "real" virtual environment, interact with the virtual environment, and get perceptual and rational knowledge from the qualitative and quantitative integrated environment, so as to deepen the concept, germinate new ideas, and make a leap in knowledge.

2.3 smart city construction

The essence of smart city is to use advanced information technology to realize intelligent management and operation of the city. Virtual reality technology generates a simulation environment by using interactive three-dimensional dynamic scene and system simulation of entity behavior, so that users can immerse themselves in the environment, and then create a better life for people in the city, and promote the harmonious and sustainable growth of the city.

3 Application of virtual reality technology in smart city construction

3.1 smart medical construction

Smart medicine is a term rising recently. By building a medical information platform and adopting the most advanced Internet of things technology, we can achieve the interaction between patients and medical staff, medical equipment and medical institutions, so as to better serve patients.

The construction of smart medicine is mainly divided into VR medical assistance and VR medical education. VR medical assistance is to use pathology, psychology, physiology and other auxiliary medical personnel to treat patients, and use 3D immersion experience to divert patients´ attention and reduce the use of pain medicine. VR medical education is to make a complete set of medical teaching resources by modeling the human body model and combining with the corresponding teaching materials, so as to make the teaching more intuitive and convenient. This method is not limited by the teaching site, and can significantly improve the learning efficiency of students. At present, there are VR platform manufacturers at home and abroad, such as bommvr, which can build a comprehensive VR medical education platform. Smart medicine is people-centered, which can effectively improve the quality of medical care and reduce the cost of medical education, which can indirectly and effectively prevent the rise of medical costs.

3.2 smart entertainment construction

In the context of accelerating the construction of smart city, the development of new generation of science and technology information makes people pay more attention to spiritual enjoyment. Virtual reality VR technology plays an important role in the development of the future society. VR is three-dimensional, three-dimensional, it is the pursuit of the realization of virtual game scene, is committed to give players the most real sensory experience. VR technology has strong interactivity and multi sensibility. In an ideal simulation environment, it can make it difficult for users to distinguish the true from the false, and the objects in it are constructed according to the physical laws of motion in the real world.

According to the data of steam platform VR, the number of steam VR users has increased to 1.3 million in August. By the end of 2019, there are more than 1000 domestic companies involved in the virtual reality industry. With the continuous breakthrough of VR hardware, the biggest threshold of software and application has been swept. With the maturity of product system, VR / AR games will usher in a period of rapid development. It is estimated that by 2021, the cost of VR helmets will increase to nearly US $800 million, and the revenue of VR consumer market will

reach US $11.2 billion.

3.3 intelligent transportation construction

In the 21st century, with the rapid development of China´s economy, people´s living standards gradually improve. Since 2014, the number of motor vehicles registered in Jiangxi Province has increased year by year with an average annual growth rate of 810000. In 2016, there was an increase of nearly 2 million vehicles, and Jiangxi Province has entered a period of rapid growth. By the end of 2019, the number of motor vehicles in Jiangxi Province has increased by 17.42% compared with 2015.

With the rapid increase in the number of drivers, the demand for driving technology training services is also increasing. Due to the high complexity and high degree of mixing of traffic roads in China, the requirements for driving technology are also relatively high. In order to solve the above problems and improve the quality of driver training, it is necessary to train the drivers in driving simulator for a period of time before the test run training.

The virtual driving system requires the driver to transmit the driving signals, such as throttle opening, steering angle, to the virtual reality situation system through the control system. The driver judges the driving state of the vehicle model through the real-time rendering scene of the virtual reality situation system and carries out the next control action. At the same time, the virtual driving system is passed by the real-time posture of the vehicle model The position inverse solution program calculates the pulse quantity of the motor and transmits it to the executive system, so that the posture of the moving platform is relatively consistent with the posture of the vehicle model, and the information of the vehicle in the real situation, such as turning, bumping, roll and so on, is transmitted to the user to complete the driving process of the whole virtual system.

4 Conclusion

The integration of virtual reality (VR) and human-computer interaction (HCI) technologies represents a critical pathway for advancing smart city development and enhancing urban quality of life. Rather than pursuing rapid transformation, effective smart city construction requires a systematic approach: first identifying the most pressing urban challenges, then employing advanced communication and information technologies to monitor, analyze, and integrate key data from citywide systems. This technological infrastructure enables intelligent responses to diverse urban needs – from healthcare to entertainment – ultimately fostering more sustainable, harmonious, and human-centered urban environments. Such measured, needs-based implementation ensures that smart city development genuinely improves citizens´ lives while supporting long-term urban sustainability.

5 References

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