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Construction and Practice of Smart Campus Based on XR Extended Reality

Xu Han, Zhiyi Wang*
School of Industrial Design, Hubei University of Technology, Wuhan 430068, Hubei, China
*Corresponding Author.

Abstract

The application research of Extended Reality (XR) technology has become one of the research trends in the education industry and the field of information campus construction. To achieve the intelligentization of campus humanities, management, and teaching, while building a characteristic smart campus, this article proposes a smart campus system design scheme integrating virtual and real worlds. Based on the functional characteristics analysis of XR technology and starting from the commonly used XR development technology UNITY3D, XR technology is applied to the construction of the smart campus system. A campus model using Hubei University of Technology as an example is built, and a system architecture for building an XR smart campus is proposed, integrating the technical processes of XR smart campus construction. XR technology can make abstract concepts more intuitive and dynamically displayed, which greatly promotes the visualization of campus big data, the construction of campus cultural landscapes, and the school's teaching and management. It brings new opportunities and challenges for the digital, intelligent, and efficient development and innovation of universities, providing a reference for promoting the construction of smart campuses in universities.

Keywords: Extended Reality; Information Technology; Smart Campus; Smart Environment

1. Introduction

The smart campus is an advanced development form of campus digitalization. In recent years, modern technology has developed rapidly, and society has paid more and more attention to modern education. Universities no longer only focus on teaching quality; nowadays, many universities vigorously advocate the construction of campus culture and promote the concept of digital campus informatization [1]. As an important platform for modern higher education, scientific research management, and life services, the smart campus plays a significant role in enhancing the competitiveness of universities, their social reputation, and promoting their development [2]. At present, with the increasing demand for smart campuses from teachers and students, higher standards and requirements are being put forward for universities beyond meeting the basic needs of teachers and students. Currently, the construction of smart campuses with unique characteristics in Chinese universities generally faces issues of focusing on management over service, functionality over practical application [3], and a lack of construction and promotion of campus culture. Therefore, this paper, based on the existing application service system of the smart campus, integrates teaching, scientific research, management, and campus culture, applying XR extended reality technology to the construction of the smart campus. This aims to provide convenient services for users, improve school management performance, and enhance the efficiency of campus cultural output.

2. Analysis of XR Technology Research

Extended Reality (XR) is a concept that emerged with the continuous iteration of computer graphics and simulation technology, representing a series of immersive and interactive technologies. VR (Virtual Reality) uses

computer technology to create a simulated environment, mainly realized through key technologies such as visual, auditory, tactile, and perception interaction. VR allows people to immerse themselves in the digital world, experiencing the real depth and rich visuals of digital objects. Unlike VR, AR (Augmented Reality) overlays virtual information onto real scenes, achieved through key technologies like optical see-through, tracking registration, virtual-real combination, and human-computer interaction. MR (Mixed Reality) naturally integrates real and virtual scenes, where real scene information is acquired through lenses, allowing for more realistic real-time interactions such as occlusion and collision between virtual and real, enhancing the authenticity of the user experience. The display effect of virtual scenes in MR is as realistic as VR, close to real scenes, and not easily distinguishable.

Looking at the present, XR technology is involved in most fields, whether it is product design and production in the manufacturing industry, online remote medical care, education, the entertainment industry, or even the retail industry [4]. Currently, XR has blossomed in many areas such as medical devices, live broadcasting, innovation and entrepreneurship, and even the military and aerospace industries. For example, XR technology is widely reported in surgery and anatomy, with evidence showing that XR may be as effective as traditional medical education methods and potentially a more cost-effective course delivery means [5]. In the "Chinese Poetry Conference" program, the technical team successfully used XR to innovate AR production, allowing the performance to integrate with the surrounding environment in real-time, providing a better visual immersive experience for the audience [6]. XR technology has also brought more possibilities to innovation and entrepreneurship roadshows, allowing traditional roadshows to be free from screen limitations, enabling judges and investors to feel the business background and better understand research content and data analysis, effectively enhancing the competitiveness of participants' projects [7]. In geoscience education, XR technology can not only display abstract models more intuitively but also visualize geological data and provide interactive access to geographic information, promoting geoscience education [8].

The combination of XR technology and education will profoundly transform the current education model and deepen the development of smart education. In the education industry, technology is the core driving force for educational development. The rise of online teaching platforms has realized the digitalization of teaching modes, and the emergence of XR technology will achieve digital twin and intelligent education.

2.1 Highly realistic visual effects, easier to remember

XR has multiple characteristics: immersion, interactivity, intelligence, and association. Its combination with education can bring disruptive changes, including changes in educational methods and improvements in educational tools. XR technology devices can interconnect with conventional teaching equipment, breaking spatial and temporal limitations, allowing users to efficiently explore the unknown, seamlessly experiencing various scenes impossible in reality, greatly enhancing students' memory and learning efficiency.

2.2 Concrete representation of abstract topics, easier to understand

Both adults and primary and secondary school students are prone to fatigue, resistance, and helplessness during prolonged monotonous learning, especially when facing complex and abstract knowledge points. XR can emphasize specific objects, techniques, and concepts through augmented and virtual reality, modeling these abstract knowledge points in the virtual world, allowing students to intuitively learn and understand them.

2.3 Flexible skill expansion, meeting specific educational needs

In education, facing language barriers, developers can add translation functions to the learning system, allowing learners to conveniently use their native language to receive knowledge and professional skills from other cultural backgrounds. For special groups, such as the elderly or special learners, traditional learning forms are much more difficult. However, with XR technology, such as myopic VR enhancement assistance, students with visual impairments can be helped by controlling contrast, text size, and adding audio annotations when necessary. It also allows users to communicate seamlessly using sign language in virtual environments.

Therefore, this paper applies XR extended reality technology to the construction of smart campuses based on its research, achieving visual and information enhancement through XR. The design combines the smart campus with

extended reality, using UNITY3D to build a smart campus platform and system, providing multi-terminal information campus service ports for all teachers and students, realizing intelligent operation modes with multiple ways and choices, meeting personalized needs, and fully building an intelligent educational environment.

3. Significance of XR for Smart Campus Construction

The development of XR extended reality technology drives educational reform towards a new stage of smart campus construction. In the construction of a smart campus, the introduction of new-generation information technologies such as artificial intelligence and virtual reality, using information technology means to fully integrate teaching, educational administration management, and campus life, achieves a smart service and management campus model [9]. The combination of XR extended reality technology and smart campus construction will promote the interaction mode of traditional smart campuses from 2D interaction to more efficient and immersive 3D interaction, realizing innovation in the visual presentation of smart campus systems. The application of XR technology also provides a new construction standard and system for the construction of smart campuses, innovates governance services, enhances the governance capabilities of various departments of the school, assists in building a smart educational environment, and supports and leads educational and teaching activities.

3.1 Supporting teaching and research with information technology to inject new vitality into development

The campus environment not only carries the human and natural landscapes of the school but also accumulates the spiritual and cultural qualities created and evolved during the educational practice process, making it an important foundation for the school's education [10]. In the field of education, virtual reality technology has a wide range of roles and impacts. Currently, many domestic universities have applied virtual reality technology to virtual teaching, virtual laboratories, virtual simulation campuses, and educational research. The realistic three-dimensional sensory experiences (visual, tactile, olfactory, etc.) created by VR technology can give people a feeling of being there. The application of VR virtual reality technology allows the construction of a smart campus environment to be unrestricted by time and space, realizing the perfect combination of virtual campus and real campus, showcasing the cultural heritage of universities through the creation of virtual scenes and the presentation of virtual human dynamics [10]. Supported by various technologies in the 5G era, VR virtual reality technology, with its characteristics of immersion, multi-sensing, and interactivity, has high usage value in the construction of smart campuses [11]. This study proposes the construction of a VR campus virtual roaming system, providing VR campus panoramic roaming services based on Hubei University of Technology. Through VR technology, it visualizes and shapes the humanistic landscapes such as the "One Belt One Corridor" and the Xunsi River landscape belt, optimizing the overall campus environment and making campus culture a prominent symbol of the school's characteristics. Users can access the campus reality and obtain the school's historical heritage and campus scenery anytime, anywhere through computers and mobile devices as platform clients and VR headsets as equipment, helping to establish and present a good campus image, expand campus culture construction, and have significant implications for the development of higher education in China.

VR Virtual Campus Roaming System is the Foundation of Digital Campus Construction. The creation of a roaming system can accelerate the promotion of campus digitalization and informatization, providing high-quality solutions for major universities, designing three-dimensional visualized campus VR panoramic roaming systems that align with the school's cultural characteristics, establishing a good brand image for the school, and improving the management efficiency and scientific level of universities [12].

VR Virtual Reality Roaming System is based on real campus. Utilizing virtual reality technology to present the specific layout, traffic routes, scenic buildings, and objects in the campus in a virtual scene, users can freely tour the system. The campus virtual reality panoramic roaming system is the foundation of smart campus construction, and its research and creation have important practical value for the comprehensive digitalization, informatization, and internationalization construction of the campus. The virtual reality roaming system is a powerful tool for the school's external publicity, and anyone can use it on the school's official website through high-end information dissemination technology combined with the internet system. The impressive visual effects, user-friendly interface, and highly practical functional settings will rapidly increase the school's visibility and influence, bringing

unprecedented benefits to the school.

Assisting campus management planning is also an important role of the campus virtual reality panoramic roaming system. When the school needs to plan and reconstruct internal buildings, traffic routes, and auxiliary facilities, construction managers can review the campus environment in the VR roaming system to clarify construction plans and designs. The virtual reality roaming system digitizes all information resources related to the school's teaching, research, management, and life services and integrates and organizes these information resources scientifically to form a unified resource management library. It creates a digital space on the basis of the traditional campus, improving campus management efficiency through technological advancements.

In smart campus construction, AR augmented reality technology supplements and annotates real campus information in the form of text and images by integrating digital campus resources, allowing users to experience a unique virtual campus environment [13]. Studies show that AR technology integrated with teaching and research can effectively improve teaching quality and research levels [14]. The visual presentation of AR technology enhances the understanding of abstract concepts. Users can obtain diverse teaching through devices, guiding users in exploratory learning, as AR presents content in 3D, characterized by vividness, intuitiveness, and imagery, aiding students' understanding and memory. With AR technology, students' classroom experience leaps from 2D to 3D, transforming from flat content presented by books or blackboards to vivid three-dimensional content. Especially for abstract or invisible content, AR can visualize it, enhancing cognition and understanding. It enables users to experience the real feelings brought by AR smart campus construction, interact with the intelligent environment, including campus landscape architecture, campus culture, and teaching knowledge. Users can also experience the situational and immersive feeling brought by AR smart campus applications and services.

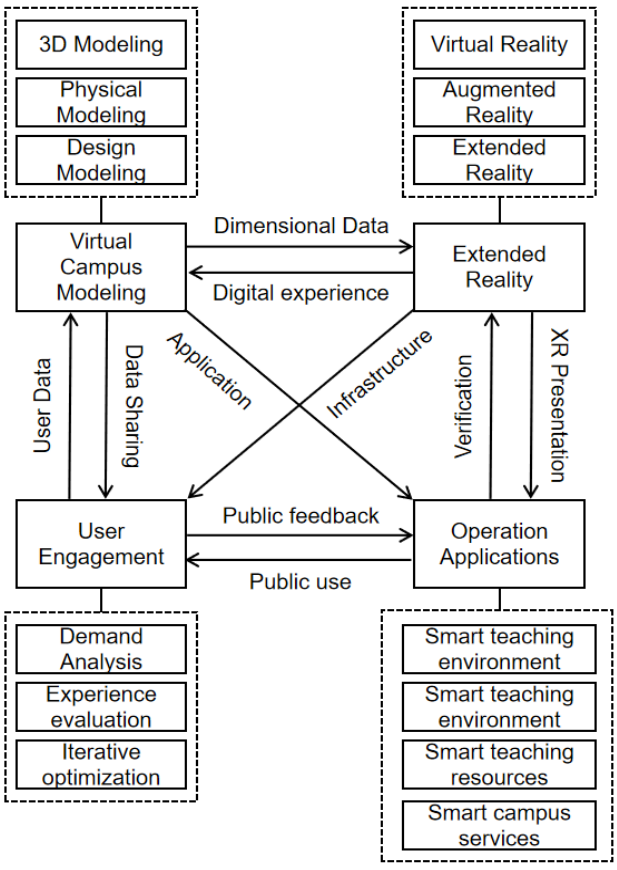

Figure 1 Three-Dimensional Scene Construction Flowchart

To achieve the construction of an XR smart campus and complete the overall XR scene construction, it is necessary to perform realistic rendering of the virtual campus environment model. This study chooses Unity3D software as the system platform for the campus XR system and designs a three-dimensional scene construction flowchart, as

shown in Figure 1. This diagram includes four parts: virtual campus model, XR extended reality technology, user participation, and business applications. It aims to integrate XR technology and the virtual smart campus model, based on user needs, experience, and iterative optimization, to build XR extended reality-based smart campus business applications.

3.2 Optimize the intelligent environment of the smart campus to enhance school governance capabilities

With the development of modern information technology, digital campuses are gradually evolving into smart campuses. In the process of smart campus construction, the focus should be on big data as the core and campus information infrastructure construction driven by the Internet of Things (IoT) [15]. On one hand, this involves promoting functions such as campus-wide network coverage, digital authentication, data visualization platforms, and data monitoring to optimize the school's decision-making capabilities in campus governance, education and teaching, discipline specialization, scientific research, and resource allocation. On the other hand, it involves integrating various business data of the school to build a unified, standardized, comprehensive, and high-quality data asset platform. This platform advances the digital and full lifecycle management of core elements such as people, events, and things, as well as business areas such as talent cultivation, scientific research, social services, and cultural inheritance. This accelerates the realization of the goal where all business is data-driven, supporting a new education governance model driven by data.

The use of big data, artificial intelligence, and other technologies transforms the organizational structure and management system of schools, optimizes daily operating mechanisms and service models, realizes refined campus management, personalized services, and intelligent perception across regions, applications, and terminals for teachers and students. This comprehensively enhances the school's governance level, forming a new data-driven governance model.

The article proposes applying multi-sensor information fusion technology and a visual big data platform to the construction of smart campuses. On one hand, the application of multi-sensor information fusion technology can greatly enhance human cognitive abilities toward complex matters. By integrating multi-sensor information such as environmental sensors, energy consumption monitoring, audio-visual sensors, and vehicle identification within the campus, comprehensive screening, processing, and integration of multidimensional campus information can be achieved, leading to more accurate information. On the other hand, the visual big data platform manages and centrally stores various data and resources of the school. Data analysis and computational processing based on the information obtained through multi-sensor information fusion technology provide data support for upper-level business applications, facilitating the school's cluster-scale adjustments and dynamic resource scheduling.

4. Practical Effects of XR Technology in Smart Campus

According to the spirits of documents such as "China Education Modernization 2035", "Standards for the Construction of Digital Campuses in Higher Education Institutions (Trial)", and "Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-Quality Education Support System", combined with the actual development and informatization work of the school's "14th Five-Year" development plan, Hubei University of Technology is gradually evolving from a digital campus to a smart campus and has achieved the following results.

4.1 Enhancing immersion and interactivity in virtual roaming, optimizing resource allocation

Hubei University of Technology has constructed a virtual campus using VR technology, presenting campus landscapes, facilities, and humanities ecologically in an intuitive manner. The scene adjusts the layering display of the Xunsi River landscape belt, the Industrial Design Corridor, etc., and sets up dynamic navigation functions for scene roaming, as shown in Figure 2. The virtual scene model of Hubei University of Technology is imported into the Unity3D software environment after 3D point cloud modeling by Pix4D and optimization by SketchUp to establish queries for campus scenes and databases. To perfect the contextual interface effects, according to actual environmental effects, the terrain editor of Unity3D is used to create terrain and tree and vegetation patches. Water surface effect components are added to the Xunsi River landscape belt within the university campus, making the scene realistic and detailed without affecting performance, showcasing the campus landscape more

comprehensively through Unity3D software. The Unity3D platform of the system has strong applicability, good interactive functions, is simple to operate, and easy to master. It also possesses powerful multimedia, networking, visualization, and 3D graphics processing functions, enabling efficient and fast organization of workflows.

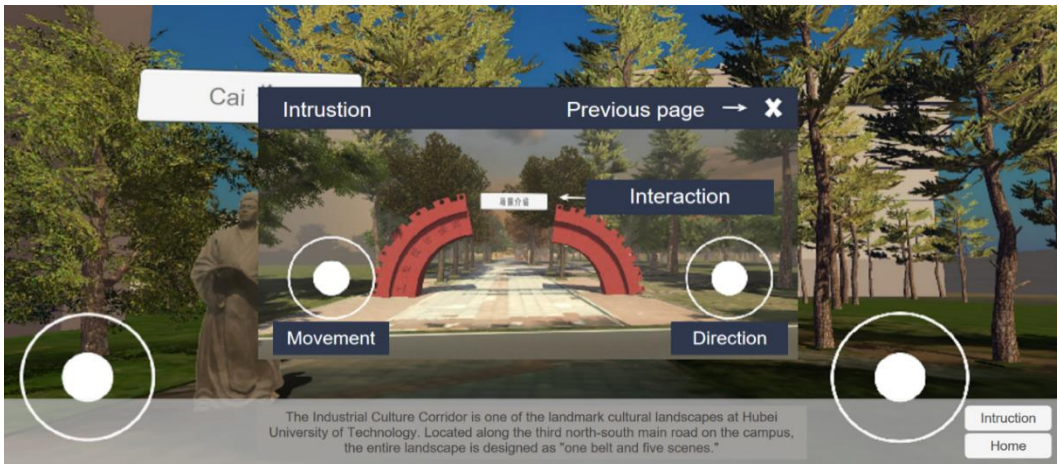

Figure 2 Smart campus VR campus

In the campus VR system, all teaching buildings, office buildings, and famous campus landscape buildings have corresponding text descriptions. The campus VR system provides detailed explanations of the corresponding scenes without hindering users from browsing the scenes. The combination of dynamic scene browsing and static scene detail explanations, as well as the combination of picture display and text introduction, enriches the scene interface elements.

This is conducive to updating campus information and campus landscape architecture, improving the efficiency of information circulation among teachers and students, and providing virtual roaming services in campus planning, construction, and admissions publicity. This form brings convenience to the daily lives and studies of teachers and students while helping the school make scientific decisions in areas such as ideological and political work, admissions and employment, education and teaching, discipline specialization, scientific research, and resource allocation. This is of great significance to our school's development. The hardware uses a PC host, Oculus headset, and handle. After users wear the headset, they can watch the campus buildings and landscapes with the movement and zooming of their perspective. In the virtual campus, users can interact with buttons and interactive switches in the virtual scene through the handle. Users can operate the functional buttons set in the scene to interact with the virtual campus. Functional buttons mainly include pointing, perspective adjustment, data visualization, and text introduction, as shown in Figure 3.

Figure 3 VR Campus Presentation in Oculus Headset

4.2 Stimulate intrinsic motivation and guide exploratory learning

Building a smart campus environment through AR technology can achieve an organic combination of the physical campus and the virtual campus, efficiently presenting complete campus information and environment. Currently, AR smart campuses can help users quickly and conveniently understand the location information of school

buildings and related functional information. Through AR technology demonstrations, users of Hubei University of Technology's smart campus can quickly and conveniently learn about the location of school buildings and information about campus landscape architecture and culture; they can also experience the contextual and immersive feeling brought by AR smart campus applications and services.

AR teaching resource design aims to create an educational space for users that fully leverages their active learning attitude and achieves learning goals based on their personalized learning needs. By combining AR with teaching resources, learners can take control in a strong experiential, personalized, and anytime-anywhere learning space, greatly improving learning efficiency. Another significant advantage of this resource is its ability to conveniently simulate any resource. Through virtual reality technology, learners can conduct targeted training in various complex and sudden environments, improving their adaptability and related handling skills, keeping learners in a leading position in the learning process, and achieving high generalization of the learning space [16].

AR smart campus has the following three main functions: (1) Viewing the names and specific locations of various landscape buildings on campus, guiding users to find campus location information; (2) Strengthening explicit cognition of abstract matters through the visual presentation of AR technology [17]. This promotes the visualization and imagery of abstract content in smart campus construction, stimulating students' interest in campus cultural knowledge, thereby guiding students to actively explore and acquire various cultural knowledge information on campus; (3) Providing process flow diagrams for buildings or areas with specific functions to guide and assist users in handling related tasks. As shown in Figure 4.

Figure 4 AR Campus in Smart Campus

This system design uses AR Foundation, combined with AR Core and AR Kit, to perform plane detection through the mobile camera, directly placing virtual models in the real scene. Unlike previous AR scenes using AR CODE/Vuforia/LBS, which achieved AR display by detecting distortion through recognition codes, AR Foundation is a cross-platform AR development tool launched by Unity in 2018. AR Foundation provides a platform-independent API, reducing developers' development time costs for technologies like AR Core on Android platforms and AR Kit on iOS platforms. Therefore, the advantage of using AR Foundation for development is that it allows the core functions of AR Core and AR Kit to be used simultaneously through AR Foundation, requiring only one application development to be deployed on devices with different systems like Android and iOS, making development more convenient.

4.3 Deepening big data applications to form a data-driven governance model

To achieve the construction of a campus big data processing platform, Hubei University of Technology has planned and continuously built the campus big data center system. By using commonly used big data information visualization platforms like UNITY3D, FineReport, and ThingStudio, and multi-sensor information fusion technology, the campus big data information visualization system was constructed to support full-domain data fusion. The goal is to construct data visualization interface designs based on the UNITY3D interface design library. Actively applying big data applications, a support platform with data fusion, analysis, mining, and visualization capabilities was built to realize the governance and application of big data at Hubei University of Technology.

By integrating campus information collected through multi-sensor information fusion technology, synchronous transmission for data visualization analysis, processing, mining, and screening is performed, ultimately forming various types of school data: traffic monitoring information, environmental information, basic data of each college, teaching building occupancy information, cafeteria dining information, etc. Users can view daily campus data and information of Hubei University of Technology in real-time through big data application terminal devices, conveniently mastering relevant information, bringing great convenience to their daily life and study; managers can also view the linkage between various departments and resource allocation information on the big data visualization platform, ensuring the smooth progress of various school tasks and evaluating the school's governance status. The big data visualization platform technology facilitates the integration of data business across departments in the smart campus, playing an important role in eliminating information silos and enhancing departmental collaboration [18]. As shown in Figure 5.

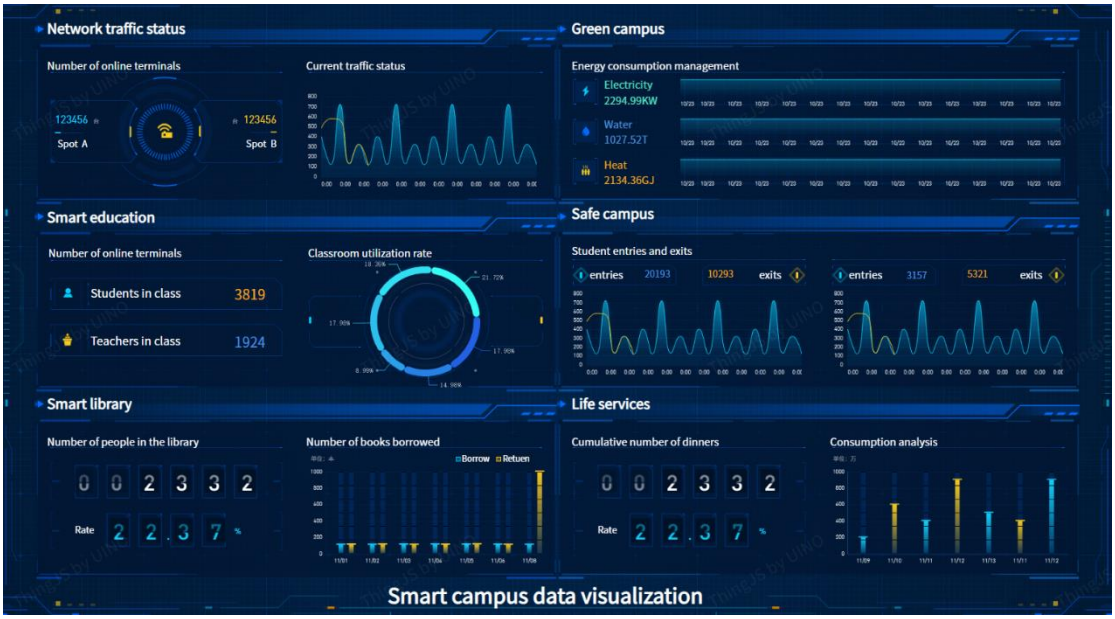

Figure 5 Data Visualization Platform in Smart Campus

5. Conclusion

This study takes Hubei University of Technology as an example and proposes the application of XR extended reality technology in the construction of a smart campus. The construction of a smart campus is based on the current state of informatization development and user pain points of the school, focusing on the XR smart campus construction strategy, and continuously exploring and improving the smart campus with the school's own characteristics. Compared to traditional digital campuses, XR smart campuses have unique advantages: VR virtual reality technology can enhance immersion and interactivity, optimize campus resource allocation, and increase the school's visibility in admissions promotion, playing a significant role in school cultural construction and planning. AR augmented reality technology can guide exploratory learning, stimulate students' intrinsic motivation, create personalized learning experiences, expand mobile teaching forms, and reform teaching mode concepts. Big data visualization technology can deeply optimize the intelligent campus environment, enhance school governance capabilities, and form a data-driven governance model. The smart campus system design in this study serves as a supplement to the research in the field of XR extended reality applications and provides a reference value for the construction of smart campus systems in various universities.

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