Research Progress of Construction of Smart Campus

Jiujiu Yu¹, Jishan Zhang¹, Liqiong Pan¹, Chunyan Yu² and Hui Qi²

¹College of Computer Engineering, Anhui Sanlian University, Hefei, Anhui, 230601, China
²Center of Information Construction and Management, Chuzhou University, Chuzhou, Anhui, 239000, China
¹Corresponding author’s e-mail: yjjjyjL@163.com

Abstract. Smart campus is a new stage in the development of educational informatization. Focusing on present construction situation of smart campus in universities in China and abroad, the paper firstly reviews of typical construction modes, types of design architecture and major functional modules of smart campus in universities. Secondly, from the perspective of application, service and management for smart education, some key technologies of construction of smart campus in universities are analyzed and summarized. Finally, further work of promoting the construction standards and evaluation of smart campus, training and improving the big data literacy for teachers and students in campus, and exploring effectively on sharing and constructing mechanism on smart campus for local application-oriented universities is expected in this paper.

1. Introduction

Smart campus is the hot spot at university information [1]. It is based on users and highlights the important supporting role of teaching, scientific research and campus management in universities [2]. In recent years, remarkable results on education modernization has been achieved in China, from digital campus to smart campus, especially during the period of construction of smart campus, a more convenient and interactive approach and learning platform is provided for teachers and students to improve the efficiency of teaching and campus management. Undoubtedly, with the emergence and widely applied of a series of new technologies of big data, cloud computing and IOT (Internet of Things), smart campus has accelerated the reform and innovation of modern education and campus service mode. Construction of smart campus has become increasingly popular in China. Now, a large number of universities in China are carrying out construction of smart campuses, but many universities are still in the planning or initial construction stage [3]. The current construction of smart campus focuses on the local campus environment, and the tasks are arduous, involving many departments of a university, the planning and construction period is long, and the intelligent level of the smart campus needs to be improved [4].

In this paper, we review of the present construction situation of smart campus, including the lastest research progress of some key technologies of smart campus in China and abroad. The structure is organized as follows: Section 2 reviews of present construction situation of smart campus. Section 3 researches some key technologies of smart campus. Section 4 concludes the paper. Finally, Section 5 points out further work.
2. Present Construction Situation of Smart Campus

Universities all over the world have issued relevant policy documents to encourage constructing of smart campus in order to promote high informationization. The construction of smart campus in different universities has shown an accelerated development trend and form different construction modes. At present, some typical construction modes of smart campus in some famous foreign universities are shown as Table 1.

Some local application-oriented universities in domestic focused on the architecture of smart campus these years, and built smart campus cloud platforms based on the corresponding architecture. For example, mobile smart campus in Sanming university [5], mode of smart campus based on management in Minjiang university [6], smart campus based on “Internet+” mode in Binzhou university [7], smart campus based on full service chain in Xi’an Eurasia University [8], smart campus based on data-opening in Jiaying University [9], and so on. Although different architectures of smart campus are constructed in colleges and universities according to actual environment in China, generally, the types of the architecture of smart campus are classified that are shown as Table 2.

Table 1. Typical construction modes of smart campus.

| Construction Mode of Smart Campus | University (Country) | Keywords |
|----------------------------------|----------------------|----------|
| Spatially-enabled Smart Campus [10] | Florida International University (USA) | Traffic and Parking; Facilities and Space; Academic Information; Course and Project |
| Platform-APP [11] | Universitat Jaume I(Spain) | Geographic Space; Service; Application |
| Service Oriented Based on Mobile Technology [12] | Yonsei University (South Korea) | Mobile Calendar; Campus Activities; Campus Experience |
| ICAP (Integrated Controls & Analytics Program) [13] | Stanford University (USA) | Building Control; IT Network Facilities; Analysis Application; Database Management |

Table 2. Types of architecture of smart campus.

| Architecture of Smart Campus | Keywords on Characters |
|------------------------------|------------------------|
| Based on cloud computing [14] | IaaS; Cloud Desktop; Double Active Data Center |
| Based on IOT [15] | M2M (Machine to Machine); Layers of Perception; Layers of Network; Layers of Application |
| Based on WebGIS [16] | Multi-functional Visualization; Virtual Reality; 3D Visualization |
| Based on Application and Service [17] | University Teaching; University Scientific Research; Campus Life and Service Mobile Application; iBeacon |
| Based on Three dimensional Network [18] | Smart Management; Smart Lab; M2M (Machine to Machine); Six Horizontal and Two Longitudinal |

At present, many universities in China have done a lot of researches on designing of functions of smart campus. However, some local universities are enjoy pursuing the external image of the smart campus through the “cool” and “advanced” technology blindly, ignoring the functional role of these technologies in education, teaching and education management [4]. In recent years, some educational experts have systematically explored the functional development and proposed the major functional modules of the smart campus to construct of a complete functional system of smart campus.

For example, subsystems of customer terminal equipment, educational information transmission channel, the deployment of information infrastructure and application system integration, applications
are composed of the functional system of smart campus in [19-20]. This viewpoint is widely accepted by most universities in domestic. Additionally, four major functional modules of the smart campus are put forward in [4] and the keywords for functional description of each module are shown as Table 3.

Construction of smart campus from the perspective of some advanced technologies of cloud computing, Internet of Things, big data, Wifi, RFID (Radio Frequency Identification), mobile Internet, ZigBee, intelligent sensing, VR (Virtual Reality), AR (Augmented Reality), and so on are also the research hotspots in many universities. But, applications and management of these technologies for the construction of smart campus are also the present construction situation of smart campus.

| Major Modules of Smart Campus | Keywords for Functional Description |
|-------------------------------|------------------------------------|
| Application System            | Smart Information Portal; Smart Big Data Integration; “Project of 118” [20] |
| Information Transmission Channel | Information Portal; Big Data Center; Application System; Smart Infrastructure; Smart Terminal |
| Smart Infrastructure and Smart Terminal | Smart Library; Smart Classroom; Smart Transportation; Smart Phone; Wearable Devices |
| Typical Application           | Smart Teaching; Smart Scientific Research; Smart Security Monitoring |

3. Key Technologies of Smart Campus

Construction of smart campus is a large systematic project. From the perspective of management, smart campus is a campus mode that serves smart education. The core of the construction of smart campus is to use a new generation of information technology as a tool to integrate campus information resources in an all-round way [21]. As a high-level form of educational informationization, it is also a new mode of integrating teaching, scientific research, management and other life service for students on campus. From the perspective of management and service, smart campus is also a campus mode that serves smart education. Therefore, some key technologies of smart campus from the perspective of application, service and management will be explored in this section.

3.1. Data Sharing on Micro-Service and Micro-Application

The construction of smart campus needs to consider the implementation process from the micro level, highlighting all kinds of micro-service and micro-application for teachers, students and university administrators. Micro-service and micro-application based on business process reconfiguration realizes online operation of various process services, in order to solve the problems of untimely, incomplete and ambiguous data [22].

Convenience on user and people foremost is an important concept of smart campus. However, some original data, important data, authoritative data, and some application service data for teachers and students are often stored in the same shared data center, and the sharing ability between data is poor, which leads to teachers and students using different application services. Repeated entry data is required, and the form is repeated. At present, in the process of constructing of smart campus for some local colleges and universities, lots of original data, important data, authoritative data, and some of the unimportant application service data for teachers and students are often stored in the same sharing data center, the ability to share data is poor and leads to division. When teachers or students use different application service, they need to repeat the data inputting and filling the tables. Service is not separated from the application completely, and users could not deal with the specific business through the micro-program directly.

This cumbersome situation has been taken seriously by experts, and some major technologies or methods are also proposed to solve this problem, such as technologies of “Based on Process Driven [1]”, “Construction of Application Data Center [22]”, “Big Data Distributed Center [23]”, and so on. The application of these technologies of data sharing needs to combine with the characteristics and
requirements of the actual micro-services and micro-applications for construction of smart campus in specific colleges and universities, thus to facilitate the service to teachers and students.

3.2. Big Data for Innovating
Under the background of big data, it is of great theoretical value and practical significance to analyse the deep-level problems of construction of smart campus deeply based on the global perspective, and effectively use the big data to think about concept, technical means and management methods to carry out the research on the construction path of universities information [24]. At present, there are also some major methods which are feasible, scientific and methodological for big data supporting of the construction of smart campus. Such as Education Big Data Ecosystem [25], Smart Campus Resource Utilization System Model Based on Big Data [26], Solution Strategy Based on Big data [27], Big Data Driven [28], Analysis and Warning Management Platform Based on Big Data [29].

The core of smart campus is to provide convenient service to users positively, and user feedback on perception experience. The basic perception is data, and the data comes from various business application platforms [24]. Function of data collection across different departments and businesses should be required in smart campus to provide knowledge and campus service for all teachers and all students. Technologies of examination of interaction on teaching activity based on education big data in [30], evaluation on learning and teaching based on big data, big data driven and development based on data literacy, and so on should be researched and implemented to realize the real value of “Internet + Big Data” fully.

3.3. Smart Campus Service
Smart campus is the application and service of smart education. It includes both the core teaching and talent training of the campus, as well as how to solve and improve the information through various means such as daily travel on campus, security, logistics, management services, innovation, entrepreneurship [16]. Some valuable management information systems for basic applications of universities and campus service are developed based on smart campus or from the perspective of convenient to students. There are some management information systems for service based on smart campus in foreign universities, such as Smart PASS [31], Smart Campus System (SEAtS) Vision [32], SMS (Eagle Eye) [33], Attendance Management System Based on Human Recognition System [33], and so on. It should be noted that different universities in China have great difference in market orientation, financial support, and development history, the development and application of smart campus and its systems for service need to be scientific and rationalized. It is necessary to consider various factors comprehensively, such as the learning characteristics of students, individual learning requirement, resource construction, financial support, management and maintenance, and so on to achieve the best results [4].

4. Conclusions
This paper reviews the progress of construction of smart campus in domestic and abroad. Although many universities in China are exploring the construction plans and applications of smart campus actively, compared with some foreign universities, theoretical research also lags behind practical activities, and the level of construction of smart campus needs to be improved.

5. Further Work
Further work will be done in the future. Firstly, the construction standards and evaluation of smart campus should be promoted [4]. In China, due to the great difference in development orientation and financial support of colleges and universities, the construction standards of smart campus are different. This requires local administrative department in charge of higher education to establish an authoritative evaluation center to develop a systematic, scientific, diversified and hierarchical evaluation criteria for smart campus construction. Secondly, big data literacy for teachers and students in campus need to be trained and improved. In the era of education information 2.0 based on big data, the path policy of effective use of big data thinking, technical means and management method are the key point
of construction of smart campus [24]. Engineers and technicians of big data should be recruited or trained to develop of intelligent software for micro-service and micro-application, and provide intellectual support and technical support for data analysis, especially in some local universities. Thirdly, sharing and constructing mechanism on smart campus for local application-oriented universities should be explored effectively. Undoubtedly, compared with some well-known universities in China, teachers’ ability is relatively poor and the financial support is not sufficient. It is much difficult to explore and implement the construction of local smart campus independently. But, the orientation of these universities and the talent cultivation goals are similar, the information literacy and professional practice ability of teachers are similar, and students’ cognitive abilities are similar [34]. Exploration on sharing and constructing mechanism on smart campus for local application-oriented universities could reduce construction costs and promote the collaborative exchange and common development of smart education among universities, and improve the level of smart education on local application-oriented universities in domestic.

Acknowledgements
The research was supported by the Excellent Young Talent Support Project of Anhui Province University (No. gxyq2019138), Project of Quality Engineering of Anhui Province University (No. 2017jxtd131), Project of Natural Science Research of Anhui Province University (No. KJ2017B17) and Project of Quality Engineering of Anhui Sanlian University (No. 16zlgc031). At last, as the corresponding author of this paper, I would like to express my heartfelt gratitude to all the authors of the references, which are listed at the end of the paper.

References
[1] G.P. Liu., J. Zhong., T. Xie. (2019) Research and Practice of Process-Driving Based Basic Framework of Smart-Campus in Higher Education. Journal of China Educational Technology., 4: 23-28.
[2] J.J. Yu. Design of Seat Selecting System for Self-study Room in Library Based on Smart Campus., unpublished.
[3] L. Chen., L.L. Hua., M. Feng., L.N. Wang. (2018) Four Great Wisdom of Wisdom Campus and the Connotation. Journal of China Educational Technology., 2: 84-88.
[4] P. Yang., Y.X. Yao., B.B. Shi., Y.W. Wang. (2019) Research Review of Wisdom Campus Construction. Journal of Modern Educational Technology., 1: 18-24.
[5] S.F. Liu., Z.L. Li. (2018) Research and Practice of the Construction of Mobile Intelligent Campus in Local Universities: Taking Sanming University as an Example. Journal of Education Institute of Taiyuan University., 2: 52-55.
[6] F. Wan. (2019) Discussion on the Construction Mode of Intelligent Campus in Local Colleges and Universities-A Case Study of Minjiang University. Journal of Minjiang University., 1: 104-108.
[7] B. Li., Z.Y. Wang. (2018) Study on Construction Path of “Internet plus” Smart Campus for Local Colleges and Universities. Journal of Binzhou University., 2: 92-96.
[8] Z. Luo., Z. Li., Y. Sun. (2019) Research on the Smart Campus in Colleges and Universities based on Full Service Chain--Taking Xi'an Eurasia University as an Example. Journal of Modern Educational Technology., 5: 59-64.
[9] J.M. Deng., G.W. Huang., J. Zeng. (2018) Building Data-Opening-Led Intelligent Campus Service Presentation. Journal of Jiujiang University., 4: 60-65.
[10] Jennifer F. (2019). A spatially-enabled smart campus for community-based learning. http://digitalcommons.fiu.edu/cgi/viewcontent.cgi.
[11] Joaquin H., Ana S., Michael G. (2019) Universitat jaume I smart campus. http://www.spatial.ucsb.edu/eventfiles/ASESCh/docs/Huerta-presentation.pdf
[12] Yonsei University. (2019) World’s best smart campus! The future of the world begins at Yonsei. https://www.yonsei.ac.kr/en_sc/campus/scampus.jsp.
[13] Shah A. (2017) Components of an intelligent campus. https://www.appa.org/ training/APPAP17/documents/ComponentsOfAnIntelligentCampus.pdf.

[14] X.H. Wu. (2014) Design and realize of Support Service Platform Based ON Cloud Computing. A Thesis for the Degree of Master (Hunan University), Changsha.

[15] P. Chen., Z. Liu. (2012) Study on Infrastructure of Internet of Things in Smart Campus. Journal of Wuhan University: Natural Science Edition., S1: 141-146.

[16] S.G. Zhang. (2014) Based on WebGIS Design and Implementation System of a 3D the Wisdom of the Campus. A Thesis for the Degree of Master (Beijing University of Civil Engineering and Architecture), Beijing.

[17] Q. Dong., T.T. Sun., T.W. Li. (2017) Research on the application of mobile intelligent campus based on iBeacon technology. Journal of Central China Normal University (Natural Sciences.), S1:121-124.

[18] X. Wang. (2016) Three-dimensional Construction and Application Study on “Internet+ Smart Campus”. Journal of China Educational Technology., 10: 107-111.

[19] Y.W. Wang. (2013) Research on Synergetic Mechanism of Digital Campus Construction Based on Synergetic Theory. China Social Science Press, Beijing.

[20] Y.W. Wang., C.H. Yu. (2016) The Wisdom Campus-The Only Way for Realizing Wisdom Education. Publishing House of Electronics Industry, Beijing.

[21] Y.Z. Li., Q. Zhou., J. Zhao. (2018) Reflections of the Construction of Wisdom Campus. Journal of China Educational Technology., 1: 112-117.

[22] G.S. Chen., M.Y. Gu., H.Y. Zhang., M. Liu. (2019) Construction Practice of Micro-service and Micro-application in Smart Campus Construction. Journal of Anhui University of Technology Social Sciences., 1: 92-93.

[23] G.H. Chen., Y. Wang., H. Huang. (2018) Three-dimensional Architecture and Application of “Internet + Platform of Smart Campus Teaching Resource Fundamental Supporting”. Journal of Education Exploration., 2: 57-61.

[24] N.P. Zhou., J. Jia. (2018) Research on the Construction Approach of Informationization in Universities under the Background of Big Data. Journal of China Educational Technology., 9: 75-80.

[25] P. Yu., Y. Li. (2018) Research on Education Big Data Ecosystem in the Construction of Smart Campus. Journal of China Educational Technology., 6: 8-16.

[26] Y. Liu. (2019) Research on University Smart Campus Based on Big Data Background. Journal of Guiyang College (Natural Sciences)., 1: 26-28.

[27] Y.J. Zhao. (2015) The Exploration on Application of Big Data in the Informationization of University Education. The Chinese Journal of Ict in Education., 19: 38-41.

[28] L. Cong. (2017) The Construction Study of College Informationization Teaching Mode under the Background of Big Data. Journal of China Educational Technology., 12: 98-102.

[29] F.G. Deng. Z.S. Zhang. (2017) Research on the Construction of Students’ Campus Behavior Analysis and Warning Management Platform Based on Big Data. Journal of China Educational Technology., 11: 60-64.

[30] H.T. Sun., Q.H. Zheng. (2016) The Technology, Application and Trends of Educational Big Data. Distance Education Journal., 5: 41-49.

[31] Wong C. (2018) NTU aims to become a tech-savvy campus with new smart pass, tech courses. https://sg.news.yahoo.com/ntu-aims-become-tech-savvy-campus-new-smart-pass-tech-courses-000141015.html.

[32] SEAtS Software. (2019) The student success platform. https://www.seatssoftware.com.

[33] R.H. Gan., Z.Q. Yuan., G.D. He. (2019) The Latest Advances of Overseas Smart Campus Construction and Its Enlightenment. Journal of Modern Educational Technology., 2: 19-25.

[34] C.Y. Yu., J.H. Guo. (2018) Theory and practice on MOOC and Blended Teaching. Tsinghua University Press, Beijing.