

# Progress in Digital Landscape Research in China based on CiteSpace

Yilu Gong<sup>1</sup>, Leichang Huang<sup>1</sup>, He Liu<sup>2,\*</sup>

<sup>1</sup> School of Art and Design, Dalian University of Technology, Dalian 116034, Liaoning, China

<sup>2</sup> School of Geography, Liaoning Normal University, Dalian 116029, Liaoning, China

\*Corresponding author. Email: liuhe1581@163.com

## ABSTRACT

With the gradual development of Internet technology, the digital era has gradually come, and digital landscape has come into being. Based on CNKI database, the progress and hotspots of digital landscape research in China are sorted out through the help of CiteSpace information visualization tool. It is found that: (1) Chinese digital landscape research results are mainly concentrated on the journals of architectural science and engineering and physical geography and mapping, and the authors of the journals show the characteristics of "large dispersion and small aggregation", with an overall network density of 0.0275, which means that the connection between authors is scattered and there are obvious differences in results from institutions, and there is a need to (2) Chinese digital landscape research has undergone a number of changes. ② Chinese digital landscape research has gone through three stages: budding (1992-2001), starting (2002-2005), and rapid development (2005-2021). At present, digital landscape research is mainly focused on the construction industry, smart site, wide linkage, and digital transformation.

**Keywords:** *Digital landscape, research progress, CiteSpace*

## 1. INTRODUCTION

Digital landscape is the product of combining digital technology, information technology and landscape architecture<sup>[1]</sup>. With the gradual development of the information society, digital technologies such as the Internet and computers gradually penetrate into the daily lives of residents and are closely related to the people, and information technology makes people's cognitive approach to time and space change, and in this context, digital landscapes are born<sup>[2]</sup>.

With the gradual development of modernization, urbanization and industrialization, the contradiction of human-land relationship is gradually highlighted, the construction and development of urban space makes the urban ecological space gradually fragmented, the integrity of urban landscape is damaged and the urban landscape imagery is changed, therefore, it is necessary to deal with the relationship between urban development and landscape protection to promote high-quality urban development.

At present, digital landscape research in China is still in its infancy, and it is meaningful to promote the scientific development of digital landscape research by

conducting quantitative statistics and qualitative analysis on the current situation and frontier trends of digital landscape research. Based on this, this paper compares the digital landscape research in China from 1992 to 2021 by using CiteSpace to discover the evolutionary trends of digital landscape research and to make an outlook on its future research.

## 2. DATA SOURCES AND RESEARCH METHODS

### 2.1. Data sources

The research data were obtained from the database of China Knowledge Network (CNKI), and all journals on the topic of "digital landscape" and "digital architecture" were searched from 1992 to 2021, and the search date was May 25, 2021, and a total of 519 documents were retrieved. By cleaning and de-duplicating the search results, finally obtained 452 documents.

### 2.2. Research methods

CiteSpace, as a visual analysis software, is able to visualize the literature in terms of keywords, authors,

research hotspots, and research frontiers<sup>[3]</sup>. In this paper, we use CiteSpace software to visualize and analyze the progress of digital landscape research in China, and get the relevant graphs and Excel tables to discuss the progress of digital landscape research in China.

### 3. FUNDAMENTAL ANALYSIS OF DIGITAL LANDSCAPE RESEARCH IN CHINA

#### 3.1. Trends in the volume of literature

The changes in the number of literature can reflect the development of this research field to a certain extent<sup>[4]</sup>. On this basis, the screened literature data were statistically analyzed to obtain the internal variation on the number of published literature on digital landscape in China (Figure 1). As can be seen from Figure 1, digital landscape research in China as a whole shows an upward trend and has mainly experienced three stages: budding, starting and rapid development. In the budding

stage (1992-2001), the cumulative number of articles published in this stage was 10, with an annual average of 0.9, indicating that digital landscape research had not yet attracted the attention of scholars in the budding stage, and the foundation of digital landscape research was relatively weak. In the initial stage (2002-2005), the number of articles published in digital landscape research was high, with 25 articles and an average of 6.25 articles per year, showing a rising trend year by year. During the rapid development stage (2006-2021), digital landscape research has attracted a lot of attention from scholars, and the number of articles published in 2006 began to exceed 10, and showed a rapidly rising trend, with a total of 418 articles, except for 2021, the average annual number of 27 articles, of which the number of articles of digital landscape research in 2020 was as high as 73. It indicates that the year of 2006 was the outbreak year of digital landscape research, and after that, the attention of digital landscape has been increasing, and the related research results have gradually increased.

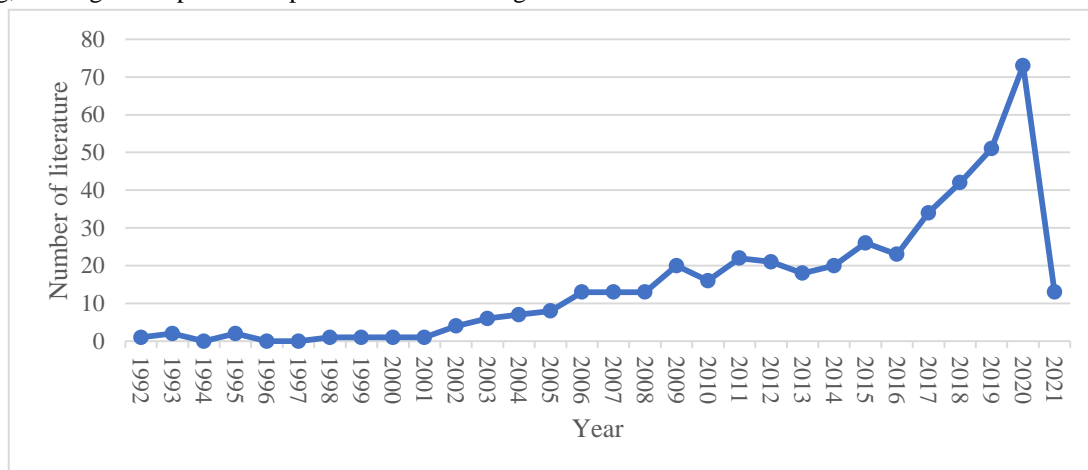


Figure 1 Number of annual publications in digital landscape research in China, 1992-2021

#### 3.2. Journal and discipline features

The number of academic journal literature can reflect the distribution of digital landscape research field to a certain extent. The 452 literatures of digital landscape research in China originate from 215 journals respectively, and the journals with more than 5 publications are counted, and the results are shown in Figure 2. Among them, the journals of Urbanism and Architecture, Chinese Landscape Architecture, Informatization of China Construction, China Engineering & Consulting, Contemporary Architecture, New Architecture, Volkswagen, and Landscape Architecture are the main academic journals of digital

landscape research in China, and there are four journals with more than 10 articles, namely, Urbanism and Architecture, Chinese Landscape Architecture, Informatization of China Construction, and China Engineering & Consulting, among which "Urbanism and Architecture" has 20 articles, accounting for 4.42% of the total literature. Besides, the research results of Chinese digital landscape are mainly concentrated on two major journals of architectural science and engineering and physical geography and mapping, followed by macroeconomic management and sustainable development, computer software and computer application, and trade economy.

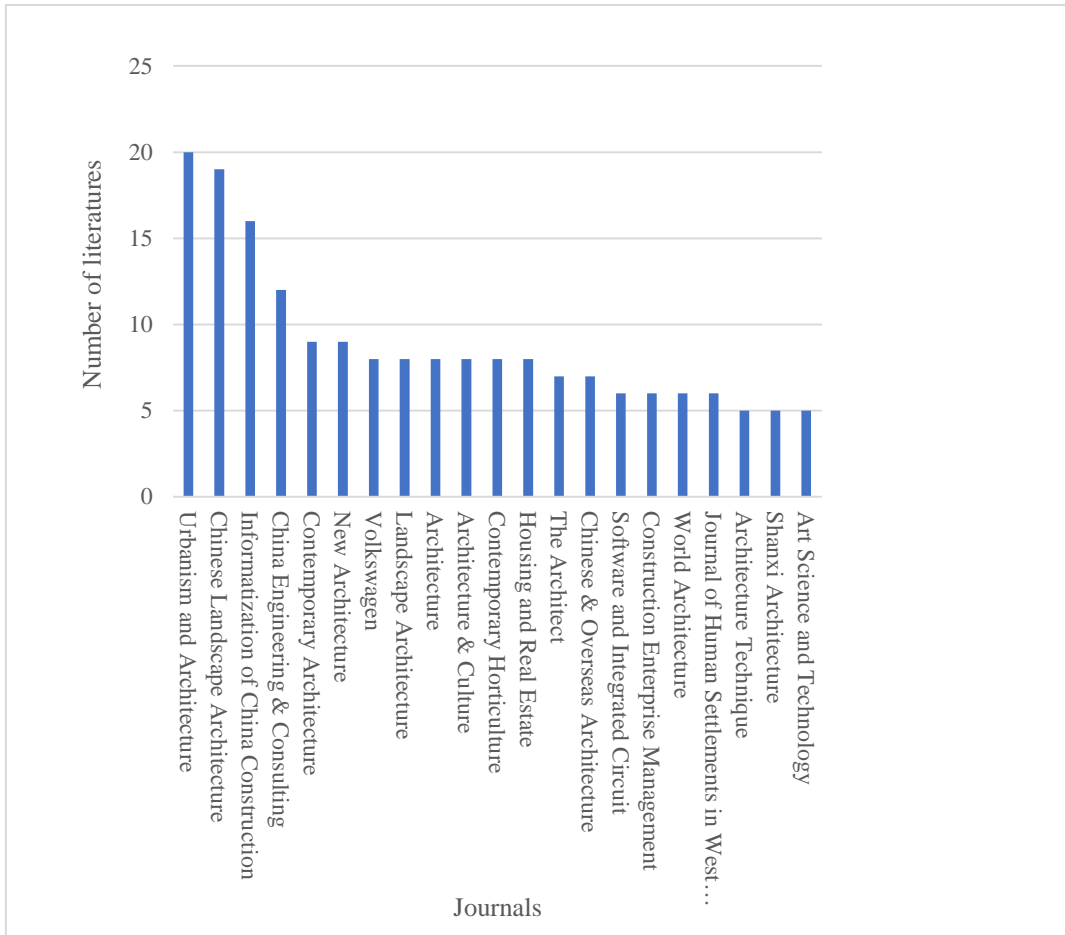


Figure 2 Names of journals with more than 5 articles on digital landscape research in China, 1992-2021

3.3. Author feature analysis

The analysis of the research paper authors collaboration mapping to enables the identification of authors of high publication volume of this research area and, at the same time, the collaboration between authors<sup>[5]</sup>. CiteSpace was used to visualize the Chinese digital landscape researched authors to generate the Chinese digital landscape authors collaboration map (Figure 3). The network density of the author cooperation map is 0.0275, which indicates that the connection between authors is relatively weak, and the

overall characteristics of "large dispersion, small aggregation" are not yet formed, indicating that the strength of Chinese digital landscape researches are fragmented, and there is still a need to focus on strengthening the horizontal cooperation of Chinese digital landscape. It is still necessary to focus on strengthening horizontal cooperation in Chinese digital landscape. The scholars that have made major contributions to the research on digital landscape in China include Qunli Zhang from Zhejiang Architectural Design Institute, Zhenggang Yuan from Quanlianda Technology Co.

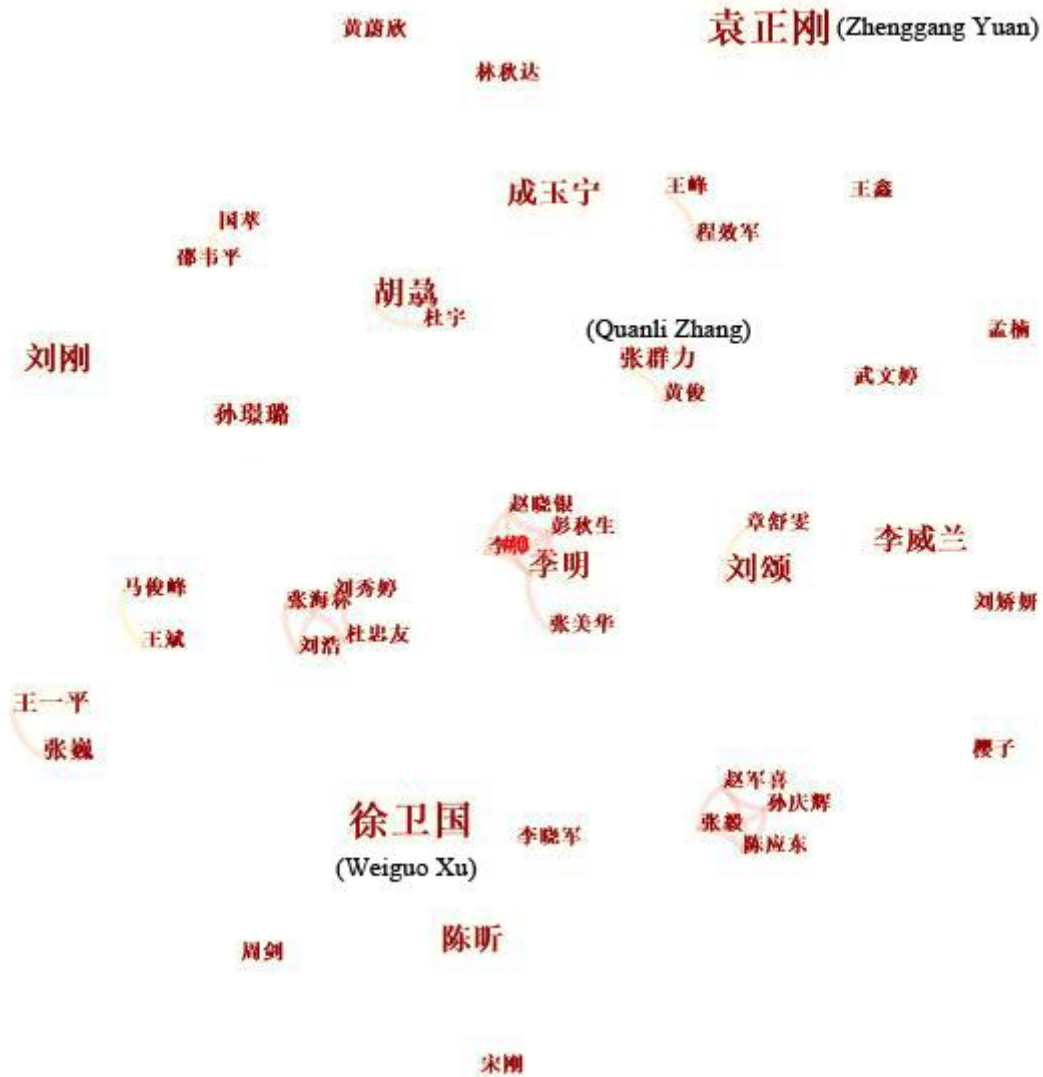


Figure 3 Collaborative mapping of digital landscape authors in China, 1992-2021

### 3.3. Mechanism characteristics analysis

The main institutions for digital landscape research in China are concentrated on research institutes, among which Zhejiang Academy of Building Science and Design and Quanta Technology Co., Ltd. have more than 10 articles, followed by Tsinghua University School of Architecture (8 articles), Southeast University School of Architecture (7 articles), etc. (Table 1). Through CiteSpace's visual analysis of Chinese digital landscape research institutions and mapping of

institutional cooperation, it is found that the network density of structural cooperation is low, indicating that the research on digital landscape is more scattered among institutions, and extensive cooperation has not yet been formed among institutions, lacking cohesion.

Headings may be numbered or unnumbered (“1 Introduction” and “1.2 Numbered level 2 head”), with no ending punctuation. As demonstrated in this document, the initial paragraph after a heading is not indented.

**Table 1.** Statistics of articles carried by digital landscape research issuing institutions in China, 1992-2021

Sort by	Institution	Number of articles/article	Year of first appearance
1	Zhejiang Institute of Building Science and Design	29	1992
2	Quanta Technology Co.	14	2017
3	School of Architecture, Tsinghua University	8	2007
4	College of Architecture, Southeast University	7	2010
5	Hunan High-speed Railway Vocational and Technical College	4	2019
6	School of Architecture and Urban Planning, Tongji University	4	2009
7	Hubei University of Technology	3	2019
8	Hebei Construction Information Center	3	2012
9	School of Architecture, South China University of Technology	3	2012
10	China Academy of Surveying and Mapping Science	3	1995
11	School of Resource and Environmental Sciences, Wuhan University	3	2004
12	School of Communication, Nanjing Arts Institute	3	2011
13	Wuhan University School of Urban Design	3	2008
...	...	...	...

**4. DEVELOPMENT PATH AND EVOLUTION TREND OF DIGITAL LANDSCAPE RESEARCH IN CHINA**

**4.1. Identification of hotspots for digital landscape research in China**

To further explores the hotspot structure of Chinese digital landscape researches, CiteSpace was used to conduct keyword cluster analysis and visualize Chinese digital landscape research (Figure 4), in addition to the high-frequency keywords of Chinese digital landscape research from 1992 to 2021 (Table 2). The high-frequency keywords of digital landscape research in

China include "Digital architecture", "Digital landscape", "Digital technology" and "Parameterization". The frequency of their occurrence is greater than or equal to 30 times. In addition, it also includes "Digital transformation", "Construction industry", "Building geometry control system", "Quanta". The high-frequency keywords such as "Digital transformation", "Construction industry", "Builds geometry control system", "Quanta", "architectural design", etc., all reflect to a certain extent the topics that experts and scholars in the field of digital landscape research are concerned about.

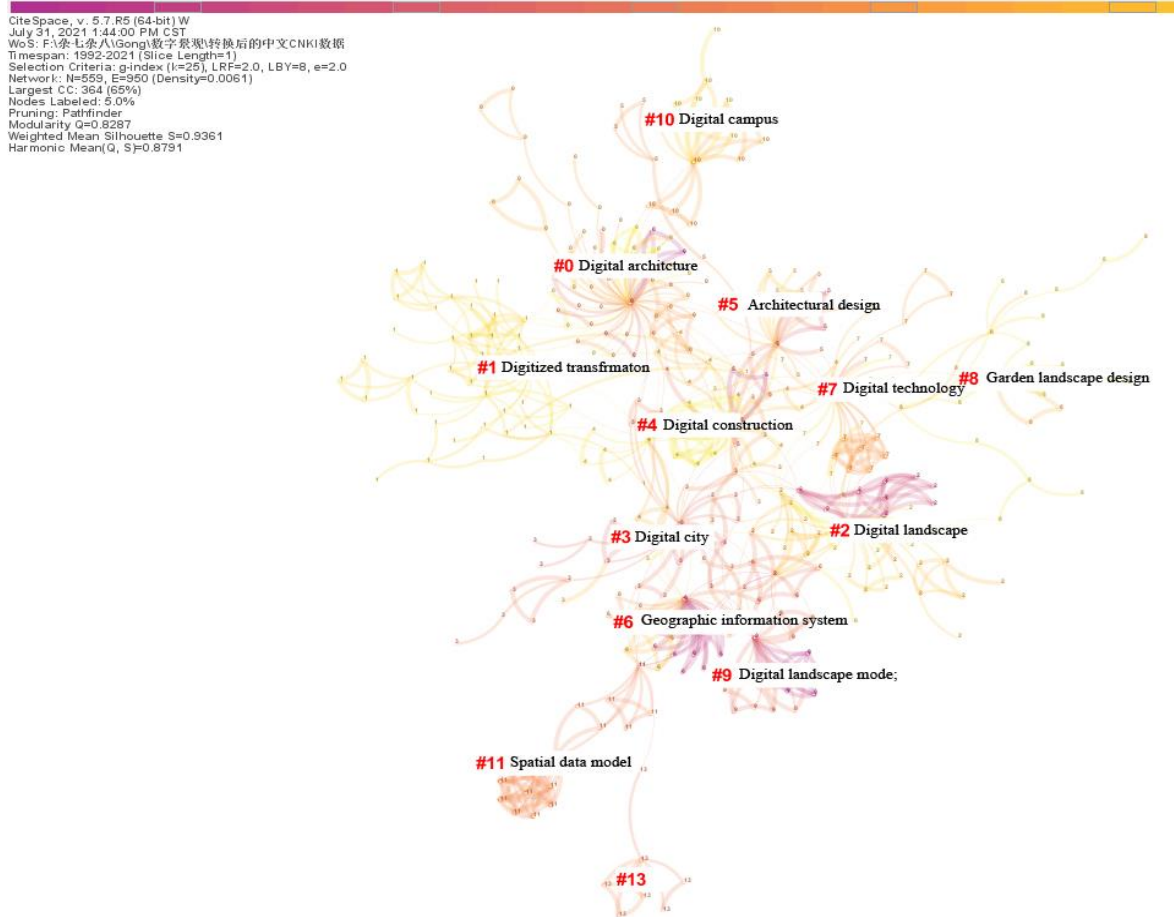


Figure 4 Clustering mapping of keywords for digital landscape research in China, 1992-2021

Table 2. High-frequency keywords in Chinese digital landscape research literature, 1992-2021

	Keywords	Frequency	Year of first appearance		Keywords	Frequency	Year of first appearance		Keywords	Frequency	Year of first appearance
1	Digital Architecture	125	1992	6	Digital Transformation	24	2018	11	Digital City	16	2002
2	Digital Landscape	35	1998	7	Construction	24	2017	12	Scenic Garden	16	2015
3	Digital Technology	31	2005	8	Building geometry control system	23	1992	13	Flow geometry	15	1992
4	Parameterization	30	1992	9	Quanta	21	2017	14	Smart Site	14	2017
5	Bim	26	2013	10	Architectural Design	18	2001	15	Construction Industry	12	2018

#### 4.2. Analysis of phased frontier research areas

The sudden words can reflect changes in the study trend in the academic community to some extent<sup>[6]</sup>. The terms that have a high emergent intensity in Chinese

digital landscape research from 1992 to 2021 are "Digital architecture", "Digital city", "Digital technology", and "Construction industry". "Digital technology", "Construction industry", among which "Digital architecture" has a higher emergence intensity

than "Digital city". The term "Digital architecture" has emerged from higher intensity than "Digital city" and has been the strongest term with digital landscape research in China from 2004 to 2011, with the longest duration. In recent years, the emerging strong term with digital landscape research in China is "Digital transformation", which started in 2019 and continues to this day.



Figure 5 Keyword emergence of digital landscape research in China, 1992-2021

### 4.3. Evolution and phasing of research themes

Based on the co-occurrence analysis of Chinese digital landscape research keywords from 1992 to 2021, CiteSpace is used to draw a time-zone mapping of them. Through the keyword time-zone mapping, we can see the research hotspots and their changing development of Chinese digital landscape research in a certain time

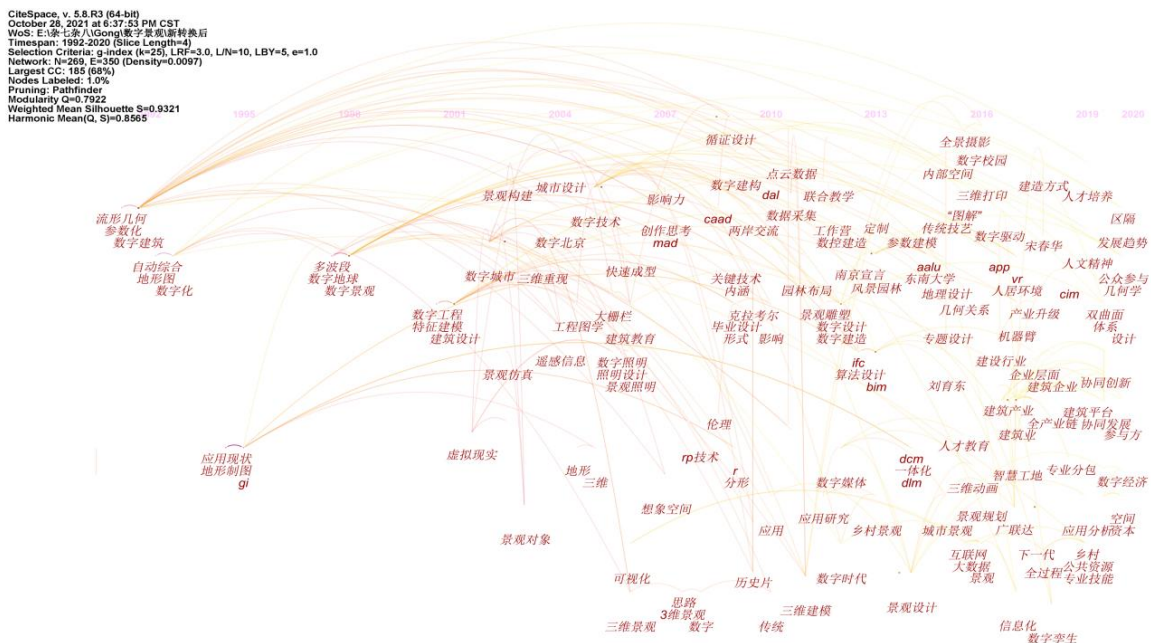


Figure 6 Time zone mapping of keywords for digital landscape research in China, 1992-2021

period, and by locating the time point of keyword appearance, we can find out the update of keywords and the condition of mutual influence.

As can be seen from Figure 6, "Digital architecture" was first introduced into 1992, and at the same time, there are also keywords such as "Building geometry control system" and "Parameterization". Subsequently, "Digital landscape" appeared as a research hotspot in 1998, and "Digital processing and construction", "Smart site", "Digital transformation" and other key words gradually highlighted. Until 2021, China's digital landscape research is mainly focused on construction, smart site, Quanta and digital transformation.

The keywords of digital landscape research in China from 1992 to 2021 can be summarized into three main aspects through the keyword time zone mapping. In terms of research object, it includes "Digital architecture", "Digital landscape", "Digital city", "Digital earth" and other hot keywords. The research content, with the gradual development of the times, the level has been gradually improved, including "High-quality development", "Integration", "Open space" and other hot keywords. The research methods show the characteristics of science and technology, including "Architecture digital technology", "Landscape modeling", "3D printing" and other hot keywords.

## 5. CONCLUSION

A visual analysis of China's digital landscape research trends from 1992-2021, conducted by CiteSpace, led to the following conclusions.

(1) The current situation of digital landscape research in China, the number of digital landscape research articles in China as a whole shows a rising trend, digital landscape research is attracting more scholars' attention; research results are mainly concentrated in two major journals of architectural science and engineering, as well as physical geography and mapping; the network density of authors' cooperation mapping is 0.0275, and the connection between authors is relatively weak, and the overall characteristics of "large dispersion, small aggregation", and a research network with high connection strength has not been formed yet; extensive cooperation among research institutions has not been formed, and there is a lack of cohesion.

(2) China's digital landscape research frontier, the current key words of China's digital landscape research show three characteristics, research object, including "Digital architecture", "Digital landscape", "Digital city", "Digital earth", etc.; in terms of research content, the level is further improved, including "High-quality development", "Integration", "Open space" and so on; in terms of research methods, highlighting the characteristics of science and technology, including "Digital technology of architecture", "Landscape modeling", "3D printing" and so on.

## 6. DISCUSSION

Based on this, this article proposes the following outlook for digital landscape research in China: (1) Improve the theoretical framework of digital landscape research and strengthen inter-institutional communication and collaboration. By playing the leading role of highly productive authors and leading institutions, a research network with high connection strength will be formed. (2) Deepen the theoretical approach of digital landscape research. By drawing on theories from related disciplines and using mathematical models, the theoretical basis and methodological support for digital landscape research will be broadened. (3) Strengthen multidisciplinary integration and carry out digital landscape empirical research. Digital landscape research involves architecture, geography, management and other multidisciplinary fields, and multidisciplinary intersection research can provide multiple perspectives for digital landscape research and promote the development of digital landscape research to a deeper level.

Headings may be numbered or unnumbered ("1 Introduction" and "1.2 Numbered level 2 head"), with no ending punctuation. As demonstrated in this document, the initial paragraph after a heading is not indented.

## AUTHORS' CONTRIBUTIONS

Yilu Gong Leichang Huang and He Liu contributed equally to this work.

## ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (Grant no. 32071831), Ministry of education humanities and social sciences research program (Grant no. 18YJCZH035), Liaoning education department scientific research project (Grant no. J2020060), Liaoning innovative talent plan candidate support project (Grant no.2020389) and Dalian science and technology innovation fund project (Grant no. 2020JJ26GX039).

## REFERENCES

- [1] Liu S, Zhang T K, Li C H. Progress in the research and application of digital landscape technology. *Journal of Human Settlements in West China*, 2016, vol. 31, pp. 1-7. DOI: <https://doi.org/10.13791/j.cnki.hsfwest.20160401>
- [2] Fan H W. Quantitative innovation of visual aesthetic evaluation of landscape - innovative application of digital landscape. *Housing and Real Estate*, 2017, vol. 27, pp. 64. DOI: <https://doi.org/CNKI:SUN:ZZFD.0.2017-27-056>
- [3] Zhang M, Chen D, Li N, et al. Knowledge map of environmental tax research in China based on Citespace. *Resources Science*, 2020, vol. 34, pp. 9-18. DOI: <https://doi.org/10.13448/j.cnki.jalre.2020.205>
- [4] Wu X J, Tan X X, Wang X Q. The knowledge structure and dynamic evolution of China's market segmentation research based on the bibliometric analysis from 1998 to 2015. *Management Review*, 2018, vol. 30, pp. 257-275. DOI: <https://doi.org/10.14120/j.cnki.cn11-5057/f.2018.12.024>
- [5] Zhang J N, Luo Y. Content-based author research similarity and potential collaboration network analysis: taking library science journals as an example. *Information Science*, 2021, vol. 39, pp. 86-93. DOI: <https://doi.org/10.13833/j.issn.1007-7634.2021.08.011>
- [6] Sun W, Wang X N, Sheng K R. Comparative study on urban regeneration at domestic and foreign based on bibliometric methods. *Scientia Geographica Sinica*, 2020, vol. 40, pp. 1300-1309. DOI: <https://doi.org/10.13249/j.cnki.sgs.2020.08.009>