Research on Knowledge Map of Way-finding System based on CiteSpace

Shuang Sun[1,a*], Mei Lyu[1,b], Yumeng Meng[2,c]

{* Corresponding author: sszdg@outlook.com[a], lynmei@sjzu.edu.cn[b] ,YumengMeng@stu.sjzu.edu.cn[c]}

School of Design and Art, Shenyang Jianzhu University, Shenyang, China[1]
Graduate School of Environmental Engineering, The University of Kitakyushu, Kitakyushu, Japan[2]

Abstract. At present, the way-finding system is widely applied in hospitals, shopping malls, airports and subway stations and other public spaces in the city. Some scholars have studied the way-finding system from its origin, function, excellent cases and design elements. However, there are fewer studies to sort out the research of way-finding system from the macroscopic perspective. In this study, we used the data of journal articles and references from 2002 to 2022 in the core databases of "China National Knowledge Infrastructure (CNKI)" and "web of science (WOS)". Meanwhile, Citescape was used to sort out the current research status, research, research subjects and research hotspots. The results show that in some research fields on way-finding systems, included computer, psychology or transportation in 20 years. Most scholars focused on two aspects of researches, such as appearance design and function. This study is helpful to provide some reference for research implementation in the future

Keywords: CiteScape, way-finding system, way-finding behavior, Knowledge map, Bibliometrics.

1 Introduction

With the rapid development of urbanization and technology, the way-finding system in urban public places is constantly moving towards scientific and rational development, playing a positive role in the development of urban residents, transportation, and economy. The way-finding system is one of the factors that influences human way-finding behavior. Its spatial layout design also impacts human spatial cognition and way-finding efficiency. The way-finding system came from Western countries. It experienced three stages, such as signs, signage system, and way-finding system. At the end of the 19th century, the way-finding system in urban public environment was standardized design. Way-finding research began with the external built environment in the city. In 1960, Lynch proposed signs play a positive role in the urban spatial environment [1]. Then, some scholars introduced way-finding theory into internal buildings. Now, the building facilities have become the study sites of way-finding research [2]. At present, way-finding studies are often widely applied in large, complex public facilities, such as hospitals, shopping malls, museums, airports, and subway stations[3]. However, the development of way-finding system design in urban public places has also led to problems such as confusion in signs and incorrect information.

Since 1983, in order to solve the problems in the way-finding system design, scholars have obtained some achievements in theory research, practice and other aspects. For the theory research, they studied the way-finding system from its origin, function, excellent cases and design elements. For example, Gail Deborah Fink introduced some cases of way-finding system design such as Glasgow, England and Fukuoka, Japan in the "Creating City Images Through Design". Korean scholar Jung Kwang-young published a book named "Sign Design". It analyzed practical cases in educational, stores, offices and hospitals.

For the elements of way-finding system design, Andreas Überle suggested that color, graphics, fonts were important for way-finding system design in "Sign System Design". He argued that these elements are being applied to signs for planned spatial information design. It is helpful to provide information to guide people during their way-finding. Some studies have indicated that color could enhance human memory of the environment and destination. The complexity of color and shape plays an important role in recognizing the spatial environment. Nodes, intersections and decision points were the most effective locations for the distribution of signs[4]; Calori and Vanden-Eynden pointed out information, graphics and hardware are the signage pyramid model [5].

In China, the research of way-finding system is later than other countries. Some scholars studied it by learning the theory and practical experience of foreign way-finding design. With the development of economic and urban construction, the requirements for urban way-finding system such as hospitals, parks and scenic spots are gradually improving. Therefore, scholars pay more attention to the research of way-finding system in urban public places. For example, Hu Min combined the graphic symbols of Shu culture with the scenic guide system. It was helpful to establish the cultural image of the scenic tourism brand, and to promote tourism development. Meng Lu pointed out the way-finding system design was an important carrier that integrated recognition, guide information, culture and art. Hu Pengfei suggested that the way-finding system design should be characterized by humanization, the different designs should be made for different groups. For example, the designs are allowed to harmonize the size and height for the handicapped or elderly. Wang Li pointed out that the overall design of the way-finding system should be uniform with words, colors, layout location, and other design elements. In addition, a series of standards and regulations have been published in China to solve the problem of irregularities in the way-finding system design. For example, "Guidance System for Public Information-Setting Principles and Requirements Part1-6", "Public Information Graphical Symbols for Use on Sign Part1-10", GB17733.1-1999 "Place name Plats- Towns and Villages", "traffic signs and markings", and "Principles and requirements for the use of signs".

Many scholars have studied the way-finding system from different perspectives. However, there are fewer studies to sort out the research of way-finding system from the macroscopic perspective. Currently, Citescape is used to explore the research structure and knowledge maps for some subjects, such as management, urban regeneration, and high technology. Therefore, this study will conduct research from the macroscopic perspective, and Citescape will be used to analyze the research hotspots, research subjects and publication of way-finding system. It is helpful to provide some reference for research implementation in the future.

2 Methods and Data Sources

The quantitative method of bibliometric analysis could reflect the progress of research related to way-finding theory. The citespace was used as the research tool in the study. The study used the citespace software to analyze the literature based on the core database of WOS (web of science) core collection and CNKI (China National Knowledge Infrastructure) for data analysis. The study was conducted for keywords related to the subject "way-finding", the time span for data extraction was set from 2003 to 2022. Based on the way-finding behavior, a way-finding system is a way-finding tool that is integrated with the environment. Therefore, in addition to "Way-finding System", the search word "Way-finding" and "Way-finding behavior" were added to the two words. Finally, the search formula is determined as TS=(("Way-finding") OR(("Way-finding system")AND("Way-finding behavior"). The study obtained 601 valid research data samples from CNKI and 1052 valid research data samples from WOS. In order to obtain comprehensive, objective and accurate data, the study removed some irrelevant publications such as news, meeting notices, interviews.The Refworks format was chosen as the format for exporting literature. In addition, the study reduced the number of duplicate literature by using Citescape software. Finally, the study obtained 533 valid research data samples from CNKI and 996 valid research data samples from WOS. The literature was imported into Citescape for visual analysis. The literature about way-finding was analyse to learn the number of publications, sources of literature journals, and subject orientation.

This study analyzed the literature and development lines in the field of way-finding system by literature co-citation analysis and literature clustering analysis in Citescape. In this case, literature co-citation refers to two or more papers being cited by one or more papers at the same time. These literature are co-cited with each other. This method is helps to understand the intrinsic connections between research directions. The analysis iterature cluster is an analytical method based on literature co-citation analysis. Based on high co-citation, some literature can be clustered, and the literature network formed by clustering of multiple groups. It could represent the research hotspot and development trend of the discipline at a certain period of time, so as to form the development lineage of the discipline.

3 Results

3.1 Literature Development Trends

By analyzing the research literature between 2003 and 2022 (Figure.1), it was known that the number of publications on way-finding has declined in individual periods of time. For example, the period of 2009-2010 and 2017-2018 were the exploration stage. But the overall trend of publications was still increasing upward. The results showed that with the development of urbanization and public space construction, way-finding behavior has received the attention of scholars in the past 20 years. Way-finding behavior was one of the important theories for exploring people and the spatial environment. The number of related literature had significantly increased between 2018 and 2019. The research on way-finding has been comprehensive and diversified until now
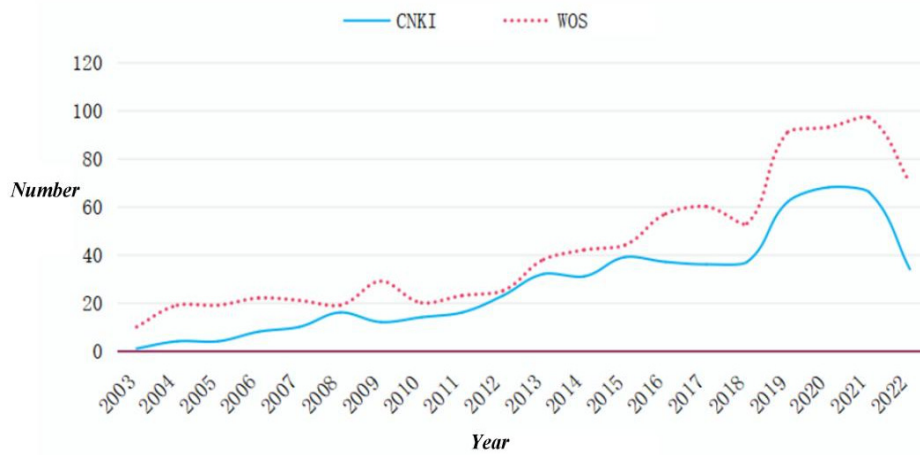
Fig. 1. The number of publication papers from 2003 to 2022

3.2 The analysis of publication journals

Table 1. The top 10 cited journals of Way-finding system.

	CNKI	WOS
1	Popular literature	Journal of Environment Psychology
2	Packaging Engineering	Herd Health Environment Research Design Journal
3	Art Science and Technology	Spatial Cognition and Computation
4	Design	Frontiers in Psychology
5	Ming Ri Feng Shang	Isprs International Journal of Geo Information
6	Art Education Research	Transportation Research Record
7	Beauty & Times	Lecture Notes in Computer Science
8	Advertising Panorama(China Signage)	Cartography and Geographic Information Science
9	Art and Design	International Journal of Geographical Information Science
10	Appreciation	Sensors

According to the publishing sources of the literature on way-finding behavior (Table.1), the top five cited journals in China were Popular literature, Art Science and Technology, Design, Ming Ri Feng Shang, Art Education Research. The result reflected that the research on way-finding system in China mainly focused on Art, which solves the design problem of the guide signs and improves its aesthetic. Some studies have considered way-finding auxiliary tools and clues. Meanwhile, they explored the impact of signs and information design on human way-finding behavior, including graphics, linguistic accessibility, color, cross-cultural symbols and cultural.

The top five cited journals in other countries were the Journal of Environment Psychology, Herd Health Environment Research Design Journal, Spatial Cognition and Computation, Frontiers in Psychology, Isprs International Journal of Geo Information. It indicated that these studies mainly focused on Psychology. Research on way-finding systems mainly from the perspective of pedestrian psychology, environment, these studies could solve the problem of application of the way-finding system and improve its effectiveness in space.

3.3 The analysis of publication subjects

Way-finding system is the basis of human way-finding behavior, it could guide people to find the path of destinations in various spatial environments[6]. Therefore, scholars have studied the relationships between way-finding system and way-finding behavior.

In China, the result showed that the most papers were mainly published on some research subjects(Table.2), such as Architecture and Civil Engineering(37.1%), Art Writing Sculpture & Photography(28.23%), Computer software and computer applications(12.9%), Transportation(5.65%). They were focused on architecture, art, transportation and other research fields. Most paper were mainly published on some research subjects, such as Psychology(25.1%), Engineering(19.88%), Computer Science(17.27%), Environmental Sciences Ecology(9.94%). Scholars pay more attention to engineering, psychology and other research fields. By comparison analysis, it indicated that the way-finding system focused on the same research fields such as computer, psychology, transportation. As a branch of psychology, way-finding behavior was widely applied in the research of way-finding system. In addition, the way-finding system was mostly used to solve the way-finding problem in public space, so it was often combined with the transportation field.

The researches of architects and psychologists mainly included the familiarity of people with the spatial environment, and factors such as the visibility of facilities in the building interiors, spatial complexity, signs use and the number of spatial distributions. However, some scholars have paid more attention to designing effective way-finding systems rather than conducting case studies that aim to understand public way-finding in complex spatial environments. Way-finding information is important to make and follow route decisions in way-finding systems. The information includes architectural cues, linearly arranged signs, and plans. Public accomplishes way-finding behavior through way-finding elements such as signs, maps, and other tools. For example, Michele de Certeau pointed out that maps were one of the ways to identify locations [7]. Li suggested that the complementary use of directional signs and maps could be effective in way-finding behavior [8]. The analysis of human way-finding process in shopping malls showed that some people could not pay attention to the guide signs. They argue that some signs with insufficient information content were located in an unreasonable position, An analysis of people's wayfinding process in shopping malls shows that some wayfinders do not notice the guide signs and believe that the signs with insufficient information content are located in an unreasonable position, which led to some problem of way-finding difficulties. Xia proposed four conceptual models based on tourist familiarity found that different landmarks used by people were related to familiarity with the environment [9].

Table 2. The research directions of Way-finding system.

CNKI		WOS	
Research directions	The proportion of literature	Research directions	The proportion of literature
Architecture and Civil Engineering	37.1%	Psychology	25.1%
Art Writing Sculpture & Photography	28.23%	Engineering	19.88%
Computer software and computer applications	12.9%	Computer Science	17.27%
Transportation	5.65%	Environmental Sciences Ecology	9.94%
Tourists	4.84%	Transportation	6.727%
Other	11.28	Other	21.538%

4 Discussion

4.1 Research Hotspots

The literature of way-finding systems are from the web of science for the last 20 years, The study conducted clustering of highly cited literature by citespace. The analysis of co-citation clusters showed the clear trends and research frontiers in the field, and identifies relationships between the research frontiers. It indicated that theory of way-finding behavior includes spatial knowledge, recognition maps, and way-finding strategies [10], which have been widely studied in spatial influences, way-finding aids, and layout planning(Fig. 2).
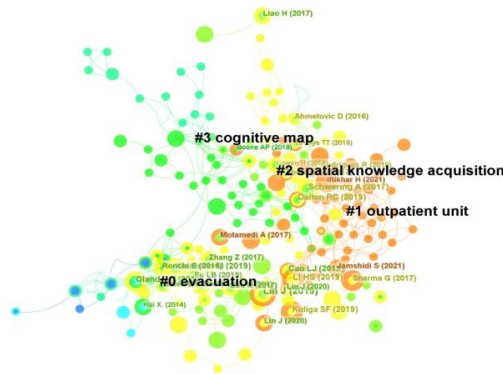

Fig. 2. The literature co-citation analysis of Way-finding.

Passini pointed out that way-finding is a mental process taht includes purposeful movement. The way-finding process included making strategy, executing way-finding decisions, and the information for making and executing decisions. As a complex cognitive process, way-finding has been widely discussed [11]. Public cognitive and reactive behaviors had an impact on way-finding in both indoor and outdoor environments. Some studies have provided theoretical guidance for evacuation in emergency situations. O'Neill pointed out that complex plans lead to reduced way-finding efficiency. Way-finding signs were helpful to enhance the speed of escape[12]; Meanwhile, some important tools such as evacuation maps, exit signs and clear directions were also able to impact passenger route choice and the evacuation process [13].

Cognitive Map is human psychological perception and memory of space. It constructed information and executed way-finding decisions using visual cues such as markers. Previous studies on way-finding have focused on individual behavioral patterns and environmental spatial factors [14]. Recent research by Mondschein, Chorus and Timmermans, and Appleyard showed that different ways of travel affect the

understanding of the same environment. They also found that active patterns increase an individual's perception of urban space construction [15]; Mondschein studied the different travel mode experiences that form the cognitive map by measuring the accuracy of the cognitive map about distance and specific locations[16].

In addition, spatial Knowledge Acquisition is part of the cognitive map. It includes the basic information for way-finding, such as landmark knowledge, route knowledge, and overview knowledge. Some studies of way-finding showed that landmarks, building structures, and other surrounding factors also have an impact on way-finding efficiency [17]. The acquisition of spatial knowledge was important for public way-finding behavior. The way-finding process includes the relationship between people and the environment. In the unfamiliar environment, some factors have an impact on the recognition and construction of the surrounding spatial environment, such as gender, education, cognitive map, age and many other factors. For example, Self and Golledge (2000) reviewed the literature and reported a large number of controversies about gender differences in cognitive mapping ability [18]; There were differences between men and women in cognitive abilities such as visual-spatial ability and episodic memory of way-finding[19]; Lawton and Kallai conducted two separate way-finding behavior studies of 513 psychology students (from the United States and Hungary). Their report showed that women's anxiety about way-finding in unknown places affects the way they guide themselves [20]. Beck found that the perception of library users is complex, and designers should consider the needs of different age groups and physical abilities.[21] Older, impaired or having other medical conditions were often challenged to construct cognitive maps [22].

4.2 The Development of Research Methods

Studies on way-finding system have developed later in China than in other countries. Based on the way-finding experiment, Xu discussed the influence of signs on way-finding behavior by photography, audio recording and questionnaire survey. It was helpful to provide theoretical knowledge and guidance for the design of sign types and the location. In the underground public space, Mijia discussed public way-finding behavior and spatial cognitive characteristics

in the case of clear signage guidance. Huang Bo summarized the design model of underground commercial street design that makes cognitive ability more efficient.

Some the previous studies have explored the method in which people execute way-finding during the way-finding process. In the early days, studies were conducted by evaluating way-finding tasks in real-world environments. It was used to develop the Global Positioning System (GPS) for digital outdoor navigation and indoor way-finding. Later studies were discussed in quantitative form based on virtual reality (VR) and laboratory environments [23]. For example, mathematical simulation models, evacuation drills, laboratory experiments, and surveys were used to predict the way-finding behavior of passengers during normal and emergency evacuations [24]. Eye tracking usability has been introduced into way-finding studies to infer how travel mode affects visual cue memory during way-finding [25].

5 Conclusions

By combining bibliometric analysis and knowledge mapping, Citescape was used to conduct macro-level study for way-finding systems and visualization analysis.

Firstly, the analysis of research subjects showed that the studies on way-finding system were focused on some research fields, such as Computer, Psychology, Transportation. Meanwhile, most studies were published in Psychology, Art or other journals.

Secondly, the analysis of research directions showed that the studies of way-finding system were different between China and other countries. The studies were focused on the appearance design of way-finding system in China; studies in foreign were focused on the functionality of way-finding systems.

Thirdly, with the innovation of research methods, the methods of way-finding system have developed from single qualitative research (photography or field survey) to quantitative research with multi-methods (VR or laboratory experiments).

Finally, the analysis of literature cluster showed that way-finding behavior was mainly focused on two aspects of spatial knowledge and cognitive maps. Scholars have conducted to research on way-finding behavior on spatial influences, way-finding aids, and layout planning.

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