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Research Article

Research on Evaluation Method of Wayfinding Signs in Medical Institutions Based on Mobile Network Intelligent Navigation

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With the rapid development of our country's economy, there has been a phenomenon of population concentration and centralization of medical institutions. At the same time, with the continuous development and improvement of medical disciplines, large-scale general hospitals have become more comprehensive and larger in area. Therefore, hospital users often get lost in the public space of the hospital. Therefore, the purpose of this article is to study the evaluation method of wayfinding signs in medical institutions based on mobile network intelligent navigation. This article first analyzes the research status of navigation signs in medical institutions and then introduces the current wayfinding behaviors of large general hospitals, and analyzes the problems and deficiencies in them. On this basis, the intelligent navigation is researched and designed. This article systematically expounds the main characteristics of hospital users' pathfinding behavior, the spatial order of the process, and the hierarchy of pathfinding behavior, and uses questionnaire survey, field survey, and other research forms to carry out experimental research on the theme of this article. Studies have shown that the hospital's public organization space model will directly affect the efficiency of people seeking medical care.

1. Introduction

Large-scale hospitals in my country often have complex building structures and can accommodate a large number of patients [1, 2]. People usually need to find the target location accurately and efficiently during medical treatment. However, preliminary studies have shown that even though most large hospitals have indoor recognition systems, many people still spend unnecessary time looking for directions during treatment [3, 4].

In the research on the navigation signs of medical institutions, many experts and scholars have achieved good results. For example, the book AboutFace4 Interaction Design Essence by Alan Cooper elaborates the goal-oriented design method in detail and puts forward a good design to make users more efficient, which is a general guideline for interaction design [5]; Yicheng Bai proposed a novel technology for hospital guidance systems, especially for the visually impaired [6]. Unfortunately, these studies on hospital navigation signs have not been paid attention to, so the topic of this article has very good practical significance.

The purpose of this article is to improve the efficiency of hospital visits for users, and to design the intelligent navigation system of the hospital's wayfinding as the purpose. By conducting questionnaire surveys and analyzing and comparing the data obtained in four hospitals in a certain place, the research theme of this article is studied. Based on the in-depth analysis and modeling of the problems in the field of information, the intelligent navigation system establishes a variety of information organization mechanisms and process control mechanisms, senses users' needs in real time, grasps and uses users' cognitive context, simulates human thinking mode, and guides users to locate their information needs through reasoning and analysis.

2. Application Research on the Evaluation Method of Wayfinding Signs in Medical Institutions Based on Intelligent Navigation

2.1. Analysis of Existing Wayfinding Behaviors in Large General Hospitals

2.1.1. Main Characteristics of Hospital Users' Pathfinding Behavior

(1) The flow of medical treatment

In the public space of the hospital, the behavioral characteristics of the hospital users have a clear process and purpose. As a large general hospital and a multifunctional and integrated architectural form, such as treatment, inspection, medicine collection, hospitalization, and academic office, it produces a variety of different purpose pathfinding process methods [7, 8].

Wayfinding behavior for the purpose of seeing a doctor

In the hospital building, there is a regular medical treatment process, which is usually registration-waiting-seeing a doctor-checking-treatment-taking medicine-leaving.

Wayfinding for the purpose of hospitalization

The hospitalization process in the hospital building is usually hospitalization application-main processing-payment-inpatient room-completed.

Wayfinding behavior for the purpose of follow-up visits

This wayfinding behavior generally includes re-examination, consultation, taking medicine, or several simultaneous medical treatment modes.

Way-finding behavior for the purpose of follow-up visits

The users of wayfinding behaviors are generally hospital communication and learning personnel or outsiders who are led and guided.

(2) The spatial order of the process

In the public space of hospitals, hospital users have the characteristics of the process, and the corresponding public space order levels need to correspond to the order, so that the space order guides hospital users to better wayfinding and spatial cognition. In order to cope with the sequential nature of the medical treatment process, the spatial logical order of the public space of the hospital has been formed, and different spaces have been set up in different levels. Hospital public space is divided into a public center system, a public subsystem, and a connection system connecting the two according to the medical treatment process from high to low [9, 10]. As shown in Figure 1, the logical order is arranged according to the relationship of reason, which conforms to the law of people's understanding of things. This order is often used to introduce complex things and phenomena, as well as expository texts that introduce reason. It is generally explained in the order of from shallow to deep, from easy to difficult, from concrete to abstract, from simple to complex, and from primary to secondary.

2.1.2. The Hierarchy of Pathfinding Behavior. For hospital users, a complete pathfinding process should start in the city. Until returning to the city, the scope of pathfinding in the public space of a large general hospital studied in this article is not limited to the pathfinding behavior inside a single building. It is an incomplete wayfinding behavior. This article divides a complete pathfinding into four levels: city to hospital area, hospital area to cell, cell to department, and department to leave. Each level is interconnected and inherited from each other [11, 12].

(1) City Campus. The wayfinding behavior of hospital users has already begun in the city. Field surveys have found the main transportation methods for hospital users, which are as follows: public transportation includes urban public transportation systems such as buses and subways, and self-driving transportation includes self-driving cars and other means of transportation. Therefore, the wayfinding behavior from urban public transportation stations to the hospital area and urban roads to the park is also an important part of the hospital's wayfinding.

(2) Campus Monomer. Large general hospitals generally cover different areas such as outpatient area, medical technology area, inpatient area, emergency department, pediatrics, rehabilitation, teaching, and research, so the second stage of pathfinding for hospital users is the pathfinding behavior from the hospital area to the individual.

(3) Monomer Department. After the hospital user accurately completes the second phase of pathfinding from the hospital area to the individual, they will enter the most important pathfinding phase in the public space of the hospital, that is, the individual to the specific medical department.

2.2. Analysis of Hospital Public Space Auxiliary System and Wayfinding Behavior

2.2.1. The Contradiction between the Navigation System and Hospital Users. The use of the navigation system has its own hierarchy based on the level of the medical treatment process. The navigation system is mainly used in the first pathfinding stage city to hospital pathfinding behavior described above, and the third pathfinding stage alone to the department. The specific use is one of the navigation systems from the city to the hospital (the first wayfinding stage); to reach the urban area around the hospital by self-propelled vehicles or urban public transportation, the city navigation system is generally used to assist the wayfinding and then enter the courtyard. The second is the use of the navigation system from a single unit to the department (the third wayfinding stage). The main

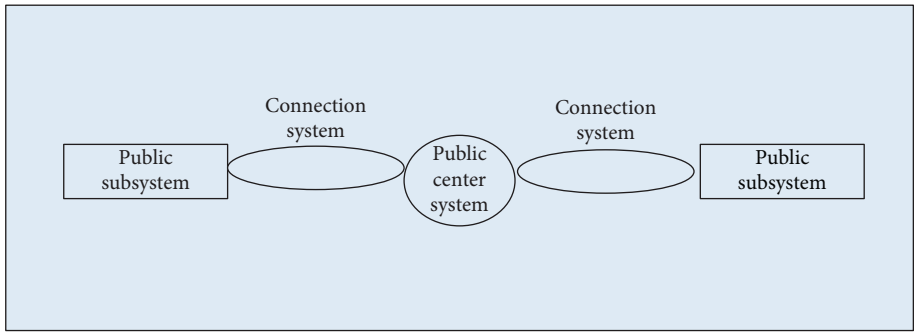

Figure 1: Hospital public space order.

function of positioning in the navigation system is to find the position, relying on the synthetic positioning method. The method is to add the route units according to the number and angle. This process includes the accumulation of errors, but these errors are compensated by constantly comparing with the road position of the digital map (map matching).

Although the navigation system in the hospital assists hospital users in the wayfinding behavior when visiting a doctor to a certain extent, the navigation system inside the building still follows the navigation mode in the city and the point-to-point navigation mode. The pathfinding behavior of hospital users in the public space of the hospital has the characteristic of the process; that is, their pathfinding behavior is a multipoint pathfinding behavior, so the navigation system cannot solve the process of hospital users getting lost.

2.2.2. The Contradiction between the Sign System and the Cognition of Hospital Users. Although the identification system in the hospital is an indispensable auxiliary tool in the process of hospital users' consultation, its design has contradictions with the hospital users' perception and wayfinding behavior. Identification system refers to the setting of a visual image system in the form of text, graphics, and symbols, which can clearly express the content, location, direction, principle, and other functions in the hospital. The setting method of the icon content in the identification system often adopts up north and down south, but the hospital users in the treatment cannot perceive their own position, and where is north is even more difficult to talk about. There is a certain correlation between the user's location perception and the presentation of hospital graphics. For example, "I am here" on the icon requires reference to the surrounding image elements. If the presentation of the icon does not highlight the imageable elements, the identification will be difficult. If there is no perfect sign system, it means that the hospital's map system and road sign system are not perfect, and it takes a lot of time to find a department. These are indispensable components in modern hospitals. It can be said that the design and setting of signs is one of the symbols to measure the degree of civilization of a hospital, and also one of the symbols to measure the quality of the hospital's planning level.

2.2.3. The Contradiction between Artificial Medical Guidance System and Path Cognition. Guiding language elements and hospital user path cognition elements. The linguistic elements of guidance should be unified with the cognitive elements of hospital users and at the same time increase the cognitive elements in the building. Element mining is to make further preparations for design and development. Based on the analysis of the survey results, the structural type and color orientation of the logo are extracted, the spirit and characteristics of the logo are listed, the relevant graphic elements are excavated, and the direction of logo design is found, so that the design work is targeted, rather than the aimless combination of words and graphics. In addition, when the route is more complex for destination guidance, it is difficult to be remembered by people if it covers more than three points of pathfinding. Therefore, hierarchical guidance appears; that is, one level of pathfinding can be completed by asking for directions at a time. The way needs to be asked twice. The signs determined in the proposal stage of the identification system may not be perfect in detail. After the correction of different forms of expression such as standard drawing, size correction, black-and-white application, and line application of the signs, the use of the signs will be more standardized. At the same time, the characteristics and structure of the signs will not be lost when used in different environments, so as to achieve unified, orderly, and standardized dissemination.

2.3. Design of Intelligent Wayfinding Navigation Marking System

2.3.1. System design principles

(1) Principle of Reliability. The principle of reliability is very important to the quality of a system. The correct route planning several times or even dozens of times is not enough to prove that the system is mature. After the design is completed, the reliability still needs to be strictly tested, including the overall system and different functional modules. Strict functional tests must be carried out, and the reliability of functions is particularly important. The purpose of reliability design is to make the life cycle of the product meet the specified reliability requirements by adopting the corresponding reliability design technology on the basis of

comprehensively considering the performance, reliability, cost, design, and other factors of the product.

2.3.2. Principle of Convenient Operation. The intelligent and simple operation method and comfortable human-computer interaction mode enable students to use the software more quickly and have a better user experience.

(2) Layout Positioning Design. Fully grasp the overall environmental characteristics of the hospital space, analyze its function, nature and internal logic, and plan in detail the route map for people to pay attention to logistics, and set the specific location of the sign. For example, the signs of the divided junctions, entrances and exits, stairways, crowd gathering points, public facilities, and important functional areas of hospital roads should be planned and dealt with appropriately at suitable locations to ensure the most effective guidance.

2.3.3. Universal Logo. The general medical logo design is based on graphics, supplemented by concise text, to achieve the purpose of easy generalization, easy copying, and generalization of hospital information. The hospital is a special public space environment, in which patients want to quickly and accurately complete the diagnosis and treatment process, and it is required that the general identification should have strong intuitiveness, prompting, and other characteristics.

2.3.4. Subject Identification. The main logo of the hospital is mostly composed of the name of the hospital and simple graphic symbols. The main logo is unique and can represent the overall image of the medical institution. This is what we often call the hospital emblem. The emblem is mainly set on the roof of the building, the wall of the outer wall, the top of the gate building at the main entrance, or the prominent position on the outer wall of the hospital. The design is usually based on the exterior wall materials of the main building of the hospital, using strong three-dimensional graphics and text for creation. At present, the most common is to use beautiful hollow fonts and flexible lamps and combined expression techniques for production. In addition, the hospital logo is often designed and applied to the public media such as the medical staff's badge, the hospital's letter paper, envelopes, and publicity albums to show the hospital's own image.

2.3.5. Space-Oriented Logo. Space-oriented signs refer to the ability to correctly guide people to find the target as soon as possible in a complex medical environment, and they are mainly set on the wall and the ground. Ground guidance signs are generally set up in gatehouses, emergency rooms, and other relatively rapid and chaotic environments. The direction system mostly indicates the direction and destination through arrows. It mainly tells people the direction of travel and the main facilities along the way, so as to guide people to reach their destination accurately and quickly. They are expressed in the form of more continuous indicator arrows combined with text descriptions or extended guidance with different colors representing different areas. Under normal circumstances, the sign guide board in the building is set at the main entrance of the building, the center of the outpatient hall, and around the elevator on the floor, and it is generally made into a solid column type and a wall hanging type. The spatial system is based on the principle of comprehensive guidance and uses maps to express the positional relationship between places. Different from the directional system, the spatial system informs the environment as a whole, making it convenient for people to use information selectively. It usually indicates the location of pedestrians, the location of entrances and exits, and other nearby transportation modes.

2.3.6. Analysis of functional modules

(1) Positioning Function. The current location positioning function is a function that any location service software needs to have. When you want to know the specific location, you can open the software to display the current location. After accurate positioning, it can also display other related location information near the current location. When the user moves, the small smart icon for positioning also moves, and the location can be determined in real time. In the case of noise interference, considering the ranging accuracy, signal bandwidth, required power, and different satellite identification, GPS adopts pseudorandom code ranging technology. Using pseudo-random coded signals can achieve low signal-to-noise ratio reception, greatly improve the reliability of communication, and achieve code division multiple access communication.

2.3.7. Query Function. You can query the specific location you want to know through the designated location query function. The system will generate a corresponding icon to indicate its location, and related information about this location will also be displayed on the phone screen.

2.3.8. Route Navigation Function. The route navigation function is the most important function of all the functions of the software. It is the function of the user to query the route planning and route guidance from the starting address to the destination address according to their actual needs, that is, from one place to another.

2.3.9. Mark Location Information Function. Display more important information to facilitate users to quickly obtain.

2.4. Indoor Positioning Algorithm Based on MEMS-IMU

2.4.1. Pedestrian Walking Gait Analysis. Pedestrians have a unique regularity in the process of movement. The main factor that affects the pace is step frequency. Usually, the gait parameters of pedestrians are symmetrical to each other. The walking time refers to one heel touching the

ground to the opposite heel touching the ground. The average time of the step length is about 0.5s. The gait cycle refers to the average time it takes for one of the heels to touch the ground to that side heel touching the ground again.

Gait analysis is an examination method to study the walking law. It aims at revealing the key links and influencing factors of gait abnormalities through biomechanics and kinematics, so as to guide rehabilitation evaluation and treatment, and contribute to clinical diagnosis, efficacy evaluation, and mechanism research. In gait analysis, some special parameters are often used to describe whether the gait is normal or not. These gait parameters usually include the following categories: gait cycle, kinematic parameters, dynamic parameters, EMG activity parameters, and energy metabolism parameters.

2.4.2. Zero Speed Detection Algorithm. Because the movement data of walking is continuous, the two adjacent data of the combined acceleration and the combined angular velocity are averaged as the current data. For the calculation of the variance of the combined acceleration and the combined angular velocity, a total of nine data in the four groups before and after the current data are calculated. Variance is a measure of the degree of dispersion of random variables or a group of data measured in the probability theory and statistical variance. In probability theory, variance is used to measure the deviation between random variables and their mathematical expectations. Calculate the mean value, and use the variance value of the nine sets of data as the current variance value. The basic formula used therein is shown as follows:

$$\begin{cases} \left|a_k^b\right| = \sqrt{\left[a_k^b(1)^2 + a_k^b(2)^2 + a_k^b(3)^2\right]}, c_1 = \begin{cases} 1, \left|a_k^b\right| < th_{a\max}, \\ 0, otherwise, \end{cases} \\ \sigma_{a_k^b}^2 = \dfrac{1}{2s+1}\sum_{j=k-s}^{k+s}\left(a_j^b - \overline{a_j^b}\right)^2, c_2 = \begin{cases} 1, \left|\sigma_{a_k^b}^2\right| < th_{\sigma\max}, \\ 0, otherwise, \end{cases} \\ \left|w_k^b\right| = \sqrt{\left[w_k^b(1)^2 + w_k^b(2)^2 + w_k^b(3)^2\right]}, c_3 = \begin{cases} 1, \left|w_k^b\right| < th_{w\max}, \\ 0, otherwise, \end{cases} \\ \sigma_{w_k^b}^2 = \dfrac{1}{2s+1}\sum_{j=k-s}^{k+s}\left(w_j^b - \overline{w_j^b}\right)^2, c_4 = \begin{cases} 1, \left|\sigma_{w_k^b}^2\right| < th_{\sigma\max}, \\ 0, otherwise, \end{cases} \end{cases} \tag{1}$$

where $a_k^b(1)$, $a_k^b(2)$, and $a_k^b(3)$ represent the three-axis acceleration, and $th_{a\max}$represents the combined acceleration threshold; $a_j^b, \overline{a_j^b}$ represent the average value of the three-axis combined acceleration and the combined acceleration, respectively, and the table $th_{\sigma\max}$ shows the variance of the combined acceleration threshold; $w_k^b(1)$, $w_k^b(2)$, and $w_k^b(3)$, respectively, represent the mean value of the three-axis combined angular velocity and the combined angular velocity. Table $th_{\sigma w\max}$ shows the combined angular velocity variance threshold; the value of s is taken as 4. When a single condition meets the zero speed, the value is 1, and if it is not satisfied, the value is 0; finally, the result of the single condition is ANDed, and when the foot is on the ground, that is, at the time of zero speed, the data at the time of zero speed is set to zero, the formula for sum operation is shown in the following equation:

$$c = c_1 \,\&\, c_2 \,\&\, c_3 \,\&\, c_4. \tag{2}$$

As for the single step time, it refers to the time required to take a step in the walking cycle, that is, the time from the first landing of the heel of one lower limb to the second landing of the heel of the opposite lower limb. It is measured in seconds. Under normal circumstances, the single step time of both lower limbs is equal. If the single step time of both lower limbs is not equal, it indicates the asymmetry of gait.

2.4.3. Adaptive Threshold Setting Based on K-Means Clustering Algorithm. The k-means algorithm selects k objects and takes these objects as k initial cluster centers. For the remaining objects, according to the distance between the object's position and the k cluster centers, divide them to the cluster centers closest to them. If the distances of multiple cluster centers are equal, they can be divided into any group and then start to calculate the average value of each cluster. The calculated new cluster center is used as the center of each cluster. Through continuous iterative calculation, when the set objective function is less the calculation stops when the error range is set. The optimization objective function adopted by the k-means clustering algorithm is shown in formula (3). Density-based method: a fundamental difference between the density-based method and the other methods is that it is not based on various distances, but based on density. In this way, the disadvantage that the distance-based algorithm can only find quasi-circular clustering can be overcome. The guiding idea of this method is that as long as the density of points in a region is greater than a certain threshold, it will be added to the clusters close to it:

$$E = \sum_{i=1}^{k}\sum X \in c_i\left|X - V_i\right|, \tag{3}$$

where E is the sum of the deviations between all points and the cluster center to which they belong, X is the point in R^m, which represents a given data point, and V_i is the average value of the cluster C_i. The process of the k-means clustering algorithm is shown in Figure 2. The first step of the graph theory clustering method is to establish a graph suitable for the problem. The nodes of the graph correspond to the smallest unit of the analyzed data. The graph theory

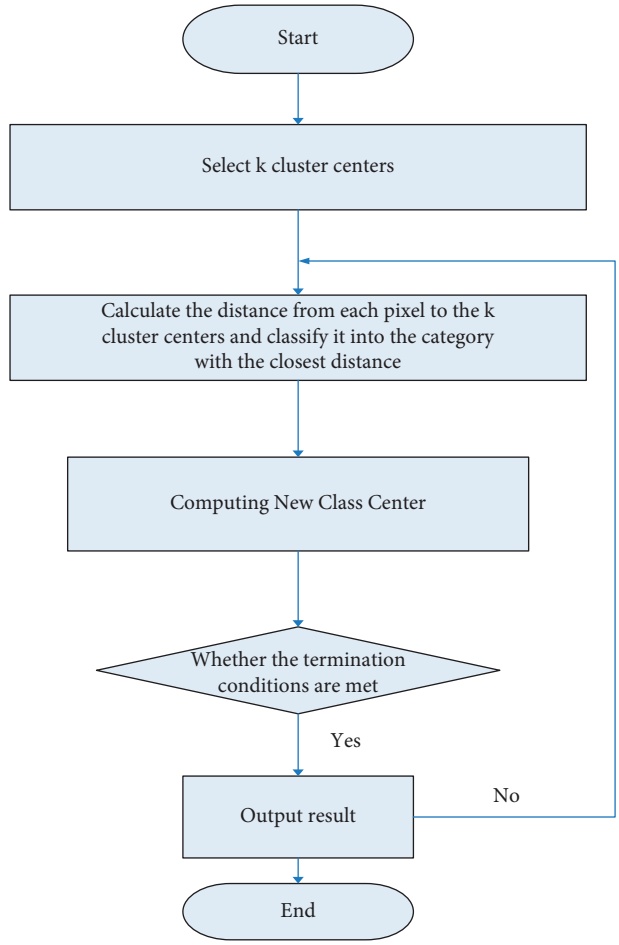

Figure 2: The clustering algorithm flow of k-means.

Table 1: Statistics of the number of investigations and experiments in the target hospital.

	Number of questionnaires	Streamline tracking	Asking for directions experiment	Pathfinding experiment
Hospital 1	39	5/10	5/15	6
Hospital 2	40	5/10	5/15	0
Hospital 3	40	0	0	0
Hospital 4	159	15/30	15/45	0

clustering method takes the local connection characteristics of sample data as the main information source of clustering, so its main advantage is that it is easy to deal with the characteristics of local data.

3. Experimental Research on the Evaluation Method of Wayfinding Signs in Medical Institutions Based on Intelligent Navigation

3.1. Experimental Protocol. In order to make this experiment more scientific and effective, this experiment went deep into four hospitals in a certain place to conduct experimental investigations. This time, a targeted questionnaire was set up according to the different organizational models of the four hospitals. A total of 160 questionnaires were distributed in this experiment, and the experimental data of the target hospitals are shown in Table 1.

3.2. Research Methods

3.2.1. Field Research Method. In this experiment, we went to four hospitals in a certain place, and conducted on-site investigation and analysis of the current situation of hospital users' pathfinding and collected data. These data provide a reliable reference for the final research results of this article.

3.2.2. Questionnaire Survey Method. This experiment conducted a questionnaire survey of four hospitals by setting up targeted questionnaires. This survey adopts a semi-closed method, the purpose of which is to promote the correct filling of the survey subjects. The types of questionnaires in the questionnaire mainly include structured, open, and semistructured. Among them, the semistructured type lies between the structural type and

Table 2: Analysis of the wayfinding behaviors of hospital users in the process of consultation.

	Follow the flow of people	Use navigation	View logo	Ask someone to ask	Identify the direction from space
Hospital 1	4	0	16	19	13
Hospital 2	5	8	8	8	21
Hospital 3	5	0	19	24	12
Hospital 4	2	0	16	19	13

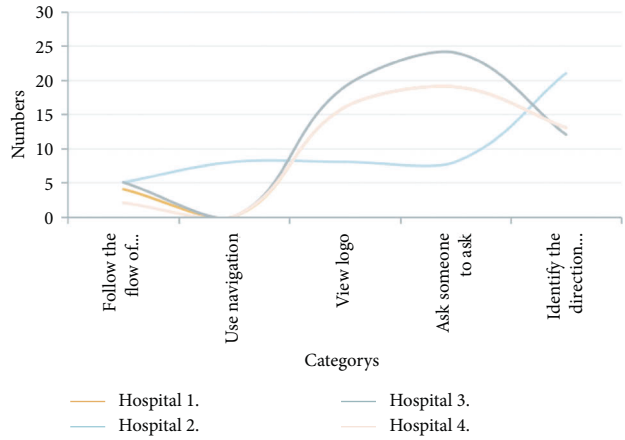

Figure 3: Analysis of the wayfinding behaviors of hospital users in the process of consultation.

Table 3: Analysis of the causes of hospital users getting lost.

	The space is too complicated	Lack of features	Identification reason	Personal reasons	Others
Hospital 1	7	14	9	7	3
Hospital 2	8	15	10	3	4
Hospital 3	10	14	12	1	1
Hospital 4	9	13	9	6	3

the open type. The answers to the questions are fixed, standard, and free for the retractors, absorbing the advantages of both. This kind of questionnaire is widely used in practical surveys.

3.2.3. Mathematical Statistics. Use related software to make statistics and analysis on the final research results of this article.

4. Experimental Analysis of the Evaluation Method of Pathfinding Signs in Medical Institutions Based on Intelligent Navigation

4.1. Analysis of the Wayfinding Behavior of Hospital Users in the Medical Process. In order to make this experiment more scientific and effective, this experiment conducted an experimental investigation on the wayfinding behavior of hospital users through a questionnaire survey. The data obtained are shown in Table 2.

It can be seen from Figure 3 that the most common way for hospital users to find their way when they are lost is to ask someone. There are 70 people, which is far more than one-third of the total number of people surveyed. The people who use the navigation system are the least. Therefore, the feature

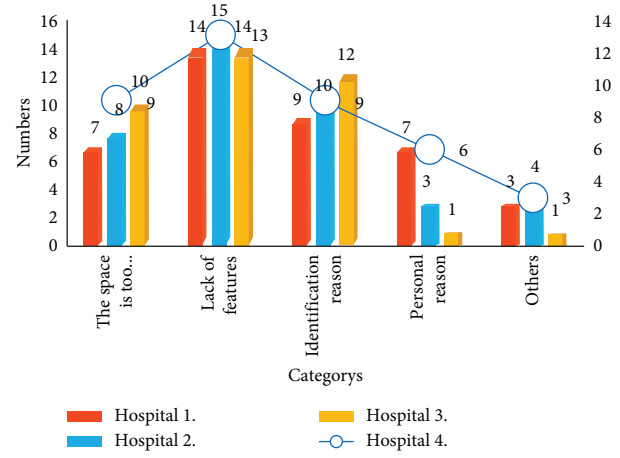

Figure 4: Analysis of the causes of hospital users getting lost.

of space is strengthened. The auxiliary system needs to be solved urgently.

4.2. Analysis of Causes of Hospital Users Getting Lost. In order to further research and analyze this experiment, this research conducted a field investigation on the causes of

hospital users' getting lost. The data obtained are shown in Table 3.

It can be seen from Figure 4 that most of the interviewees believe that the hospital's intricate design, lack of space, and legal features lead to getting lost. The main reason for people getting lost is the lack of spatial features, followed by the more complicated spatial plane. And hospital users believe that the complexity of radial spatial organization is less than that of linear network spatial organization. To sum up, the spatial organization mode of the hospital will directly affect the efficiency of hospital users.

5. Conclusion

This article aims at improving the efficiency of outpatient clinics for hospital users and analyzes the problems between the current hospital public assistance system and pathfinding, and use the indoor positioning algorithm based on MEMS-IMU to study the intelligent medical institution wayfinding navigation system studied in this article. This article conducts on-site investigations in four hospitals in a certain place and concludes that the pathfinding behavior of hospital users comes from the perception of space signs, etc., which lays the foundation for the optimization of pathfinding behavior.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

There is no potential conflict of interest, and all authors have seen the manuscript and approved to submit to the journal. The authors confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

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