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Application of UWB Indoor Positioning System in Different Types of Space

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Abstract: *In this study, a series of data collection and analysis in two different types of spaces are carried out by UWB indoor positioning system. The obtained data are divided into two different types——full-sample data and multi-sample data, and the two types of experimental methods and analysis methods are compared to provide theoretical support for the refinement, quantitative research and design optimization of different types of architectural interior space. The research shows that the UWB indoor positioning system has good applicability in different indoor scenes within a certain area, and different types of indoor space can be analyzed from the overall scale to the detail scale. This study has certain significance in using indoor behavior data to analyze different types of internal behaviors in space, and it is a systematic attempt to apply behavior analysis technology to indoor optimization strategies.*

Keywords: *UWB indoor positioning system; Data classification; Spatial scale; Heat map*

1. Research Background

UWB (Ultra Wideband) indoor positioning system is a high-precision indoor positioning system, which can be used in a wide range of indoor scenes. At present, most of the research on indoor space is classified according to typology, but the indoor positioning system is more suitable for building scales and types, and the classification method of a single type of indoor space is not suitable for the research of UWB indoor positioning system. Therefore, it is necessary to combine the inherent characteristics of UWB indoor positioning system and the research types of behavioral architecture for classification. The UWB indoor positioning equipment is a K-Ranging ultra-wideband real-time positioning system based on bidirectional ranging technology developed by Southeast University and NexiotAG research team in Switzerland. The K-Ranging positioning system includes a Tag, an Anchor (Anchor), a connecting unit (router) and NexiotRTLS software at the control end.

According to the characteristics of the data acquired by indoor positioning system, a targeted classification method is proposed, which classifies the data obtained by different spatial types into two types——Full-sample data and multi-sample data. The acquisition of full-sample data is generally applied to obtain all-weather action data of subjects with people as reference; Multi-sample activity data generally takes space as a reference and records the data of multiple test subjects. At the data level, the whole sample data is mostly all-weather activity data with a small number of tags from morning till night, while the multi-sample activity data is the activity data of a large number of tags in the same space for a certain period of time. The research forms of architectural interior space through behavioral architecture theory are mostly these two types, and they are more closely combined with the data obtained by UWB indoor positioning technology.

2. Research Objects and Experimental Survey

2.1 Middle-aged couples in ancient dwellings

UWB indoor positioning system for all-weather residential behavior research, the data type obtained is a typical full-sample data type. Living behavior is one of the most important indoor activities of people. The spatial form of traditional dwellings has a great influence on the living behavior because of its own spatial characteristics. Users always look for the best way to distribute the space pattern during their living, which is particularly obvious in the living behavior of traditional ancient dwellings.

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In the long-term experimental process, researchers chose many types of living space and users as the research objects. The research objects are an ancient dwelling with a history of 100 years and couples who live in it and produce and sell pot roast at the same time. The reason for choosing this research object lies in the richness of activities and behaviors in its dwellings. Compared with ordinary dwellings, this dwelling not only has residential behaviors, but also undertakes commercial behaviors such as production, storage and temporary sale, and the space utilization rate in the dwellings is higher.

The housing area is about 377.7 square meters, of which the courtyard area is about 115.7 square meters. The wing on the east side was built in the Republic of China, and two bedrooms were built in the 1970 s. Except for the bedroom of the couple, the other room was only used during the New Year; There are also restaurants and toilets in the courtyard, which are the main spaces for residents' activities; On the westernmost side is the oldest hall in the residential building, which was built in the late Ming Dynasty. At present, only a part of the main room still bears the function of daily use, and the old wing rooms on both sides become rooms for stacking sundries, which are regarded as sundries rooms when dividing functions (Figure 1).

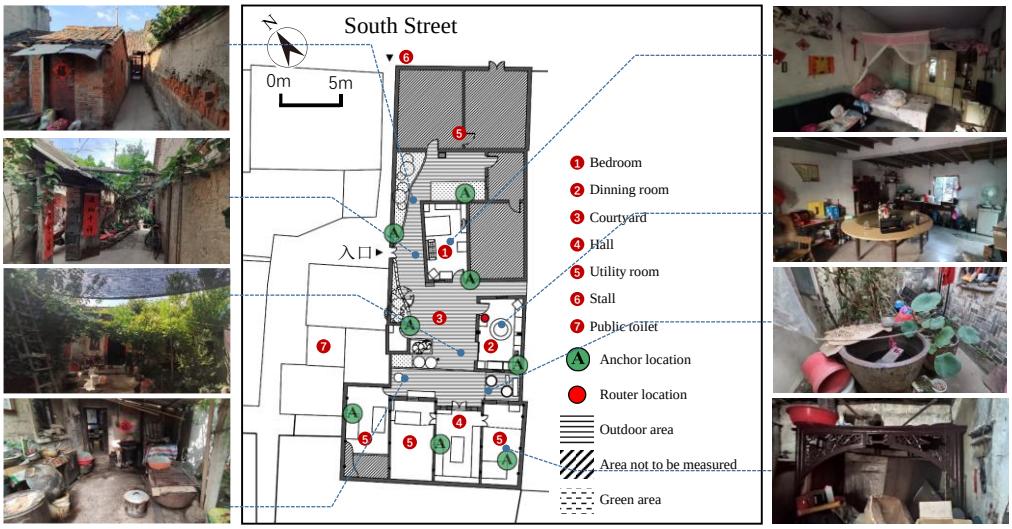

Fig. 1 The position of the folk house in the old street and the composition of the building

The investigation lasted for one week, including surveying and mapping of ancient dwellings, debugging and installation of UWB indoor positioning equipment, questionnaire investigation and interview records of couples, etc. In the residential environment conditions are more complex, so after surveying and mapping of the anchor layout for pre-design, need to be appropriate adjustment according to the actual situation. For example, in the actual equipment layout process in the residence, the couple of ancient dwellings refused to install equipment in the bedroom, so they used fixing devices to fix the anchor around the outer wall of the bedroom. The anchor is installed at a height of about 2.1 meters from the ground and concealed. A total of 8 anchors cover the whole experimental area, and routers are placed in the corner of the restaurant as close to the center as possible without affecting the living conditions of couples, as shown in Figure 1.

2.2 A food market in the city center

Food market space is one of the typical research objects of multi-sample data collection, and shopping behavior is one of the typical behaviors of people in public space, which is influenced by complex interactive factors such as psychological choice factors of buyers and external environmental factors. Shopping behavior in food markets is often closely related to its internal spatial pattern and stall layout. The object is a food market in the old city. With the renovation and development of the old city, the space of the food market needs to be upgraded according to the overall development trend. Because the land area of the old city is limited, it is particularly important to improve the use efficiency of the internal space.

The population density around the food market is relatively high, which affects the daily shopping of tens of thousands of residents around. In 2018, the market was transformed in the urban reconstruction activities, and now it covers an area of about 3,030 square meters, of which the main part covers an area of 1,500 square meters, with 57 vendors settled in. The second-stage supermarket area under construction

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has not yet been opened. The food market has a complete range of formats, and the whole food market is distributed in a hollow square, as shown in Figure 2. The merchants against the wall in the periphery are facade shops, while the middle part is a unit table for selling vegetables. Each unit consists of four stalls (half a unit and two stalls in the northwest corner). The distribution of sales types in the plane is uneven. The vegetables that occupy the main body are arranged in the center in a zigzag shape, while the meat occupies the whole northeast side and interlaces with the vegetable area, while the others are scattered in the south and west sides

The investigation lasted for many days, and the buyers in the food market mostly concentrated in the morning, so the daily experiment time was set from 8:00 to 11:00 in the morning. The food market covers a large area, reaching 1,500 square meters, so the anchor layout with uniform grid is adopted for signal coverage, and the whole anchor is arranged in a combination of W-shaped and M-shaped plane to form a triangular grid with moderate density (Figure 2). The distance between the two anchors on the westernmost side is 26 meters, which is still within the applicable range of UWB indoor positioning equipment (50 meters). Due to the limitation of power supply location, the router is arranged at the entrance on the south side, which will cause the signal of the anchor on the north side to be weak, which may lead to the interruption of the anchor signal during the experiment. The connection can be strengthened by adjusting the router signal channel or adding a router relay signal amplifier (AP).

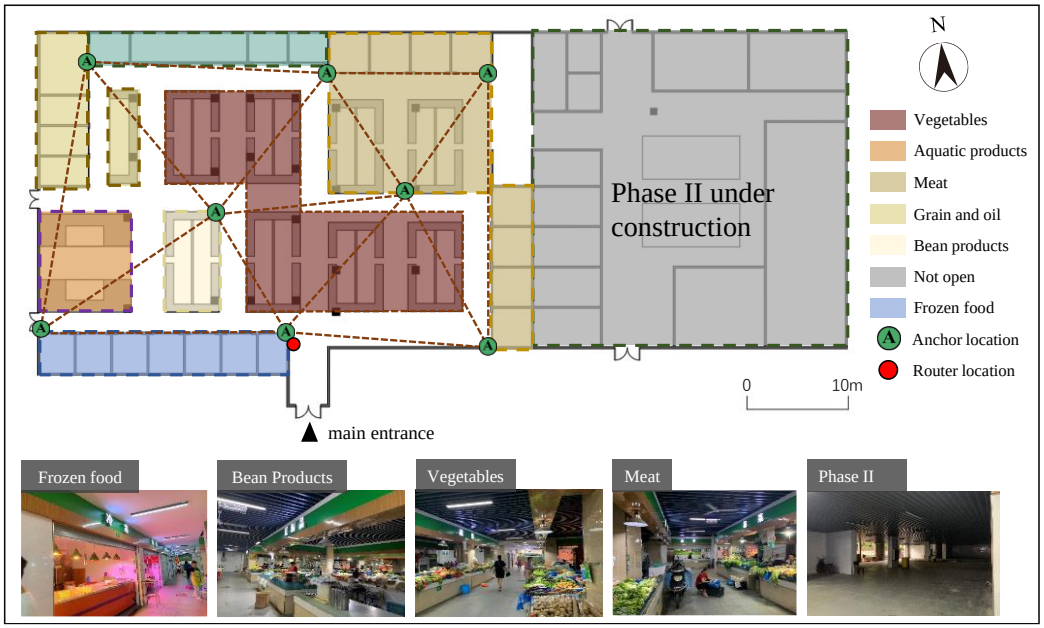

Fig. 2 Food Market Status and Plane Functional Zone

2.3 Similarities and differences between the two types of experiments and their effects

As shown in Table 1 below, although the experimental area of food markets is nearly 6 times that of residential houses, the number of anchors used is the same, which is due to the more complex environmental interference in residential houses in the experiments of residential houses and food markets. For example, the partition walls in residential buildings are mostly composed of solid brick walls, and the anchors need to be arranged at positions with weaker signal interference such as windows and doorways. In the food market, there are almost no obstacles that cause signal blocking except pillars. Although the data types obtained by the two groups of experiments are different, and the average experimental time of each object is also quite different, the overall number of coordinate points obtained is close, so it can be used as cross-reference objects for comparative analysis. It should be noted that multi-sample data often need to mark the initial starting point and the end point of the path. The food market in this study has four entrances and exits, so it is necessary to closely record the access of the observed people.

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Tab. 1 Reference of the two groups of experiential objects and experiential profiles

Attributes	Element	Classification	
		Ancient dwelling	Food market
Architectural features	Type of space	Private space	Public space
	Behavior	Residential behavior Production behavior	Purchase behavior
	Construction area（㎡）	380.6	3029.5
	Plane geometry	Irregular shape	Rectangle
	Export quantity	1	4
Experimental summary	Area（㎡）	257.3	1500.4
	Anchor number	8	8
	Tag number	2	8
	Number of subjects	2	100
	Time of subjects（hour）	12	3
Data overview	Type of data	Full-sample data	Multi-sample data
	Number of data groups	2	80
	Active time of each subject（minutes）	516.3	9.5
	Total active time（minutes）	1032.6	760
	Number of coordinate points obtained by data	20610	14876

3. Analysis of Full-sample data

3.1 Expression of overall trends

After data preprocessing, heat map is generally used to express the overall trend of activities. Due to the small area and complex internal environment of residential buildings, the size of grid division should be flexibly selected according to the specific situation of spatial scale. Because of the small internal scale of residential buildings, the grid of 50 cm×50 cm is calculated, and the number of scattered coordinate points in each grid is counted to express the whole visualization. As shown in Figure 3, the darker the color in the cell, the longer the experimental object represented by the data stays in the area.

It can be seen that the proportion of staying in each functional space of male and female hosts is obviously different. Both male and female hosts stayed in the yard for a long time, but the scope of staying was different. Indoor, the male host stays in the restaurant for the longest time, while the female host stays in the bedroom for the longest time, and the other indoor spaces are similar to each other.

In order to further understand the spatial distribution state of the subjects with time, the behavior time series diagram is introduced to express it. Behavior time series diagram is generally used to express the stay state of the research object in different space at different time periods, which is an important expression of combining behavior with time and space. Through the position data can be applied to the analysis of time series, with time as the abscissa, spatial position as the ordinate of the spatial stay sequence diagram. We can see that the daily life rules of the couple fluctuate little, so we choose a random day to make a behavior time series diagram, as shown in Figure 4. It can be seen that apart from going out, resting and eating, the main activities of the couple in a day are all around the yard, restaurant and main room. Male and female hosts have two hours to go out every day. When the male host goes out in the morning and when the female host goes out in the afternoon, the people who stay in the residence mainly move back and forth between the yard and the main room; The hostess went into the bedroom to rest at dark, while the male host still moved back and forth between the dining room and the yard. When

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two people coexist, they take the yard and restaurant as the center of their activities. The couple are often in two stay modes: "restaurant-yard" and "main room-yard", and the proportion of the hostess staying in the restaurant and main room is far less than that of the male host.

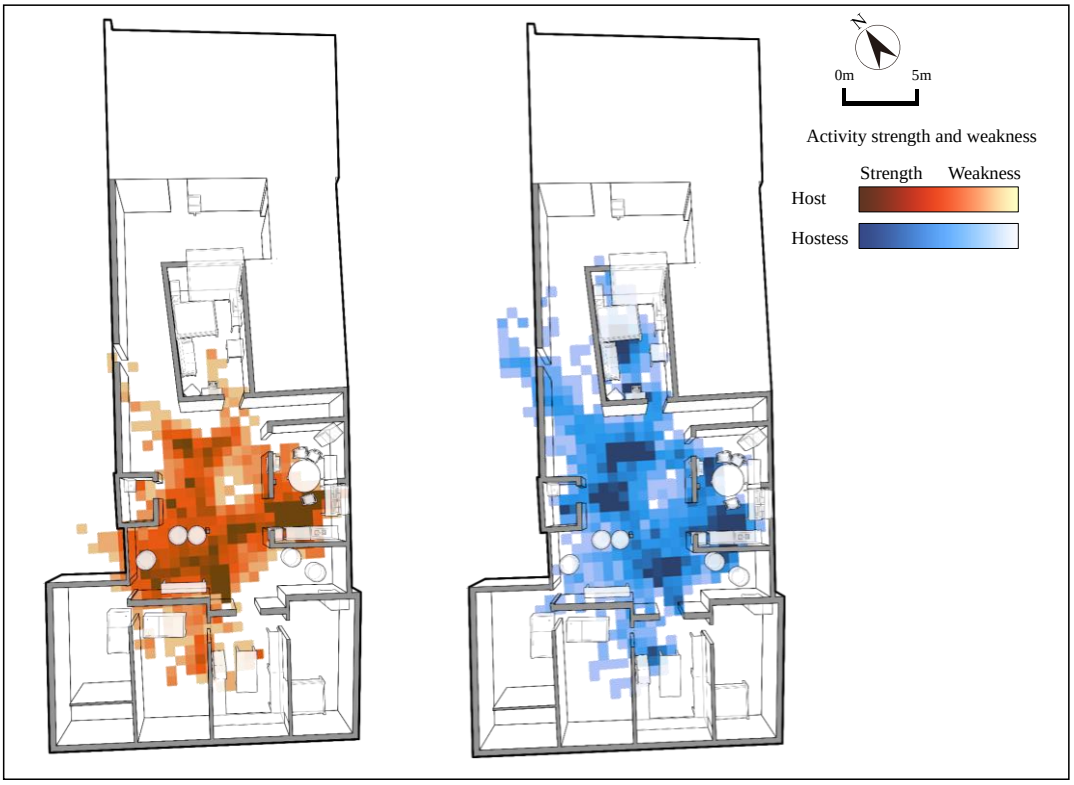

Fig. 3 Heat map of the indoor activities of the host and the hostess

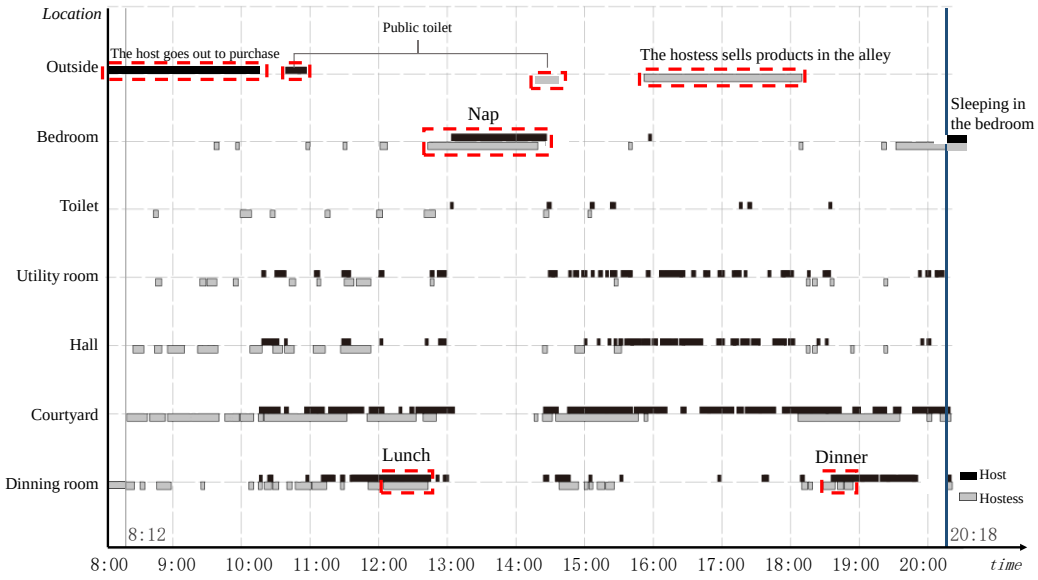

Fig. 4 Time series of residence of the host and the hostess in various functional spaces in residential houses

Further statistics of each functional space can find the specific use frequency and proportion of each functional space by male and female masters, as shown in Figure 5. It can be seen that the total proportion of male and female masters staying in the yard accounts for more than 50%, which means that half of the couple's daily activities are carried out in the yard. We can know that in addition to making a lot of food in the yard, the couple also have guests entering the yard to buy, and they rest and wait in the restaurant while waiting for production. The restaurant accounts for 56% and 13% of the stay ratio of male and female owners respectively, while the original old house only accounts for 8% and 5% of the daily

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activities of male and female owners.

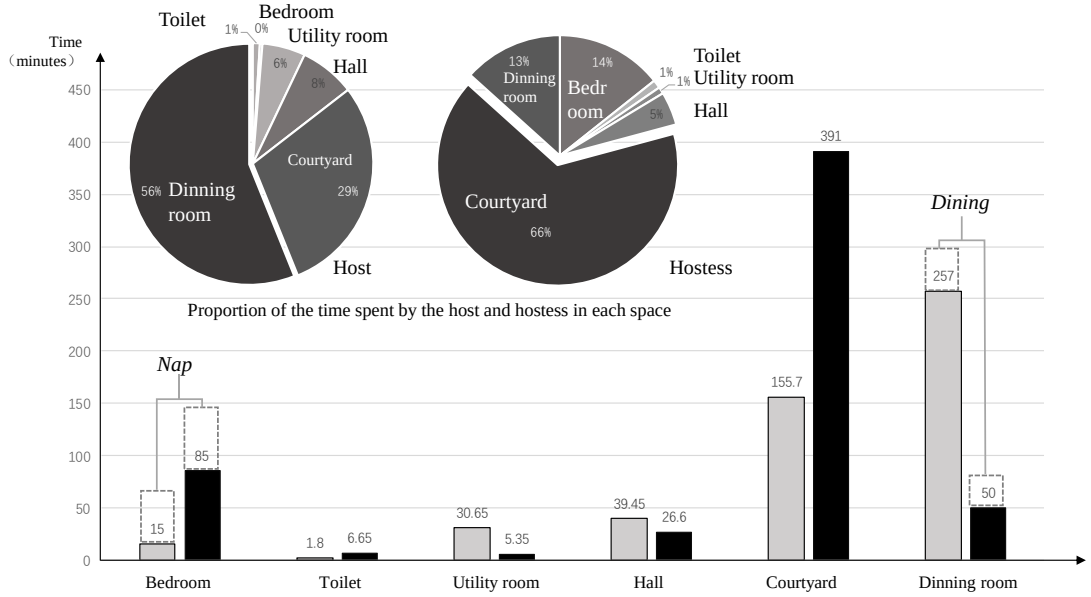

Fig. 5 Proportion of residence time of the host and the hostess in each space

It can be considered that the restaurant, as the core space of the yard, gradually replaces the main room to assume the function of living and receiving visitors, which can also be seen through the sum of the stay time of male and female hosts in various functional spaces. As shown in Figure 6, except the courtyard, the sum of the stay time of male and female hosts in the restaurant accounts for 29% of the total time, which is almost equal to the sum of 30% of the stay time in other spaces. The restaurant space has become the most important indoor activity space in the daily life of male and female hosts.

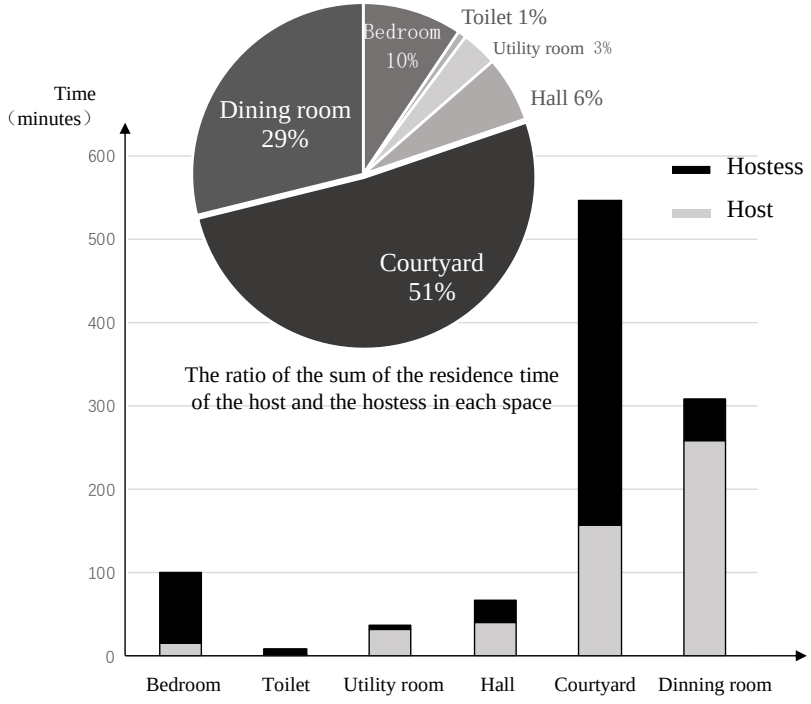

Fig. 6 Roportion of the sum of the residence time of the host and the hostess in each space

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3.2 Microscale analysis

In the first section of this study, the method of grid division is adopted to get the overall heat map distribution of the couple, and the residence time of subdivision grid is also obtained. Dividing the residence time in each space by the number of grids, we can find that the dining room and bedroom are the areas with the longest residence time in the unit grid of male and female owners respectively. Although this method of grid division statistics is fine to the scale of human body, it still has some limitations in a more microscopic scale because the grid is subjectively divided. For example, it is impossible to define the grid accurately in the oblique part of the irregular plane space, and it is also impossible to study the influence of actual furniture. Therefore, on a more detailed level, it is necessary to take the influence of furniture in space into account.

When the influence of furniture in the plane needs to be studied, it is necessary to divide the influence range of furniture first. Some scholars have used the convex polygon division method in space syntax theory to measure the influence range of furniture in each room when studying the influence of indoor furniture scale on space. However, convex space measurement criteria are formed based on the connection of line of sight in space, and there are often some furniture in space that does not affect the line of sight relationship but affects the behavior, so it has certain limitations. As the basis for dividing the influence range of furniture, it has certain subjective judgment interference.

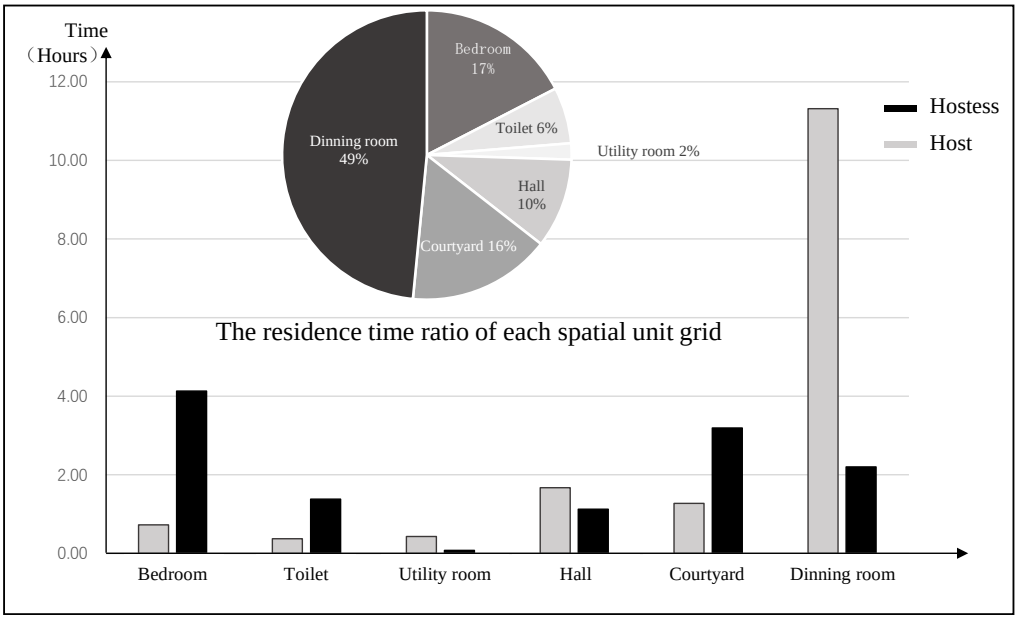

Fig. 7 The residence time of couples in each functional space unit square meter

Assuming that every furniture in space is fixed and the influence of edges on human behavior is the same, the geometric principle of Voronoi polygon can be used to judge the influence range between furniture. Voronoi diagram theory was first put forward by British anesthesiologist John Snow to locate the core water source through Voronoi diagram in multiple cholera areas. The form of space division can be deduced inversely by the principle of Voronoi diagram, and the formation and division of Voronoi diagram is the division of space in plane form. Its characteristics are simply that is, any position in Voronoi diagram is close to its sample point, far away from its adjacent sample point, and the sample point is unique, that is, the point on the adjacent edge of the adjacent Voronoi diagram is the same distance from the sample points of the polygons on both sides, as shown in Figure 8.

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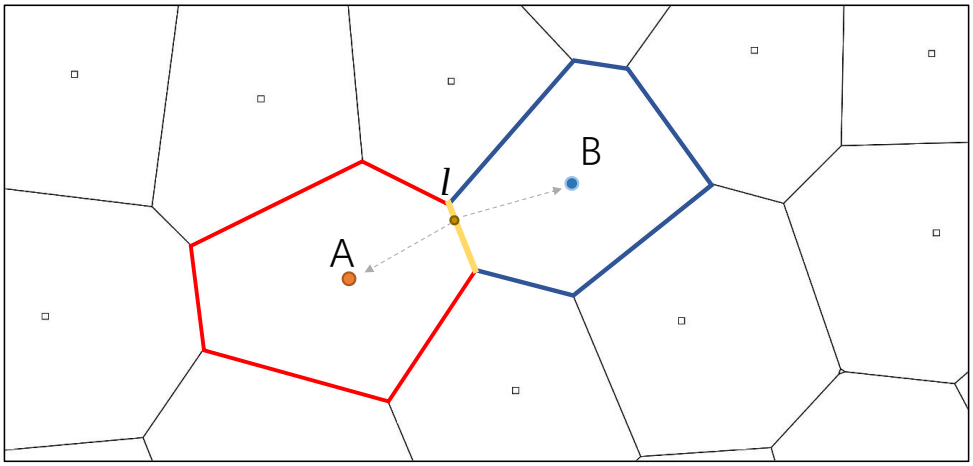

Fig. 8 Voronoi diagram principle diagram

After a certain degree of geometrical simplification of the furniture plane contour, the uniform and dense dots are made along the edge of the furniture through the grasshopper visual programming software based on Rhino. The points of a furniture are a group, and these points are used as sample points to generate Voronoi diagram. The same group of Voronoi diagrams form the overall outer contour and merge, and multiple furniture forms multiple merged grids. The grid fitted by multiple sets of Voronoi diagrams can be regarded as an aggregation network of mutual influence areas of furniture. Taking the stay state of a man and a couple in a restaurant as an example, as shown in Figure 9, the distance from each point on the contour line of the influence range of red furniture to the nearest edge of adjacent furniture is equal. Through the visualization method in the second section of this chapter, the residence strength in different furniture influence areas is expressed.

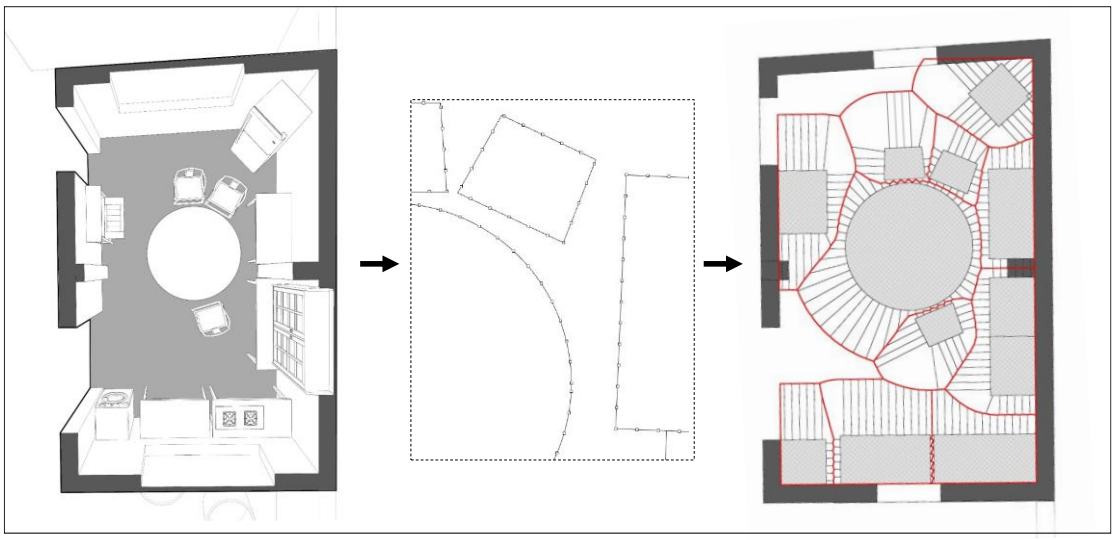

Fig. 9 Schematic Diagram of the Network Generation Process of the influence range of restaurant furniture

This setting is based on the assumption that the influence distance d of each furniture is the same, but the different setting of the influence distance of Tai Sen polygon affects the performance of the grid, as shown in Figure 10, the performance of the plane grid under the three distance settings of 0.5m, 0.75m, 1m and 1.2m.

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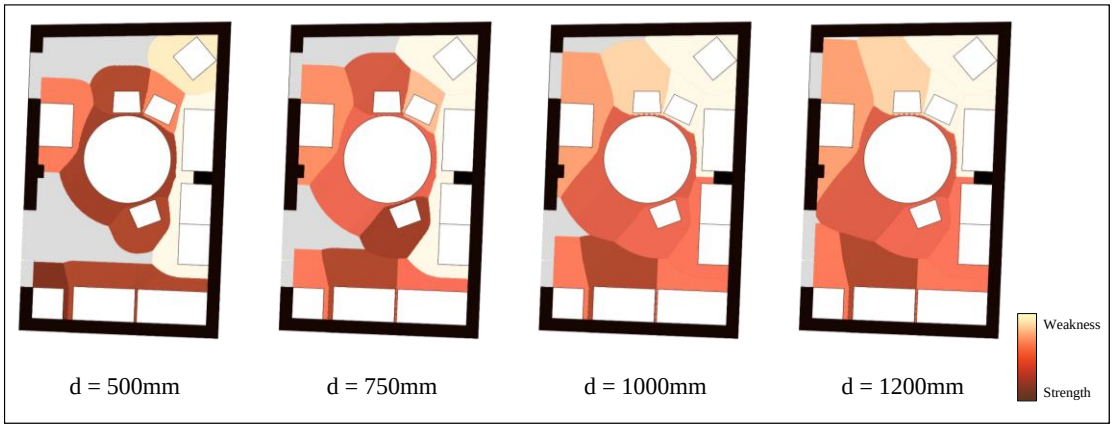

Fig. 10 Variations in the network heat map of the furniture impact area caused by different Voronoi diagram impact areas

It can be found that when the Voronoi diagram influence range D is set, the influence on the drawing surface exists, because when the range is expanded, the influence range grid of furniture will include more coordinate points, which will lead to the change of color ratio. For example, when D is greater than 1000mm, the range of chairs in the restaurant expands more upward, which is not suitable for the actual situation. Therefore, the value of D is 750mm, which is close to the average step size of people. After determining the influence range of furniture, it can be intuitively found that the hostess takes the south side as the main activity space in the restaurant, as shown in Figure 11.

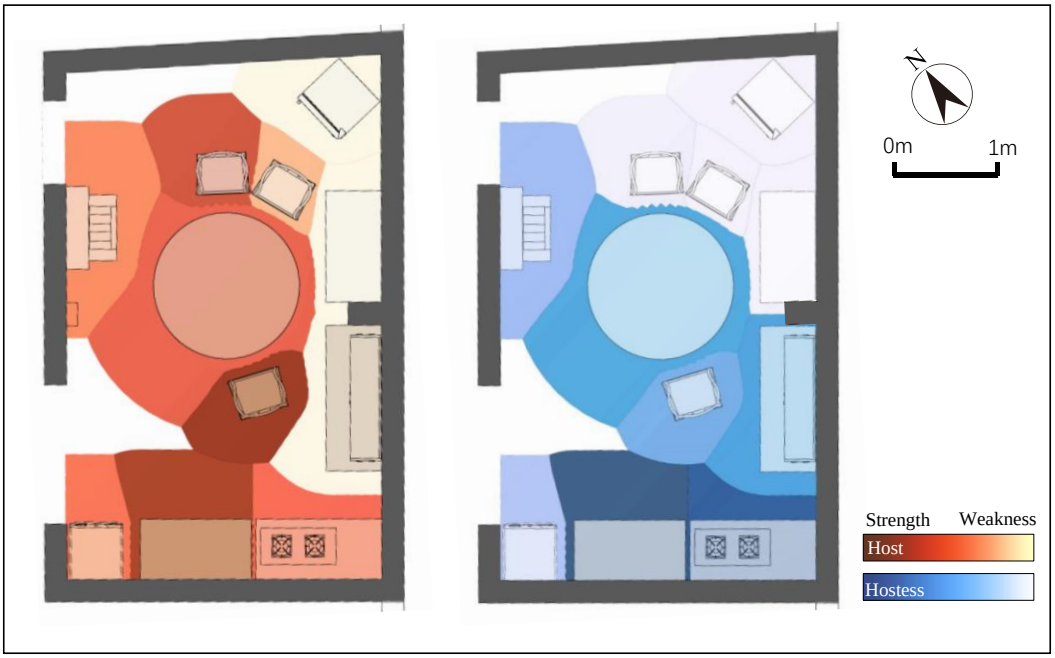

Fig. 11 The time density of the couple's activities with the influence

It can be found that the couple have less activities in the large free position on the north side, while the male host has activities in most positions of the restaurant, and they pay less attention to the desktop on the east side; In the influence of specific furniture, the male host is mainly inclined to lockers and big round tables, while the female host is mainly active around the stove. This visualization method has a strong targeted expression on the influence of each or each group of furniture.

4. Analysis Method of Multi-sample Data

Multi-sample data can be analyzed from two levels, namely, internal differences and overall trends in multiple samples. By cleaning the original data, the expression of behavior trajectory tends to be smooth, that is, the behavior path of moving objects in space is expressed visually through behavior

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trajectory graph. Individual object behavior trajectory diagram can be classified and analyzed by comparing with each other, and the path of all research objects can also intuitively reflect a certain behavior trend when stacked together. It can also express the high and low residence quantity in different areas by means of human residence density heat map, and then reflect the residence characteristics in different indoor spatial modes.

4.1 Expression and analysis of stopping behavior

1) Grid division heat map display

Similar to the grid division method of residential houses in the previous section, the two-dimensional plane space of the whole food market is divided into networks and the statistics of residence density are carried out. Different from the division scale of residential houses, the food market has a larger area and the average experimental time of each subject is shorter, which means that when the grid scale is too small and the density is too large, the average residence time to each grid is shorter. Adopting a larger grid in the food market can better reflect the overall activity trend of food buyers. However, when the partition of cells is too large, it will make some small space in the plane cannot be fully reflected. For a large indoor space such as food market, a network composed of cells with suitable size should be selected for heat map performance. The network division under 0.5 m×0.5m, 0.75 m×0.75m and 1m×1m cell grids is selected, which correspond to the shoulder width scale, walking scale and activity scale of human body respectively, as shown in Figure 12.

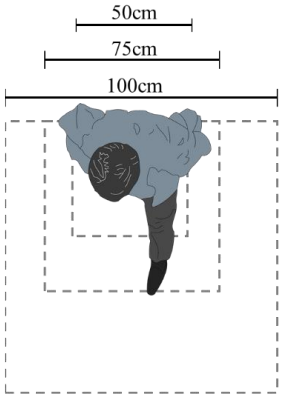

Fig. 12 Extraction of three grid scales

The number of points A contained in each cell grid at these three scales is calculated. The weight of color assigned to each cell by the grid heat map depends on the number of coordinate points in the cell. The interval (Amin, Amax) formed by the minimum number of points Amin and the maximum number of points Amax contained in the cell is projected into the target interval with (0, 1) as the value range, and the lightness of color is also converted from high to low to (0, 1) interval, so that the distribution of strong and weak colors can be judged by counting the distribution of numerical values in one interval. The number of coordinate points A included in the cell and the proportion s of the median A0 of the series Ar to the whole interval are schematically shown in Fig. 13.

The closer the median A0 is to the average of the series, that is, the closer S is to 0.5, the more balanced the displayed color is and the better the color performance of the grid heat map is. When the minimum Amin is 0, the less the grid with A=0, the better the color concentration. According to the statistics of the number of points included in the cell grid scale of the three scales, as shown in Fig.13, it can be seen that the S value of the cell grid of 0.75 m×0. 75m is closest to 0.5, and it can be recognized from the statistical level that it is the grid heat map with the best overall color degree performance.

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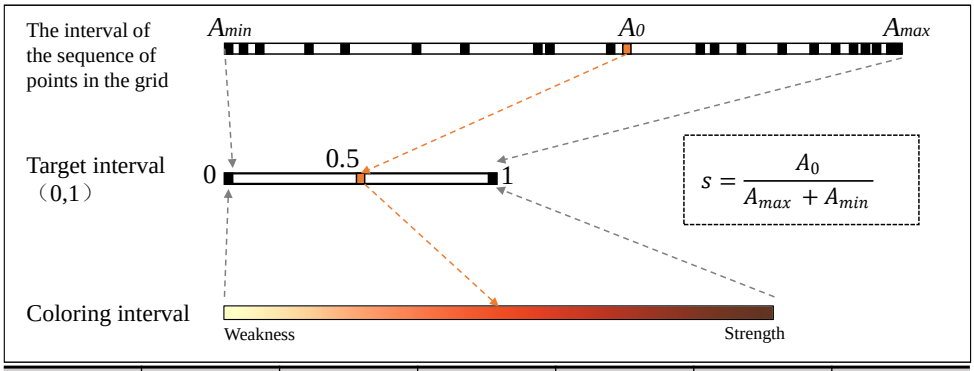
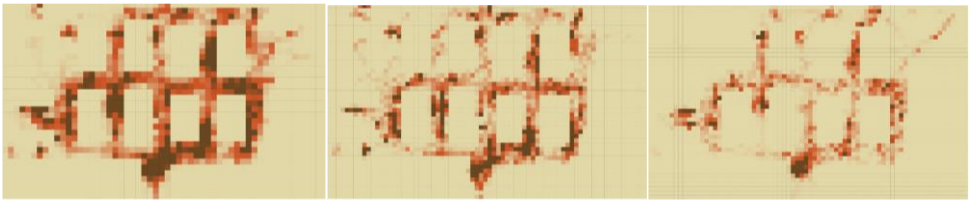


The scale of the grid	Number of grids	Amin	Amax	The number of grids where A=0	median	s
0.5m×0.5m	8214	0	172	4317	33	0.192
0.75m×0.75m	3375	0	264	1342	155	0.364
1m×1m	1903	0	333	1116	0	0



1m×1m　　0.75m×0.75m　　0.5m×0.5m

Fig. 13 Schematic diagram of the principle of color assignment to the cell grid and thermal map generated by three scale grids

Comparing the actual image performance of the three, it can be seen intuitively that the grid of 0.75 m×0.75m scale can reflect the spatial situation as a whole, and the color gradient degree is good and the stay feature details are more. The scale of 0.75m is closer to the average step size of people when shopping, which is more suitable for the real situation. After selecting the appropriate scale of heat map, the three-dimensional spatial model is substituted into the overall visual expression, as shown in Figure 14.

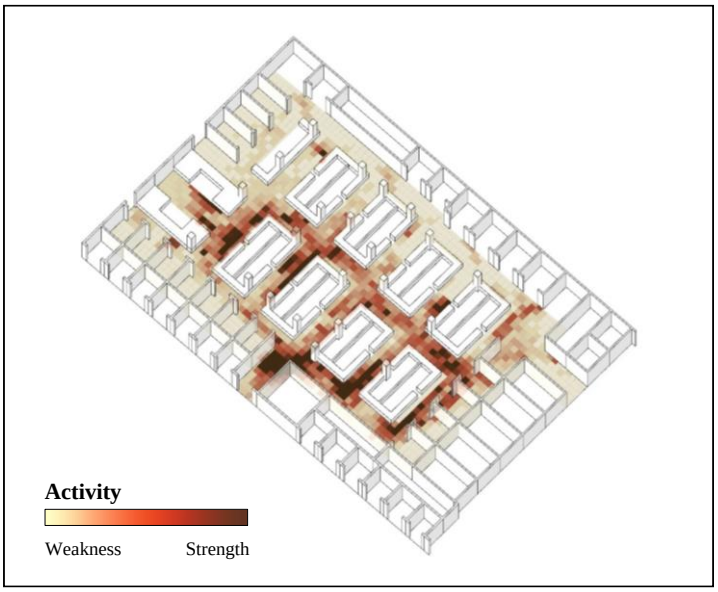


Fig. 14 Heat map of the food market stay behavior

2) Activity distribution and velocity grid distribution in the region

The introduction of velocity grid distribution, combined with residence density grid matching and

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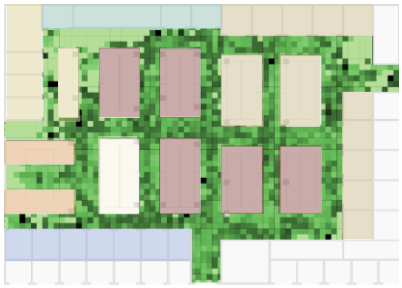
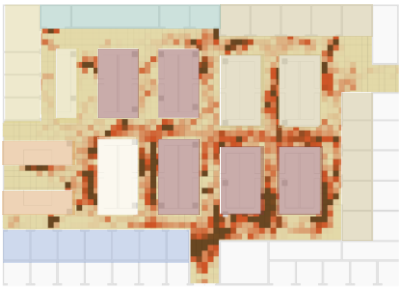
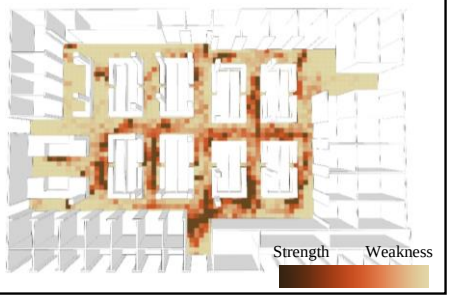
comparative analysis can better reflect the actual visits of food buyers to different areas. When the speed grid formed as shown in Table 2 is set in accordance with the scale of the stay grid (0.75 m×0. 75m), the preference degree of buyers for different spaces can be clearly and intuitively obtained. The slower the speed, the longer the stay time in this area and the darker the color of the drawing, while the faster the speed means that the shopper is moving through this area quickly and the lighter the color of the drawing.

Tab. 2 Comparison of velocity distribution grid heat map and stay grid heat map

	Floor plan	Perspective
Heat map of speed distribution		
Heat map of stay distribution		

It can be found intuitively that there is a certain correlation between the thermal diagram performance of residence distribution and the thermal diagram performance of velocity distribution. In an ideal state, the color shading degree of velocity distribution grid should be inversely proportional to the shading degree of stay distribution grid. After observation, it is found that the relationship between them is not completely consistent. For example, there is a faster speed and a higher residence time in the north-middle area of the food market, which is due to the accumulation of excessive walking times, which will also cause the accumulation of residence time. When the low-speed area overlaps with the part with higher residence time, it can be judged that the residence time in this area is longer, and when the high-speed area matches with the part with shorter residence time, the attraction of this area may be weak, and the number of passes and residence time are relatively short. For example, the south area of the two heat maps, that is, the vegetable area, has a good degree of coincidence and matching, and the velocity heat is the shallowest and the residence heat is the highest, so it can be concluded that the number of visits in this area is higher. However, there are obvious characteristics of high speed and low stop at the two corners on the north side and the southwest corner of the food market. In the vegetable areas with high visits, the southeast corner also has a certain speed increase, which means that buyers are rarely willing to shop at the corners, and most buyers tend to buy at the long side of the vegetable stall.

4.2 Expression and analysis of moving behavior

1) Action path distribution

By connecting the coordinate points obtained by UWB indoor positioning system in time sequence, the action track of each investigated object in the food market can be obtained. After data processing, they are connected by smooth curve. All the subjects' action paths are superimposed on the plane of the food market. As shown in Fig. 15, the participation of action track images can more intuitively reflect the behavior selection of linear data at some spatial nodes, and directly map the choice tendency and movement pattern of grocery buyers.

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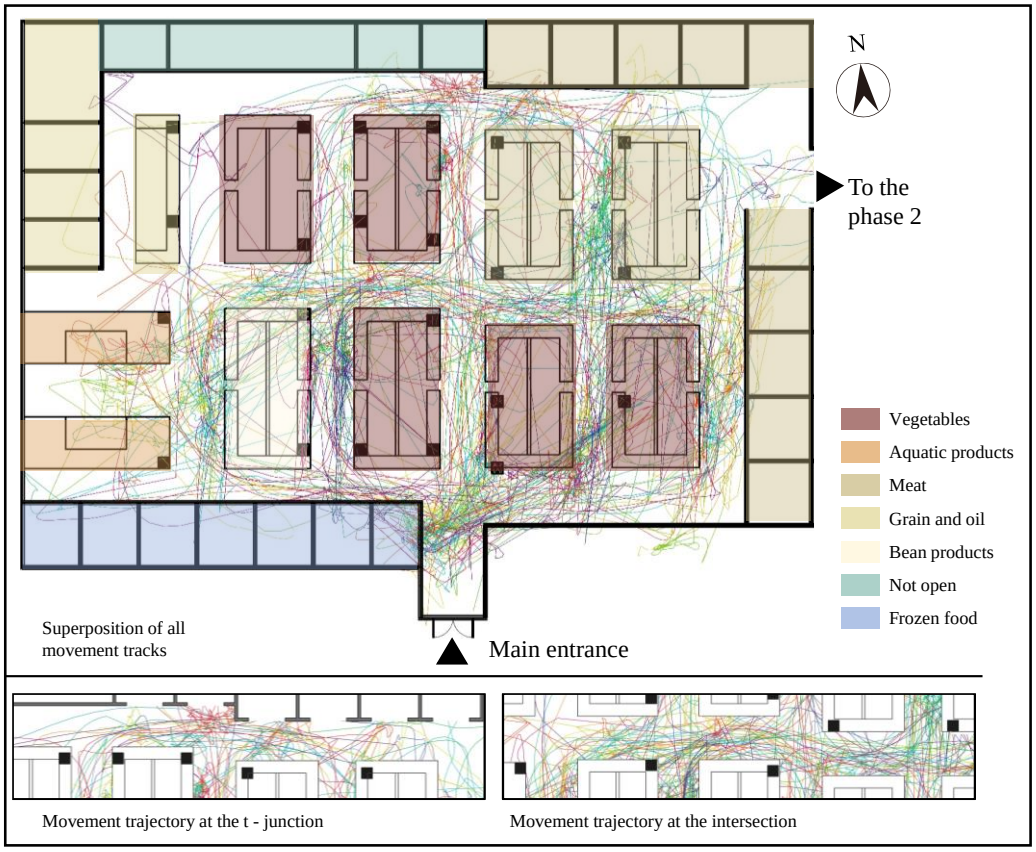

Fig.15 Superposition of the trajectory of grocery buyers in the Food market

It can be found that after the buyers in the food market enter from the main entrance, some buyers choose to pass directly from the center, while more buyers usually choose to start shopping from the right side, forming the strongest flow of people. The trajectory map also shows that grocery buyers usually choose to detour and walk through the grain, oil and food in the northwest corner, which leads to the sparse flow of people in some areas, which indirectly leads to the decrease of visits to shops in the northwest corner, which may be caused by the fact that the shops in the north side are not open to attract people. The T-shaped intersection in the food market has more circuitous and turn-back than the cross intersection. We should further classify the attributes of the crowd, and observe the common characteristics and behavior characteristics of the behavior tracks of the respondents with different attributes, such as the behavior path distribution of male and female grocery buyers, and the behavior path distribution of purposeful buyers and aimless buyers.

2) Connection strength between functional division grid thermal map and each region

In order to further explore the overall traffic relationship in each functional space, it is necessary to introduce the scale of functional partition to further explore. Compared with dense cell grid division, the grid number is less, each grid has different internal area, and contains less detailed information. Compared with the unit grid which has no practical significance, the division of functional grid is based on the actual functional partition from a systematic point of view, and it is an organic whole which is independent and isolated but highly related. When dividing the internal public space of the food market, assuming that each area has equal influence on the walkway, the visit volume of food buyers in each area in different areas can be intuitively reflected by coloring the residence time in different areas according to the formed functional network and counting the residence time in each area. As shown in Fig. 17, the visit volume of each common area can be intuitively reflected by the heat map. It can be found that the vegetable area, as the largest area, has the highest number of visits, followed by meat, while the number of visits to grain, oil, frozen food and non-staple food is lower.

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Fig 16 Distribution of visit intensity in different regions within the food market

By further analyzing the regional network, we can further understand the moving frequency of vegetable buyers by studying the connection strength between adjacent regions. When analyzing the connection between regions, the moving track of vegetable buyers is shaking to a great extent, which cannot intuitively express the connection between regions. The shuttle times between the action track line and the overlapping line of two adjacent functional areas are counted, and the corresponding areas are connected by lines with corresponding proportions and thicknesses. The size of circles is used instead of the depth of colors to respond to the area strength, reflecting the connection strength of any two adjacent areas (Figure 17).

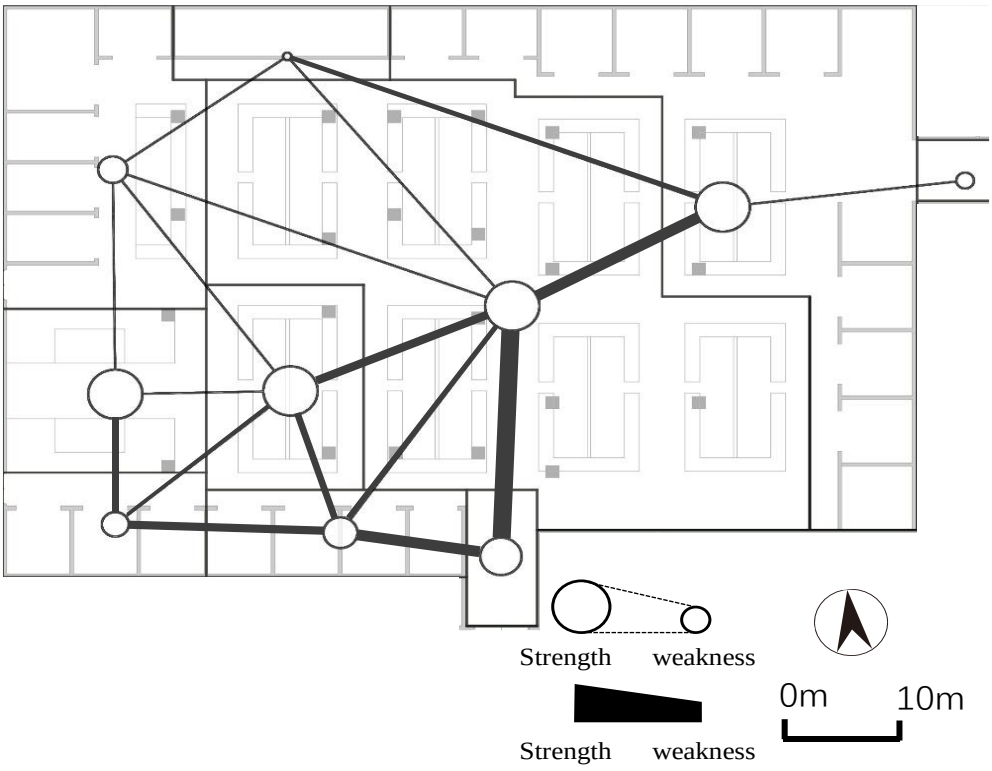

Fig. 17 Map of the strength of connections between different functional areas in the farmers market

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It can be found that, the highest contact intensity is the vegetable area-the entrance. The vast majority of vegetable buyers enter the whole food market through the vegetable area, followed by the connection strength between vegetables and meat, but the connection strength between meat area and other areas is low, so it can be judged that vegetable buyers basically return along the vegetable area after staying in the meat area, and pass through other areas less often. Although there are few stalls and a small area in the bean products area, it has five adjacent areas, second only to the six adjacent areas in the vegetable area. It can be seen that the bean products area has a high density of visits, which is an intersection area from south to north, connecting the south area with the northwest area with low visits.

5. Conclusion

The overall structure of the study is shown in Figure 18. Through the above research, it can be proved that UWB indoor positioning system has good applicability in different indoor scenes within a certain area, and different types of indoor spaces can be analyzed from overall scale to detail scale. For the analysis of the whole sample data, the trajectory analysis cannot be carried out because of the small experimental space scale, but it can be discussed from the more subtle furniture scale; For multi-sample data, because the experimental time of each sample may vary greatly, it is necessary to intervene and assist the research through data such as path and speed. Due to the large sample size of data, we can explore the correlation degree of different types of people's behaviors in space by classifying sample attributes. Two experiments prove the applicability of UWB indoor positioning system in public places with different sizes and sample types.

After classifying the behavior data of different spaces obtained by UWB indoor positioning system, two groups of research objects with typical characteristics are selected for analysis examples, and the similarities and differences between the two sample type analysis methods and data expression are discussed. Although the division of the two types is based on the sample types of data, there is a high degree of correlation between the acquisition sources of different sample types, and both experimental forms can obtain enough spatial behavior data for data processing and analysis.

UWB indoor positioning technology has the characteristics of accuracy, real-time and easy data analysis, which provides a new method and approach to study the relationship between human behavior and building interior space. Through the study of human stay relationship and spatial pattern association characteristics, it provides a certain theoretical support for the promotion of interior space design optimization strategy.

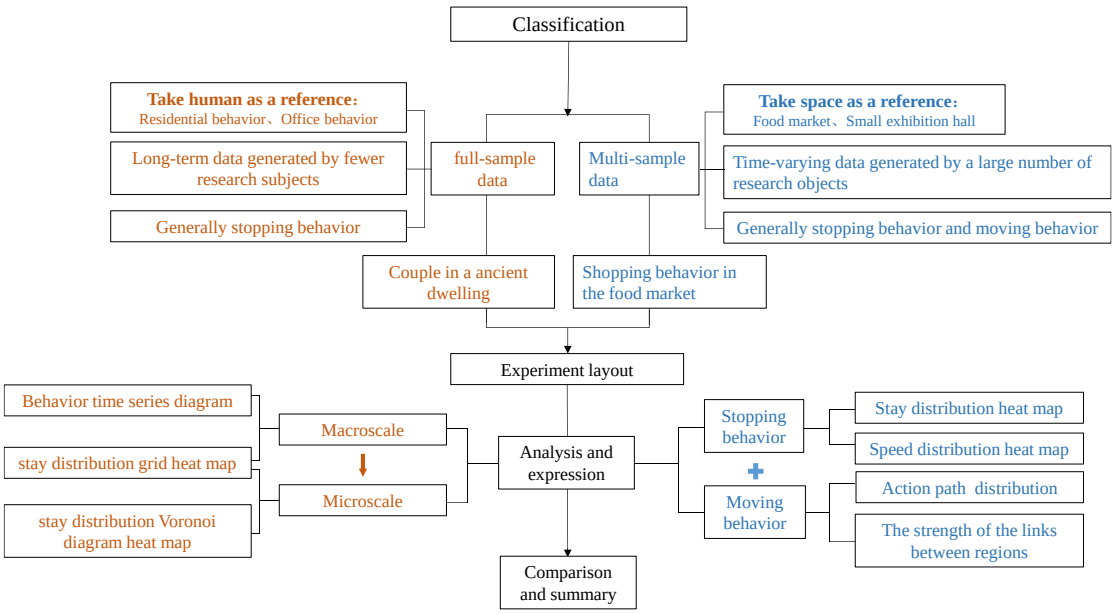

Fig. 18 Research object classification method of UWB indoor positioning system based on research data type

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