DOI: 10.53469/jssh.2024.6(11).34

Interior Space Reconstruction Design Based on Human Settlement Behavior Analysis

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Abstract: ***The renovation of residential space based on the analysis of human settlements behavior is an important method to improve the quality of old houses. Especially for small houses, in the limited space, it is necessary to optimize the spatial layout, enhance the function of storage space, and improve the user's living experience, which needs to start from the user's individual needs and psychological level, and explore the method of design and transformation. Taking residential housing in Beijing as an example, this paper analyzes and investigates the current situation of indoor scenes, layouts and interfaces, and focuses on the methods of residential space transformation through the application of ergonomics and mixed reality technology.***

Keywords: Habitat behavior analysis, Spatial design, Ergonomics, Participatory design, Virtual reality.

1. Introduction

With the development of social economy and the continuous growth of population, people's requirements and needs for living environment are getting higher and higher. As an important part of the analysis and discussion of human settlements, residential behavior analysis provides a useful theoretical support for analyzing the behavioral characteristics and behavioral needs of people in living space, and optimizing and transforming the living environment. In the past residential environment design, due to the lack of behavior analysis and research in the early stage of design, many designs could not apply the relationship between time difference and space difference well, and did not organize the behavior flow line and spatial layout efficiently and reasonably, resulting in the contradiction of time series and spatial sequence in some living environment spaces, which had an adverse impact on the comfort of the living environment. Therefore, the analysis of human settlements in the early stage of human settlements and space design, and the efficient arrangement and integration of space behaviors, are becoming important issues in the field of interior space design and transformation.

2. Research Methods

2.1 Analysis of Human Settlements

Habitat behavior analysis aims to analyze and rank the behaviors and actions generated by people's physiological and psychological needs in indoor living space, which we discuss here at three levels. First, the physiological level. Second, physiological extension. Third, the level of comfort. Through the behavior analysis in the early stage, it provides guidance for the subsequent analysis and drawing of matrix and bubble diagrams, as well as the organization of space. Through questionnaire survey and actual collection and analysis, the behaviors required by people in the indoor environment due to physiological needs and comfort needs were summarized, and the needs and placement of furniture were determined on this basis. At the same time, the ergonomic design is individualized according to the user's height to achieve the highest level of comfort.

By recording the time span and spatial scale of behaviors, we divide them into several modules. At the same time, the ergonomic scale specification design is integrated into the use scenarios of each module, and the time difference relationship caused by multiple behaviors in the same space and the spatial difference relationship in different spaces at the same time are fully considered. Starting from satisfying people's physiological needs, the user's personalized needs, psychological needs and physiological scales are combined, and refined design is carried out for indoor space division, organizational planning of circulation lines and optimal design of furniture products, so as to improve the comfort of indoor living environment and meet the livability and functional needs of human settlements [1].

Residential Behavior Analysis Table

				Exclusive Space	Frequency of occurrence	Fixed degree	privacy	Quietness level	correlation behaviour	furniture	an electric appliance	goods	remarks
Physiological level	1	(1) Sleep behavior	Go to bed	bedroom	high	high	high	high	Food, entertainment, changing clothes, reading and writing	Bed, sofa, tatami mat, storage cabinet, bed box, bedside table	×	Bedding equipment	
	2		Take a nap	×	--	low	in	high	Food, entertainment, reading and writing	Bed, sofa, tatami, lounge chair, bay window, storage cabinet, bed box	×	Bedding equipment	
	3	(2) Dietary behavior	three meals	restaurant	high	high	low	low	Food, entertainment, reading and writing	Dining table, storage cabinet, bar counter	×	Tableware, food, seasonings, trash cans, tissues	
	4		drinking water	×	high	low	low	low	--	--	Water dispenser, water heater, kettle	Tableware, water, and tissues	
	5	(3) Go to the bathroom	Defecate and urinate	Toilet room	high	high	high	--	Reading, writing, entertainment	Toilet and urinal	Smart devices	Toilet paper, paper basket	

Figure 1: Habitat Behavior Analysis Form (Section)

Source: Author's homemade.

2.2 Participatory Design Approach

The "participatory design approach" aims to enable stakeholders to jointly participate in the research, analysis, decision-making, and evaluation of the program [2].

Based on the OpenBuilding theory and the SI housing system, Heckmann (2020) created a participatory computer-aided

decision-making method for high-rise housing, which allows users to customize residential units according to their own wishes within a given algorithm, while meeting the requirements of industrial production. The key to participatory design is multi-party communication, information sharing and collaborative creation, and the openness of the design method is conducive to the participants to express their diverse needs. By strengthening the interaction of opinions in the early stage, guided by the professionalism of the designer and the personalized needs of users, the effectiveness of directional design is improved, and the repeated design and modification due to repeated communication are reduced.

2.3 Application of Mixed Reality Technology

Milgram and Kishino (1994) define mixed reality as the superposition of virtual objects, information, and the real environment. Through point cloud scanning modeling technology, VR imaging technology can interact with physical and digital objects at the same time in a visual environment to achieve real-time interaction. Mixed reality technology has important advantages in architectural interior design, highlighting its display and interactivity advantages. Mixed reality technology allows users and designers to visually experience design solutions and communicate feedback in real time. This technology changes the traditional design model, helps to improve the efficiency of communication between all parties, promotes the formation and practice of participatory design concepts, and promotes the breadth, depth and efficiency of public participation, so as to achieve economic and social benefits.

3. Retrofit Examples

Based on the above analysis of human settlements and design methods, a standard house type (two bedrooms, one living room, one kitchen and one bathroom, with an area of 85 square meters) was selected in Beijing, northern China, which is located in the central part of Fengtai District, Beijing. The community was built in the 90s of the last century and is mainly commercial housing. The research team conducted an in-depth interview with one of the households to understand its needs and personalized characteristics, and jointly carried out the interior space design and transformation. The transformation process is shown in Figure 2.

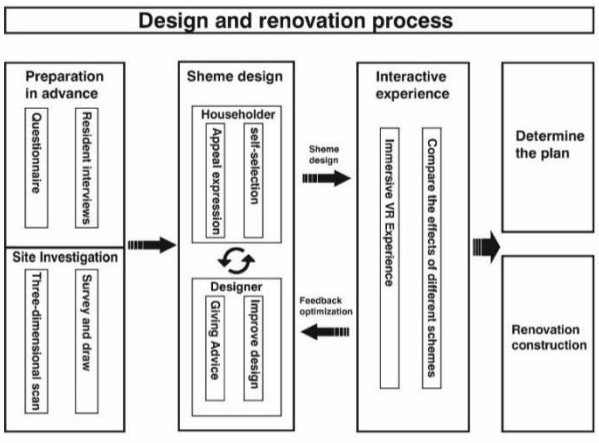

Figure 2: Design and Renovation Process
Source: Self-drawn by the author.

3.1 Preliminary Analysis

The research team qualitatively and quantitatively analyzes the needs of users and the current situation of the room.

Through the written information collection form, the user's family structure, functional needs and personalized preferences are collected and analyzed. And for furniture selection, material selection and other issues, through Q&A to collect users' transformation intentions. Through the data in the table, it can be concluded that the user is in the stable period of family structure, has high requirements for storage and space flexibility, and has a need for spatial visual experience of the form and color of interior decoration.

The research team analyzed the current plane of the interior. It can be seen that the entrance space is messy, the lack of visual center, the layout of the living room and kitchen leads to a sense of crampedness, the lack of overall planning and layout of furniture placement, and the lack of storage space, and the random stacking of scattered items, which affects the life line and has an inconvenient impact on daily life. The layout of the bedroom is not reasonable, and the cabinet space is insufficient. For the design of specific functional spaces, under the basic premise of meeting functional needs, humanized, intelligent and customized design is integrated, and through the flexible organization and time space arrangement of customized furniture, the storage attributes of the existing interface are increased and the composite potential of indoor space is improved. x

Figure 3: Photo of the current situation before renovation
Source: Filmed by the author.

3.2 Detailed Transformation Strategy

3.2.1 Transformation strategy focus

In terms of space organization and arrangement, in the new

plane layout, the opening mode of the kitchen is adjusted, and the position of the bathroom is adjusted, and the moving line is readjusted, so that the entrance space is straight and smooth, and the entrance hall, kitchen, living room, bathroom, and bedroom have a complete return curve, and the space bubble sequence is reasonable and coherent.

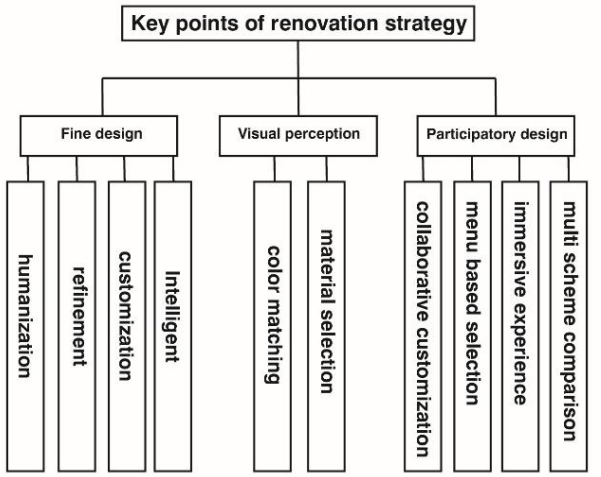

Figure 4: Key points of renovation strategy
Source: Self-drawn by the author.

The human habitation behaviors that occur in the kitchen are concentrated at the physiological extension level, which is mainly reflected in the cooking actions, such as washing, cutting, cooking, and plating, which have a high frequency of occurrence and a fixed degree, and the furniture that produces the corresponding linkage relationship is the cabinet, bar counter and dining table, and the linkage behavior items include tableware, cooking utensils, knives, cutting boards, trash cans, rags, etc. Designed for functional kitchens; The height of the original operating table and the water basin is designed to be low, and the reference is based on the scope of the ergonomic standing arm space, which is not conducive to the application of force and operation in the process of cutting vegetables and washing vegetables, and long-term use will increase the burden on the lumbar spine. Therefore, in terms of kitchen design, the comfort of kitchen activities is improved by increasing the height of the worktop and designing the drop countertop. The worktop is designed as an integrated U-shaped worktop to maximize the space, facilitate the turnaround and operation, and achieve the maximum acceptable area within the smallest range of motion. In addition, the storage is unified on the vertical wall surface through customized wall cabinets, which reduces the redundant space that occupies the worktop, and improves the visual size of the kitchen space by adjusting the material and color of the interface.

The living behaviors that occur in the living room are concentrated at the comfort level, which is mainly reflected in entertainment activities, reception, reading and writing, etc. The main actions are watching TV, listening to music, and looking at the phone. Reading sessions, family chats, etc. The home with which it has a corresponding linkage has a coffee table, sofa, TV, and chairs. For the living room, which accounts for a large proportion of the house, through the customization of furniture and lighting, the interior perception is amplified and the comfort is improved. Among them, the lighting is arranged through wall washers and linear lights to ensure good lighting effect, and create a warm and comfortable atmosphere through the adjustment of color temperature.

Habitat behaviour generated in the bedroom. It is mainly distributed in the physiological level and comfort level, and the main actions are reflected in bed, resting, changing, looking at mobile phones, reading, writing, computer use, taking medicine, injections, massage, etc., and the home has a bed reclining chair, locker, etc. Therefore, the design of the bedroom space mainly increases its functional level and improves variability, expands the area of its internal storage space, and sets up a working area. Electric curtains are installed in the window area, and tatami mat cushions are used to create a small relaxation area.

The design of the bathroom achieves the separation of wet and dry through partitioning, and places the washroom at the spatial node where the bedroom is connected to the living room for a larger radiation range. A niche is designed on the wall to place the related items needed for bathing and increase the storage capacity.

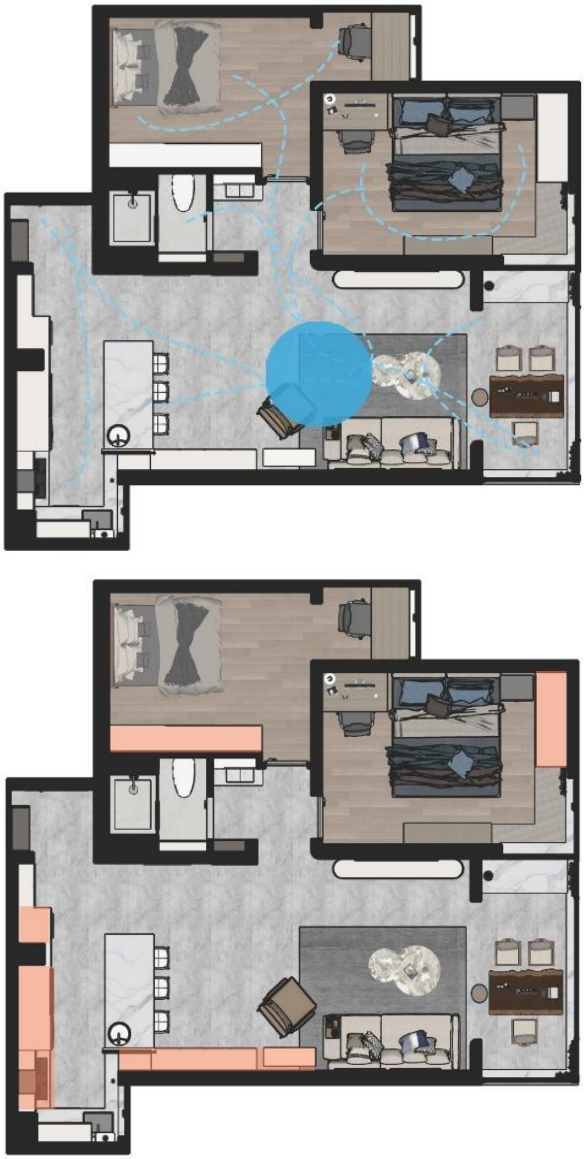

Figure 5: Adjusted plan layout and furniture arrangement
Source: Self-drawn by the author.

3.2.2 Application of visual laws

For the interior renovation of smaller houses, it can be applied through visual rules to improve the visual experience. Based on people's intuitive visual experience of light, shape and color, the user's living experience is enhanced through the adjustment of patterns, colors and materials.

Colors with higher lightness have a magnifying effect, while colors with lower lightness have an indented effect. Through the color ratio of high and low brightness, the depth of field of the indoor space can be enriched. Therefore, during the renovation process, the team adopted a strategy of combining background color and accent color, and used background color for large areas, such as walls, floors, and ceilings. The cabinet table, chair and bed are the theme color, and the ornaments are with. Ornaments, small furnishings and plants are accented with colors. By adjusting the proportion of the three types of colors, a richer and more appropriate visual sense is obtained.

For the color design of the kitchen, wall cabinets and worktops. Marble with moderate brightness is used, the cabinets are made of beige with high brightness, and the floors are made of terrazzo bricks with low brightness. Visually extend the width of the space and visually enlarge the operating space of the kitchen (Figure 6).

In the color configuration of the living room, the wall and floor are used as the background color. Tables and chairs, etc., are decorated with less saturated greys and woods, and are embellished with more lively greenery (Figure 7).

Figure 6: Kitchen color matching

Source: Self-drawn by the author.

Figure 7: Living room color matching

Source: Self-drawn by the author.

In the color selection of the bedroom, choose gray wallpaper with low brightness and light-colored wooden furniture to contrast with the warm-colored wooden floor, and expand the visual experience of the space at the user's psychological level through visual contraction and expansion.

The material selection of the interior space is mainly wood, cloth and ceramic tiles, aiming to form a warm atmosphere of the indoor space, improving the brightness of the interior through the light-colored wood grain flooring, and laying the floor along the shorter direction of the room, so as to weaken the sense of depth of the space and adjust the proportion of the space. In addition, in terms of soft furnishings, textured fabric furniture is used to assist in dissolving the feeling of fragmentation caused by the hard interface.

The choice of lighting is mostly 3500K color temperature, and the warm color lighting with the texture of the wood grain and the texture of the wall creates a warm and soft texture, eliminating the sense of boundary of the space and improving the visual comfort.

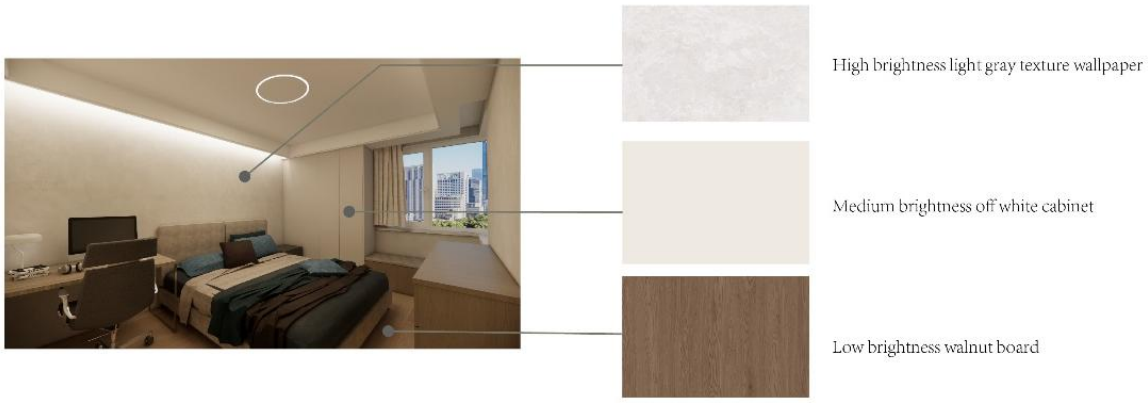

Figure 8: Bedroom color matching

Source: Self-drawn by the author.

3.3 Mixed Reality Participatory Design

Based on the existing research and analysis and the consideration of the personalized needs of users, the team starts from the visual sense. The user's design intention is presented in 3D through information modeling, and can be used for 3D interaction through mixed reality technology with wearable devices and mobile devices. It is also possible to observe and feel the indoor effect of the panoramic effect through the mobile device.

Figure 9: Color extraction

Source: Self-drawn by the author.

The research team built a digital model of the interior using the design tools sketchup and Rhinoceros. The design parameters of the interior furniture construction interface can be dynamically adjusted. Users can make local adjustments and customizations through the existing database.

When communicating with users, designers can always respond to the ... The model is adjusted. Realize the collaborative design, decision-making and adjustment with residential users, break the barriers of communication, and form participatory design, which is professional, dynamic and interactive.

After the information model is built, you can use the mixed reality application plug-in fologram to publish the model to the sketchupviewer application through sketchup's VR/ARExtension, so as to realize the dynamic connection with wearable devices and smart devices for immersive collaborative display. In this design experiment, users participate in the interior renovation design through wearable devices, through depth cameras and gravity sensing. Obtain the user's spatial location information, and present the corresponding information in the form of holograms in front of the user.

Figure 10： VR virtual imaging living room scene experience

Source: Self-drawn by the author.

Participatory design with the intervention of new technologies in the information age is conducive to the evaluation and modification of the design scheme from the visual experience and psychological level of residential users, and the design of composite living space is judged by whether the living space meets the necessary living functions and individual needs. Mixed reality technology gradually transforms human-computer interaction into human-environment interaction, so all parties can make multi-scheme comparison decisions in the virtual environment, form customized transformation plans, and finally determine the construction plan and budget in the real environment by professionals who further optimize and integrate.

4. Conclusion

With the development of residential renovation towards the people-oriented design method, the focus of the renovation has gradually expanded from the appearance of the building and the performance transformation of the building to the improvement of indoor livability and functionality. The analysis and collection of quantitative and qualitative factors is an important step.

The renovation of indoor space based on human settlement behavior analysis and the application of mixed reality participatory design have an obvious role in improving the quality of interior design, meeting the personalized needs of users, and improving the efficiency of multi-party communication.

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