A Study on Information Visualization Depicting Life Model and Employed in Interior Design

Chiung-Hui Chen

***Abstract*—In respect of interior design service, how to build a service platform that can document the process of the user's joint participation in the design communication and visualize their life model and design requirement is worth of further study and development. Designers need more messages that influence the interaction between the user and design objects in order to produce a design object that complies with the user's experience and meets their expectations. For the purpose of saving designer's time in searching for design data and of emphasizing the method of converting the data acquired from a user's personal life model, data are visualized into design information that contains specific meaning. After the visualized design information is understood by the interior designer, it is further employed and converted to design knowledge, and eventually applied in the real service design. It is believed in this study a joint design method that involves users and interior designers should be developed to allow users' participation in design process. Users may also participate the activity of creation through a joint design process, thus achieving the goal of service optimization.**

***Index Terms*—Design service, information visualization, lifestyle patterns, interior design.**

I. Background and Objective

Architecture Design refers to a design activity that is specific to the purposes of architecture, including design activities per requirements for the environment, usage, and visualization, and presents specifically historical, cultural and symbolic meanings of architecture. The scope of Architecture Design includes Appearance Design and Interior Design and can be further extended to the relationship between architecture and environment. Interior design is then the recreation of the interior environment of architecture. In the area of residential space design, the style and preference of inhabitants are transformed into design concept and employed in the process of design, thus converting interior space to the value of life, emphasizing the taste of the family and individual, expressing the user's attitude toward life, and eventually providing a more cozy living space. Therefore, as far as functionality is concerned, Architectural Design provides an existing space, yet lifestyle and interior space need to be refined in detailed design. In other words, Interior Design is not only beautification of architectural interfaces, but more like a recreation of interior functionality and space form.

Traditional service channel is losing its edge due to emerging service technology. To establish interaction with the clients, the service industry is using effective mechanism to give clients direct access to services with emerging technologies. Thus, as service science receives attention, special and unique consumption pattern evolves, henceforth leading to new market mechanism and influencing attitudes toward life and consumption patterns. The market demand for customized services is thus valued due to the emphasis of personal value, and is gradually changing the demand and supply relationship in the traditional industry. In respect of interior design service, in the process of traditional interior design, a designer converts to a concrete form the concept generated from the ideas and needs dictated by a client, by using his/her professional knowledge and drawing tool. The final product is generated through iterations of communication and modification, which is a very time-consuming process. Although this process has been accelerated with the help of computer graphics software today, repeated discussions and confirmations with users are still required to complete the task. Besides, in providing innovative design service of interior design, innovation must take into consideration user's needs in order to reach consensus with the user. It is believed in this study that users should have access to sufficient information related to design in the course of communication, and they are hence allowed to understand the style elements of their needs and to participate in the provision of innovative service design. The time and the cost of communication can therefore be reduced, and the user may feel the sense of achievement.

In consideration of what is addressed above a space user's life model is analyzed with visualization technique to create an interaction system modeled after interior design knowledge. The space user document intuitively personal life experience in a model requirement chart, allowing a researcher to analyze interrelation between analysis documents, identify the logic and the substance of data conversion. The repeated data which is documented are then transformed into design information for reuse and sharing. A professional interior designer may sort out the correlation among user's preference, life pattern and design specification, thus deciding the critical design elements in the process of service design.

II. Theoretical Framework and Literature Review

A. Description of Life Model

Human develops close interaction with the environment which consists of human's standing behaviors and the

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locations where such behaviors occur. Behaviors of the environment are thus multifaceted [1]. Barker [2] proposes that there are four factors in Behavior Settings, which are user, standing pattern of behavior, physical environment, and a period of specific time. Lang [3] also proposes that Behavior Settings are standing patterns of behavior which appear repeatedly in a specific place and time. If different users access this place, Behavior Settings do not disappear as a result. They will disappear only when physical environment changes. In other words, the standing pattern of behavior in Behavior Settings has close relationship with time. Wicker [4] makes a further discourse from the perspective of time, proposing a dynamic change model of Behavior Settings. He describes the behavior arrangement for the Behavior Settings in the time segment with Behavior Settings segmented in the time sequence and with composition factors as the major entry point of view. From initial gathering, standing pattern of behavior, to ending behavior, this process may be considered as a dynamic change process of Behavior Settings.

Based on the above description, it is concluded that the time for which Behavior Settings appear may be short or lengthy. For the benefit of analysis, the records obtained during the study must be well controlled during investigation. Wicker [5] and Schoggen [6] also point out that if confirmed Behavior Settings are to be described objectively, Behavior Settings must be divided into four parts for discussion of relationship between all parts and all information must be recorded. These four parts are user's frequent behavior and classification, amount and attributes of Behavior Settings, times and duration of occurrence, and the location and the size of the dimensions. The life model in this study is thus defined as a cycle that consists of generation, growth, change, fading, ending of user's behavior in a residential environment in a time sequence. On the other hands, in the study of the value of life model in a society and a culture, Højrup [7] stresses that designers should not only focus on understanding a user's life model, but also integrate the preferences of the user, family, and future demands with the characteristic information of a house, thus creating a complete map of user's life model. Overall speaking, in order to develop a joint design service based on a life model it is mandatory for users to share their ideas and opinions, particularly in the initial design phase. Communication and reflection are crucial to the core of design. In summary, this study employs the theory of Behavior Settings as the infrastructure for investigation, thus enabling space users to record behaviors that occur at home and the locations where such behaviors occur during test period. The user's life models in one day and in a period are analyzed accordingly.

B. Technology Used in Information Visualization

Information Visualization is a unique academic discipline. It combines multiple disciplines, such as Computer Science, Psychology, Semiotics, Graphics Design, Interaction Design and Art. It pays close attention to how to create an effective interaction between abstract data and users in a visual and metaphorical way. Lack of space initiative is the characteristic of abstract data; therefore, the visualized presentation of abstract data and development of new visual metaphors and data presentation method are challenging to researchers of Information Visualization. With respect to the definition of Information Visualization, Card [8] *et al*. define it as visible presentation of the interaction between abstract data for better understanding. Therefore, we can say that visualization can improve the interaction between users and abstract data, and users' degree of awareness. On the other hand, Information Visualization consists of two concepts, i.e., data and visualization. This means that the objects, concepts or abstract data are expressed in images instead of text. Due to the multiple types and various structures of data, Shneiderman [9] defines and divides data into seven basic types, which are one dimension, two dimensions, three dimensions, multiple dimensions, time, tree, and network. One dimensional data is one of linear data type which can be combined in a proper sequence. The visual presentation of two dimensional data is typically expressed in a coordinate plane with X and Y axes.

Danyel Fisher quoted the test performed by Robertson *et al*. [10] in his book *Beautiful Visualization* [11]. Robertson employs a model in which data move with time and numeric data are presented in a traditional XY Scatterplot. He creates an animation that plays with time. He then gives the tester a question, asking the tester to find the answer from the animation. The test result tells us finding an answer from animation is very slow and the answer obtained this way is inaccurate. We discover that Exploration and Presentation of the data differ from each other a lot. For people who need to explore data, Animated Visualization, though fascinating, may produce results contrary to the intended purpose. Several causes may be concluded from the findings of Robertson *et al*. [10]. Firstly, readers cannot predict the variation of data and thus need to watch animation repeatedly because they do not understand the data. In a multiple data structure, people normally can only pay attention to one dimensional data and observe at most 3 to 4 points; moreover, they need to pay additional attention to reflect on the meaning to which the axis corresponds in the process of tracking data, thus causing delay in making a judgment. What is worse, the tester may be divided in his/her attention and thus gives misjudgment if the data do not change in consistence with the speed of the movement. For the purpose of comparison, Robertson *et al*. also show the trajectory of each point's movement in a static chart and perform a re-test. The tester could make the judgment not only faster, but also more accurately. In order to help the user understand better the presentation method of dynamic information, Heer and Robertson [12] makes a simple classification for animation and provides some methods which are used more commonly, such as shifting perspectives, shifting coordinate plane (like shifting linear axis to logarithm axis), presentation of specific data (filtering data), shifting data category or dimension, moving data with time, etc. When we begin to prepare or analyze data, we can also consider suggestions from Fisher, such as maintaining compatibility in the process of data movement or conversion, ensuring data to have meaningful coordinate motion, and ensuring each motion is a meaningful

motion. With these methods and guidelines of self-inspection the data can be presented more precisely.

C. Life Model-Based Information Visualization Model

Visual Programming Language (also called Graphical Programming Language) can process mass data to obtain information and then presents the message such information intends to communicate in graphics which is easy for human to recognize. Human typically spends more time and effort to understand when facing huge amount of text and data. To help a user analyze efficiently and understand quickly the structure and characteristics of information, visualization methods based on computer graphics technology are thus developed to help people grasp quickly and absorb efficiently the message which the information intends to communicate. The results obtained from visualization may reveal the necessary messages of the information, thus allowing a professional interior designer to observe overall information and then grasp the key point. However, Information Visualization is mainly functionality- and efficiency-oriented. The potential and implicit influence brought about by aesthetic factor may be overlooked if practicality is emphasized too much. When viewed from another perspective [13], data-based aesthetics puts much emphasis on artistic metaphor, and ignores functionality that should be considered in employing information visualization, hence leading to messages too abstract to understand. Therefore, Aesthetics, as an independent media, can effectively eliminate the gap between functionality and artisticity and increase the value and functionality of the information.

Ancient Roman Architect Vitruvius, in his book titled The Ten Books on Architecture (De Architectura) [14], mentions three architectural design principles that should be adhered to: Completeness, Practicality, and Aesthetics. Vande Moere, A. and Purchase H, in their co-authored book, titled On the Role of Design in Information Visualization [15], point out that these three principles may be applied in Information Design and various applications that are suitable for Information Design. They also indicate that good visualized content should be very complete. In other words, the form of the design must match with the information described by the design. Moreover, visualized content should be practical so that the user may derive meanings from it. Finally, like any design, Information Design should be aesthetically appealing, draw attention from the user, and provide pleasant visual experience. The three design principles that Vande Moere, A. and Purchase H propose serve as a solid foundation for our judgment of the value of information visualization. This study is built upon above-mentioned view points, and the four steps of visualization by Colin [16] which are, respectively, collecting and storing data, pre-processing and converting data to an intelligible form, displaying, on the screen, image generated by the graphical engine, and human's observing and cognizing the image. There are also feedbacks existing between these steps whose correlation is shown in Fig. 1. Quantified data are used to express certain characteristics with symbols in lieu of digital expression of data. In term of visual meanings and perception, a project interior designer is more inclined to accept symbols than text mainly because he/she can quickly understand the data and grasp their characteristics with the help of symbols. In term of data itself, the area scale, color, length, and quantity of the image are used to express content. The created image symbols replace the explanation in language in way of visual metaphor. Project interior designer can thus review digital data, provide opinions, and propose design service with better quality.

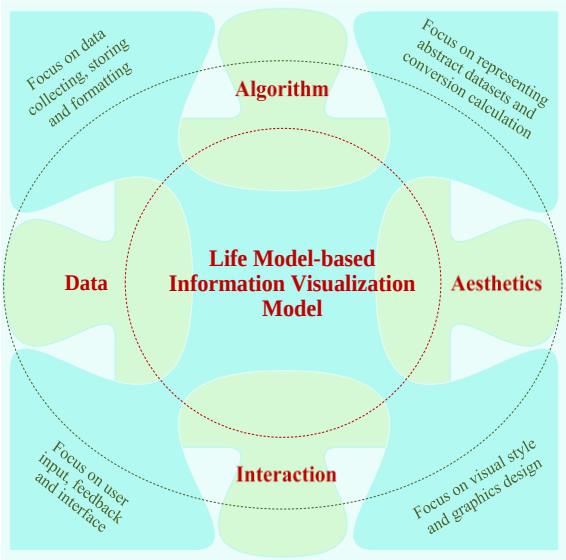

Fig. 1. Life model-based information visualization model.

III. Exploring Life Model

Interior design process places emphasis mainly on design object itself. However, as user-centered concept gains popularity in recent years, more and more design methods have improved design quality by understanding the user [17]. This trend also impacts the design process of a traditional service platform. Designers communicate with users by utilizing co-design technology and tool, thus allowing more effective design ideas and creating more opportunities for service innovations. Based on theories and study objectives explored previously, the method employed in this study is detailed as below.

A. Background of Client

Due to tediousness and complexity involved in interior design, the interior designer provides design expertise and services based on design knowledge, builds up the framework of user requirement, and analyzes the attributes of style and design elements so that re-creation conditions of design elements in service combination may be met. This study first uses a nuclear family in a case study. There are three members in this family – Mr. Peng, Mrs. Peng and their son who is a student of senior year in high school. Mr. Peng, 47 years old, is the owner of a medium sized company. His hobbies are reading and travel. His friends often visit him at home. He likes to have a chat over coffee and spend most of his time before a computer. Occasionally he plays basketball. Mrs. Peng, 45 years old, stays home most of the time. She is a very good cooker. Occasionally she would invite friends over for a meal. She likes coffee, arts, and crafts. She often goes for a walk in the country and travels overseas. The house of

the Peng family is located at the Main Street. The total floor area of their two-floored house is 1,800 square feet. The main amenities such as living room, dining room, kitchen, rest room and yard are on the first floor while master bed room, their son's bed room, study room, bathroom and balcony are on the second floor.

B. Space Encoding

For human being, different space forms account for different cultures under different environments. Any space has sphere depth and defined sphere is the result of encompassed boundary. The definition of Space Sphere Depth in this study is given according to the theory of sphere structure given in the study of Hiller [18], [19]. Hiller's study indicates that the sphere depth in space is obtained from observing physical environment, and from walking distance in space and accessibility of visual permeability. His study also indicates the relation in space is not geometrical, but topological. The study of space structure is thus rid of plane-based study, and the space encoding is symbolized and numeralized into symbols and mathematical system with single meaning for better exploration of correlation between spaces. As a result, we can conclude that the lower one's accessibility to a space is and the more private a behavior is, the deeper the sphere depth is. On the contrary, the more the people who share the control over a space are and the higher one's accessibility to such a space is and the more open a behavior is, the shallower the sphere depth is.

Therefore, this study is guided by the degree of privacy of a behavior and divides the sphere structure of living space in the case study into four levels (i.e., space coding) on a scale from "private" to "open." Living space thus includes several independent space units: rest room, master bed room, child bed room, kitchen, study room, dining room, living room, balcony, and yard. Each room is described as below. Bathroom and bed rooms are space-encoded as No. 1 because they are considered spaces under the same category and with the highest level of privacy. Kitchen and study room are spaces where independent behaviors occur, but they may be shared by members of the family, thus leading to cooperative behavior. They are space-encoded as No. 2. Dining room and living room are where family members gather and visitors stay for cooperative behaviors; they are space-encoded as No. 3. Balcony or yard can be seen by pedestrians; they are space-encoded as No. 4. Behavior settings for holidays or weekends, such as school, office, park, and market, are space-encoded as No. 5. Space levels encoded from No. 1 to 4 are the main subjects in this study. Space outside of the house (No. 5) is not considered for information conversion. Definitions for each level are shown in Table I as below.

TABLE I: INTERIOR SPACE ENCODING FOR THE HOUSE

Sphere Characteristics	Sphere Encoding	Name of Space
The larger the Number is, the lower the privacy is	1.	Bathroom, bed rooms
	2.	Kitchen, study room
	3.	Dining room, living room
	4.	Balcony, yard
	5. not included	Space outside the house

C. Journal Encoding

Family is the starting point of a community life and the most basic unit of a society. Everyone's daily life is filled with people, events, times, things, and places. This study begins with a space user's daily life sphere. Various conditions caused by each factor of a space user are used to create task description on a case study basis. Unlike ordinary questionnaire and interview, a space user records his/her own daily activities and uses a journal and a camera to complete recording of his/her own daily behaviors. Keeping journal allows us to receive details of a space user's daily life. The descriptions of a space user's preferences, activities, environment, and use of an object are hence received through this mechanism. The interior designer then obtains a complete script of life. With camera exploration, family members are required to record videos of the locations of their activities, environment, or equipment used so that the interior designer may observe the environment and conditions in real life. Journal is recorded every one hour, 24 hours a day, and for 14 days (two week). During the period of recording, family members are required to record the behaviors that occur in daily activities, and where and when they happen. The samples of journal encoding are listed in Table II.

TABLE II: JOURNAL ENCODING: A DAY IN THE MRS. PENG'S

Time	Activity	Name of Space	Duration (hrs)	Sphere Encoding
12:00 AM	Sleeping	Bed room	1	1
1:00	Sleeping	Bed room	1	1
2:00	Sleeping	Bed room	1	1
3:00	Sleeping	Bed room	1	1
4:00	Sleeping	Bed room	1	1
5:00	Sleeping	Bed room	1	1
6:00	Sleeping	Bed room	1	1
7:00	Get up and wash up	Bathroom	1	1
8:00	Prepare breakfast	Kitchen	1	2
9:00	Eat breakfast	Dining room	1	3
10:00	Chore	Kitchen	1	2
11:00	Chore	Dining room	1	3
12:00 PM	Prepare lunch	Kitchen	1	2
1:00	Eat lunch	Dining room	1	3
2:00	Nap time	Bed room	1	1
3:00	Nap time	Bed room	1	1
4:00	Walk the dog in the park	Space outside the house	1	5
5:00	Go grocery shopping	Space outside the house	1	5
6:00	Prepare dinner	Kitchen	1	2
7:00	Eat dinner	Dining room	1	3
8:00	Eat dinner	Dining room	1	3
9:00	Do laundry	Balcony	1	4
10:00	Take a bath and get ready for bed	Bathroom	1	1
11:00	Sleeping	Bed room	1	1

D. Changes in Life Sphere in a Day

In this section, journal codes collected from the daily records in the case study are analyzed. A visualization analysis is performed for changes in life sphere in a day, and for numeric data about members' sphere distribution records during test period. Family member's activities in the environment are presented by the hour, as shown in Fig. 2 (base on Table II) which are the maps of sphere change in a day during test period of case study. The measurement scale of life sphere change in a day is defined according to three principles:

1) The line coordinate of concentric circles has 24 gradations with each representing one hour. The number increases clockwise. One circle represents one day.
2) Concentric circles are indicative of degree of privacy. The farther the circle is away from the center, the more open the sphere characteristics of the space it represents is and the bigger the number is.
3) Colored area indicates that some family members were using that space at that particular time.

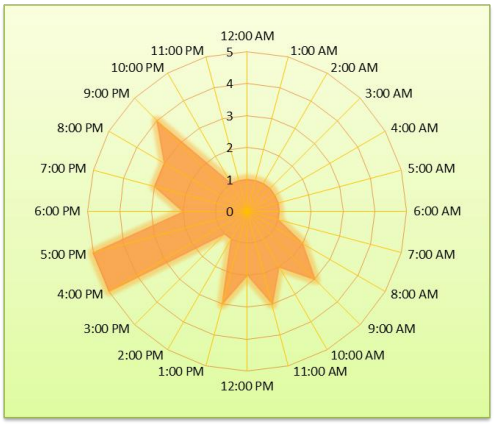

Fig. 2. The map of Mrs. Peng's life sphere change in each space.

IV. Discussion and Analysis

A. Sphere Activity Change Index in the Test Period

Continued from the member's map of life sphere change in the previous section, a two-week numerical analysis for the Peng's sphere activity change was performed. The results are shown in Table 3. In this process, two assessment indexes were derived, which are Duration-Days(D.D.) and Frequency-Days (F.D.) respectively. These two indexes can show the sphere change of the family members, the space sphere where each spends most of his/her time, and the frequency of visit to the bathroom, bed room, kitchen, study room, dining room, living room, balcony, and yard. The formulas of index D.D. and F.D. are indicated as below:

1) Duration-Days (**D.D.**) $=\Sigma\, d\mathrm{D} / \mathrm{Days} \rightarrow \Sigma$ Total time used for the space during the period of recording/Days of recording. This index is used to estimate the time the family members spend in the space per day.
2) Frequency-Days (**F.D.**) $=\Sigma\, d\mathrm{F} / \mathrm{Days} \rightarrow \Sigma$ Total visits to the space during the period of recording/Days of recording. This index is used to estimate family members' number of visits to the space per day.

B. Visualization of Sphere Activity in the Period

Generally speaking, Illustration Design is preferred in a narrative type of information map while the presentation of objective observation is required in a study type information map; thus there are fewer illustrations used in the latter. A good visualization design not only expresses the value of aesthetics, but also makes it easier to read for analysis and comparison of charts. In this section, the distribution of average usage time of the family members in each space sphere has been visually simulated and then converted to graphic information according to sphere activity change indexes D.D. and F.D. as mentioned above. Like plants which have different outlook under different conditions of light, water, and soil, Family members' "Life Model Information Tree" developed through this process also behaves similarly. The structure of the growth model is detailed as below:

Table III: Numerical Analysis for Mrs. Peng's Sphere Changes during a Two-week (14-day) Period.

Name of Space	∑ Total visits	F.D. Total visits/ 14 days	∑ Total time of usage (hours)	D.D. Total time/ 14 days
Bathroom	42	3	24	1.71
Bed room	47	3.36	121.5	8.68
kitchen	35	2.5	33	2.36
Study room	7	0.5	10	0.71
Dining room	34	2.43	34.5	2.46
Living room	12	0.86	11.5	0.82
Balcony	11	0.79	6	0.43

1) Tree trunk: This is the center as well as the beginning of growth.
2) Branch: This refers to the direction of growth. The number of spaces varies from one interior design project to another. The degree of privacy of a space sphere is indicated by different colors. The change and calculation of angle bear relationship with the number of spaces, thus generating different patterns.
3) Number of leaves: D.D. index is indicated by the number of leaves which represents average amount of the time the family members spend in the space. The more the leaves are, the more the time spent in the space is. This indicates the time the family members spend in the space per day. The area of the circle is scaled as 100%. The area occupied by the leaves indicates the percentage. The more the leaves are, the more the time spent in the space is.
4) Segments of branch: F.D. index is indicated by the length of the segment of branch. The length of a segment represents the total visits to a space. The longer a segment is, the more frequent of visitation to the space is. This indicates the total visits to a space. The total length of the segments is scaled as 100%. The whole length is then divided into sections in proportion to the percentage of each part. The length of each segment indicates the percentage of each part. The longer a segment is, the more frequent the visit to the space is.
5) Rule of growth: The growth model is divided into two basic elements–Core and Direction. A polygon represents

the originating core of a tree trunk while the text inside the polygon represents the appellation of the family members. The number of sides of polygon (N) depends on the number of spaces in the interior design project, as an example of hexagon is shown in Figure 3. The rule of growth of single member's Life Model Information Tree is defined as follows: Multiple branch axes are generated and extended from the center with the direction of each axis representing a space. The angle of each branch (θ) is obtained by evenly dividing 360 degrees by the number of space in the interior design project (θ = 360 degrees/6 = 60 degrees). The length of a branch axis (F.D.) is derived from such a member's frequency of visitation to each space while the number of leaves at the end of the branch axis is derived from the average amount of time spent in the space (D.D.).

The objects of multiple members can also be shown on one computer screen. A branch connecting line is drawn between every member and another member; thus an image that resembles a plant is created. Such an image is therefore called Life Model Information Tree. However, if there are too many lines, showing them all on one screen may be a mess, thus preventing the model to give a clear explanation. The study result is then built into an interactive Life Model Information Tree System on a network platform, allowing the user to select the member to view and those he/she does not wish to view in real time, and to select dynamic functions such as space and time change. The upload of data and analysis are then made easier for the user.

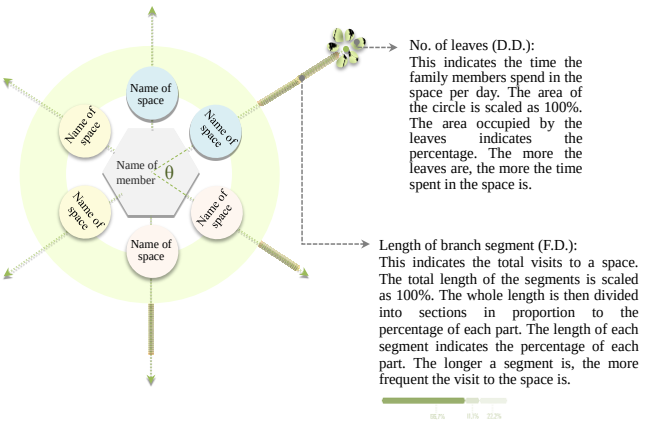

Fig. 3. Representation of the life model information tree.

V. Conclusion and Follow-up Studies

In the process of visualization the characteristics of data and the problem to be resolved must be defined first. A dynamic presentation may be helpful to allow the user to understand the change of data movement. If the change of data before and after movement is required, then a static presentation may be a better choice. Though dynamic presentation may bring adverse effect due to improper handling, it is undoubtedly an important data visualization technique. In this study a method of providing an interior design data source which is fit for the objective of this study has been created. Meanwhile how the consistency of number data is maintained in the process of format is also detailed. It will take a long time for project interior designer to find a periodic mode that is inherent in the data if only a simple electronic data table is provided. Although current design outcome of visualization is a static image, the whole iconic infrastructure and hierarchies have been established, which is the most difficult part of the task. Overall speaking, mass information may be converted to meaningful image framework through information visualization. Compared to the pure digital display used in the past, information visualization is more intuitive and easy for interior designer to quickly understand and use information. With the improvement brought about by new technologies and algorithms, the data dimension and width that information visualization can present today are more diversified and interactive.

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References

[1] K. Lewin, "Defining the Field at a Given Time," *Psychological Review*, vol. 50, pp. 292-310, 1943, Resolving Social Conflicts & Field Theory in Social Science, Washington, D.C.: American Psychological Association, 1997.

[2] R. G. Barker, "Ecological psychology: concepts and method for studying the environment of human behavior," Stanford University Press, Standford, California, 1968.

[3] J. Lang, "The behavior setting: A unit for environmental analysis and design, creating architectural theory-the role of the behavioral sciences in environmental design," Van Nostrand Reinhold Inc, pp. 113-125, New York, 1987.

[4] A. W. Wicker, "Behavior setting reconsidered: Temporal stages, resources, internal dynamics, context," in D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology*, pp. 613-653, NY: John Wiley & Sons, 1987.

[5] A. W. Wicker, "Making sense of environments," in W. B. Walsh, K. H. Clark, & R. H. Price (Eds.), *Person- environment Psychology: Models and perspectives*, pp. 158-191, Hillsdale, NJ: Lawrence Erbum Associates, 1992.

[6] P. Schoggen, *Behavior settings: A revision and extension of Roger G.Barker's Ecological Psychology*, Stanford, CA: Stanford University Press, 1989.

[7] T. Højrup, *State, culture, and life modes: the foundations of life mode analysis*, London, UK: Ashgate, 2003.

[8] S. K. Card, J. D. Mackinlay, and B. Shne Iderman, *Readings in information visualization: Using vision to think*, San Francisco: Morgan Kaufmann, 1999.

[9] B. Shneiderman, "Tree visualization with treemaps: A 2-D space-filling approach," *ACM Transactions on Graphics*, vol. 11, no. 1, pp. 92-99, 1992.

[10] G. Robertson, R. Fernandez, D. Fisher, B. Lee, and J. Stasko, "Effectiveness of animation in trend visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 14, no. 6, pp. 1325-1332, 2008.

[11] J. Steele and N. Ilinsky, *Beautiful visualization, looking at data through the eyes of experts*, Sebastopol, CA, 2010.

[12] J. Heer and G. Robertson, "Animated transitions in statistical data graphics," *IEEE Transactions on Visualization and Computer Graphics*, vol. 13, no. 6, pp. 1240-1247, 2007.

[13] C. Horn, "Natural metaphors for information visualizations, massachusetts college of art and design," Master Thesis, 2007.

[14] V. Pollio, *The Ten Books on Architecture*, Courier Dover Publications, transl. Morris Hicky Morgan, 1960.

[15] A. V. Moere and H. Purchase, "On the role of design in information visualization," in A. Kerren, C. Plaisant, and J. T. Stasko, (Eds), *State of the Field and New Research Directions, Information Visualization Journal*, vol. 10, no. 4, pp. 356-371, 2011.

[16] W. Colin, *Information visualization: perception for design*, 2th ed., San Francisco, CA: Morgan Kaufmann, 2004.

[17] F. Samalionis, "Can designers help deliver better services?" in S. Miettien and M. Koivisto (Eds.), *Designing Service with Innovative Methods*, University of Art and Design Helsinki, 2009.
[18] B. Hillier and J. Hanson, *The social logic of space*, Cambridge University Press: Cambridge, 1984.
[19] B. Hillier, *Space is the machine: a configurational theory of architecture*, Cambridge University Press: Cambridge, 1996.

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