THE INTEGRATION OF BEHAVIORS MAPPING AND CONNECTIVITY MEASURES: A NEW METHOD FOR INTERPRETING HEALTHCARE ENVIRONMENTS

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1 ABSTRACT

The current extended lifespan of people makes healthcare a fertile topic in the field of the built environment (Glanz, 2015). Most previous studies regarding the healthcare environment has been conducted using traditional methods such as interviews, focus groups, and on-site observations. However, those traditional methods rarely integrated with network connectivity measures which has been widely used in transportation planning, urban design and indoor circulation simulation. This research aims to develop a new method for interpreting the importance of various spaces in healthcare environment using behavior mapping and network connectivity calculation.

A senior center designed for Chinese immigrants in the United States was selected for this study. Using 42 points selected in this center as observation points, two well-trained observers conducted behavior mapping hourly from 9 am to 1 pm following the same route but starting from different directions. Based on these maps, a value was assigned to each point indicating its importance of the users' daily activities. The connectivity significance of each point weighted with its corresponding value was then calculated based on the Graph theory using customized parametric tools. The results inform the relationships between differently spaces and usage; future research can use these relationships to develop appropriate design principles. The resulting method can potentially inform the future research and design regarding healthcare environments, for example, for retirement communities, hospitals and children daycares.

1.1 Keywords

Behavior Mapping, Connectivity Measure, Healthcare

2 INTRODUCTION

Healthcare is a fertile topic in the field of built environment. Considering the increasing aging population worldwide, eldercare is an urgent area requiring researchers' attention (Rowe, Fulmer, & Fried, 2016). However, healthcare research faces multiple challenges due to the special health conditions of the population. For example, seniors with cognitive issues cannot give clear responses to verbal communication, meaning interviews and focus groups may not be the appropriate methods for aging studies. To address this issue, behavior mapping has been proposed as a method for interpreting the significance for outdoor spaces in healthcare environments. But there is still a lack of data analysis for this method. This paper extends a new method by combining behavior mapping and connectivity measures to analyze the observation data.

2.1 Behavior Mapping

Behavior mapping, an observational method that has been widely used in child studies, is an unobtrusive, direct method for analyzing the participants' activities in the observed locations (Cosco, Moore & Islam, 2010). Two concepts sculptured this approach, behavior settings and affordance. Behavior settings include not only the physical settings but also the people and their behaviors, i.e., how people behave in a functional space. Affordance is how the physical environment supports people's activities in a specific setting. As a well-developed method, behavior mapping includes observation systems such as System for Observing Play and Leisure Activity in Youth (SOPLAY) (McKenzie, Marshall, & Sallis, 2000), Observational System for Recording Physical Activity in Children – Preschool Version (OSRAC-P) (Brown, Pfeiffer, & McIver, 2006), and Environment and Policy Assessment Observation (EPAO) (Bower, Hales, & Tate, 2008). These three systems code children's locations during the observation process using a base map. Although all the systems were developed for child studies, they represent the potential to be adopted to aging studies. Compared to interviews and focus groups, which require direct communication with the target population, behavior mapping, is a more effective method in collecting data from aging groups, especially those with cognitive issues.

2.2 Connectivity Measures

Connectivity measures is based on Space Syntax Theory introduced by Bill Hillier and Julienne Hanson (1989). The primary concept is to graph a space consisting of edges and nodes. The edges represent all the possible routes in the study area connecting the nodes, which are locations of the start and end points of each edges. By integrating the distances of each edge, the least cost route can be identified for a given pair of nodes (origin node and destination node). For each node in the study area, its betweeness, meaning how often a node is traversed when traveling between other origin and destination nodes, can also be calculated (Varoudis, Law, & Karimi, 2013). This concept has been implemented in lots of practices such as bicycle facility allocations, pedestrian network use and user behavior prediction, etc. (Dursun, 2007).

3 METHODS

A senior center designed for Asian immigrants in Atlanta, GA was selected as the case for this study, using behavior mapping as the primary method of data collection. Since the population for this study is elders 65 and older, not children, a new behavior mapping protocol was proposed for this population. The process is based on the following the five steps:

(1) Develop a base map for behavior mapping. The base map requested from the senior center was grouped into five functional zones including sitting spaces, service spaces, indoor activity spaces, outdoor activity spaces, and relaxing spaces. Under each functional zone, multiple points, representing the physical features of interests, were placed on the map to illustrate detailed functions, in total 42 points were assigned on the map (Figure 1). For example, under indoor activity spaces, there were 9 points representing different activities such as billiard, ping-pong, Mahjong, CaraOK, and dancing stage.

(2) Clarify behaviors to be recorded. Considering the purpose this study, exploring the importance of different spaces in the senior center, people's behaviors are classified by the function of the

space. For example, if they were stayed at the billiard area, either playing or watching, their behaviors were defined as billiard related. Detailed behaviors, such as chatting, were not listed as an observed behavior. The buffer zone was 6 feet around the observational points, meaning people who were 6 feet away from the observational points will not be counted.

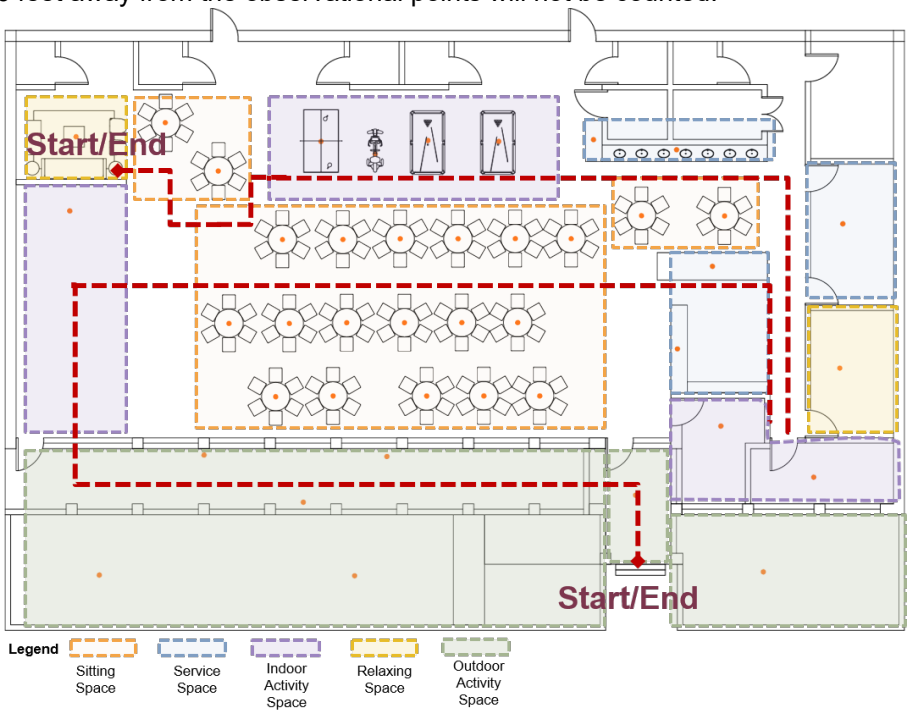

Figure 1. Functional Spaces and Functional Points. Produced by the author.

(3) Design a behavior mapping path. A path was designed going through both indoor and outdoor spaces of the senior center to record the people's behaviors at the 42 observational points during the observational periods.
(4) Schedule behavior mapping periods. The behavior mapping is scheduled hourly from 9 am to 1 pm due to the operation time of the senior center. Each period lasted about 25-30 minutes.
(5) Record behaviors. Two observers walked along the designed path to record the users' behaviors. As the researcher walking along the designed path, the number of people at each observational point was counted and recorded on the base map. The reason of two researchers doing observation at the same time along the same path is to address the reliability issue (Gifford, 2016; Yin, 2014).
During the five-hour observation, 10 maps were collected, five from each observer. The maps were overlaid to calculate the value of each points based on a 1-5 value scale, with 1 representing the least important and 5 the most. Based on the value of each point, we developed a method similar to the Space Syntax theory. Each point is defined as a node, while a route connecting two points is defined as a path. The possible routes connecting each point were calculated when the routes repeated, the more routes overlaid, the more important the path spaces.
The data were analyzed in two phases. The first phase, behavior mapping, statistically analyzed the value of functional spaces and functional points to obtain some basic understanding of the space usage in the senior center. The second phase combined behavior mapping and connectivity map to assess the significance of different functional spaces and circulation in the center

4 RESULTS

4.1 Significance of Different Functional Zones

The average value of each functional zone was calculated using the value of each point as seen in Table 1. Relaxation space and Indoor activity space received higher average values than other spaces. Sitting spaces and service spaces had the same value 3. These two spaces were the supportive spaces for elders, indicating their general roles in the functional zones. Outdoor activity space had the lowest value. One reason was because the senior center limited the elders' access to the outdoor space that elders cannot go out by themselves. They can only go out with care staff. The other reason was because the outdoor environment was poorly designed for activities.

Table 1. Average Value of Functional Zones

	Outdoor Activity Space	Sitting Space	Service Space	Indoor Activity Space	Relaxing Space
Average Value	2	3	3	3.29	3.5
Points (In each functional zone)	7	21	5	7	2

The map below demonstrates the significance of the points under each zone (Figure 2). For indoor activity spaces, billiard area, dancing stage, and mahjong room received the highest value of 5, meaning these indoor activities are mostly preferred by the elders. For outdoor activity spaces, entrance point received the highest value of 5. The center has two entrances, but one is blocked by the terrace. Thus, the main entrance is the only one the people enter and exit the senior center. Although the senior center has a small vegetable garden and a terrace for walking, few elders came outside and use them.

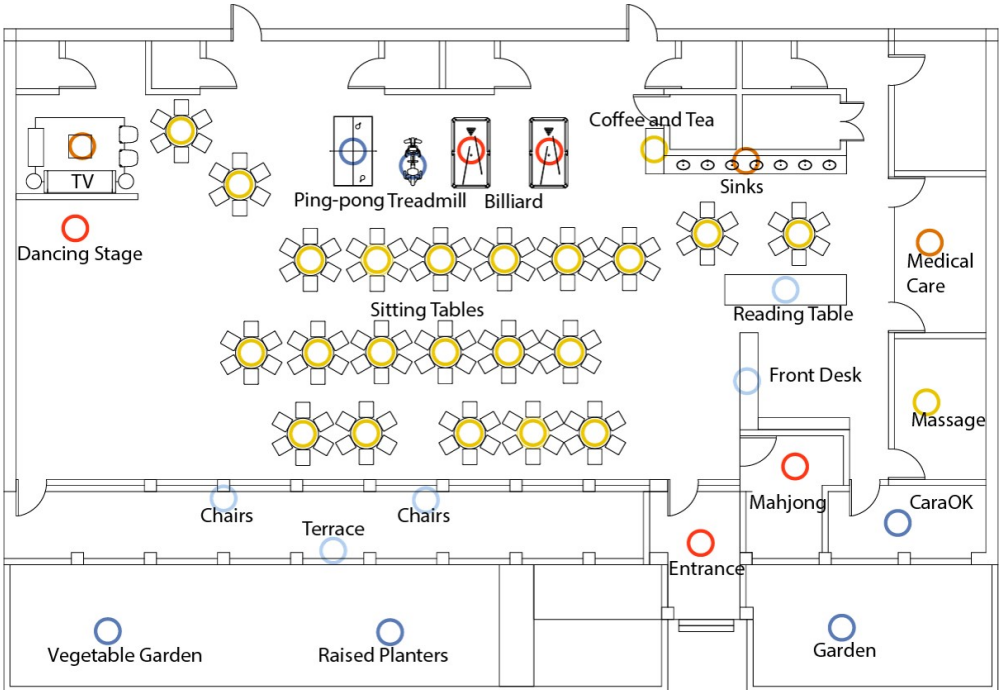

Figure 2. Value of Functional Points. Produced by the author

4.2 Circulation Between Functional Zones

The circulation map seen in Figure 3 was calculated using connectivity measures. By connecting the 42 points, 861 routes were generated. The color illustrates the possible routes between these points, with blue representing fewer routes and red representing more routes. The routes were then used to represent the significance of the paths between different functional zones as illustrated in Figure 3. Entrance is the most important path on the map with highest flow of people since this is the point connecting the indoor and outdoor spaces. The path between the front desk and the reading tables to connect sitting spaces was found to be important. The circulation between tables represented by yellow, indicates that those paths are the most efficient routes connecting tables and other functional points such as billiard area and entrance. At the edge of the building, the color in dark blue, suggests a low connectivity between these spaces. Although TV corner was in high usage (value of 4), people came here only to sit, this lack of movements meaning the calculation results matched the observation results.

Approximately 90% of the significance of the paths are same with the observation results with only the flow around the raised planters, the mahjong room, and the billiard area being different from the observation. Mahjong room and Billiard area represent in highest usage of the indoor activity spaces, but the connectivity to these points is not as convenient as was expected. The map indicates high connectivity between the raised planters; however, they received the lowest value of1, meaning few elders enjoying them. The results of the behavior mapping and connectivity measures were combined to develop the findings.

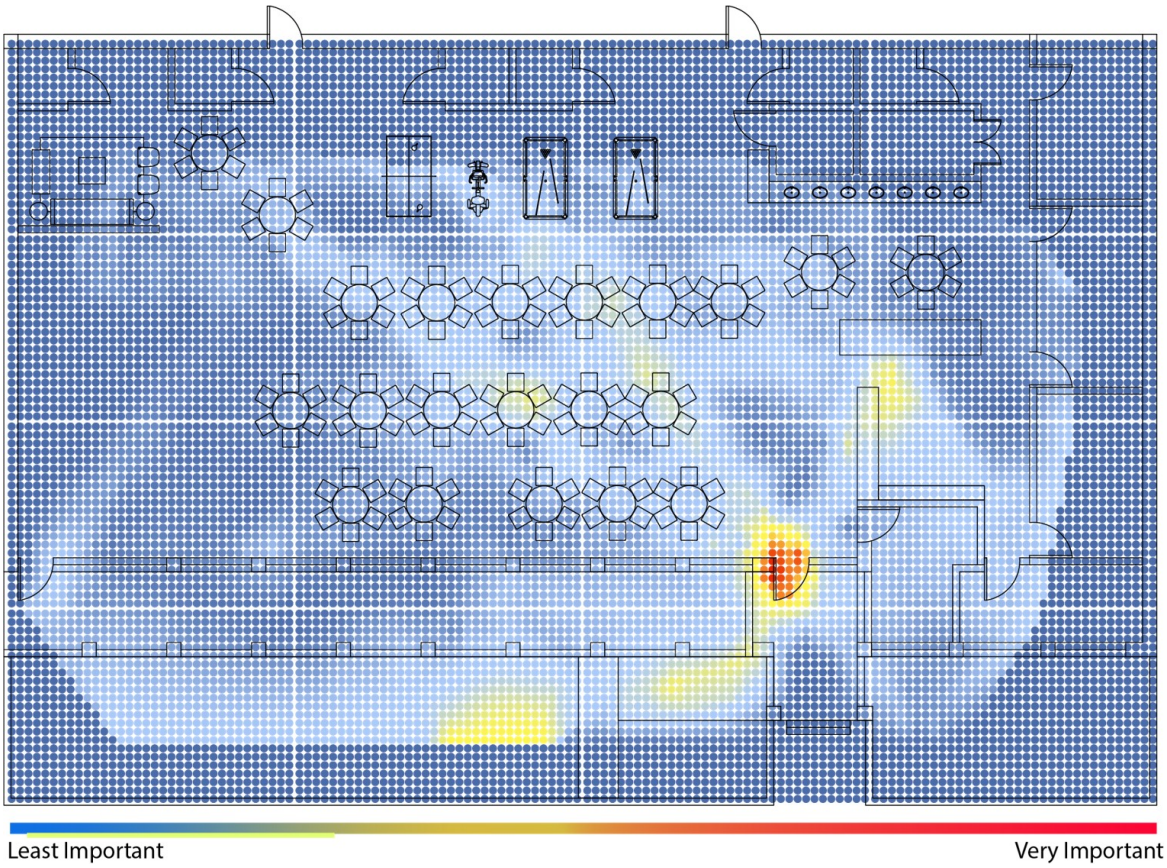

Figure 3. Heat Map of Circulation Significance. Produced by the author.

5 DISCUSSION OF FINDINGS

5.1 Design Suggestions for Circulation

Sitting Spaces and Arrangement

Different from retirement communities, senior centers do not provide accommodations as elders come there for day activities. Instead of a bedroom, they have an assigned seat in one of the sitting spaces (Miner, Logan, & Spitze, 1993). Thus, ensuring that every elder sits on the seat they prefer is a challenge for care givers. The connectivity measures provide a possible solution. For elders who are willing to participate in social activities, their seats can be assigned along the high flow routes (yellow in the map above). Elders who prefer quite spaces can sit along the low flow routes (blue in the map above). In addition, from a design perspective, the designers can add barriers in or between the sitting spaces and the activity spaces to rearrange the routes connecting these two. For example, several planters can stop elders going from their sitting to the billiard area, changing the former from a high flow social space to a low flow quiet space.

Entrance

The Entrance is one of the most important points in a healthcare facility since it sees the highest flow of people. All the possible routes connecting the entrance point to other functional spaces should be designed carefully due to the high flow of people. Different from some spaces for general groups, the entrance and front desk spaces at healthcare facilities should have easy access to elevators, stairs to divide the flow of people.

Outdoor Activity Space

How to encourage users of healthcare facilities enjoy the outdoor environments is a typical issue for designers. Elderly users prefer moderate level activities, such as billiards and dancing in the indoor space since outdoor activities are difficulty for them (Lennartsson, & Silverstein, 2001). Their primary need for outdoor spaces is a long-covered terrace for walking, meaning a space with indirect sunshine. In addition, the space should be easily accessible from their sitting spaces.

5.2 New Method to Interpret Space and Circulation

The purpose of this study was to propose a new method for interpreting the significance of various spaces and circulation. Behavior mapping formed the base of this study for collecting the values of different functional zones in healthcare facilities, which is a senior center in this case. Connectivity measures are the advanced step for optimizing the observation results as a measurable model. For example, in this study, the connectivity map illustrated a high flow between the service spaces and the indoor activity spaces. If future studies demonstrate the same flow, then the routes connecting these two require more design and auxiliary features. This research is only the initial step using this combination method. In the future, when more cases are added to the database, a framework can be developed to guide the future design of spaces and circulations in healthcare environments, especially in elder care facilities. By using this framework, designers can easily obtain a map of the significance of the spaces and circulation for a proposed site, thus effectively enhancing the design process.

6 CONCLUSION

In the near future, healthcare will become an even more important field for designers and researchers in the built environment. There is no doubt that research methods such as interviews and focus groups, which directly communicate with users, are effective for obtaining people's perception of the built environment. However, as the healthcare environment becomes more dependent on Artificial intelligence, new methods and technologies need to be involved in this interpreting process. A framework providing a standard of spaces and circulation significance can guide future design and research in the healthcare environment, both indoor and outdoor spaces. This study represents the beginning of the framework development, introducing the primary methodology that can enrich the database for developing the standard.

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