Development of Tools for Healthcare Environments Research and Practice

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Contents

Measuring the 'PLAN': Possibilities of Space Syntax in Healthcare Environments Research

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CONTEXT

In architecture, the term 'configuration' is widely used to indicate how spaces are arranged and connected to one another. Sometimes we speak about configuration as if we see with x-ray eyes from the sky, and use words such as 'radial', 'double-corridor, 'single corridor', etc. or describe overall shapes such as 'rectangular', 'circular', 'H-shaped', and so on. Yet, as peripatetic users of buildings, we experience spaces in a diachronic manner, moving from one to the other and getting new visual information with every change of position. Thus, the connections between spaces become one foundation for understanding the larger layout, regardless of its aerial/external shape.

Space Syntax deals with layout 'configuration' based on connections (Hillier, Leaman, et al. 1978; Hillier and Hanson, 1984). It has developed a theory and a method to analyze layouts according to that theory. The latter, being more mathematical and technological, led to the development of various computerized software. This allowed use by other researchers interested in quantifying layouts for use as predictor variables. Since the late 1990s, Space Syntax has been increasingly used to study healthcare facilities, making it relevant to healthcare researchers.

VARIABLES OF INTEREST

Space Syntax measures the overall plan of a setting and unit spaces within it. These spaces can be socially described, such as 'patient rooms', 'corridors', etc., or precisely defined, such as 'longest uninterrupted visibility lines', or a small area of convenient dimensions, i.e., a small tile on the floor. Variables produced for each unit are called 'Integration', 'Connectivity', etc. Variables applicable to the overall layout are 'Intelligibility', 'mean integration', etc.

TOOL DEVELOPMENT AND USE

An example is a good way to introduce Space Syntax. Assume that each corridor in the plan shown in Figure 1b is an individual space identified by numbers 1 through 24. The entrance is at X, leading to corridor # 1. This corridor (i.e., # 1) connects directly to corridor numbers 24, 4, 3, and 2. Each of these corridors is, in turn, connected to other corridors. For example, corridor #4 is connected to corridor numbers 10, 1, and 5; corridor #10 is connected to numbers 4, 16, 11, and 14; and so on. This relationship of connections is graphically illustrated as a system of nodes and links in Figures 2 a, b, and c for corridor numbers 1, 4, and 10 respectively. The number of direct connections to other spaces is called 'connectivity'. Thus the connectivity values of corridor numbers 1, 4, and 10 are 4, 3, and 4, respectively. After considering immediate connections, we see that each corridor is progressively connected to far-away corridors through a set of secondary, tertiary, and sequentially deeper corridors. For example, corridor #1 is connected to corridor #10 through corridor #4. Corridor #10 is directly connected to corridor numbers 4, 16, 11, and 14; has secondary connections to corridor numbers 1, 5, 15, 12, and 13; tertiary connections to corridor numbers 24, 2, 3, 8, 6, 17, and 21, and so on, until all the other 23 corridors are connected. All the connections encountered from corridor #1 and #10 are indicated in Figures 3a and 3b as a graph. This also shows that each corridor has a different relationship to all other corridors in the spatial system. If we consider any corridor, it will be directly connected to certain corridors, and at varying depths to all others.

Figure 3a shows that corridor #1 needs seven steps to connect to all 23 other corridors, while corridor #10 only needs five depths (Figure 3b). Corridor # 1 therefore has a 'deep' relationship to all corridors, while corridor #10 has a comparatively 'shallow' relationship. If we flip the relationship, it means that it will be easier to come to #10 from all other corridors, on an average, when compared to #1. In a similar manner, considering the relationship of all corridors to all other corridors in the system, we can discover which one has the shallowest relationship. This is expressed by a numerical concept, 'integration'. Syntax has a mathematical equation to determine this value. It considers both the number of corridors one is connected to, as well as the step-depth of all those connections (Hiller and Hanson, 1984). A corridor with high integration is, on an average, closely connected to all other corridors in a given layout. Conversely, a corridor that is distant from all other corridors, on average, is called 'segregated'. Space Syntax software produces a table with values of each unit space, and a color-coded diagram matching the plan drawing indicating the distribution of those values (see Figure 4.)

The preceding description is (very) simplified. The unit spaces considered are corridors. Actually, Syntax is very particular about identifying unit spaces, and most predominant space in the literature is 'axial lines' (Hillier and Hanson, 1984). These are the set of the longest and fewest lines that can cover all convex spaces in any layout. An axial line analysis of a hypothetical MSU is shown in Figure 5. The top 10 percent of integrated lines, called the 'integration core', is indicated by the thicker lines. The distribution of the 'integration core' in the plan is of special interest to designers.

A finer unit is a 'tile'. Hypothetically, a set of square 'tiles' of a convenient dimension can be laid on any plan. Walls and furniture, wherever they occur, break up the relationship of tiles to one another. This system can then be examined to uncover each tile's relationship to adjacent tiles, and sequentially to distant tiles, in the same manner as the corridors were examined earlier. Thus we can calculate the same values of each tile (see Figure 6). Theoretically, when the tiles are laid at eye level and only walls break up the inter-tile relationships, then its analysis will represent the 'visibility' structure of a layout. When placed at knee level, i.e., when furniture is considered, the analysis will display the 'accessibility' structure.

We mentioned earlier that Space Syntax also measures entire layouts or plan drawings. The first measure is 'Intelligibility', which is the correlation (r-value) between the 'connectivity' and 'integration' values of all spaces in the layout. If this value is high, then presumably a good sense of global connections will be perceivable from unit spaces. Additionally, average values of units, such as 'mean integration', 'average mean depth' etc., are also used.

FINDINGS AND CONCLUSIONS

Space Syntax has been used to study health-care buildings since the 1990s, and its use has increased dramatically in the last decade (see Table 1). Highlights of some research are given below:

- A series of studies inside four hospital buildings in the U.S., three in China, two in Taiwan, and in one virtual reality setting have demonstrated the following: (1) exploring visitors and those who are lost tend to use more integrated corridors, (2) the Syntax values of an entry space have a role in wayfinding success, and (3) more connected corridors feature more prominently in human cognitive maps. (Peponis, Zimring, et al., 1990; Haq, 2003; Haq and Girotto, 2003; Haq and Zimring, 2003; Pramanik, Haq, et al., 2006; Haq, Hill, et al., 2009; Lu and Bozovic-Stamenovic, 2009; Tzeng and Huang, 2009).

- Another set of studies indicate that nurses who have assignments in rooms corresponding to higher Syntax integration values will enter them more frequently and spend more time there, thus potentially increasing care quality (Choudhary, Bafna, et al., 2009; Hendrich, Chow, et al., 2009; Heo, Choudhary, et al., 2009).
- Nurses constantly move from one point to another. However, they tend to locate themselves for work and interaction in areas that provide higher visibility to patient rooms. Visibility in this case was measured using Space Syntax techniques (Lu, Peponis, et al., 2009; Lu, 2010; Lu and Zimring, 2010).
- Another study suggests that patients prefer ward beds in lower integrated areas for privacy, but feel safer when they are in more integrated locations, presumably because this makes them more visible to nurses (Alalouch and Aspinall, 2007; Alalouch, Aspinall, et al., 2009).
- Finally, in old people's homes in England, more mean integration of environments was associated with a larger proportion of residents being active and being more engaged (Hanson and Zako, 2005).

Table 1: Research in healthcare that has used Space Syntax variables. Articles by publication year.

	Before 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Journal Articles	2			2				1		5	5
Conference Proceedings	1					4				2	2
Total	3			2		4				7	7

Figure 1: 'City Hospital' (a) Ground Floor Plan, (b) Public corridor system showing connections between corridors

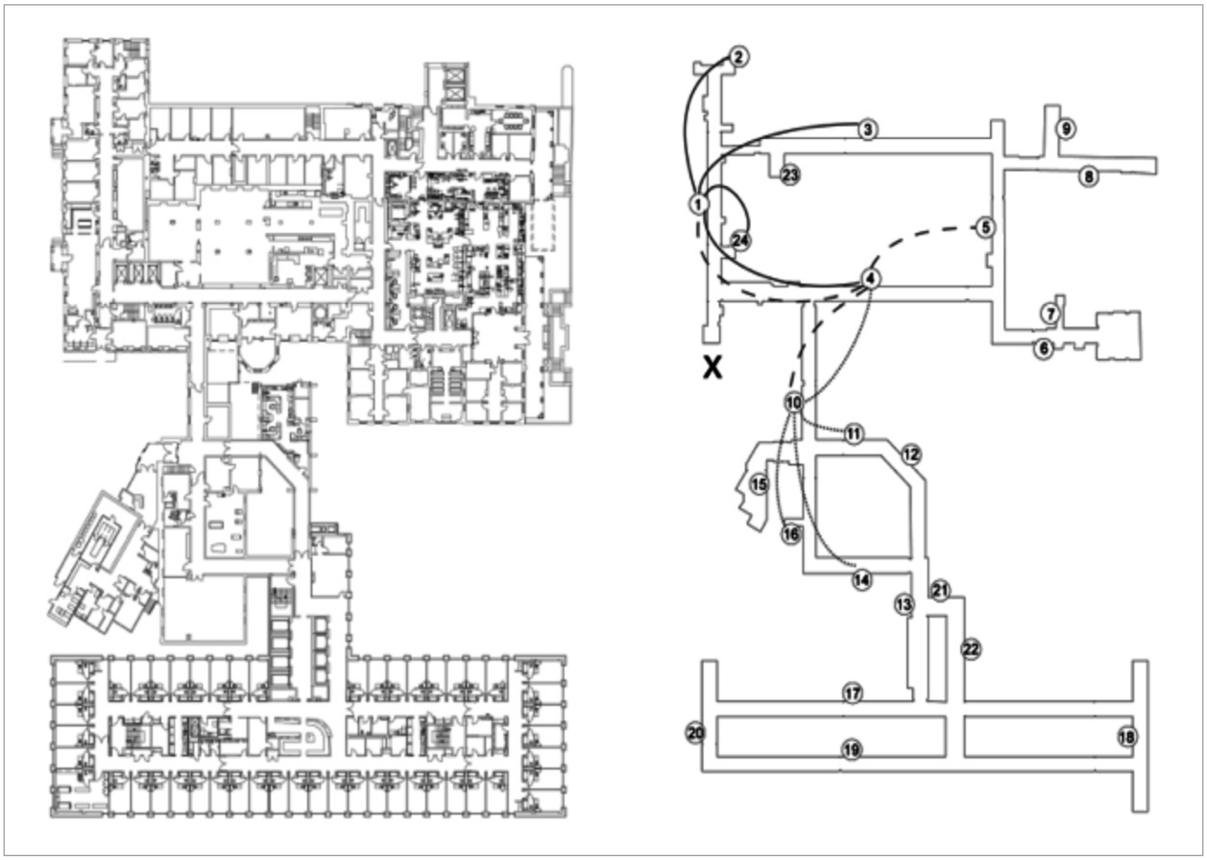


Figure 2: Relationships to ADJACENT corridors from (a) corridor #1, (b) corridor #4, and (c) corridor #10

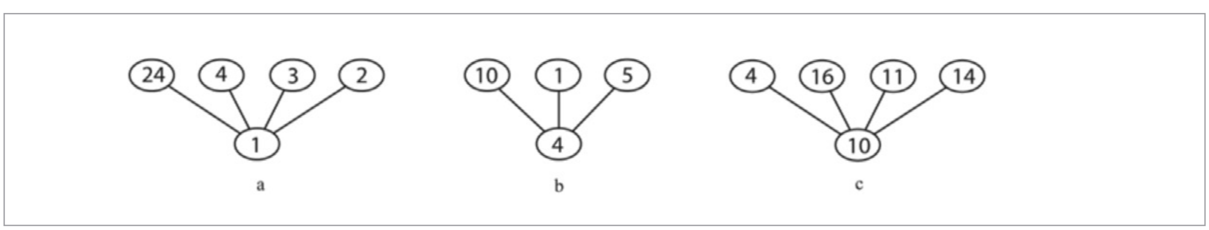


Figure 3: Relationships to ALL other corridors from (a) corridor #1, and (b) corridor #10. These are also called justified graphs.

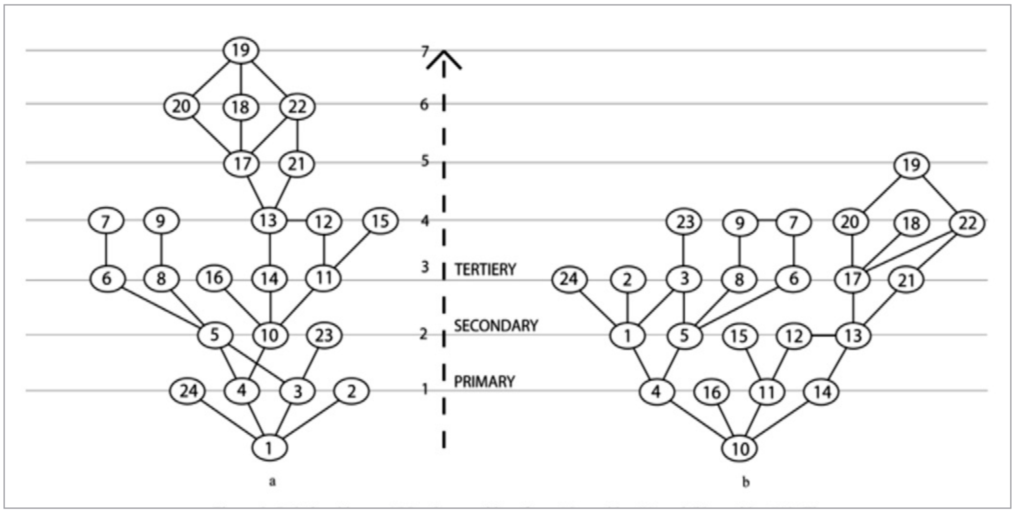


Figure 4: Space Syntax (axial) analysis showing integration-n of the public corridors of 'City Hospital'. Warmer colors are more integrated.

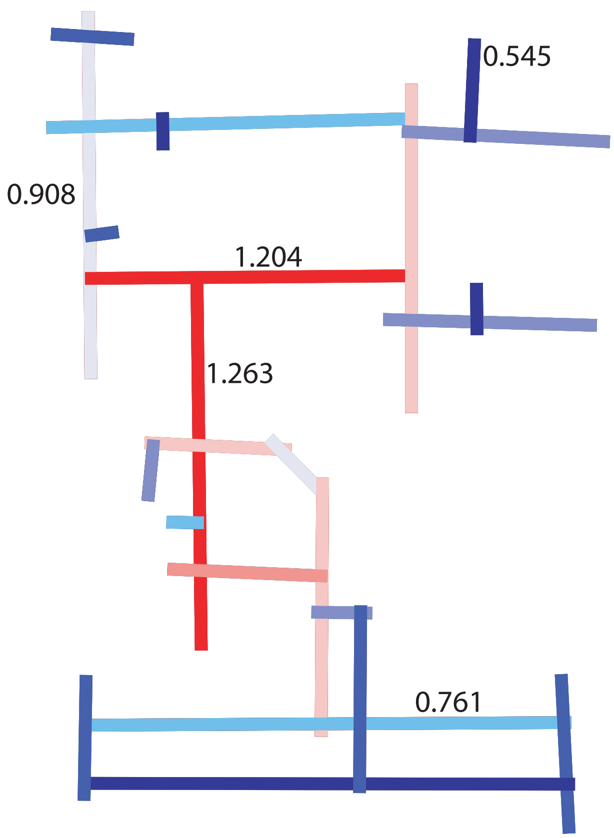
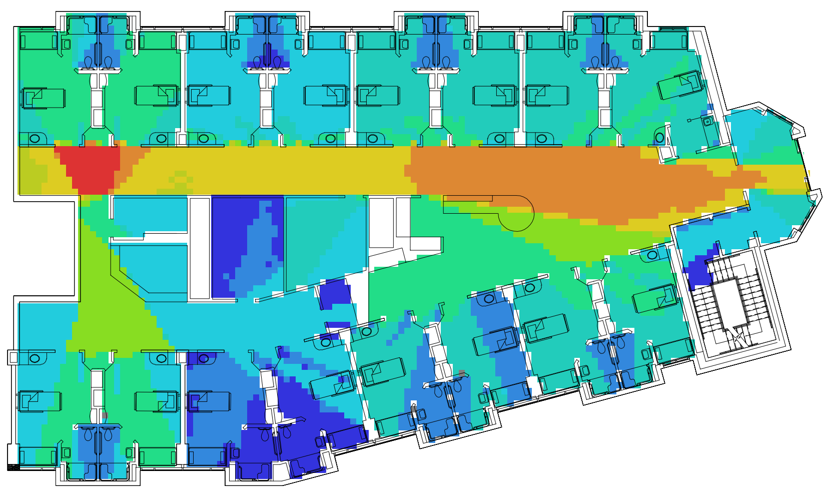


Figure 5: Integration-n analysis in a hypothetical MSU. Higher integration values are shown by darker lines, and thicker lines indicate the 'integration core'

Figure 6: Integration analysis of convex spaces of hypothetical MSU. Higher integration values are shown by warmer colors.



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