Spatial Structure as an Architectural Performance Metric

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SPACE SYNTAX

Designers intuitively understand space as a distinguishing characteristic of architecture and urbanism. Space itself, however, resists description. In our everyday conception of it, space is boundless and mostly formless, and so it does not readily lend itself to analytical approaches. When designing or assessing design proposals, intuition and precedent are often used to forecast or predict the effects of space on how a design will be.

Spatial design can be approached as both an art and a science with a quantitative dimension. This paper provides a short overview of how quantitative measures of visual and spatial structure, taken using space syntax methods, are correlated with well-recognized health metrics in Intensive Care Unit settings. Three hospital case studies are used to demonstrate links between space syntax metrics and health performance metrics, drawing on both emerging and published, peer-reviewed research.

A short and necessarily partial introduction to space syntax measures is in order. Architecture suffers no shortage of normative theories, or theories of how things ought to be. Whether it is Rem Koolhaas promoting a culture of congestion or Andrés Duany calling for walkable, mixed-use design (to name two somewhat recent examples), normative theories of design underlie many of the analytical frameworks we bring to bear on forecasting how designed environments are likely work. The problem with normative approaches is obvious; there is plenty of opportunity for gaps between the way things should work and the way things do work. When Bill Hillier, John Peponis, and other collaborators developed space syntax starting in the 1970s, the ambition was to create an analytical theory grounded in description that could be used to predict what designs would be like once built. Such an analytical theory needed measures of space, a slippery entity, that were unambiguous, corresponded to how societies tended to organize themselves, and could be combined in mathematical formulations.

One important measures currently used in space syntax is the isovist (Benedict, 1979). An isovist reflects the view available from a point as delimited by all of the walls and other occluding surfaces that shape the view. (See figure 1.) Isovists reveal aspects of space by discretizing the boundless flow of space and representing it as “chunks”. However, a central development of space syntax is the development of variables, such as integration, that use mathematical equations that calculate with these chunks to assess interscalar relationships of various parts relative to a built whole. Integration, a key space syntax variable, reflects whether a space is central or peripheral, not geometrically, but in terms of spatial accessibility. Highly integrated areas,

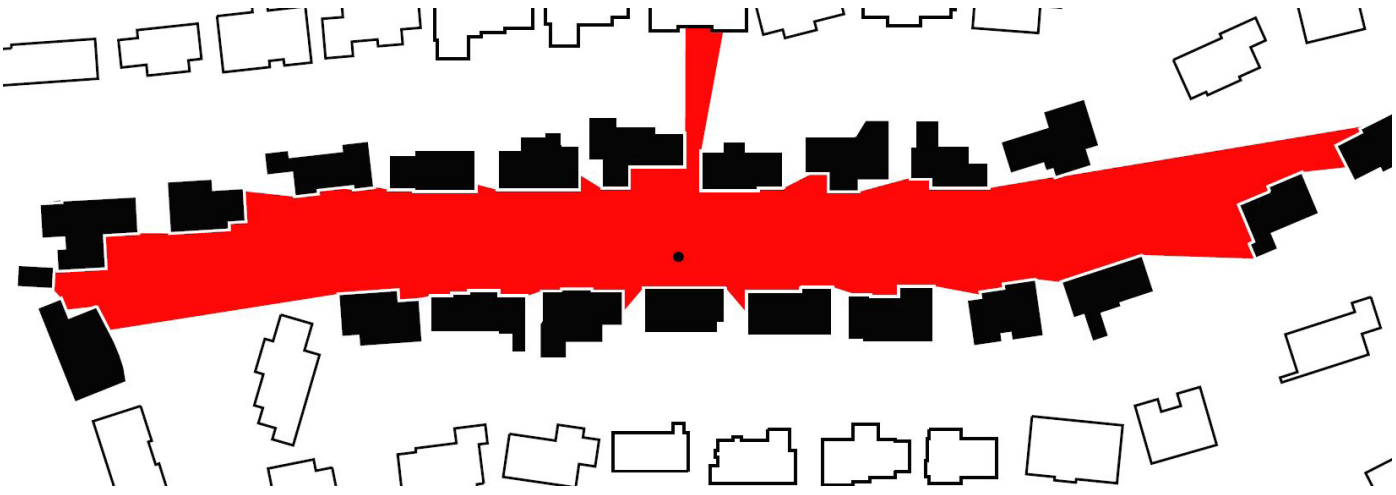

Figure 1: An isovist representing the space visible from the black point

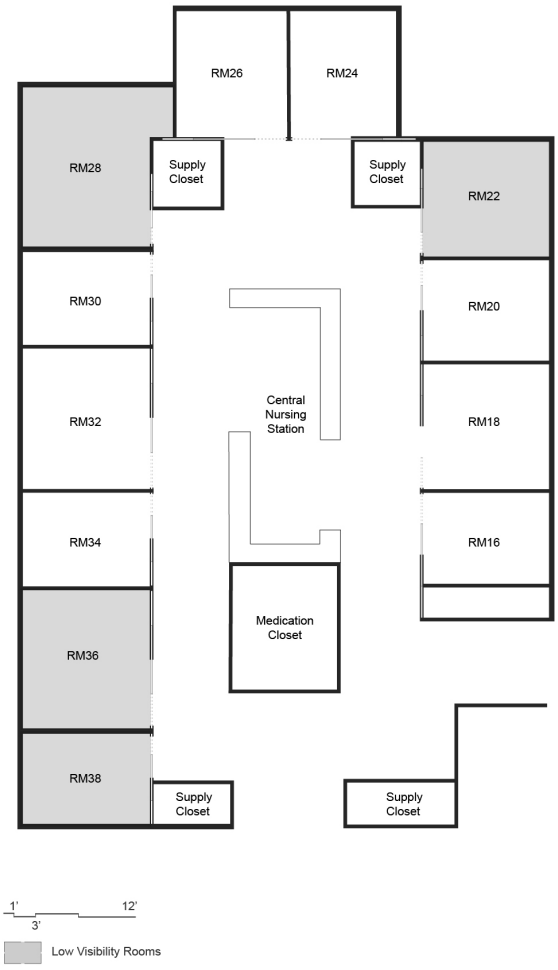

Figure 2: An ICU plan redrawn from Leaf and colleagues, 2010, by Spencer Reddick. Low visibility rooms are shown in gray and have no visual connection from the patient to the Central Nursing Station. Image

which can be conceived of as those areas that act as the spatial centers of gravity in a building or city, have been associated in empirical research with higher concentrations of interactions (e.g., Grajewski, 1993) and appear to play a crucial role in the formation of cognitive maps (e.g., Peponis, Zimring, & Choi, 1990).

VISIBILITY AND PATIENT SAFETY IN INTENSIVE CARE UNITS

Space syntax analysis using isovists usually takes place in a computational environment. UCL Depthmap (turner, 2001) is a commonly used program. Isovist-based analysis proceeds by overlaying a grid (e.g., a 1 square foot grid) on a plan drawing, drawing isovists from the center of each time, and calculating isovist-based measures, such as size or integration, for each isovist. (Again, all of this is done by the computer.) In the last decade, this visibility-based approach to spatial analysis has proven particularly fruitful in the study of ICU environments.

The issue of visibility in Intensive Care Units (ICUs) is a good example of some fruitful applications of space syntax in recent years that have helped refine our understanding about the role of visibility and patient safety in ICUs. That patient visibility is critical to safety in ICUs is reflected various design guidelines. Monitoring and timely response to the dynamic conditions of the sickest patients relies on visual connections to them.

Space syntax concepts and measures have assisted in refining our understanding about the nature of visual connections to ICU patients. Several years ago, physician David Leaf and colleagues, conducted a retrospective study of patient data in which they found that acuity-matched patients in low visibility ICU rooms had a greater risk of dying than those in high-visibility rooms (Leaf, Homel, & Factor, 2010). For the purposes of the study, they defined visibility in a simple way; low visibility rooms were “those in which a direct line of sight between an observer and any part of the patient could not be established from anywhere within the central nursing station” (1023). (See Figure 2.) This suggests, as do the most ICU design guidelines, the primacy of the central nursing station as the locus of visibility and patient safety.

However, several studies suggest that patient-safety-through-visibility is somewhat more complex than clear lines of sight from the nursing station to the patient. In her dissertation, YoungSeon Choi found statistically significant relationships between visibility and patient falls in ICUs (Choi, 2012). However, she noted that, first, visibility to the head of the patient, and not just the body, mattered. Second, she found that there were two markedly distinct types of visibility to the patient head that were associated with reduced falls. Specifically, both visibility from the nursing station and visibility from the corridor had protective effects. Choi’s recognition of a distinct mode of ICU visibility, apart from lines of visibility from the central nurse station to the patient bed, is an important step toward recognizing the importance of the people in the space and not just the space itself. From the point of view of how people behave in space, focusing exclusively on visibility from the nurse station would seem to assume that clinicians situate themselves in a static position from which they keep the patient in view. The second mode of visibility, however, is akin to the kind that occurs in city streets; it arises from the animation of a space by multiple users, none of whom are firmly fixed to a particular location.

A study by Yi Lu and colleagues provides further insight about the dynamic nature of visibility in ICUs. Using a measure called the Targeted Visibility Index, the authors found that ICU nurses, more than doctors, tended to seek positions from which they were best able to view patient beds while going about other activities, such as interactions (Lu, Peponis, & Zimring, 2009). Such positions were not necessarily at the central nursing station.

A recent dissertation by Michelle Ossmann developed a theory and measure aimed at formalizing the more dynamic form of ICU visibility and testing whether it correlates with patient safety. Ossmann theorized that, in the interest of patient safety, nurses and other care providers aim to balance visual access to the patient head with staying visually connected to the rest of the ICU floor. She developed

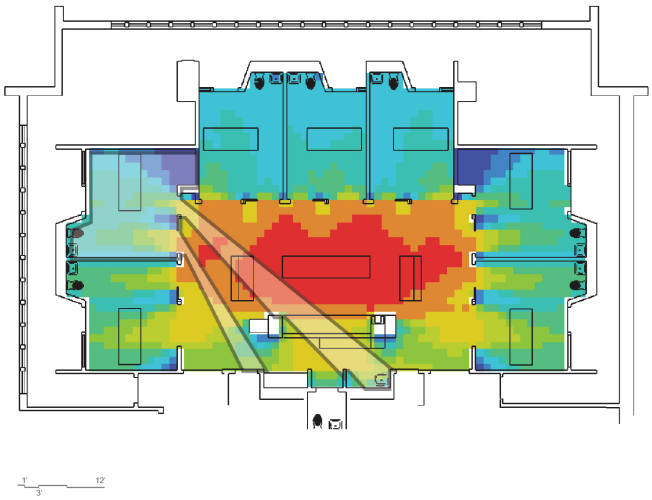

Figure 3: Isovist Connectivity is based on calculating the average size of the view from each point contained within the isovist taken from the head of the patient bed. Drawing adapted from Ossmann, 2016.

a measure called Isovist Connectivity that assesses how the view from the head of the patient bed visually "reaches" into the rest of the unit. (See Figure 3.) Ossmann found higher Isovist Connectivity scores on a per-bed basis were correlated with much lower odds of death for a large sample of acuity-matched patients. Isovist Connectivity is a conceptually exciting visibility measure because it incorporates a rich mix of spatial and social characteristics of health-care settings that are relevant to patient safety. Clinicians don't sit at the central nursing station all day; they exchange support with one another, they visually surveil both the patients and the unit at large, and they move about in a probabilistically predictable way. Future publications will outline Ossmann's work in detail, including the magnitude of the large increase in patient safely associated with high Isovist Connectivity values.

The descriptive tools of space syntax have demonstrated usefulness in uncovering and clarifying the subtle but powerful effects of spatial design. Moreover, they can be used to forecast design performance. Specifically, the measures identified by Choi and Ossmann, among others, can be conducted on floorplans while projects are still on the boards, preventing mistakes, both the financial sort and the kind that impact the quality of life as it unfolds in designed space.

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Note: Both the Morphology Lab at the Georgia Institute of Technology and the Spatial Morphology for Health group at Texas Tech University offer consulting services in space syntax analysis. The author directs Spatial Morphology for Health at Texas Tech.