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RESEARCH ARTICLE

The Authors

# Measuring the spatial and social characteristics of the architectural plans of aged care facilities

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## Abstract

This paper presents a method that combines visibility graph and isovist analyses to investigate the spatial and social properties of architectural plans for aged care facilities. The potential of the combined method is examined by measuring the properties of three sets of plans for residential aged care facilities. The first set is a pair of hypothetical, idealized plans, which allegedly reflect the “best practice” in the industry. The second set comprises a pair of plans for recent Australian designs, and the third set is a pair of plans for South Korean facilities. Results of the computational analysis of these six plans suggest that social and cultural factors may shape the design of aged care settings and partially explain their international differences. The application of this methodological approach contributes to the understanding of the relationship between spaces and their cultural and social properties in the design of aged care facilities.

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## 1. Introduction

Winston Churchill's aphorism, “we shape our buildings and thereafter they shape us,” has become famous in spatial psychology, architecture, and planning. Multiple theories have attempted to explain the reciprocal relationship

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between spatial properties and human intuitive responses. For example, Appleton's habitat and prospect-refuge theories (Appleton, 1975) are among the best-known explanations for environmental preference in architecture. Gibson's ground theory (Gibson, 1950, 1979) and Kaplan and Kaplan's information theory (Kaplan and Kaplan, 1989) are also used to explain human responses to space. Such theories use psychological and philosophical constructs to analyze environments and their social and behavioral properties; thus, their results are not always reproducible (Stamps, 2005a). Quantitative theories and methods have also been developed for understanding and modeling the relationship between space and social patterns. Among the most famous of these methods, in architecture at least, is Space Syntax, which uses the mathematics of graph theory to measure various properties of plans. Isovist analysis is a related technique that has been traced to the work of Tandy (Tandy, 1967). An isovist is "the set of all points visible from a given vantage point in space" (Benedikt, 1979). The mathematical properties of isovists have potential correlations with human spatial perceptions and responses, and they have been used to test or apply enclosure and permeability theories (Stamps, 2005a, 2005b; Turner et al., 2001). Space Syntax approaches of this type have been developed for predicting patterns of pedestrian movement, improving surveillance, reducing crime through observation, and understanding access and control issues well (Hillier, 1999; Hillier and Hanson, 1984). These common computational approaches to visibility analysis in architectural plans are combined in visibility graph analysis (VGA).

Although these theories are useful in analyzing various aspects of architectural planning, their application tends to assume that human responses are relatively universal (or at least that mathematical patterns can be derived from them, which reflect universal tendencies). Although statistical evidence supports the general use of several computational methods for modeling and understanding the socio-spatial and spatio-visual properties of plans, relatively few examples show attempts to accommodate the needs of particular demographic groups, such as the aged. This lacuna is significant because recent research suggests that the spatio-visual properties of physical environments have an impact on various health-related outcomes (Hadi and Zimring, 2016; Hendrich et al., 2009; Pachilova and Sailer, 2013; Seo et al., 2011). Thus, researchers have used Space Syntax methods to support the analysis of health facilities, including nurses' behaviors (walking patterns, entries to patient rooms, and spatial positioning), patients' preferences and satisfaction levels (preference for bed privacy, perceived quality of care), and visitor movement in hospitals (Haq and Luo, 2012). For example, Seo et al. (2011) identified that the spatial characteristics of routes taken by nurses from intensive care units to patient rooms and medication areas can contribute to behavioral patterns. Setola et al. (2013) investigated the role of spatial layout in hospitals and analyzed the integration of public and staff spaces. They revealed the patterns of relationships between patients and the medical staff (P-M) through the density of interactions and accessibility maps. By combining VGA and axial map analysis, they began to develop an understanding of the cultural differences in nursing unit designs (Cai and Zimring, 2013). Indeed, the investigation of hospital planning and the correlation of computational

measures for spatial visibility and accessibility with behavioral responses has become relatively common in recent years (Carranza et al., 2013; Lu, 2010; Lu et al., 2009; Morgareidge et al., 2014).

Although such studies demonstrate the usefulness of computational analysis in health care design, they also focus largely on functional planning and optimization. By contrast, the challenges of designing for residential aged care environments are not just functional but social and cognitive. For example, past research identified that some of the most challenging factors in the design of retirement villages and aged care centers include isolation, loneliness, and confusion (Gardner, 1994). Thus, the problems of designing for aged care are not only about surveillance and safety. The way a space is designed directly impacts the way people socialize, stay visually connected, avoid becoming lost, and become available for visits by relatives and watching by nurses for care and safety. Aged care facilities should be designed to accommodate social and cognitive needs in parallel with functional requirements.

In response to this situation, this paper presents a computational and mathematical method for capturing selected spatial and social properties of aged care facilities. This study revisits VGA and isovist analysis to investigate the properties of residential aged care facilities. Setola et al. (2013) demonstrated the usefulness of VGA in understanding the cultural differences in health care environments, and several related syntactical measures, including target visibility analysis, spatial positioning tool, weighted isovist area, multilayered network, Place Syntax, and team-base and peer distances, have been found effective in health care environments (Sadek and Shepley, 2016). In the present study, VGA is used to develop holistic measures for examining six plans for residential aged care facilities, and then individual isovist measures are used to analyze differences among typical spaces for the residents, visitors, and nurses in each facility.

To examine this combined method and its uses, the present study analyzes six plans for residential aged care facilities. The study commences with an overview of the method and its application in the analysis of the plans. Subsequently, two stages of a case study are presented, highlighting visibility graphs and isovist properties. The quantitative analysis of the six case study plans supports the qualitative discussion regarding the relationship between spaces and the cultural and social properties of each plan. This paper concludes with a discussion on the application of VGA and the need for future research.

## 2. Method and application

### 2.1. Visibility graph analysis (VGA)

Since the 1970s, techniques have been developed for analyzing the 2D spatial properties of architectural plans and the spatio-visual properties of locations within these plans. In such techniques, the properties of an architectural plan are typically abstracted into a set of nodes and edges in a graph, which can then be mathematically analyzed. This method can be used to reveal the relationship between spaces and the social properties that necessitate or sustain these relations (Hillier and Hanson, 1984). Convex and axial

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