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RESEARCH ARTICLE

Planting design for urban parks: Space syntax as a landscape design assessment tool

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Abstract
Trees are a major factor in defining the spatial qualities of outdoor spaces. This study investigates the influence of spatial configuration produced by the proposed tree planting design on the visual fields of an urban park using space syntax theory. Space syntax theory assumes that an urban area can be represented as a matrix of connected spaces. The quantitative properties of this matrix in the form of syntactic measures can be measured using computer simulations. This research investigates how space syntax techniques can help assess the effect of tree configurations on the social structure of a small-scale garden in an urban park. Such techniques are assumed useful in predicting the social structure of the proposed space and in assessing design alternatives. An experimental study using three different planting design proposals for an urban park is conducted. Data are analyzed using space syntax techniques. Results reveal a significant effect of planting configurations on syntactic measures across the three proposals. This study suggests that space syntax techniques may have a significant value in the assessment of schematic planting design, especially at the pedestrian movement level.

1. Introduction

The current literature has investigated the influence of landscape vegetation on the frequency and range of movement (Shriver, 1997; Foltête and Piombini, 2007; Chamberlain and Meitner, 2013) and on the choices of routes in specific places such as public gardens (Loiteron and Bishop, 2005). However, these studies are focused on pedestrian behavior in small and closed spaces (Zacharias, 1997; Moskell and Allred, 2013) and in unknown areas (Zacharias, 2006). Generalizing these observations in large, familiar environments is necessary to distinguish the processes of space perception that affect movement. Research

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on movements in an intraurban environment must integrate a large amount of qualitative data to generate useful inputs for urban planning (Røe, 2000; Stahle and Marcus, 2010), such as landscapes. Such approach will help in understanding how individuals choose their routine trips in an environment and how social structure is affected by pedestrian trips.

Visual representation and simulation techniques are traditionally used to help designers in the design process. These techniques help in visualizing design concepts and in exploring how proposed layouts might work in reality. This study investigates the use of identifying the visual properties of spatial configurations initiated by planting designs in a landscape setting.

1.1. Aim of the study

This study investigates the effect of the planting design of urban parks based on the assumptions of a space syntax model, especially at the pedestrian movement level. This method may have an extensive value in the evaluation process at the schematic planting design stage. The main question motivating this study is whether a planting design method can be developed by integrating space syntax techniques. In this context, the space syntax technique of the visibility graph analysis (VGA) is adopted. This technique offers the possibility of estimating theoretical accessibility or "natural movement" by measuring integration. VGA measures can be used to study the effect of the spatial configuration of the proposed tree planting design for landscape spaces on visual fields and expected pedestrian movement. This technique is supposed to help in predicting the visibility and accessibility of planting design schemes of an urban park.

2. Background

2.1. Planting design

Robinson (2004) showed that plant size relative to the dimensions of the human figure is critical when designing spaces for people. An important design stage is distinguishing areas on a plan using canopy height because plant height establishes much of the spatial framework and controls vision, movement, and physical experience (Robinson, 2004, p. 28). Preben Jakobsen (1977), a Danish landscape architect, identified the most useful size categories for designers as ground level, up to knee height, knee to waist height, and below or above eye level. Dividing trees according to size (small: mature height, 5–10 m; medium: 10–20 m; tall: 20 m) is helpful for design purposes. The present research focuses on small mature and medium trees, which create a visual and physical barrier. Medium trees can create spaces that contain small structures and therefore have a significant influence on the spatial structure of urban landscape (Austin, 1982; Conway and Bourne, 2013).

Trees are capable of defining space and increasing the degree of enclosure (Booth, 1983; Bell, 2004). The spatial arrangement of trees affects the visual field of a space. Salingaros (1999) reported that the use of urban space is linked to the information field generated by surrounding surfaces and to how easily the information can be received by pedestrians. Successful urban spaces also offer tactile information from local structures meant for standing and sitting. The total information field in turn determines the optimal positioning of pedestrian paths and nodes.

Tree placement is a key element in urban landscape architectural design. Trees are one of the tools for defining outdoor open space. They provide shape and configuration to spatial environments. Many aspects must be considered when proposing sites for tree planting in urban areas (Wua et al., 2008). The important site conditions related to tree selection include climate factors, soil characteristics, environmental conditions, planting space, site location, existing vegetation, esthetics, land ownership and regulations, social influences, and maintenance requirements (Bassuk and Trowbridge, 2004).

Gilman (1997) recommended various minimum widths of planting sites for trees with different full-grown sizes: 3–4 ft (0.90–1.20 m) for small trees, 4–6 ft (1.20–1.80 m) for medium trees, and over 6 ft (1.80 m) for large trees, with 1 ft (30 cm). These recommendations were later supported by Kirkpatrick et al. (2011). Arnold (1980) encouraged the collective use of trees in groves, rows, and symmetrical units in urban design and explained the esthetic principles used in grouping trees in a variety of settings. Wu et al. (2008) developed a computer program to iteratively search, test, and locate potential sites for tree planting by virtually planting large, medium, and small trees on plantable areas, with large trees given priority because of the great benefits accrued from them.

2.2. Simulation of visual fields in environmental design

In environmental design studies, visibility techniques have been incorporated with advances in agent-based simulation and virtual reality (VR) technology. For example, Penn et al. (1997) used "agents" that navigate through VR environments to retrieve isovists, which represent the measures of visible space throughout configurations and the associated visual fields through the space that they produce (Benedikt, 1979a, 1979b). On the contrary, Batty and Jiang (1999) developed a parallel "agent system" to construct isovists. Extending the work on isovists, Conroy (2001) investigated the formal visual properties of paths that people take within controlled experiments in VR environments. Fisher-Gewirtzman and Wagner (2002) suggested that visibility analysis should cover and quantify the third dimension as Benedikt (1979a, 1979b) managed to achieve for two dimensions. They proposed a three-dimensional analysis of the "spatial openness" (or isovist volume) of views from flats. However, they restricted themselves to a two-dimensional isovist area because of inadequate computing processing capacity. Teller (2003) suggested an innovative solution to overcome the problem of computational complexity in a three-dimensional analysis. He investigated the angular area of the sky observable throughout the urban environment to analyze "sky opening" from locations. This method offers a scale-invariant measure of the environment, which Teller recommended as a practical way to