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...
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
avoid the scale dependency of many measures of isovists, such as area or visual integration. He suggested that apart from offering examples of typical values, the method is also useful for classifying town squares and investigating the effect of new buildings on the perception of the environment. A related approach was established by Ratti (2002), who mapped the distribution of perceived sky area from various positions that give a weighted directional measure of visual openness.

Turner (2003a, 2003b) argued that although these innovative techniques add a three-dimensional quality, they cannot be broken down into the recent uses of visibility analysis, which can be divided into two categories: (1) classification and (2) assessment of the perceptual qualities of the environment. The present study extends the argument that the visibility analysis of the proposed planting designs could detect the specific effects of spatial properties caused by various planting arrangements in landscape design.

### 2.3. Space syntax theory

Space syntax is a research program that studies the correlation between human societies and space from the perspective of the general theory of the structure of populated space in all its different forms: buildings, settlements, cities, and landscapes (Hillier, 1996; Hillier and Hanson, 1998; Bafna, 2003; Koohsari et al., 2013). Space syntax is also defined as a graph-based theory used by architects and urban designers to examine how the spatial layout of buildings and cities influences the economic, social, and environmental outcomes of human movement and social interaction (Dawson, 2002). Its techniques offer precise quantitative descriptions of the way in which the built spaces of a setting are organized (Hillier et al., 1983). According to Hillier and Hanson (1984), the social meaning of the environment arises from spatial composition, and the topological structure of an environment is a primary element by which a society creates and establishes roles to develop some types of social relationships. Therefore, constructed environmental spatial patterns incorporate and give shape to social patterns.

Space syntax is built on two recognized ideas that attempt to reflect both the objectivity of space and our intuitive engagement (Hillier and Vaughan, 2007). The first idea is that we should think of space not as the background to human activity, as we think of it as the background to objects, but as an essential aspect of everything human beings do in the sense of moving through space. Movement is essentially linear, and interface requires a “convex” space in which all points can see all others and a variably shaped, often sharp, visual field referred to as an “isovist” can be seen from any point in space (Benedikt, 1979a, 1979b). The second idea, called “configuration of space,” indicates that human space is not only about the characteristics of individual spaces but also about the interrelations between the many spaces that make up the spatial layout of a building or a city.

The current study investigates the effect of the spatial configuration of trees on the development of design proposals for urban parks using space syntax theory. The results of this work could be used to generate a strategic design framework based on a detailed analysis of spatial configuration.

### 2.4. Space syntax methods

A fundamental principle within space syntax theory is that social structure is fundamentally spatial and, inversely, the configuration of populated space has a primarily social logic. This principle is very important in landscape design, which seeks to create an outdoor environment for people to accommodate their social interaction.

Converting the landscape space to a discrete configuration is helpful because different labels can be applied to its individual parts. These parts can then be allocated to different groups, people, or activities. Various rules of behavior and conventions can be related to various parts of the landscape space. Individual parts of a landscape space can carry a specific symbolic or cultural value. This point of view would usually imply that the planned landscape space improves the readability of existing social structures. Space syntax theory rejects the straightforward space-as-form and society-as-content distinction (Hillier and Hanson, 1984). The fundamental concepts of space syntax include “integration” and “connectivity.”

#### 2.4.1. Integration

The “integration” of space is a function of the mean number of lines and changes in direction required to go from that space to all other spaces in the spatial system. Integration is accordingly about “syntactic” and not “metric” accessibility, and the expression “depth” rather than “distance” is used to illustrate how far a given space is from another space. All lines in a spatial layout have certain depth values from every other line. The integration value of a line is a mathematical way of expressing the depth of a line from all other lines in the system. These values significantly differ from one line to the next but are one of the most significant properties of architectural, urban, and landscape spatial configurations (Hillier and Hanson, 1984, 1998; Hillier, 1996). According to Ortega-Andeane et al. (2005), a space is “integrated” when the other spaces have a relative shallowness in relation to it. A space is “segregated” when the other spaces have a relative depth in relation to it.

#### 2.4.2. Connectivity

The connectivity of a node can be defined as the number of other nodes directly connected to it. Connectivity, path length, and clustering coefficient are three key measures for a topological analysis of a given space. They constitute essential measures for exploring small-world and scale-free properties. Some studies have pointed out that integration is closely related to human spatial behavior. A consistent relationship has been found to exist between the spatial integration measure of an urban space and the observed human movement that flows in it (Hillier et al., 1993a, 1993b). Kim and Penn (2005) reported a consistent relationship between spatial cognition and syntactic integration in urban areas. A pedestrian movement rate in an outdoor space can be predicted with other syntactic results from space syntax analysis. Several studies have been conducted...
to compare measured pedestrian movement rates and spatial integration (Hillier, 1996; Dawson, 2003; Raford, 2003; Read, 2001). The results endorse such relationships. Evidence suggests that the space syntax methods of representation and measurement of the spatial configuration of outdoor spaces could be useful in studies of planting design because they influence pedestrian movement patterns in urban parks.

3. Modeling outdoor spaces using space syntax

Many methods of spatial analysis have been developed to improve our understanding and modeling of real-world experience. Space syntax theory assumes that any urban area can be represented as a matrix of connected spaces and that the quantitative properties of this matrix can be measured using computer simulations. Space syntax models the spatial configurations of outdoor urban spaces by using a “connectivity graph” representation. Such a configuration of space identifies patterns that can be used to study urban layouts and human behaviors (Jaing et al., 2002).

Visibility and visual perception significantly influence how people behave, appreciate, and experience the environment. They could serve as determining factors in designing landscape spaces. Space syntax studies of pedestrian behavior in building and open urban environments have found a consistent correspondence between the configuration of space and the patterns of usage found within such space. Researchers in the space syntax community (Hillier et al., 1993a, 1993b; Penn et al., 1998; Desyllas and Duxbury, 2001) claimed through several empirical studies that both pedestrian and vehicle movement can be predicted by local integration measure.

3.1. Visibility graph

Benedikt, 1979a, 1979b suggested isovists or viewshed polygons as objectively determinable basic elements for analyzing the spatial characteristics of spaces. Isovists depict spatial properties by illustrating the visible area from a single observation point. Several quantitative descriptors that describe the physical properties of the corresponding space can be derived from these viewshed polygons; examples of these descriptors include area, perimeter length, number of vertices, and length of open or closed boundaries (Franz and Wiener, 2008). The shortcoming of the method by Benedikt is that it only considers the local properties of space and disregards the visual relationship between the current location and the entire spatial environment (Turner et al., 2001). Turner et al. (2001) suggested that the experience of space is related to an overlay of isovists and that more than a single isovist is needed to quantify the actual perceived space because the way an individual experiences and uses space involves motion. To effectively describe the spatial characteristics of environments, Turner et al. (2001) developed VGA as a technique that permits the integrative analysis of several positions inside an environment by calculating the intervisibility of positions regularly distributed over the entire environment. This technique suggests additional second-order measurands, such as “clustering coefficient” and “integration” (global topology-oriented characteristic values). Another advantage of VGA is that its process analysis can be completely automated (Benedikt, 1979a, 1979b). Empirical evidence shows that isovists capture the environmental properties of space that are relevant for spatial behavior and experience. Desyllas and Duxbury (2001) reported that in open and less-defined outdoor spaces, a more significant correlation exists between VGA visibility and pedestrian movement than between other space syntax analysis techniques, including an axial map representation of space.

3.2. Pedestrian movement and agent-based model

The agent-based model is among the most important space syntax techniques used to simulate pedestrian movement in an environment. Turner and Penn (2002) compared the number of visitors moving through an indoor architectural space with the number of “agents” progressing through an agent-based model of the same environment. They reported that the agents use natural movement rules by randomly selecting a position from the current field of view and moving toward it for several steps before redefining the destination. Turner (2003a, 2003b) applied a similar model to an urban environment. He recommended that in an outdoor environment, arrival zones and duration periods in the system that are closely correlated with pedestrian movement patterns must be carefully selected. The significance of the analytic method of Turner (2003a, 2003b) is that the agent-based model suggests to focus on the human accessible topology as invoked through the process of inhabitation, accordingly simplifying the tools an architect or environmental designer requires to assess the social adequacy of a specific project. The current study attempts to extend this assumption to the context of landscape design by assessing the effect of a proposed planting layout on space inhabitation and its feedback on design proposals.

Figure 1 Aerial photograph of the study area. Hatched area shows the experimental area.
4. **Methods**

4.1. **Study area**

El-Qanater Gardens is a large rural environment located 20 km northeast of Greater Cairo, Egypt. It is popular among middle-class families as a destination for one-day trips and outdoor recreation. Figure 1 shows a satellite image of the study area and the immediate surroundings of El-Qanater Gardens. The area highlighted by a hatched pattern is the specific area of study. This area is a primary destination and has a high density of users and activities. It can be considered in the practical application of space syntax theory in landscape design. Three different planting schemes are proposed as subjects of this study. A detailed analysis of space use pattern and a quantitative analysis of each planting design proposal for El-Qanater Gardens are conducted using the VGA technique (Figure 2).

4.2. **Measures and techniques**

The spatial analysis technique applied in this study is based on the analysis of the visibility polygons drawn from each grid of tiles covering all accessible areas (Turner et al., 2001). One global measure, “visual integration,” and one local measure, “visual clustering coefficient,” are used to investigate a large landscape area, that is, El-Qanater Gardens, Cairo. Similar to global integration, visual integration explains the relationship of each space to the space network as a whole. It describes the relative visibility of

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**Figure 2**  (a) Planting design proposal no. 1. (b) Planting design proposal no. 2. (c) Planting design proposal no. 3.
a point location to all the other points within the space. This “visual clustering coefficient” measure is important because it has been correlated with “pedestrian movement gate counts” in previous studies (Batty et al., 1998; Turner et al., 2001; Desyllas and Duxbury, 2001).

The clustering coefficient of a given location quantifies the degree of convexity or converse multidirectionality of the isovists generated from that location. It is a result of the ratio of the actual direct connections of nodes within the isovist to the maximum possible connections of the same number of nodes if they were in a convex arrangement. Its value ranges from 0 (extremely “rough” multidirectional isovists) to 1 (perfectly convex isovists). The clustering coefficient is an important spatial indicator of the potential perceptuality of copresence and, therefore, the potential to form groups or to interact (Turner et al., 2001; Franz and Wiener, 2008).

This study conducted VGA using Depthmap 9.0, a computer program for visibility analysis, to investigate the landscape (Turner, 2001, 2004; Mahmoud and Brown, 2009). A comparative method was developed to investigate the effect of planting pattern, including the visibility properties of the three planting design proposals in a single statistical model. Multiple regression and correlation analysis was performed using SPSS to test the hypothesis.

Three planting design proposals were developed. All three proposals used the same number of trees. The recommendations of Gilman (1997) for tree spacing were followed. The first proposal applied rectangular array (Arnold, 1980). The second proposal used curved, freeform configuration. The third proposal applied rectangular array with the addition of a central space along the main walkway to test the effect of Bell’s proposition that “node” can increase the balance and visual inertia of landscape space (Bell, 2004).

4.3. VGA of the study area

A visibility graph of the pedestrian movement spaces of the study area was developed using Depthmap 9.0 to identify the space syntax measures. The visibility graph was constructed for all locations (nodes) specified on an evenly spaced grid of 1.50 m, covering publicly visible and accessible areas. A planar isovist—visibility or accessibility field—was generated from each grid point to produce a network of all direct connections between nodes. A visibility graph was then derived and analyzed to acquire the patterns of configurational and visual properties (Turner et al., 2001). The landscape features one level of publicly accessible space. In the gray scale, the most integrated and shallowest nodes on average are shown in dark gray, and the least integrated and deepest nodes on average are depicted white. The visual integration shows the pedestrian spaces within the proposed park design. Circulation spaces connecting the park spaces served as the focus of integration in the area.

Intelligibility analysis using the correlation between connectivity and integration provided a clue of how the entire spatial configuration is clear to its users (Syntax, 2004). Previous studies have shown that visual integration is significantly correlated with movement (Parvin et al., 2007; Desyllas and Duxbury, 2001).

4.4. Gate count analysis

In this context, the calculations were applied to the proposed environment. A theoretical gate count must be used to estimate the proposed movement pattern. The Depthmap “agent” tool was used to calculate the expected “gate count” by predicting pedestrian movement within the three proposals based on the spatial configuration of trees. This tool was developed by Turner (2003a, 2003b) and has been found useful in predicting theoretical movement (Hillier and Iida, 2005; Bada and Guney, 2009).

Numerical data were exported from Depthmap in a tabulated format and inserted in the SPSS software to detect the difference between the proposals using space syntax measures. The data of each design proposal were grouped into a single SPSS file. Statistical analysis of variance (ANOVA) was performed to reveal the effect of spatial configuration on space syntax measures.

5. Results

5.1. Intelligibility analysis

The relationships between planting design and the characteristics of spatial space and pedestrian movement were analyzed based on the results from the VGA and the data on the case study area. Figure 3 shows a graphical comparison of the proposed planting designs based on the results of the space syntax analysis. According to the results of the VGA, the second proposal showed the highest value of global integration shown as curved pathways (Table 1). Both the first and the third proposals showed nearly equal values of global integration. In the first proposal, the measure of visual integration varied from 13.23 at the entrance and reached its peak at 19.57 at the space in front of the kiosk. In the second proposal, an emergent warm color in the visual integration map resulted in the left portion of the park to have a higher value of visual integration (22.55) compared with the low measure at the entrance space (14.77).

The measure of clustering coefficient was mostly consistent along the pathway in the first proposal. In the second proposal, the measure of clustering coefficient decreased along the pathway starting from 0.545 at the entrance space to 0.494 at the space in front of the kiosk. By contrast, the third proposal showed a consistent increase in clustering coefficient from 0.465 at the entrance to 0.527 at the kiosk.

The measure of mean depth in the VGA was strongly correlated with visual integration. By comparing the coefficients of determination ($R^2$), we found that the first proposal was the highest ($R^2=0.9710$), followed by the third proposal ($R^2=0.9637$) and the second proposal ($R^2=0.9511$). The measurement of mean depth was also strongly correlated with connectivity in the three proposals ($R^2=0.9998$, 0.9989, and 0.9997). However, the strength of the correlation between mean depth and clustering coefficient varied. The correlation was stronger in the third proposal ($R^2=0.2592$) than in the first proposal ($R^2=0.2283$). By contrast, the correlation was weak in the second proposal ($R^2=0.0019$).
Figure 4a-c shows the results of the intelligibility analysis (i.e., correlation between connectivity and visual integration). The correlation coefficient ($R^2$) between the visual connectivity and the visual integration of point was significant in the first proposal ($R^2=0.9737$) and in the third proposal ($R^2=0.9719$). It was not significant in the second proposal ($R^2=0.9559$). The correlation between visual stability (clustering coefficient) and connectivity was stronger in the third proposal ($R^2=0.2535$), which integrates grid planting with a central curved space, than in the first proposal ($R^2=0.1146$), which includes a rectangular array of plantation. The correlation was inadequate in the second proposal ($R^2=0.0009$).

5.2. The effect of spatial configuration on visual fields

The effect of spatial configuration on visual fields (represented by space syntax measures) was analyzed with ANOVA using SPSS software (Table 1). Spatial configuration was found to significantly affect all visual fields ($p<0.001$).
The different alignments of trees in the proposed designs resulted in different spatial configurations. This condition is expected to influence the visual fields experienced by users when they encounter the spaces in reality.

6. Discussion

This study describes a method for determining how planting design can influence the visual fields through three planting design proposals of an urban park using space syntax techniques. The proposals were developed using three different approaches. The first proposal followed the symmetric, rectangular array of trees and straight pathways. The second proposal followed a curved pathway and a random grid pattern. The third proposal applied a combination of symmetric rectangular array and a circular space at the center of a straight pathway.

Is it possible to predict the social structure of space using space syntax techniques? The answer appears to be positive. The first proposal, with the straight linear pathway, did not show significant changes in the visual integration analysis through Depthmap. The straight line and symmetric layout did not generate a variety of visual fields. In the second

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**Table 1**  Analysis of variance, influence of spatial configuration on syntactic measures, and comparisons of mean scores.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Levels</th>
<th>Mean</th>
<th>F-value</th>
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<tr>
<td>Spatial configuration</td>
<td>Rectangular array</td>
<td>1525.08</td>
<td>15.8304</td>
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<tr>
<td></td>
<td>Curved composition</td>
<td>1515.57</td>
<td>16.2719</td>
</tr>
<tr>
<td></td>
<td>Central node</td>
<td>1498.34</td>
<td>15.9128</td>
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</table>

**Note:** *p < 0.001.

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**Figure 4**  (a) Correlation between visual integration and connectivity measures of the first proposal. (b) Correlation between visual integration and connectivity measures of the second proposal. (c) Correlation between visual integration and connectivity measures of the third proposal.
proposal, the visual integration analysis showed an emergent warm color, which appeared as a spot resembling a main node connected to the western side of the pathway through the designed park. Salingaros (1999) stated that spatial network appears to have structure and a strong integration with the global space at this portion of landscape space. Conway and Bourne (2013) suggested that this result could inform the designer to insert an attractive visual component, e.g., colorful flower composition or a piece of sculpture. Bell (2004) suggested that the height of this element should not exceed eye level to avoid the obstruction of the visual field.

In the third proposal, visual integration analysis showed an emergent warm color, which appeared like a main node along the pathway through the designed park. The spatial network appeared to have structure and strong integration at this space. This finding agrees with that of Bell (2004) given that the circular arrangement of trees created a degree of enclosure defining the space. This condition could motivate the designer to add a visual element, e.g., a water fountain below eye level to maximize and emphasize this visual integration.

The results of the intelligibility analysis showed that the third proposal integrated a grid-planting pattern with a central curved space and thus provided a stronger correlation between visual stability (clustering coefficient) and connectivity compared with the first proposal, which included a rectangular array of plantation. The second proposal showed inadequate correlation. This result revealed an area within the second proposal that showed a high degree of connectivity within the space (Figure 5a and b). This outcome may guide designers in making use of this advantage and adding some design elements within this area to enhance design esthetics. Furthermore, the third proposal created a space system with a potential for copresence and interaction at the central space. The two other proposals did not show sufficient clustering potential.

6.1. The social structure of space

The literature indicates that visual integration is significantly correlated with movement (Parvin et al., 2007; Desyllas and Duxbury, 2001). The “agent” facility in the Depthmap software was used to show the traces of 500 sighted agents with 170 degrees of vision who randomly select a point within their field of vision, move three pixels (2.4 m) toward it, and repeat the process (Turner (2003a, 2003b); Bada and Guney, 2009). In the first proposal, the density of traces followed the central pathway structure to a remarkable degree. In the second proposal, the density shifted to the western side of the park and away from the main pathway, thus allowing further exploration of the park landscape. This process reflected the local scaling of spaces rather than the overall configuration. In the third proposal, the density of traces was the highest in the central space along the pathway, thereby emphasizing the focal point at the central space and reflecting the local scaling of the overall configuration.

The curved and central node alternatives will satisfy several visual aspects, including connectivity and increased integration in the global context. They are also expected to encourage social activities in large portions of the park. By contrast, the grid alternative will develop a rather static space where the central walkway is isolated and does not permit further exploration of the rest of the park.

Although trees are one of the most important factors influencing landscape preference, their spatial configurations influence visual fields. This finding confirms that of Wua et al. (2008). This contribution will affect pedestrian movement and the social structure of the landscape. Landscape architects should not limit park planting designs to symmetric layouts because curved and free-form arrangements may enable enhanced visual and social experiences within a space. Such considerations correspond to the findings of Bell (2004) that curved free-form shapes contribute to a highly dynamic
7. Conclusions

Tree planting design was found to have a significant effect on visual fields in urban parks. Although the experimental study sought to understand different issues, the results led to a general conclusion that the curved free-form arrangement of trees and, to a certain extent, the central spatial node of trees generated relatively integrated and connected spaces within the park design. The space syntax techniques used in this study could be used to enhance design proposals. A careful study of visual fields embedded in design proposals could help predict pedestrian movement and social structure of proposed designs. The results of such study could aid landscape designers in understanding how their designs will work. In this context, the space syntax approach can be used in future research to investigate other spatial parameters, including tree heights, colors, texture, and form.

Acknowledgement

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References

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