Legibility as a Result of Geometry Space: Analyzing and Comparing Hypothetical Model and Existing Space by Space Syntax

Sharifah Salwa Syed Mahdzar, Hossein Safari*

Department of Architectural, faculty of built and environment-Universiti Teknologi Malaysia 8131o-Johor, Malaysia
Hossein.safari110@gmail.com

Abstract: In modern and developed cities, large office buildings and factories occupy the center of city destroying the legibility of these areas. The city center of Kuala Lumpur (KLCC) was chosen as a case study because this area faces these challenges. In this study, the relationship between geometry and legibility was reviewed using two models that were created base on the literature. The two models were an existing vicinity of KLCC and a hypothetical model that analyzed by Space Syntax. The results were further analyzed using a T-test and the correlations were examined using SPSS. Enhanced integration as a result accessibility was observed. There was also a strong correlation between integration and connectivity in the hypothetical model. According to this simulation study, regular geometry can increase integration, accessibility, intelligibility and legibility in urban spaces.
[Sharifah Salwa Syed Mahdzar, Hossein Safari. **Legibility as a Result of Geometry Space: Analyzing and Comparing Hypothetical Model and Existing Space by Space Syntax.** *Life Sci J* 2014;11(8):309-317]. (ISSN:1097-8135). http://www.lifesciencesite.com. 42

Keywords: Legibility; Geometry; Space Syntax; intelligibility; accessibility; integration; connectivity

1. Introduction

The growing influence of the postmodern movement in urban design and architecture has been continuously debated (Institute of Engineering, 2002; DOPM, 2002). Urban designers, planners, and architectures try to recognize fundamental procedures that would improve the behaviour of people in the streets. They have considered how urban spaces such as squares and streets influence wayfinding, the creation of cognitive maps and the legibility of urban landscapes (Najafpour et al., 2013; Tibbalds, 1992).

Two factors that lead to functional and vibrant cities are physical characteristics and social structures (Kharkwal, Mehrotra, & Rawat, 2014; Stephenson, 2008).Cities is the result of constant communication between physical structures and social behaviour. In other words, the identity of an urban space is created by the interaction between its physical and social characteristics (Ghods, Najafpour, Lamit, Abdolahi, & Bin, 2014; Ocakçı & Türk Aydın, 2012). Consequently, the identity of an urban space is more than just its physical features as it includes the effect its physical characteristic have on the behaviour of the people who use the space (Kaymaz, 2013).

The identity of an urban space is directly connected to how it is perceived (Seamon & Sowers, 2008). How individuals perceive urban spaces illustrate how they understand that space. The physical characteristics of an urban space affect how it is perceived and the cognitive map of the individual who use it. Studies have shown that three elements affect how an urban space is perceived. These elements are, the compatibility of the space with the activities that take place in that space, the perception that it provides a preferable visual environment, and its legibility(Najafi & Shariff, 2011).

Legibility is connected to the identity of an urban space. There are three elements that define legibility: clarity, visibility and coherence (Lynch, 1960).

This article discusses geometry as an important variable that can impact clarity and coherence, based on the characteristics of legibility. Studies show that two factors that place a role in legibility are the simplicity of spatial configuration and the saliency of landmarks. The simplicity of spatial configuration is related to the two-dimensional information about a space. The saliency of landmarks is related to the three-dimensional aspect of a space. These two elements are also employed in wayfinding(E. Koseoglu & D. E. Onder, 2011). This study focused on only 2-dimensional configurations because in modern and developed cities, large office buildings and commercial facilities occupy city centres and the legibility of these areas no longer exists.

The goal of this study was to show how the geometry of space can affect legibility and to determine if there is a significant relationship between geometry and legibility. For this purpose, the relevant literature was reviewed and terms were defined. Next, the city centre of Kuala Lumpur (KLCC) was used in a case study. Finally, the space syntax method (Depth map software) and SPSS were discussed.

Identify and assess legibility

Legibility allows for an urban space to be understood and memorized(Lynch, 1960). It is also related to navigation (Weisman, 1981). Passini (1984) suggested that legibility is used in navigation to configure urban spaces and it influences how those spaces are comprehended(Passini, 1984). O'Neill (1991) stated that legibility is the capability of objects to aid in the formation of a successful cognitive map(O'Neill, 1991). In addition, legibility is a reflection of how easily a cognitive map can be used for successful way finding in urban spaces(Belir & Onder, 2013).

According to Kevin Lynch (1960), legibility is a major quality of a city (Lynch, 1960). Base on his theory, the legibility of a city is the simplicity with which a route can understand and identified. Clarity, visibility, and coherence can affect legibility. Legibility is used by individuals in several urban tasks including way finding. It is also central to the emotional and physical knowledge of space on an individual and communal level. Lynch claimed that legibility is equal to imageability. According to him, imageability is a characteristic of a space, which observers can simply and strongly represent the image of a in their minds(R. C. Dalton & Bafna, 2003a; Emine Koseoglu & Deniz Erinsel Onder, 2011).

The image of an urban space created in on the mind of an individual is called a cognitive map. Lynch believed that the cognitive map of a city is created using five elements: nodes, paths, districts, landmarks, and edges(Lynch, 1960). These elements are divided into two groups: a two-dimensional group and three-dimensional group. Nodes, paths, and districts are in the first group. They help observers by acting as anchors for a location. To the observer, these elements are topological. Edges and landmarks are in the second group. These elements have a higher geometric order that help observers to locate themselves. They can create a sense of both distance and direction (R. C. Dalton & Bafna, 2003a).

Investigations are underway to develop these characteristics for wayfinding. Studies show that routes are used as cognitive maps in successful wayfinding and these maps are constructed based on a skeleton of paths (Kuipers, Tecuci, & Stankiewicz, 2003). There is a hierarchy for spatial and visual factors. Cognitive maps are fundamentally dependent on spatial factors. Spatial factors are first-order factors and visual elements are second-order factors. The perception of structured unity and clarity is more essential than the perception of visual factors.(R. C. Dalton & Bafna, 2003b).

The ability to analyze and understand urban spaces is known as "reading" an urban space. However, spatial legibility is different from the ability to read a space. Legibility is a fundamental principal in urban design that defines how the built environment is organized so that imageability, unity, and clarity context are maintained. Reading a built environment is a process. It begins by gathering spatial data from the built environment and with cognitive mapping(R.C. Dalton, H'olscher, & Turner, 2012).

The process of gathering spatial data is a two-part process that defines the qualities of the space and identifies the kind of observer. The qualities of a space are identified in the mind of the observer through spatial psychological processes. Legibility is affected by spatial qualities and is defined by the simplicity of a two-dimensional layout and the saliency of landmarks in three-dimensions. Base on the literature, the legibility of the built environments depends on its clarity, perceivable, simplicity, coherence, unity, and understand ability. All of these qualities are deriving from the structure of the urban space. Yet, it is impossible to accurately measure the legibility by these qualities (R.C. Dalton et al., 2012). However, it may be possible using two dimensional qualities and new software (Depth map) to calculate and assess legibility.

Effect of Geometry on navigation

Geometry is defined as "the science of properties and relations of magnitudes such as points, lines, surfaces, or solids in space and the way the parts of a particular object fit together" (Concise Oxford English Dictionary, 1999). Geometry is derived from the Greek words ''geo'', meaning "the earth," and ''metry'', meaning "measurement." Geometry is a framework that allows elements to be organized and arranged into a pattern. It also shows the relationship between elements. (Dabbour, 2012b; Marcus, Westin, & Liebst, 2013).

Contemporary architecture develops geometric complexity using digital models with simple shapes. However, there are many issues with this type of geometric model(Pottmann, 2013).In some instances, geometry is seen as one of the highest forms of knowledge even though its fundamentals remain unclear (Sang Ah Lee, Sovrano, & Spelke, 2012).This view of geometry sees geometry as holy. The history of application of holy geometry by humans goes back many centuries. There are several symbolic shapes in geometry that are seen as representing the multiplicity of Unity that are used in traditional geometry, These shapes are: circles, spirals, the square, triangles, and a variety of regular polygons, (M. Hejazi, 2005).

Since the initial realization that geometric models could be used, these models have been applied to the geometry in the built environment

(Cheng, 1986). As a result, they have an impact on navigation and exploration (Cheng, 2008; Lew, 2011; Marcus et al., 2013; Spelke, Lee, & Izard, 2010; Tommasi & Thinus-Blanc, 2004; Twyman & Newcombe, 2010). Despite numerous debates over geometric data as either a primary or a secondary cue, there is an agreement that geometry is helps navigators with wayfinding. For instance, the cognitive map of an individual allows them to navigate from space to space. This cognitive map is made using an internal representation of the built environment that conserves the geometric relationships between different landmarks and situations (Gallistel, 1990; Sang Ah Lee et al., 2012; O'Keefe & Nadel, 1978; Tolman, 1984). In this regards, the present study explains how the geometry of the built environment affected wayfinding, cognitive mapping, and legibility (Sang Ah Lee et al., 2012; Yaskia, Portugalib, & Eilama, 2011).

Inertial navigation, or path integration, has been shown in humans (Landau, Gleitman, & Spelke, 1981; Sang Ah Lee et al., 2012; Loomis, Klatzky, Golledge, & Philbeck, 1999). Navigation that uses path integration requires the individual to make a mental Euclidean geometric map of the built environment. Many individual have a remarkable ability to apply geometrical knowledge(Foo, Warren, Duchon, & Tarr, 2005) and perceive the relationships between paths that have been navigated (Sang Ah Lee et al., 2012).

There is difference in the perception of geometry between adults and children. Geometric intuition may be a universal human trait, although cultures may use geometry in different ways.(Dehaene, Izard, Pica, & Spelke, 2006; Izard, Pica, Spelke, & Dehaene, 2011; Sang Ah Lee et al., 2012; S. A. Lee & Spelke, 2008, 2010, 2011; S. A. Lee, Spelke, & Vallortigara, 2010).Even though Euclidean geometry can be understood, philosophers and scientists continue to debate many aspects of Euclidean geometry. Despite the universality of geometric ability, when investigating how a cognitive map of the environment is made, it is essential to consider the physical condition of the built environment as an independent variable (Marcus et al., 2013; Yaski, Portugali, & Eilam, 2012).

2. Material and Methods

In this section, the reasons behind using KLCC as a case study and context of the space syntax as an analytical method for measurement and procedure are discussed. A set of alternative methods for analyzing and comparing the contents of models such as the hypothetical model and existing model was also presented.

This study focused on the integration and connectivity configuration and subsequent attempts to recognize the effects of geometry on legibility and accessibility. In other words, the effect of utilizing regular geometric characteristics in a hypothetical model, based on topological and irregular geometric information were investigated and the hypothetical model was described and analysis.

The predicted movement of people in a space was illustrated using Depthmap software. Connectivity, integration values, and intelligibility (the correlation between integration and connectivity) were used to establish legibility. The axial map analysis predicted what paths would be most likely used. Ultimately, the paths identified by the map in our experiment were compared with the paths predicted by the hypothetical model.

Finally, a T-Test and correlation examination by SPSS was used to understand the difference between the hypothetical model and the existing model developed in this study. Visual factors related to the physical structure of the space and the people as three-dimensional characteristic were not considered. The only focus on this study was on the two-dimension configuration of urban spaces.

Case study

The KLCC (Figure 1) was chosen as a case study because this area was filled with historical and cultural heritage buildings. The Jalan Ampang passes over this area and the Twin PETRONAS towers are located in this area. However, their ability to act as salient landmarks is limited due to the presence of several skyscrapers that have decreased legibility. As a result, the KLCC was considered because its lack of landmarks makes it ideal for determining how legibility can be increased in this area.

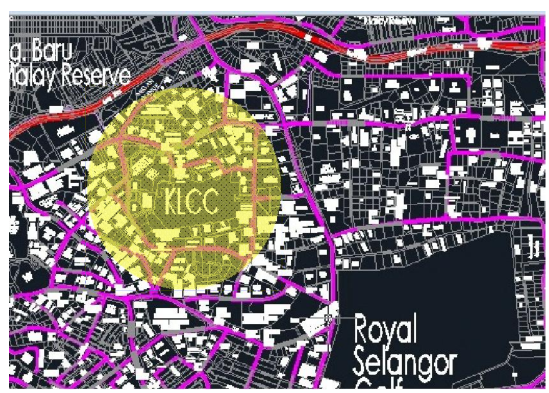

Figure 1. Kuala Lumpour City Centre –KLCC

Measures and Procedure

Depth Map software seeks to capture the condition of the built environment and determine if it is easy to understand and navigate. These results are called 'intelligibility'(B. Hillier, 1996). 'Intelligibility' is the level to which an area is linked to other areas and the integration of each element of the urban space on the system as a whole. Intelligibility defines the beneficial linked elements of urban spaces that indicate how well integrated the urban space is. Moreover, the concept of intelligibility considers the relationship between local characteristic and the global configuration of the urban space within a system. In an intelligible urban space, this relationship helps navigation(R. C. Dalton & Bafna, 2003b). The comparison between local characteristic and global configuration influences navigation making intelligibility an important characterization (J. Hanson, 1989; J. Hanson, 1989; B. Hillier & Penn, 1996).

Intelligibility is used in the urban design process. Intelligibility as the level of understanding of the built environment has a direct relationship with legibility. Intelligibility was initially discussed by Hillier et al (1987) who quantified it as the degree of correlation between connectivity and the global integration values of the axial lines in space syntax analysis. Hillier claimed that a strong correlation between connectivity and global integration ensures that the spatial configuration of an area is comprehensible and can predictable pedestrian movement. An urban space with a high level of intelligibility occurs when the degree of the correlation is high (Karimi, 2012; Zhang, Chiradia, & Zhuang, 2013).

Space syntax is intended to characterize urban space configurations as a whole. In a study conducted by Lynch (1960) the cognitive maps of individuals were examined and found to depend on certain features of the urban space. In this regards, the elements of space syntax corresponded with Lynch's elements providing the structure of urban space. Paths are described as axial lines, nodes are seen as the intersection of paths, and groups of intersecting paths with distinctive properties are classified as districts. (R. C. Dalton & Bafna, 2003b). Axial lines also combine the dual properties of sight and movement. They represent both a line of vision and the possibility of movement (R. C. Dalton & Bafna, 2003b).

The three categories of Lynch's elements (paths, nodes, and districts) were linked to the axial lines of urban spaces(R. C. Dalton & Bafna, 2003b). Axial lines represent the perfect descriptor because they provide a general representation in space syntax. An empirical system is found to be the most successful for urban spaces. Axial lines are very useful in studies on wayfinding because they can be closely computed (Kuipers, 1996; Kuipers et al., 2003; Penn, 2003). For instance, accessibility is defined by integration reflected by the times of pedestrian flows. High accessibility is related to high pedestrian flows (LAW, CHIARADIA, & SCHWANDER, 2012). In addition, Space syntax independently determines the geometric configurations of urban spaces. (LAW et al., 2012).

Theory

In theory, the space syntax method demonstrates that spatial construction is principally affected by what happens in the space, such as the behaviours of pedestrians(B. Hillier, 1996; B Hillier, Penn, Hanson, Grajewski, & Xu, 1992).

The axial line analysis using Space syntax shows the accessibility of the space. These results are obtained using a computer simulation to measure the movement and the distribution of urban elements in the space. (Buchanan, 1965; Hill, 1984).The axial map are also analyzed to describe the behaviour of people in the space. This method provides a social space analysis and the actions of people as a computer simulation (B. Hillier & Hanson, 1984; B Hillier et al., 1992).

Analyzing spatial construction is a valuable function offered by the Space syntax, which appraises how people treat an unfamiliar space. Space syntax method can measure morphological elements such as connectivity, choice, mean, Depthmap, integration and intelligibility as indicators of legibility(Haciomeroglu, Laycock, & Day, 2007).

3. Results

The principal aim of this study is to determine if there is significant relationship between geometry and legibility.

Legibility is identified using clarity, visibility and coherence (Lynch, 1960). In this regards, Lynch introduced five elements that create an image of a city. These elements can be further classified as being either two or three dimensional(R. C. Dalton & Bafna, 2003a). These elements are important to the cognitive maps that are used in wayfinding(Kuipers et al., 2003). To prepare a cognitive map, spatial factors such as a unity and clarity are more important than visual factors(R. C. Dalton & Bafna, 2003b; R.C. Dalton et al., 2012). Consequently, this study only focuses on two dimensional elements such as nodes, paths and districts because they are used by observers as anchors to determine their locations. Figure 5.1 (A1-3) illustrates an existing map of KLCC, with guidelines and a graph shows nodes, paths, and districts based on the existing map.

The regular geometry between elements can be organized to create a pattern (Dabbour, 2012a). Unity can be created using traditional geometry

(Mehrdad Hejazi, 2005) rather than complex geometry (Pottmann, 2013). Figure 2 (B1-3) shows a hypothetical model that is created using traditional geometry and based on existing streets. Graph 2 (B3) shows the nodes, paths and districts of the existing streets; however, the geometry is unclear (Sang Ah Lee et al., 2012). The hypothetical model is used because it can use geometry for both navigation and exploration (Cheng, 1986, 2008; Lew, 2011; Spelke et al., 2010; Tommasi & Thinus-Blanc, 2004; Twyman & Newcombe, 2010). In this regards, the present study exhibits that regular geometry affected legibility (Sang Ah Lee et al., 2012; Yaskia et al., 2011).

In Figure 2, two different urban models are compared. Both patterns have 28 links and 15 nodes. Although these models are different from each other, the conventional graphs do not differ and cannot be used to represent the structural differences between the models(Marshall, 2005). Syntactical relations and syntactic graphs exhibited topological relationships and features of spatial models(B. Hillier & Hanson, 1984) (Figure 2 (A1-3,B1-3)).

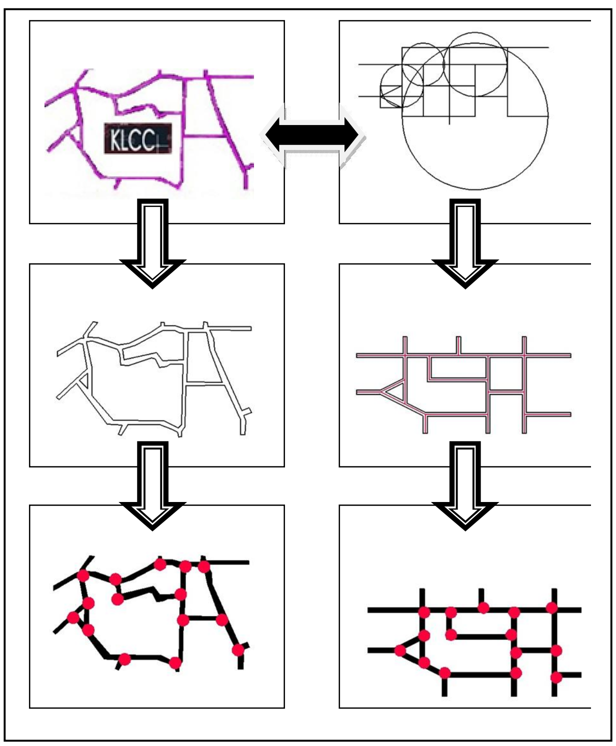

Figure 2 (A) Urban patterns and conventional graph (existing map); (B) Urban patterns and topological relations (Hypothetical model)

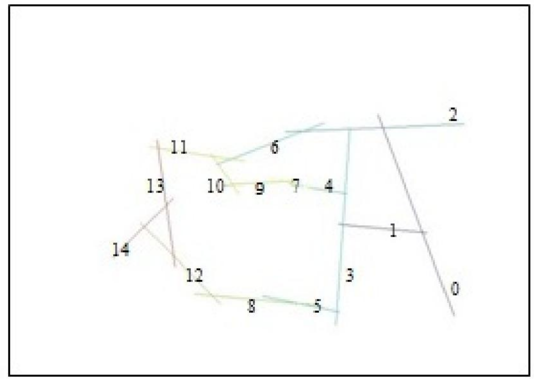

Figure 3 illustrates the Reference Number for routes based on axial map for both the existing model and the hypothetical model. These numbers are given in Table 1.

4. Discussions

The configuration of urban space cannot only influence movement and wayfinding, but it can also allow individuals to comprehend the relationship between the elements in an urban space and create a cognitive map. However, poor configuration means it become more difficult to recognize how one part of space is linked to the other part and legibility and wayfinding can become worse (Faria & Krafta, 2003; B. Hillier, 2003).

Table 1. Data of vicinity of KLCC base on an analysis using Space syntax (Depth map software)

Ref Number	Existing Model Integration	Hypothetical Model Integration	Existing Model Connectivity	Hypothetical Model Connectivity
0	0.78458	1	2	2
1	0.81163	0.916667	2	2
2	1.23882	2.2	3	4
3	1.30764	1.83333	4	4
4	0.90528	0.916667	2	2
5	1.02337	1.22222	2	2
6	1.23882	2.2	3	4
7	0.81163	0.916667	2	2
8	0.87175	1.22222	2	2
9	0.80625	0.916667	2	2
10	1.06989	1	3	2
11	1.12083	2.2	3	4
12	0.84062	1.1	3	3
13	0.90528	1.375	3	3
14	0.71325	0.785714	2	2

Table 1 shows spatial configuration factors such as connectivity and integration from the existing model and the hypothetical model. As can be seen, most streets have the same level of connectivity in the hypothetical model. However, comparing the integration of streets in the existing model and the hypothetical model (Figure 4 & Table 1) reveals that integration can enhance for all streets in this area when the hypothetical model is used. Increased integration may result in better accessibility for KLCC (Figure 4).

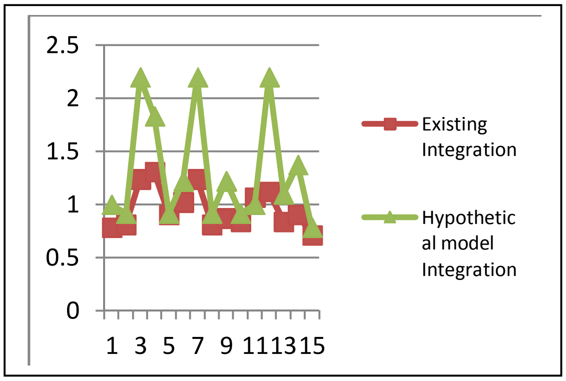

Figure 4 comparing the integration of the existing model and hypothetical model

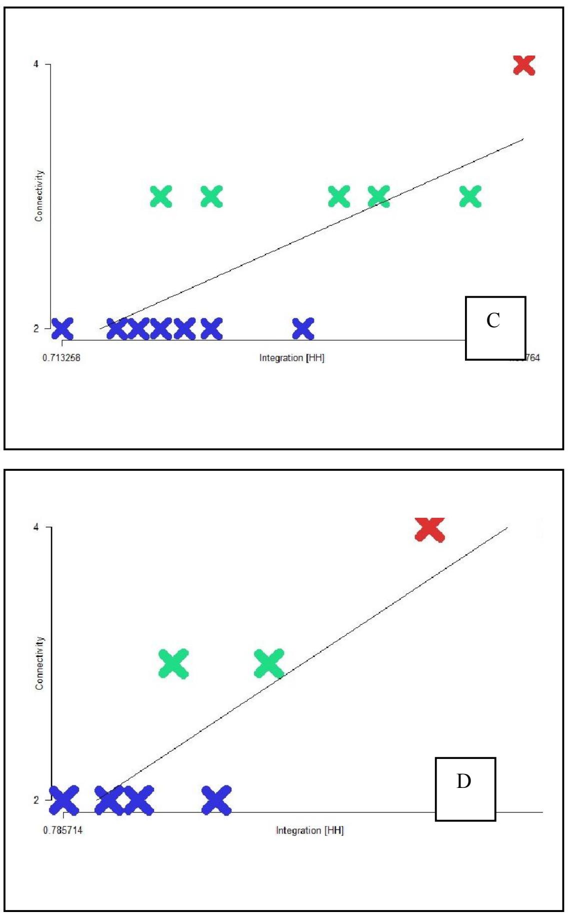

Figure 5 Correlation integration and connectivity C–existing model; D-hypothetical model

According to our results (Figure 5), the correlation between integration and connectivity as a measure of intelligibility reveals that when the rate of the correlation is high, then the element of configuration may have higher levels of intelligibility. Base on the graph shown in Figure 5, the equation that represents the correlation line for the existing model is:

$y=2.63171x-0.00785255, R^2=0.5988855.$

In the hypothetical model, the correlation line was expressed as:

$y=1.70009x+0.500452, R^2=0.831958.$

R^2In the hypothetical model is higher than the existing model. It is possible that in the hypothetical model, the correlation is closer to the equation line than in the existing model indicating that correlation may be better.

A one-sample t-test was conducted to compare the level of integration for the existing model and the hypothetical model. There was a significant difference between the scores for existing model (M=0.97, SD=0.188); t(14)=19.873, p = 0.000 and the hypothetical model (M=1.32, SD=0.521); t(14)=9.818, p = 0.000. These results suggest that geometry can affect integration and accessibility (Figure 4).

A Pearson product-moment correlation coefficient was computed to assess the relationship between integration and connectivity for the existing configuration. There is a positive correlation between the two variables [r = 0.774, n =15, p = 0.001] A scatter plot is used to summarize the results (Figure 5.C).Overall; there is a positive correlation between integration and connectivity. On the other hand, computing to assess the hypothetical model reveals that there is a strong positive correlation between the two variables [r = 0.936, n =15, p = 0.000].Another scatter plot is used to summarize the results (Figure 5.D). In general, there is a strong positive correlation between integration and connectivity. Increases in integration were correlated with increases in rating of connectivity.

According to the correlation results, the correlation between integration and connectivity is a stronger possibility in the hypothetical model than the existing model. This data illustrates how regular geometry may affects intelligibility and legibility. Particularly, the results of this study suggest that when regular geometry is used in urban design, unity, as a result of intelligibility and legibility, can be increased.

According to this simulation study, in some circumstances regular geometry may increase accessibility, intelligibility, and legibility of urban spaces.

Our discussion suggests that regular geometry might help create unity in urban design and effect intelligibility. Such designs would require highly legibility spaces, strong geometric forms, and high levels of integration and intelligibility. Areas of a city that lack legibility may be improved using geometric designs that would contribute to the legibility of the city. Even though it is impossible to change all configurations of a city, it is possible to renovate and refurbish some areas using regular geometry to contribute to legibility.

Acknowledgements:

Foundation item: The Universiti Teknologi Malaysia (No.: UTM.J.10.01/13.14/1/128). Authors are grateful to UTM for financial support to carry out this work.

Corresponding Author:
Hossein Safari
Department of Architectural, faculty of built and environment-Universiti Teknologi Malaysia 8131o-Johor, Malaysia
E-mail: Hossein.safari110@gmail.com

References
1. Belir, O., & Onder, D. E. (2013). ACCESSIBILITY IN PUBLIC SPACES: Spatial legibility for visually impaired people. Paper presented at the Ninth International Space Syntax Symposium, Seoul.
2. Buchanan, c. (1965). Traffic In Towns: a Study of the Long Term Problems of Traffic in Urban Areas. London: HMSO.
3. Cheng, K. (1986). A purely geometric module in the rat's spatial representation. Cognition, 23, 149–178.
4. Cheng, K. (2008). Whither geometry? Troubles of the geometric module. Trends Cogn Science, 12, 355–361.
5. Dabbour, L. M. (2012a). Geometric proportions: The underlying structure of design process for Islamic geometric patterns. Frontiers of Architectural Research, 1(4), 380-391.
6. Dabbour, L. M. (2012b). Geometric proportions: The underlying structure of design process for Islamic geometric patterns. frontiers of Architectural Research, 1, 380–391.
7. Dalton, R. C., & Bafna, S. (2003a). The syntactical image of the city: A reciprocal definition of spatial elements and spatial syntaxes. Paper presented at the 4th International Space Syntax Symposium London.
8. Dalton, R. C., & Bafna, S. (2003b). The syntactical image of the city: A reciprocal definition of spatial elements and spatial syntaxes. Paper presented at the 4th International Space Syntax Symposium London.
9. Dalton, R. C., H'olscher, C., & Turner, A. (2012). Understanding space: the nascent synthesis of cognition and the syntax of spatial morphologies. Environment and Planning B: Planning and Design, 39(1), 7-11.
10. Dehaene, S., Izard, V., Pica, P., & Spelke, E. S. (2006). Core knowledge of geometry in an Amazonian indigene group. Science, 311, 381–384.
11. Faria, A. P. N., & Krafta, R. (2003). Representing urban cognitive structure through spatial differentiation. Paper presented at the 4th International Space Syntax Symposium, London.
12. Foo, P., Warren, W. H., Duchon, A., & Tarr, M. J. (2005). Do humans integrate routes into a cognitive map? Map- versus landmark-based navigation of novel shortcuts. Journal of Experimental Psychology: Learning, Memory, and Cognition, 31, 195–215.
13. Gallistel, C. R. (1990). The organization of learning. Cambridge, M.A.: MIT Press.
14. Ghods, M., Najafpour, H., Lamit, H. B., Abdolahi, N., & Bin, M. S. F. (2014). Evaluation of the Effective Factors on Online Internet Usage in Organizations. Life Science Journal, 11(1).
15. Haciomeroglu, M., Laycock, R. G., & Day, A. M. (2007). Distributing Pedestrians in a Virtual Environment. Paper presented at the International Conference on Cyberworlds, Norwich, UK, School of Computing Sciences, University of East Anglia.
16. Hanson, J. (1989). Order and structure in urban design: The plans for the rebuilding of London after the Great Fire of 1666. Ekistics, 334/335(Jan/Feb, Mar/Apr), 22–42.
17. Hanson, J. (1989). Order and Structure in Urban Space: A Morphological History of the City of London. London: UCL.
18. Hejazi, M. (2005). Geometry in nature and Persian architecture. Building and Environment, 40, 1413–1427.
19. Hejazi, M. (2005). Geometry in nature and Persian architecture. Building and Environment, 40(10), 1413-1427.
20. Hill, M. R. (1984). Walking, Crossing Streets, and Choosing Pedestrian Routes: A Survey of Recent Insights from the Social/ Behavioral Science. USA: University of Nebraska Studies.
21. Hillier, B. (1996). Space is the Machine: A Configurational Theory of Architecture. Cambridge, MA: Cambridge University Press.
22. Hillier, B. (2003). The architectures of seeing and going: or, are cities shaped by bodies or minds? and is there a syntax of spatial

cognition? Paper presented at the 4th International Space Syntax Symposium, London.
23. Hillier, B., & Hanson, J. (1984). The Social Logic of Space, Reprint. Cambridge, UK: Cambridge University Press.
24. Hillier, B., & Penn, A. (1996). Cities as movement economies. URBAN DESIGN International, 1(1), 49–60.
25. Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1992). Natural Movement: Configuration and Attraction in Urban Pedestrian Movement. environment and Planning B: Planning and Design, 19.
26. Izard, V., Pica, P., Spelke, E. S., & Dehaene, S. (2011). Flexible intuitions of Euclidean geometry in an Amazonian indigene group. Proceedings of the National Academy of Sciences, 108, 9782–9787.
27. Karimi, K. (2012). A configurational approach to analytical urban design: Space syntax methodology. Urban Design International, 17(4), 297-318.
28. Kaymaz, I. (2013). Urban Landscapes and Identity.
29. Kharkwal, G., Mehrotra, P., & Rawat, Y. S. (2014). Taxonomic Diversity of Understorey Vegetation in Kumaun Himalayan Forests. Life Sci J, 11.
30. Koseoglu, E., & Onder, D. E. (2011). Subjective and objective dimensions of spatial legibility. Procedia - Social and Behavioral Sciences, 30, 1191 – 1195.
31. Koseoglu, E., & Onder, D. E. (2011). Subjective and objective dimensions of spatial legibility. Procedia - Social and Behavioral Sciences, 30(0), 1191-1195.
32. Kuipers, B. (1996). A Hierarchy of Qualitative Representations for Space. Paper presented at the Tenth International Workshop on Qualitive Reasoning about Physcial Systems, QR-96, Menlo Park CA, AAAI Press.
33. Kuipers, B., Tecuci, D. G., & Stankiewicz, B. J. (2003). Environment and Behaviour, 35, 81-106.
34. Landau, B., Gleitman, H., & Spelke, E. (1981). Spatial knowledge and geometric representation in a child blind from birth. Science, 213, 1275–1278.
35. LAW, S., CHIARADIA, A., & SCHWANDER, C. (2012). TOWARDS A MULTI - MODAL SPACE SYNTAX ANALYSIS. Acase study of the London street and underground network. Paper presented at the Eighth International Space Syntax Symposium, Santiago de Chile.
36. Lee, S. A., Sovrano, V. A., & Spelke, E. S. (2012). Navigation as a source of geometric knowledge: Young children's use of length, angle, distance, and direction in a reorientation task. Cognition, 123(1), 144-161.
37. Lee, S. A., & Spelke, E. S. (2008). Children's use of geometry for reorientation. Developmental Science, 11, 743–749.
38. Lee, S. A., & Spelke, E. S. (2010). Modular geometric mechanisms for navigation in disoriented children. Cognitive Psychology, 61, 152–176.
39. Lee, S. A., & Spelke, E. S. (2011). Young children reorient by computing layout geometry, not by matching images of the environment. Psychological Bulletin and Review, 18, 192–198.
40. Lee, S. A., Spelke, E. S., & Vallortigara, G. (2010). Spontaneous reorientation behavior in chicks: Evidence for evolutionary continuity across distantly related species. Poster presented at The Rovereto workshop on cognition and evolution. Italy: Rovereto.
41. Lew, A. (2011). Looking beyond the boundaries: time to put landmarks back on the cognitive map? Psychol Bull, 137, 484–507.
42. Loomis, J. M., Klatzky, R. L., Golledge, R. G., & Philbeck, J. W. (1999). Human navigation by path integration. Baltimore: Johns Hopkins.
43. Lynch, K. (1960). The image of the city. Cambridge, Massachusetts: The M.I.T press.
44. Marcus, L., Westin, S., & Liebst, L. S. (2013). Network buzz: conception and geometry of network in geography, architecture and sociology. Paper presented at the Ninth International space syntax symposium, Seoul.
45. Marshall, S. (2005). Streets & patterns. Oxon: Spon Press.
46. Najafi, M., & Shariff, M. K. M. (2011). The concept of a place and sense of place in architectural studies. International Journal of Human and Social Sciences, 6(3), 187-193.
47. Najafpour, H., Lamit, H. B., Roshan, M., Malekinezhad, F., Ghahramanpouri, A., & Rosley, M. S. F. B. (2013). Finding Ways in an Unfamiliar Tourist Destination: Salient Clues for Visitors to a Malaysian Town. Life Science Journal, 10(4).
48. O'Keefe, J., & Nadel, L. (1978). The hippocampus as a cognitive map. Oxford, England: Clarendon Press.
49. O'Neill, M. (1991). Evaluation of a Conceptual Model of Architectural Legibility. Environment and Behavior, 23(3), 259 - 284.
50. Ocakçı, M., & Türk Aydın, T. (Eds.). (2012). İstanbul: Ninova.

51. Passini, R. (1984). Wayfinding in Architecture. New York: Van Nostrand Reinhold.
52. Penn, A. (2003). Space syntax and spatial cognition: Or, why the axial line? Environment and Behavior, 35, 30-65.
53. Pottmann, H. (2013). Architectural Geometry and Fabrication-Aware Design. Nexus Network Journal.
54. Seamon, D., & Sowers, J. (2008). Place and Placelessness, Edward Relph. Key Texts in Human Geography. Sage, 43-51.
55. Spelke, E., Lee, S., & Izard, V. (2010). Beyond core knowledge: natural geometry. Cogn Sci, 34, 863–884.
56. Stephenson, J. (2008). The cultural values model: an integrated approach to values in landscapes. Landscape and Urban Planning, 84, 127-139.
57. Tibbalds, F. (1992). Making people-friendly towns: Improving the public environment in towns and cities. London: Longman.
58. Tolman, E. C. (1984). Cognitive maps in rats and man. Psychological Review, 55, 189–208.
59. Tommasi, L., & Thinus-Blanc, C. (2004). Generalization in place learning and geometry knowledge in rats. Learn Memory, 11, 153–161.
60. Twyman, A., & Newcombe, N. (2010). Five reasons to doubt the existence of a geometric module. Cogn Sci, 34, 1315–1356.
61. Weisman, G. (1981). Evaluating architectural Legibility. Environment and Behavior, 13(2), 189 - 204.
62. Yaski, O., Portugali, J., & Eilam, D. (2012). Traveling in the dark: The legibility of a regular and predictable structure of the environment extends beyond its borders. Behavioural Brain Research, 229(1), 74-81.
63. Yaskia, O., Portugalib, J., & Eilama, D. (2011). Arena geometry and path shape: When rats travel in straight or in circuitous paths? Behavioural Brain Research, 225, 449– 454.
64. Zhang, L., Chiradia, A., & Zhuang, Y. (2013). IN THE INTELLIGIBILITY MAZE OF SPACE SYNTAX: A space syntax analysis of toy models, mazes and labyrinths. Paper presented at the Ninth International Space Syntax Symposium, Seoul.

5/2/2014