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Examination of effects of urban street configuration on the amount of commercial buildings establishment (according to natural movement theory), Case study: Hamedan

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Abstract

The pattern of the urban layer is one of the factors that influence land use within the cities. Since the focus of this research is movement, accessibility, street network and urban form, the theory of Natural Movement is applied. This theory believes that movement is fundamentally a morphological issue in urbanism. It is a functional product of the intrinsic nature of the grid, and not a specialized aspect of it. In fact, spatial configuration is potentially a predictor of both pedestrians and vehicular traffic flows in urban environments. According to the theory of Natural Movement, the setting of uses and pedestrian's movement are influenced by space configuration. Also, there exists a remarkable correlation between the density of setting uses which attract the populations and syntactic spatial variables. This research aims at verifying these relations in two trade regions adjacent to city center in Hamedan. The reason to choose Hamedan city is using unique situation of this city, for example symmetry in designing axes and accessibility spaces. To analyze the setting of trade uses adjacent to main axes and correlation ratio of these settings with spatial syntactic features of axes, we use correlation analysis. The rate of space legibility was also studied. It was known that where correlation variables, connectivity, control and local integration, regarded as spatial syntactic variables in Natural Movement Theory (Hillier),have greater values and their correlation with density of setting trade uses adjacent to main axis is greater, the commercial units are set more densely around this axis. This relationship was also verified by space intellilgibility. The main hypothesis of the research indicating the direct relationship between settings uses spatial syntactic variables. The application of Natural Movement Theory was investigated in this study.

Keywords: Natural Movement Theory, Space Syntax, Commercial Buildings, Hamedan

Introduction

Cities are like living organisms going through constant change and transformations. This condition has demanded the development of suitable and adaptive design solutions that require the full consideration of the spatial continuity of the city, its physical and social peculiarities, user needs, and desire for safe and healthy communities (Erinsel Onder *et al,* 2009). Urban space is composed of real estate and streets that connect them (Kim *et al,* 2002). Urban forms are usually represented as the patterns of identifiable urban elements such as locations or areas (forming nodes in a graph) whose relationships to one another are often associated with linear transport routes such as streets within cities (Batty, 2004)

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The pattern of the urban layer is one of the factors that influence land uses within the cities. Since the focus of this research is movement, accessibility, street network and urban form, the theory of Natural Movement is applied in this research. This theory believes that movement is fundamentally a morphological issue in urbanism. It is a functional product of the intrinsic nature of the grid, and not a specialized aspect of it. In fact, spatial configuration is potentially a predictor of both pedestrian and vehicular traffic flow in urban environments (Toker *et al,* 2005). Thus, in order to investigate movement and space use in general, the question of urban form itself needs to be considered (Hillier *et al,* 1993). According to Natural Movement Theory therefore, in order to have sufficient and well-used urban spaces, the local properties of the space such as their form, size, and physical components are not as important as its configuration in relation to the wider urban system (Hillier *et al,* 1993). Movement we can define not as the small local movements that may be associated with some forms of occupation, and therefore to be seen as aspects of occupation, but movement between spaces of occupation, or movement in and out of a complex of such spaces. Movement is primarily about the relations between spaces rather than the spaces themselves, in contrast to occupation which makes use of the spaces themselves. We can see this as a scale difference. Occupation uses the local properties of specific spaces, movement the more global properties of the pattern of spaces (Hillier, 1996). It suggests that the configuration of the urban spaces, e.g. streets, itself is the main generator of the movement patterns and not the local properties and attractions such as shops and offices. These attractions are then located to take advantage of the opportunities offered by the spatial configuration and the subsequent passing trade and such movement may then act as further multipliers. However, while it does not mean that the greater proportion of movement is generated in all situations by the configuration it remains important to consider the spatial configuration as the primary generator without which we cannot understand the pattern of pedestrian movement or the distribution of attractors (Rismanchian *et al,* 2012).

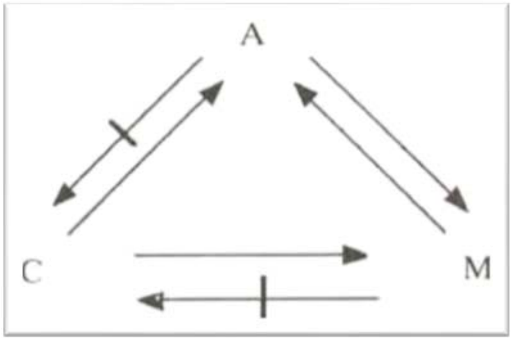

Figure 1. 'A' is attraction, 'C' is configuration, and 'M' is movement (Hillier et al., 1993).

In recent years, research results have accumulated in cognitive science which suggest that the metric distance assumption is unrealistic, not perhaps because we do not seek to minimize travel distance , but because our notions of distance are compromised by the visual, geometrical and topological properties of networks.(Hillier and Iida, 2005). It is hypothesized that individuals, when travelling through the space, have a preference for carefree excursions. Central to Space Syntax is 'integration' and it is believed that the distribution of individuals' movement is correlated to the distribution of integration in the space (Enstrom and Netzell, 2008). In terms of the probable effects of the three factors of attraction, configuration and movement on each other, this theory proposes that while configuration can affect both movement and attractions it cannot itself be affected by the other two (Rismanchian *et al,* 2012).

Hypothesis

1. According to Natural Movement Theory (Hillier), it seems that commercial uses enjoy accessibility, should be set more densely around the axes which have more suitable spatial syntactic indexes.

2. It appears that the area of trade units can be considered as an index of attracting population and movement, as proposed in Natural Movement Theory (Hillier).

Research aim

This study investigates the effects of urban street configuration on pattern of distribution of commercial buildings and their density in the two selected areas in the vicinity of the CBD of Hamedan. This research aims at identifying the validity of Natural Movement Theory: showing the reliance of setting places which attract population around spaces with more suitable behavioral features.

Introduction of research site

Hamedan is one of the first settlement of Arian people in Iran plateau and first capital of Iran. The design of Hamedan was first introduced by Karl Frisch (1932) based on concentric circles.

Figure 2. The situation of two cases of study within the Hamedan city

The reason to choose Hamedan was using its unique situation, for example symmetry in designing axes and spaces. Also, two regions were chosen regarding their commercial use density, their similar distance to Hamedan city center and their similar path length and size.

Literature Review

The purpose of this section is to review previous researches into the effects of urban spatial structure on the locating of commercial land uses. This is in order to clarify what findings have already been made on this subject and what major methodological and theoretical issues have been identified (Desyllas, 2000).

Jake Desyllas (2004), analyzed the relationship between urban street configuration and office rent patterns in his dissertation (Desyllas, 2000). He focused on the relationship between change of street patterns and the range of the rents. In the conclusion of his dissertation he found that urban street configuration must be considered according to whole of the city wide to realize its relationship with the rent range and entire city provide pattern of the city lands value.

Hong-kyu Kim and Dong Wook Sohn (2002),worked on this subject that what relationship is established between land use density of office buildings and urban street configuration in two areas in Seoul and for this purpose used space syntax method within their analysis.(Kim *et al,* 2002). At the end of their analysis they assert that obtained rsults are representative that there is a significant correlation between land use density of office buildings and urban street configuration. Meanwhile, global integration influences more intensely in the less integrated areas than the more ones.

Space Syntax Model

Space syntax is a logics of behavioral analysis based on configuration and setting of the space which considers space setting as an independent variable. Space Syntax was developed at the Bartlett School of Architecture and Planning, University College,

London (Hillier and Hanson, 1984). The general idea is that spaces can be broken down into components, and that these components can be analyzed in terms of their relation to all other components (Enstrom and Netzell, 2008). In this research we pay attention to street spatial features based on Natural Movement Theory in a manner that the analyses are directed through the hypothesis of the theory.

Although locating a shop is an individual decision, it is clear that the decision will be shaped first and foremost by the properties of the network) Hillier *et al,* 1993).

The need to develop methods for representing part-whole relationships in spatial configurations has also figured in studies of the social function of the built environment. In order to describe and analyze these characteristics of spatial configuration, Hillier and Hanson developed a two-stage methodology for representing and measuring the pattern properties of open space in the built environment (Hillier *et al,* 1984).

Methodology of Axial Map Construction

Axial lines are the fewest, longest lines of site which completely describe the spatial structure in question.(Hillier and Hanson, 1984). The first stage involves representing continuous open space as a series of linked elements such as maximal 'convex' spaces or longest 'axial' lines of sight and access. They call the latter the 'axial map'. The axial map of an area is drawn on the basis of open space structure in a plan, and consists of the fewest and longest set of lines of sight and access that pass through all the open spaces in an urban area and minimize the number of changes of direction between another pair of lines (Chio *et al,* 2005). Looking at configurational analysis with axial lines, there is no doubt that it has been both a very successful, and a generally robust measure - working in both European, Asian, Islamic and American Cities.(Dalton, 2001). In this research, the axial map of two regions was chosen to identify the spatial features of streets through Depth Map software. Commercial buildings and places are one of the main goals of intra city-travel of citizens. According to Natural Movement Theory, commercial places choose advantages of space configuration, places with more suitable spatial syntactic indexes for population's movement and attendance so that they can have the greatest efficiency. This research sets Natural Movement Theory as the starting point to extract and analyze the spatial syntactic variables for these two chosen regions.

The Concepts of Syntactic Properties

Extracting graph map of the streets, we can produce a system of syntactic relationships. Hillier and Hanson (1984) suggested that the relation of all the axial lines in the system is measured by the two basic properties of "symmetry–asymmetry" and "distributedness–nondistributedness" (Kim *et al,* 2002). Depth is the most remarkable index in analysis of spatial features of the axes. Depth is interpreted as the least spaces which must be paved from a space to another.

Relations of depth involve the notion of asymmetry and the measure of relative asymmetry generalized. To calculate relative asymmetry, sum the values of mean depth in the system and divide by the number of spaces in the system.

Relative asymmetry:

$$(RA) = 2(MD\_1) / k\_2$$

(MD is the mean depth, and k is the number of spaces in the system)

In the case of real urban systems, RA values are highly influenced by the total number of spaces in a system, and real relative asymmetry (RRA) is introduced to reduce the system size effect. RA is divided by the RA of a diamond shaped system with the same number of spaces (D).

$$RRA = RA/RA(D)$$

Integration or global integration is defined as 1/RRA. The values above 1 mean the strong 'integration', while the values between 0.4 and 0.6 show more 'segregation'. On the other hand, local integration is calculated by considering only three steps from a space itself and is called radius-3 integration. In brief, the global integration considers the whole system structure, while those considering fewer steps of depths indicate more local structure.(Kim *et al,* 2002).

Other Parameters

Connectivity: As the number of points by which a point connects to other points directly which is defined as:

$$Ci=K$$

where K is the number of points which connect to the desired point directly.

Control: It is a parameter which determines the freedom degree of a point from the points which are connected to it as defined in

$$1/Cj\sum kj=1 =i \quad : ctrl$$

Mean depth: The basis of depth formation is the number of steps which must be paved from one point to another. A point is called deep when the various steps between it and other points are available. Depth isn't the main parameters in space syntax but it is considered as an important variable to calculate connectivity of a point if Di,j is the shortest distance between two points I & j in graph G. the total depth of point i is the summation of all distances of , based on mean depth, defined as

$$MDj= \frac{\sum_{j=1} di\,,j}{n=1}$$

In which N is the number of points in graph.

Integration: It shows the extent of the point relationship with the general structure of its set or subset. If it is possible to reach a space by paving less spaces, that space has greater integration and vice versa. The case studies show the direct relationship between integration and the presence rate of people space (Jiangl *et al,* 2000).

Intelligibility: The rate of correlation between two criteria of connectivity and the relationship between axes show the legibility of the space.

Analysis of the urban street configuration

Space syntax, in its ambition, is a way to the understanding of the complex effects, on the horizontally distributed social body of the city, of its physical infrastructural move- ment network (Read:2005). In this research, the configuration of the streets in both regions were studied and all areas of city between the first and second Hamedan city ring were analyzed in terms of space syntax by Depth Map software. All the spatial criteria of integration, connectivity, control and legibility were extracted by the software.

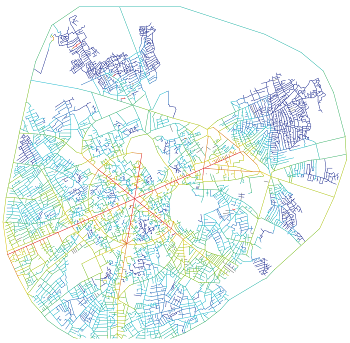

Figure 3. The axial map extracted from the Hamedan city street map

The sizes related to the analyses carried out are shown in table (1):

Table 1. The summary of information related to spatial variables in this two regions

	Global integration	Connec-tivity	Local integration
Area A(mean)	1.17	4.2	1.16
Area B(mean)	0.89	2.12	0.93

Region A has 84 axes and region B 134 axes which are reflected in global integration. These axes show the pedestrians and rider's access space. The information related to spatial variables, shown in tables 1 and 2,indicate that the average of integration values, connectivity and local integration are higher in region A. Tables(2) and (3) show the differences in street configuration of the regions.

Figure 4. Axial maps extracted from the street map of region A(left), and the region B(right)

Region A has developed with the axes of higher rate of integration crossing each other and joins all the areas, while region B has a central axis which is allocated the maximum rate of integration. The greater distance of axes from the central axis, the lower the rate of integration. From these analyses, it can be concluded that despite the symmetry in designing six central axes of Hamedan, the syntactic variables have remarkable differences in these two axes. Now, we aim at determining the relationship between this variables and commercial density through the analysis of correlation between spatial syntactic variables and commercial unit density. Then, we specify the value difference of spatial syntactic variables in two desired regions in compatibility with density difference of commercial uses to verify the intensity of this relationship.

Results

Five indexes were collected as spatial syntactic data and those related to density of commercial units as the representative of commercial unit density in the region. The data were displayed in the tables separately. The results show that the average of integration, connectivity, control and local integration indexes are greater at the region A and therefore, the average of commercial unit density increases adjacent to major axis in the region A.

Table 2. The information summarized for the variables of axis A

	Global integration	Connectivity	Control	Local integration	Substructure area
Mean	1.78	9.66	2.35	3.55	13.46
Range	1.03	16.3	4.2	3.19	25.77
Min	0.92	2	0.3	0.91	6.02
Max	1.93	22	4.8	4.62	43.70

Table 3. The information summarized for the variables of axis B

	Global integration	Connectivity	Control	Local integration	Substructure area
Mean	0.59	6.18	1.13	2.34	11.72
Range	0.37	14.78	2.23	3.28	20.77
Min	0.29	2	0.28	0.70	6.00
Max	1.02	19	2.61	4.05	40.79

Correlation Analysis

The analysis of correlation was applied to verify the relationship between the variables of spatial syntactic and areas of commercial units adjacent to desired regions. This helps us to measure how much commercial use has been involved with the index of space syntax for the axes. Table (4) shows the results of correlation analysis in two desired axes.

In region A, integration, connectivity and local integration have acceptable correlation with the area of commercial units located in main axis and control index has acceptable correlation. In region B, integration, connectivity and control have strong correlation with area of commercial units and the local integration has an acceptable correlation with the area of commercial units.

Table 4. General information for correlation coefficient in region A

		Global integration	Connectivity	Control	Local integration	Substructure area
Global integration	Pearson correlation	1.000	0.724	0.591	0.800	0.878
Connectivity	Pearson correlation	0.724	1.000	0.723	0.844	0.729
Control	Pearson correlation	0.591	0.723	1.000	0.683	0.544
Local integration	Pearson correlation	0.800	0.844	0.683	1.000	0.900
Substructure area	Pearson correlation	0.878	0.729	0.544	0.900	1.000

From this information, it can be concluded that spatial syntactic variables have strong correlation with the location of commercial units (as the representative of commercial use density in two desired regions). It seems that the differences in the amount of integration, influences the tendency to attract commercial uses and the correlation coefficient between region A and B. Therefore, the assumption that commercial uses exploiting the access advantages should be set around the axes with more suitable spatial syntactic variables more densely, is verified in this research. Also, the location of commercial units can be considered as the representative of use density to attract population, movement.

Table 5. General information for correlation coefficient in region B

		Global integration	Connectivity	Control	Local integration	Substructure area
Global integration	Pearson correlation	1.000	0.858	0.825	0.867	0.708
Connectivity	Pearson correlation	0.858	1.000	0.870	0.856	0.700
Control	Pearson correlation	0.825	0.870	1.000	0.808	0.726
Local integration	Pearson correlation	0.867	0.856	0.808	1.000	0.630
Substructure area	Pearson correlation	0.708	0.700	0.726	0.630	1.000

Comparing the accessibility in the two study areas

The degree of complexity of the inner structure of the vicinal is another factor mentioned by Hillier et al (2007) as applying to the two selected areas. Since there is usually an inverse correlation between the complexity of the structure and intelligibility, meaning the more complex the structure is the less intelligible the area is, the intelligibility measure is also investigated here. Also the correlation between the degree of connectivity and the global integration in the area A is R2 = 0.123276, while the same correlation for the area B is R2=0.0879583, which also shows a considerable reduction (Figure 5). These results confirm that the area A is more intelligible and the structure of the deprived area is more complex (Rismanchian *et al,* 2012).

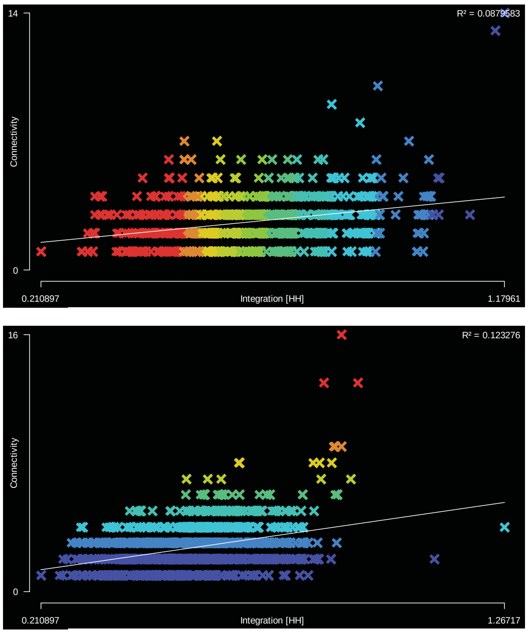

Figure 5.The correlation analysis in the selected areas A(top), and B(bottom)

The acceptable degree of connectivity around the street with great integration causes integration to be distributed around all areas and adjacent regions. This brings about a suitable opportunity for pedestrians to travel from one point to another and to increase social integration of space. The results of analysis show that the legibility is greater in region A and the movements are carried out more easily so that the commercial units will use the advantage of more dense. This relationship can be tangibly seen in these two regions.

Conclusions

The purpose of this article is to investigate the effects of urban street configuration on the amount of commercial buildings establishment.

The basis of this research is the Natural Movement Theory (Hillier) in a part of which we can see that: Configuration of the urban spaces, e.g. streets, themselves are the main generator of the movement patterns and not the local properties and attractions such as shops and offices. These attractions are then located to take advantage of the opportunities offered by the spatial configuration and the subsequent passing trade and such movement may then act as further multipliers.

The findings of this research are based on urban morphology compared with the reaction of setting commercial uses. To verify the intensity of commercial units with spatial syntactic features, the urban axes of two regions around the city commercial center with similar design and different intensity of commercial use were studied. The aim of this selection was to investigate the hypothesis stating that it seems commercial uses exploiting access advantage should be located around the axes which have more suitable spatial syntactic indexes. Having analyzed the spatial syntactic features, we specified the main axes of two desired regions.

Through the analysis of space syntax, the features such as integration, control and local integration were measured. The difference in the value of indexes showed the different configuration. The features of two regions were analyzed through the space syntax analysis.

Region A which has greater integration, connectivity, control and local integration than region B, has a central axis with the maximum integration and the greater the distances of axes from central axis, the lower the integrity. This results in the lower integration in region B than region A. To investigate the main research hypothesis, based on Hillier's theory, the density of setting commercial use around main axes of two regions was assessed through correlation analysis. It was known that the density of these settings is influenced strongly by spatial configuration and there is a direct relationship between the values of spatial syntactic variables with density amount. In region A which has greater integration, connectivity, control and local integration, the density of setting commercial units is greater; Therefore the research hypothesis is verified. It can be concluded that the index of area of commercial units can represent the setting density of these units. Applying the correlation analysis, we can see that legibility of region A is greater than that of region B. Therefore, it can be said that Natural Movement Theory (Hillier) can be verified in the region under study.

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