

Original Research Article

Landscape Syntax, Landscape Assessment Using Landscape Approach Indices*

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Abstract | Space syntax theory proposes a quantitative and tangible method to recognize and analyze the space configuration and structure. Although it is not a new technique, it is still applied and evolved. In this regard, the current study sought to solve some of the structural and conceptual limitations and deficiencies of the space syntax by providing a novel method through recognizing the landscape aspects. Then, the novel term definition, "Landscape Syntax", can be obtained using the achievements of this method. This research seeks to answer the question that How different will the indicators and assessment method be if we use landscape syntax instead of space syntax? This study aims to reconcile the definition of landscape with space and syntactic patterns of space, seeks to enable a specific syntactic pattern of landscape to understand the syntax of the landscape. The current basic research is qualitative in nature and applied in terms of purpose. The research process is a mixture of content analysis (descriptive, analytical, and deductive explanation). The space syntax concepts are classified using the content analysis method and are corresponded to the landscape concepts. According to the results of this study, the landscape has neglected aspects in space syntax concepts. (Some of the landscape aspects has been neglected in space syntax.)The main part of the new concepts of the landscape approach that are not in the syntactic system is the semantic factors, especially interpretive-subjective factors. These factors have value indices that must be inserted into the syntactic simple graph calculations. To this end, a network of the new landscape approach indices is put on the syntactic network to determine the valuable points. The newly developed method is the landscape syntax network. The graph obtained from the landscape syntax is a weighted graph, which is weighted through the value of the landscape approach indices. Landscape syntax is developed by adding the new aspects of the landscape approach, which is an upgraded and developed version of the previous versions.

Keywords | *Landscape syntax, Space syntax, Landscape approach factors, Weighted graph.*

Introduction | In the book "Social Logic of Space", published in 1984 (Hillier & Hanson, 1984), Hillier and Hanson introduced the space syntax theory and its solution to analyze the urban and architecture plans. "The methodology of the space syntax has been confirmed over the recent decades" (van der Hoeven, van Nes, 2014, 65). Space syntax is a tool to recognize the configuration, design, and planning of the space. The space syntax is

used widely as the basis for strategic spatial planning in the urban master and detailed plans. Therefore, it is a new modeling method in the cities (Hillier, 2007). Space syntax is a theory based on the graph principles in the mathematics field that determines the space configuration structure. This method attempts to identify social interactions by explaining and analyzing the space configuration. In the meantime, basic techniques are required to use the graph in the space of the surrounding

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environment and transform the complicated spaces into a set of topological relations. The space syntax defines three bases of 1. Convex space, 2. Axial lines, and 3. Visibility graph analysis to solve this problem. The spaces defined by the fundamental factors are then transformed into a topological network (a geometry without angles and distance) using the graph diagram. The output of this process is the factors obtained from the mathematic graph. Also, the relationships between these factors can be analyzed in terms of mathematics. The convex space is defined as follows: “All the points in the space that can be connected to the other points of the space without intersecting the space borderlines” (Hillier, 1988). The axial lines map is a space system based on the open space structure in the external urban spaces and the accessible spaces in the architectural interior spaces in a plan. “The visibility graph map overlays a regular network on the plan of the environment and then determines the relationships between each unit in the network” (Turner, Doxa, O’Sullivan, & Penn, 2001). One of the convex space and the analysis of the axial line’s weaknesses is their abstract method, which only includes the path spaces, such as streets. Also, it ignores the space energies and potentials, such as space attractors or the landscape approach signs. This technique signifies access and does not include the significant places in its analysis. The visibility graph map is the same, although it has fewer limitations than the previous maps. On the other hand, the landscape designers value the human and environment the same in design. They seek meaningful concepts for the human besides the physique. The landscape designers often seek to create spaces with a particular spatial sense and meaning than other spaces. These spaces are the main part of the design and have more value. While these spaces have a particular value, they are analyzed by the same value as the other spaces in the space syntax analyses. Therefore, the space physique analysis limitations lead to ignoring a part of the landscape’s meaningful physique in the analyses. Also, the subjective-semantic concepts of the landscape that are the main aspect of the landscape definitions lack the meaning in the syntax method. Therefore, a technique is required to value the equivalent and low meaningful spaces of the space syntax. Given the definitions of the two approaches, it is understood that they are different concepts. However, the main purpose of the current study is to identify the relationship between two models rather than studying the differences and similarities of these concepts. This paper attempts to fill the semantic aspect gap of the space syntax by the landscape concepts. As previously mentioned, these approaches have different conceptual foundations and seek to explain various things. However, it is possible to establish a two-way relationship between these concepts to improve them by recognizing their aspects.

Research Question

In the case of defining space with a landscape approach, what is the difference between criteria, indicators, and method of measuring space as a landscape with the current situation in Hiller space syntax? In other words, what is the landscape syntax?

Research Background

Space syntax is a set of theories and methods to model and analyze the cities, which uses space as the city’s fundamental generator. Space Syntax Theory was developed in late 1970 by Bill Hillier in the Bartlett UCL in London. “In 1998, Hillier and his colleagues proposed a novel method to analyze the constituent components of space, and great architects used this method” (Hillier, 1998, 21). Other sub-theories were developed to explain and investigate the urban systems in terms of various aspects under the space syntax theoretical framework. “Natural Movement Theory”¹ (Hillier, Penn, Hanson, Grajewski & Xu, 1993) and its complementary theory, “Economic Movement”² (Hillier & Penn, 1996), and “Pervasive Centrality Theory”³ (Hillier, 2001) are among these theories. In parallel, the academic researchers suggested various methods, techniques, and new software by developing new tools and methods using the space syntax theory, such as Segment-Angular Spatial Network Analysis (Hillier & Iida, 2005), Visibility Graph Analysis (VGA) (Turner et al., 2001), Vision-guided Agent-based Modeling (Turner & Penn, 2002), Origin-Destination weighted network analysis to advance the methods of spatial accessibility analysis (Ferguson, Fridrich & Karimi, 2012), tools and software related to GIG to produce and use the space syntax analysis in GIS environment (Gil, Varoudis, Karimi, & Penn, 2015), space syntax, a combined accessibility, and the urban environment elements analysis tool (Stahle, Marcus & Karlstrom, 2008). In the east of Asia, Kim and Shin (Kim, Shin & Kim, 2007) analyzed the characteristics of sidewalks application, land uses, and sidewalks volume and network in the central part of Seoul using this theory. In Iran, the researchers were first to become familiar with this theory in 2002. Nowadays, the number of urban consultant companies that use space syntax research in their projects or present space syntax consultant services are increasing. Most of these studies analyze space data using space syntax and its tools.

Research Method

The current paper is fundamental research that addresses the landscape syntax definition, which is a novel term. The research process is a mixed method of content analysis (descriptive and analytical-deductive explanation). After studying the space syntax method and its justification graph, this structure in the landscape approach space will

be analyzed. To this end, the indicators and variables of space configuration defined in space syntax are used to assess the landscape approach factors. Finally, the new indicators with common features are obtained to evaluate the landscape syntax, which provides a new method to design, analyze, and assess the space in terms of landscape.

Space Syntax; From Theory to Practice

Space syntax is a technique used to analyze the space access and tries to determine the complexity of the space configuration in the urban morphology and its impact on urban life (Paul, 2011). This method is implemented based on the configuration and eventually provides the solution by graph concepts. The advantage of space syntax to other methods is the possibility of the graph and quantitative evaluation and recognition. As it is based on mathematics, it is tangible and practical for everyone. The graph shows a network of space connections. This network is used to analyze the connectivity of a space unit to other spaces in a system. Each graph node indicates the space unit or a line of the map of the axial line. Also, each graph line shows an intersection to space connection. Binary Matrix⁴ can be used to map this graph. In this matrix, one indicates the space connection, and zero shows the lack of connection (Fig. 1). "Integration" is the most significant indicator of the graph used to show access to a united space in a system. The graph diagram and its matrix can be transformed into a set of algorithms. The algorithms are used to analyze the access of each space unit to the other spaces of the complex. After investigating the access, it is possible to conduct analyses to "understand the relationship of an urban space network with social and economic factors and their impacts and constituent factors" (Hillier, Turner, Yang, Park, 2007; Van Nes & Yamu, 2017).

Space Syntax Factors and Indicators

Space syntax theory is based on the fact that each urban

region can be considered as a matrix of connected spaces, and the mathematical feature of this matrix can be measured quantitatively and investigated using computer simulation (Choi, Kim, Oha., & Kim, 2005, 355; Mahmoud & Omar, 2014, 35). Depth Map software is one of the space syntax tools that are often used in analyzing the space configuration. Turner and Alasdair in Bartlett UCL of London developed Depth map software, which can analyze the Visibility Graph. The main idea of the software is based on two aspects of 1. Isovist context (analyzing the visible area in a specific point of space), and 2. The graph theory of space syntax. The Depth map software output is the space parameters using this analysis. The mean integration, mean depth, and mean connectivity (Access) are the space parameter indicators. The space concepts can be analyzed using these indicators, and the social concepts and activities can be investigated (Table 1). The space parameters of the space syntax are analyzed using three types of distance that are 1. Topological (the minimum of rotational paths), 2. Geometrical (the path with minimum angular changes), and 3. metrics (the shortest physical path) (Turner, Penn & Hillier, 2005; Turner, 2007; li, Xiao, Ye, Xu & Law, 2016, 31). It measures the centrality of space by replacing the distance with pervasive distance. The distance here means the distance from one point to another point. Pervasive distance refers to a point to all the points in the system. As interpreted from the space syntax parameters analysis in Table1, "integration" of the diagram dimension is the main indicator of the space syntax technique. Increasing this parameter leads to increasing the physical quality of the public area.

Landscape Syntax Factors and Indicators

The landscape is a systematic, multifaceted and complicated knowledge. "Landscape is known as a dynamic phenomenon in today's definition, which

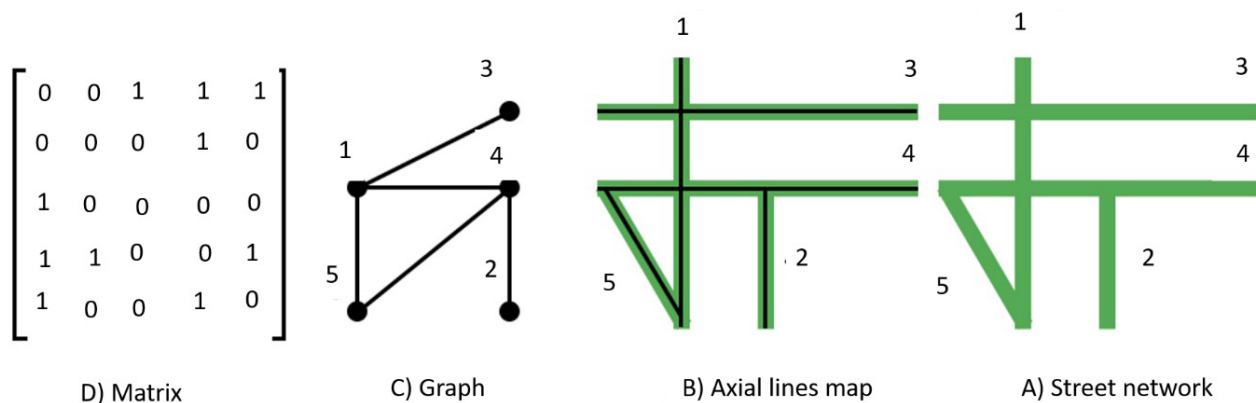


Fig. 1. A) Shows a network of the presumed streets. B) The map of axial lines of streets network are mapped. C) The graph diagram is drawn. The graph includes lines and nodes. A number of each node indicates the axial line and its related street. The graph lines show the connection in two nodes (street). E) Is the Binary Matrix of the street network? One shows that two streets are connected directly, and zero indicates the lack of direct connection between the streets. Source: Authors.

Table 1. Space syntax indicators include integration, depth, and control-connectivity. The numerical value can be given to these indicators for easier measurement. Then, the space configuration description can be obtained by analyzing these values. The current table presents some conclusions often obtained due to an increase or decrease in the space parameters. These parameters are also evaluated together for a better conclusion. Source: Authors.

Space parameters Space syntax indicators	Definition Definition of indicator	Valuation	Discussion The relationship between the above criteria with the social, economic issues, etc.	Conclusion Inferential analysis
Integration	Integration in a neighborhood measures the proximity of a street to other streets at different scales, which also is considered as the movement destination.	Indicates a degree of connection or dissociation from the whole system	Integration explains the easiness of movement from a plot of the street to other plots. In practice, the pedestrian prefers to travel a street with minimum effort.	The higher the degree of integration, the greater the integration between the space under study and other spaces and the overall space network. Therefore, increasing integration leads to enhancing the quality of the physical public area.
Depth	Depth of a space means to reach a space, other spaces must be passed.	The number of phases which is defined from one node to other nodes	There is often a strong relationship between the depth of spaces and ruined and useless lands so that these parts are in the high depth. Therefore, increasing the depth reduces the visual quality, such as lighting.	The more the space depth, the more it is separated from the other spaces of the complex. Depth states the degree of the space separation from the whole complex.
Control (choice)	Selection measures the probability that a person chooses a path from among other paths to reach his destination.	The degree of choice of each node to the nodes that are directly connected to the destination	Choice measures the extent of movement to travel in each street plot among the whole streets and shows the paths the possibility of using them to reach the urban destinations with high integration is high.	An increase in the choice degree leads to the easier access and increase in the integration. However, it does not always increase the quality of the public area.
Connectivity (access)	The objective concept of connectivity means the space connection and access	It is the number of the nodes that are directly related to the one node. The numerical value of the connectivity indicates the number of accesses leading to the destination.	The more the number of connectivity to a street, the more connections and access to other streets.	Increasing the accessibility leads to increasing the space attractors. Thus, in case of reduction in some roads of a neighborhood, the collective attractor land uses are directed to those roads.

is the product of the object and mind together and is perceived tangibility and immediate” (Mansouri, 2004, 69). In the contemporary era, the landscape is considered and defined as a field of knowledge in the scientific frameworks and is considered as a redeemer discipline in the crisis of one-dimensional approach in the human and environment relationship (Alehashemi & Mansouri, 2017, 33). Therefore, the landscape is an objective-subjective, relative, and dynamic concrete, which is the result of the individual and social interaction of the human with the place in a historical and geographical context. “Landscape as a multifaceted discipline, due to its multidimensional nature as a mediator and multidimensional relationship, is the solution to one-dimensional approaches ruling environmental and landscape planning and management” (ibid., 42). As interpreted from landscape’s definition, it has objective and subjective aspects. The more objective and physical the landscape approach factors, the more

these factors overlay the space syntax factors. Therefore, the syntactic factors are practical to analyze the more objective factors of the landscape. However, the more the landscape factors lose their physical dependency, the syntactic analyses lose their accuracy. Also, due to the vital⁵ and dynamic nature of the landscape, and its factors are dependent variables not independent, the syntax factors cannot analyze the landscape in some cases. Therefore, new landscape approach parameters and factors must be added to the space syntax. The new indicators of the landscape are subject to the landscape approach factors. A landscape approach factor has various aspects of objectivity and subjectivity. Its objective and subjective aspects are interrelated, and its indicators change based on the landscape approach factor. For example, the physical and objective aspect is more in permeability and movement, and its indicator is independent. Therefore, it can be easily analyzed by a syntax system. However,

the subjective aspect is more than the objective aspect in the vitality factor. Its indicator is semantic and based on humans. That is, the variable indicator is based on all humans. These subjective-emotional indicators have an objective and measurable manifestation despite being semantic. For example, collective furniture is the turning place and indicates the landscape approach sign and other elements of the landscape approach. Memorability is the semantic variable, depending on the individual, and its objective manifestation might be eliminated, or its manifestation is interpretive-subjective and requires its specific audience's interpretation and reason (Fig. 2). As can be perceived from Figure 2 and Table 2, the factors of the emotional-subjective-objective spectrum require necessary condition factors, and the interpretive-subjective factors are sufficient conditions. The interpretive-subjective factors are the desirability criterion of space and are directly related to the individual's experience from space and the time that he/she has spent. The result of having lived experience of space is memory and familiarity. On the other hand, according to experts, 1. Symbolic and sign aspect, 2. Personal experience, 3. The collective event, 4. Historical reputation are the most aspect of the semantic desirability of the urban landscape. The common feature of all these indicators is memory and lived experience. Therefore, in the normal conditions when the factors and necessary conditions are provided for the lived space, memorability can be considered as the most significant factor of the landscape approach desirability. Memorability is a relative factor and

depends on the individual's mind. What is manifested as memory in mind requires material and objectivity on the outside. However, objectivity is a tool to associate mental memory. This interpretive-mental (drama⁶) factor is the most significant parameter for the desirability and sense of belonging to space. The new indicators of landscape compensate for the semantic aspect, which has been neglected in the space syntax indicators.

Discussion

The landscape has aspects that have been neglected in the space syntax system. The syntax system can investigate the necessary conditions of the landscape approach (objective, and emotional-mental) but is inefficient in the sufficient conditions of the landscape approach (Interpretive-mental). New indicators must be considered in a simple graph to insert the semantic-drama factors (sufficient conditions) of the landscape approach into the syntax system. A weighted graph is used to this end. That is to say, a weight must be considered for any landscape factor which has a strong subjective aspect and dependent variable and must enter this indicator in the quantitative analyses. Therefore, landscape and its new indicators with subjective-semantic value overlay on the space syntax network, which is an objective-physical network, as a network of values. After integration of two syntactic and semantic layers, the landscape syntax is formed as a new network with a landscape approach (Fig. 3).

Figure 3 is an example to show the orientation of the landscape approach to compensate for the gap in the

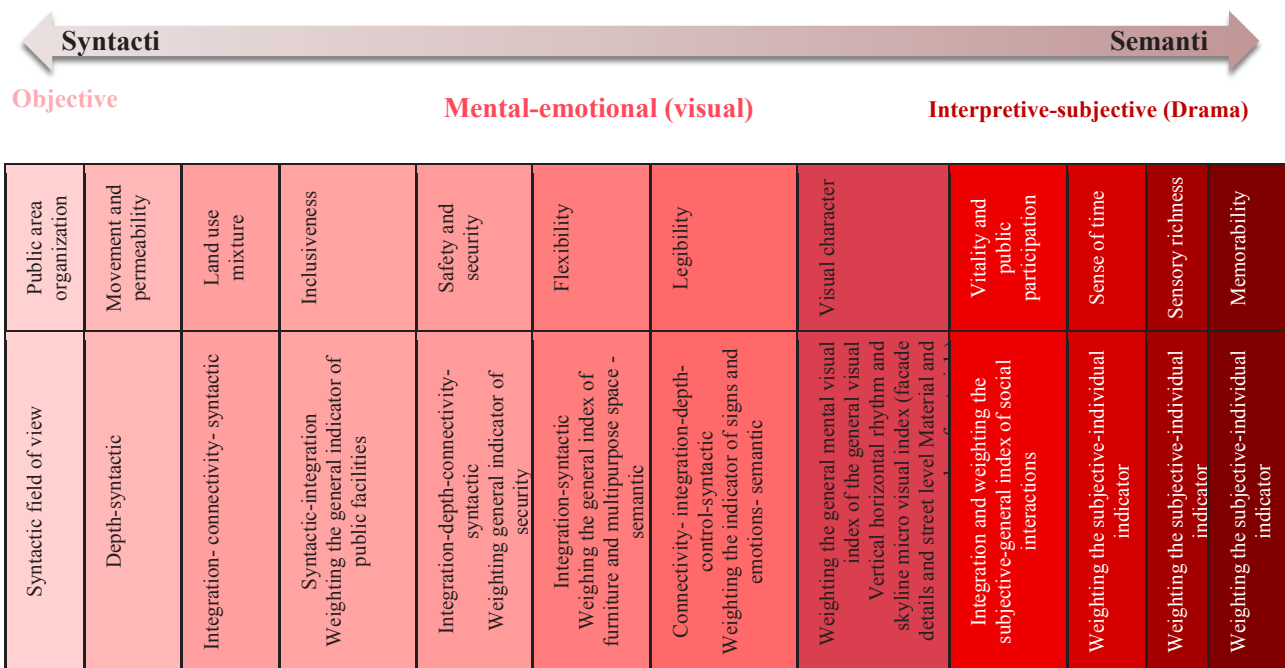


Fig. 2. Conceptual model of the spectrum of some of the landscape approach factors from the functional area to semantic and the required indicators. Source: Authors.

Table 2. The landscape is both an objective-subjective phenomenon. Its objectivity and subjectivity are inseparable. However, it is possible to study objectivity and subjectivity separately. The objective and physical factors of the landscape can be investigated due to their syntactic nature using the space syntax technique. The more subjective and semantic the factors, the less their syntactic dependency, thus, the more inefficient space. Source: Authors.

Landscape factors		
Objective factors (Syntactic)		<ul style="list-style-type: none"> - Space physique and body - The necessary condition required to create the subjective factor measurable by space syntax software and experts analysis
Subjective factors	Emotional-mental-visual (classic)	<ul style="list-style-type: none"> - It does not require previous experiences, and it is perceived by sensory confrontation or space's physique and objectivity. - It can be perceived by the public. - They are natural, intrinsic, and are dependent on the sense and emotions. - Necessary condition factors - Can be investigated by space syntax system, and evaluated by experts' analysis
	Subjective-interpretive (drama)	<ul style="list-style-type: none"> - Subjective-interpretive factor depends on time and requires previous experience. Its meaning is perceived by the reason and establishing relationship between the scattered perceptions. - It is interpretable for the specific audience. - It depends on the audience's experience and is a rational combination. - It is the desirability criterion and sufficient condition - It is evaluated by users' valuation (citizens)

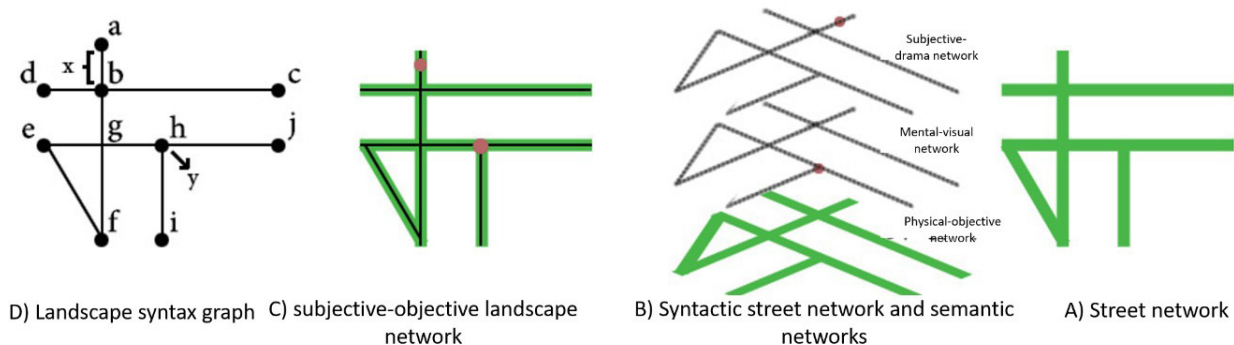


Fig. 3. A) Shows a network of presumed streets. B) Semantic networks of landscape approach (visual and drama), C) integration of syntactic and semantic network, the subjective-objective network of landscape with all its features and semantic and physical aspects, D). A diagram of the considered graph is mapped. Source: Authors.

space syntax technique. First, the street syntactic network and its semantic networks are analyzed to study the presumed streets network. The street with a mosque is in the a-b path, and a central bank (visual sign) is in the h intersection. The mosque is a drama-mental parameter because a sense of mosque space requires individual experience. Therefore, the more lived experience of the individual (the time spent in this space), the more its memorability and sensory richness. The central bank is a visual sign of the visual-subjective factor. Space lived experience is not required to perceive. Also, its semantic space can be perceived by the public. Syntactic indicators specific for landscape are considered in the objective aspect. However, in the landscape syntax network, the geometry of the street network is preserved the same.

In contrast, the syntactic network of space syntax technique is a simple graph of zero and one. In Hillier's space syntax technique, the geometry and part of space have been neglected. Also, all the urban spaces, including intersections, streets, and collective spaces are considered the same in the calculations. In this method, the accesses are merely considered, and the dimensions, size, height, and form are ignored. Therefore, in the landscape syntax, the physical network is considered the street network form. In the next phase, these semantic and syntactic networks are integrated. Then, an objective-subjective network of the landscape results with all its semantic and physical features and aspects, which makes it possible to study the qualitative factors quantitatively. Then, the considered diagram is mapped. The graph includes

nodes and lines. In contrast to the space syntax theory nodes that indicate the main streets and spaces, here, the nodes indicate the intersections. The graph edges indicate the streets. Therefore, drawing the graph is the same as imaging the plan, in which all the spaces are considered, and it is possible to value and weight the space parameters. In this graph, the a-b edge has a mosque. Therefore, it is weighted and valued by the x coefficient. H node also includes a sign and is weighted by the Y coefficient. These numerical values are considered between zero and two and vary based on the space parameter qualitative value. If the space parameter has more semantic value, the coefficients are close to 2. However, if the qualitative value is negative and has spatial repulsion (such as bad smell along a street), this value is close to zero. Therefore, the objective and subjective aspects of the landscape are investigated together using this method.

Conclusion

If we want to replace the term “space” with the term “landscape” in the space syntax structure, the new landscape approach indicators must be added to the syntactic factors to enter the landscape concepts in the space syntax structure. The space syntax factors are based on a simple graph diagram. In evaluating four indicators, integration, connectivity, control (choice), and depth, integration is the most significant space syntax technique indicator. Hillier’s space syntax theory considers its increase as a reason to increase the physical public area quality. The landscape approach factors are in a range of their dependency on the objective aspect (physical) and the subjective aspect (semantic) to obtain the new landscape approach indicators. In this spectrum, the landscape approach factors and their indicators

are classified into three groups as follow: 1. syntactic factor: based on the dependent objective and physical indicator, 2. emotional-subjective (visual) factor: based on the public dependency indicator, 3. the interpretive-mental meaning factor (drama): based on the dependent individual indicator. In the normal conditions where the factors and necessary conditions are provided for the lived space, memorability is the most significant landscape approach factor for the space desirability. This semantic factor can be investigated through symbolic and sign indicators, personal experience, collective events, and historical reputation. In the landscape syntax, the semantic indicators, such as a network of values, overlay the landscape syntactic network. In contrast to the simple graph of the space syntax, in the landscape syntactic graph, the geometry and form of the space physique are preserved. The landscape approach factors with appropriate values are added to the weighted landscape syntax graph by valuating each landscape indicator. The valuation is mostly conducted in the semantic factors, especially the interpretive-subjective factors ignored in the simple syntactic graph. The weighted graph resulted from the landscape syntax can be transformed into the matrix and algorithm and evaluate quantitatively. The research results are consistent with the landscape syntax definition.. Although a systematic and comprehensive method is required for broad interdisciplinary studies, this paper can provide the ground for these studies by presenting a solution. Adding the landscape approach factors to the space syntax method is a two-way interaction to improve both landscape and space syntax approaches. The landscape syntax is included in the landscape area, and the space syntax will have semantic aspects.

Endnote

* This article is taken from the Ph.D. thesis of “Saba Sultan Qurraie” entitled “Explaining the nature of the landscape using the space syntax” which was supervised by Dr. “Seyed Amir Mansouri” and Dr. “Maryam Singery” in 2021 in the Faculty of Art and Architecture of Islamic Azad University, Tabriz Branch has been completed.

1. “Natural Movement Theory” argues that it is the movement that creates the space network and forms the urban life and rejects the common idea of place as an object and the movement between two places as another object.
2. “Economic Movement Theory” explains that the city’s activities become compatible for the maximum use of the movement.
3. “Pervasive Centrality Theory” shows that the centrality functions are distributed throughout the network and create a pattern, which is more complicated than what has been predicted in the poly-centrality theories. However, it can be recorded by the analysis of the space network configuration.
4. There are only two values of 1 and zero in binary values. Binary

matrix is a one and zero matrix.

5. In definitions, landscape has always been dependent on two main elements. Eliminating each of these elements can disrupt the landscape perception. First, it is the environment that surrounds the human, and second is the human who enters the environment to perceive and establish a relationship with it and visualizes it in his mind over time. Therefore, it is necessary to consider landscape a dynamic and alive organism. Landscapes are affected by human and the relationship with him. On the other hand, it associates the memories occurred over the long time in the environment and affected the human-landscape relationship, resulting in changing the civilization and culture of the human (Mahan & Mansouri, 2016, 26).

6. In Greek, the meaning of Drama has been “Implementing”. However, in today’s English, drama is a specific way of narrating, a story, and indicates the reaction in function. In the current paper, drama is used to refer to the subjective factors that require interpretation, such as story.

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