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A Comparative Analysis of Spatial Configuration in Designing Residential Houses Using Space Syntax Method (Case Studies: Houses of Isfahan and Modern Architecture Styles)

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Abstract

In the traditional Persian architecture, the design of different spaces of houses was based on the needs of their inhabitants, and these needs affected even the arrangement and the mode of spatial relationships. In contemporary architecture, housing patterns do not usually meet the needs of their inhabitants. This research investigates spatial configuration in a sample of houses of the first modern and Isfahan style architecture; in order to find the functional space and the most important factor affecting the space syntax. Selected samples were analyzed using "E-Graph" software, and by calculating the average and the Pearson coefficients of three variables of depth, integration and connectivity, and the correlation of these variables on space syntax was studied. The results show that in traditional houses, the yard and the porch, had the role of connection in the system; and Majlesi (chamber) was located at the lowest depth. In modern houses, the living room and the hall are functionally used and perform as space divider while other spaces connect to this space with direct access. Finally, the variables of integration and connectivity had the greatest impact on the space syntax, both in traditional and modern houses.

Keywords: Comparative Study; Connectivity; Depth; Integration; Residential Houses; Space Syntax; Spatial Configuration

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1. Introduction

Home is meant to be a place to live and is considered as the safe privacy of a person. The dimensions of tranquility and comfort are among the most important qualities of a desirable house, and their lack may distort the serenity of the man. In Iranian and Islamic culture, the concept of home as a place to meet the various needs of residents has been considered. In terms of characteristics of an Iranian house, it is possible to refer to features such as the definition and distinction between territories, secrecy, privacy, security and safety, tranquility, introversion, and human scale (Pirnia, 2013).

Some of these features have been transformed by new constructions and inspired by the western style of homebuilding, and have been transformed into mere imitation, and has been overlooked during the time. More important than the physical changes seen in modern buildings, there are spiritual and psychological changes, and today's housing is completely different from traditional homes. Family focusing in an environment with a delightful and delicate structure would bring family members comfort and relaxation, and the distance from the house's entrance to the house's seating place gave the person a chance to fit into the interior environment of the house. A person who enters the home without any preconceptions, the dichotomy of the environment inside and outside, makes him confused in the proper communication (Saremi & Shahbazi, 2016).

In the space and structure of traditional houses, before entering the main building, the courtyard and the entrance hall create a different space for the man, and the special space of the house makes him ready to face the household and spiritual and mental connection with them. Consequently, using the comparative study of spatial configurations in traditional houses and analyzing the greatest changes in the connectivity of the public and the private spaces, this traditional pattern can be used in modern houses.

This research attempts to study the adaptive space syntax in a sample of primer, modern architecture houses and Isfahan style architecture in order to find the functional space and the most important factor affecting the connections and the composition of the space in houses. How to make this comparison is using space syntax method and using "E-graph" software, which will analyze the priority of the arrangements of the spaces in the studied houses. Therefore, the hypothesis of the research is that it seems that the type of functional spaces has undergone changes, in the course of time, and it also seems that the index of integration affects the syntax of the space in different domains of the houses more than other variables. Thus, the questions of this research are:

- Which of the various home spaces has had a more functional role over time?
- Which of the variables has the most impact on the syntax and configuration of the space in traditional and modern house samples?

2. Theoretical Basis

2.1. Space Syntax

Space syntax is a theory and a technique for analysis in architecture and urbanization, which began in the late 70's and the early 80's by Steadman in London. The syntax or configuration of space here means the examination of the relation of each space unit among spaces in a complex. Just like examining a word inside a text and its relation to the other words. If a building is considered as a tool, consisting of a spatial connection system, the presentation of the connection system will be in the form of a graph (Hillier et al., 1987).

Understanding these graphs and patterns means recognizing social relations in spaces. Understanding social relations means knowing the activities of consumers inside the spaces. These activities and relations in the space are premier to the shape or general form of the space. Ultimately, the space syntax providers argue that it can be used to analyze spatial relations (Dawson, 2002). Although the constructor or the architect creates a unique form, in order to achieve this form, he/she arranges the spaces together (Haq & Zimring, 2003). The building is the creation of spaces by elements and components. These spaces are created for specific functions and for people or consumers using them. Each space creates a specific connection between the consumer and the space. Here, the arrangement of spaces together means the internal relations of the spaces that are used by the consumer (Montello, 2007).

Thus, it is possible to recognize the social relations of the users, by recognizing spatial relations. In this field of concept, building is seen as a social object and architecture is seen as a social art. The shape or final form of the building introduces a system of spatial relations.

2.2. Configuration Theory in Architecture

This theory was founded by Hillier and Hanson in London in 1984, and is based on researches on the relations between social and spatial forms. The spatial configuration is based on the theory of graphs and is used for space syntax analysis (Jeong & Ban, 2014). This theory believes that space is the core of how social and cultural incidents occur. Since space in turn develops throughout social, cultural and economic processes, it is usually regarded as a platform for social and cultural activities, to the point where the form is almost not considered and it is assumed as invisible (Makri & Folkesson, 2000).

The theory emphasizes that, in deep understanding of urban spaces, the role of urban spaces as individuals and the characteristics of that space in small scale is less important in comparison to its role in combination with other elements of the city and its macro-scale and the whole urban system characteristics (Hillier et al., 1993).

In this regard, the main idea behind the configuration theory is the concept of spatial configuration, in which the connection of each element to other elements of the entire system is essential (Hillier, 2007). From the view of this theory, the relations between activity and space are understood and defined in relations between spaces or spatial structure and also connections between responders and social interactions, rather than being individually defined in the characteristics of space (Rismanchian & Bell, 2010; Hillier, 2007).The features of space syntax approach are examined by using indicators that are as follows:

1. Connectivity: It is defined as the number of points in the space that are directly connected to the other spaces. For instance, the connectivity of a room with two entrance doors to an adjacent space equals to two according to the Equation 1:

$$C_i = K \tag{1}$$

Where K is the number of points that are directly connected to the intended point and C_i refers to the connection at i-th point (Khalesian et al., 2009).

For studying the connectivity, based on the type of movement in each space, the nodes in each graph are divided into four categories:

- Space with one connection
- Space with two connections or more
- Space with two connections or more that is part of a ring.

- Space with three connections or more that connects two rings at least.

Therefore, the type of space is determined in terms of movement (communicational, syndetic, and static space) influenced by the socio-cultural aspects of everyday activities.

2. Integration: According to some people, this is the most significant output of this method. Degree of integration is the depth average that is passed to reach from a node to all other nodes in the system. On a linear map, the integration value of a line or space is the average number of lines that by using them, reaching to all other lines in the whole system from that one line is possible. Obviously, lesser the average, the closer the connection of the node with the other existing nodes, or in other words, the node is more accessible. The more depth average means the more separated space. Spaces that have higher levels of integration in the system usually have more permeability.

Given that the integration value usually computes the relationships of a line with other lines, the value obtained or the concepts taken by it, such as the concept of permeability, have a communicational and conceptual value, and not the metric one (Lam, 2008). Of course, in new methods, by converting a linear map into a segmental map, it is possible to include metric factors in the calculation, which extends beyond the scope of this paper.

This value is checked to determine the degree of continuity or differentiation of each space in the system. Integration can be measured by relative asymmetry or real relative asymmetry as follows:

$$RA_i=\frac{2(MD_i-1)}{n-2} \quad \text{and} \quad RRA_i=\frac{RA}{D_n} \tag{2}$$

Where $D = 2\{n(\log_2{}^{((n+2)(3)-1)} + 1)\}[(n-1)(n-2)]$, n is the number of points, and MDi is the average depth from the i-th point (Khalesian et al., 2009).

3. Control: Control is a parameter that determines the degree of privilege of a point over its immediate neighbor points. In other words, a lower degree of choice of one point with regard to a specific point means that the former has a lower amount of control over the latter (Kamalipour et al., 2012). See the Equation 3:

$$Ctrli \ : \sum_{j=1}^{k} = 1/\mathrm{Cj} \tag{3}$$

Where K is the number of points immediately connected to the point I, and Cj refers to the connection at the j-th point. Ctrli denotes the amount of control at i-th point (Khalesian et al., 2009).

4. Choice: Choice is a general measure of the flow rate in a space. In fact, a space offers a high probability of choices from a large number of shortest connectivity paths intersecting that space (Jiang & Claramunt, 2002; Lima, 2001).

5. Depth: Depth is not a main parameter in space syntax, but it is central for calculating integration at a given point. In general, it should be illustrated as one of the steps one must take to pass from a point to the other points (Jiang & Claramunt, 2000; Lima, 2001). See the equation 4:

$$\mathrm{MDi} = \frac{\sum_{j=1}^{n}=d_{ij}}{n-1} \tag{4}$$

Where MD_i is the average depth from the i-th point, n is the total number of points and $d_{i,j}$ is the shortest path between points i and j (Khalesian et al., 2009).

2.3. Spatial Arrangement

The spatial arrangement means the composition of spaces together and their interconnections. As it is seen in the Figure 1 below, there are three different types of layout arrangements. The two cubes on the left are not connected; in the middle, the relation is symmetric and equal; and on the right, the relation is asymmetric (Hillier et al., 1993).

Now this relationship can be checked with a third object. In Figure 1; on the left, each of the cubes is individually linked to the lower cube; in the middle, each of the three cubes is connected; and on the right, to reach each of the last cubes, it must be passed through the middle cube. The illustrated justified graphs describe the issue better.

To get from each cube to another, it must be passed through one or more objects. The number of objects to pass through is the same as the depth of the cube related to the original cube. By changing the layout of the cubes, all the spatial arrangements will alter. In the city, this phenomenon can be seen that changing the shape of buildings and streets or creating new streets will change the entire spatial relations of the city, and these changes will affect the citizens' imagination of the city and, subsequently, the behavior of the citizens in the space (Raeisi & Habibi, 2008).

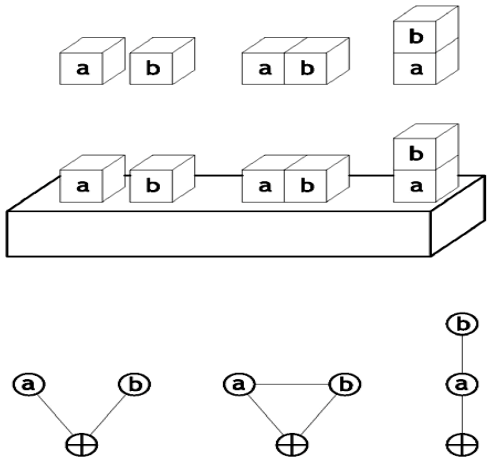


Fig 1 Justified graph of space syntax (Hillier et al., 1993)

There are also three main concepts in the analysis of space syntax, which are (Klarqvist, 1991):

Convex Space: Space where no line between the two points goes outside the perimeter of the space. Therefore, a concave space should be divided into the minimum number of convex spaces.

Axial Space: Axial space or axial line is a straightforward sight-line view that is understandable as a walker.

Isovist Field: This field includes all areas that are visible from any single point.

Accordingly, there are three types of analytical systems in space syntax:

a) Axial line analysis:

Axial lines (axial map) are a graphical diagram that derives from the catalysis of streets and open spaces. This diagram is developed on special software and it is the basis of the space syntax. On the axial map, the highest sight-lines and access lines, which are visible, are displayed. This map will contribute to divide the urban spaces into convex spaces, in all of which there are two basic principles of access and visibility (Hoeven & Nes, 2014).

b) Convex space analysis:

In this system, the convex space is analyzed from two aspects: (a) Spaces exhibiting non-linear behavior, and (b) Buildings and common spaces between them, as well as the interior arrangement of houses (Jiang & Claramunt, 2002; Klarqvist, 1991).

c) Visibility graph analysis:

The initial idea of this analysis comes from the fields of view that were visible from a certain point. Hence, the basis for this pattern is the reflection of light, which determines the patterns of people's motional behavior in the environment (Bendikt & Burnham, 1985; Jiang & Claramunt, 2002; Montello, 2007).

2.4. House and Layout Concept

Among the surrounding environment, house is the most immediate human-related space, and in everyday life, it is both influenced by human and influences human. The house is the first atmosphere in which humans experience the sense of spatial belonging. The five senses always pass through it all over, and shortly afterwards, they get accustomed (Norberg-Schulz, 1980).

House is the only place where the first immediate experiences with space are formed, both in isolation and group. For Moore, "The home is the center of the world for its inhabitants, and is the most significant building for consolidation of the place for its vicinity"(Moore et al., 1974).

To be an effective and active building, it is necessary to identify and categorize all its spaces, and then, by predicting the appropriate relationship between them, the building can be operated as a particular unit (Rossler & Glasgow, 2005). Housing design is also no exception, and before designing, it is necessary to determine the classification or, in other words, the layout of spaces. Before doing the job, the appropriate criteria for this task must be specified, so that the placement of harmonious and consistent spaces in one category is done correctly and the inconsistent areas are separated. Typically, these indicators are derived from an examination of cultural, continental and belief patterns (Hansson, 2008).

3. Research Methodology

This research is practical based on its purpose and is methodologically comparative with the use of analysis and description. The space syntax method has been used for this research. The research process consists of eight different houses (four modern styles and four classic Isfahan style) with a number of almost identical spaces that are selected in the city of Isfahan. The ground floor plan of the houses has been studied, and the courtyards and the alley or street space are also considered as a space. In addition, the spatial relations of different parts of the houses with the spaces have also been studied to compare the degree of privacy in different constructions. For this purpose, using “E-graph” software, the justified graphs are drawn according to the building plans the sets.

E-graph software draws a justification graphs based on the plan entered as a background and it calculates the main parameters of the spatial syntax based on the plotted diagram (Manum et al., 2005). Finally, by calculating the average of the three variables of depth, integration, and connectivity, first, their normal distribution or abnormalities will be evaluated using the Kolmogorov Smirnov test, and then the Pearson coefficient and the correlation of these three variables on the space syntax will be investigated.

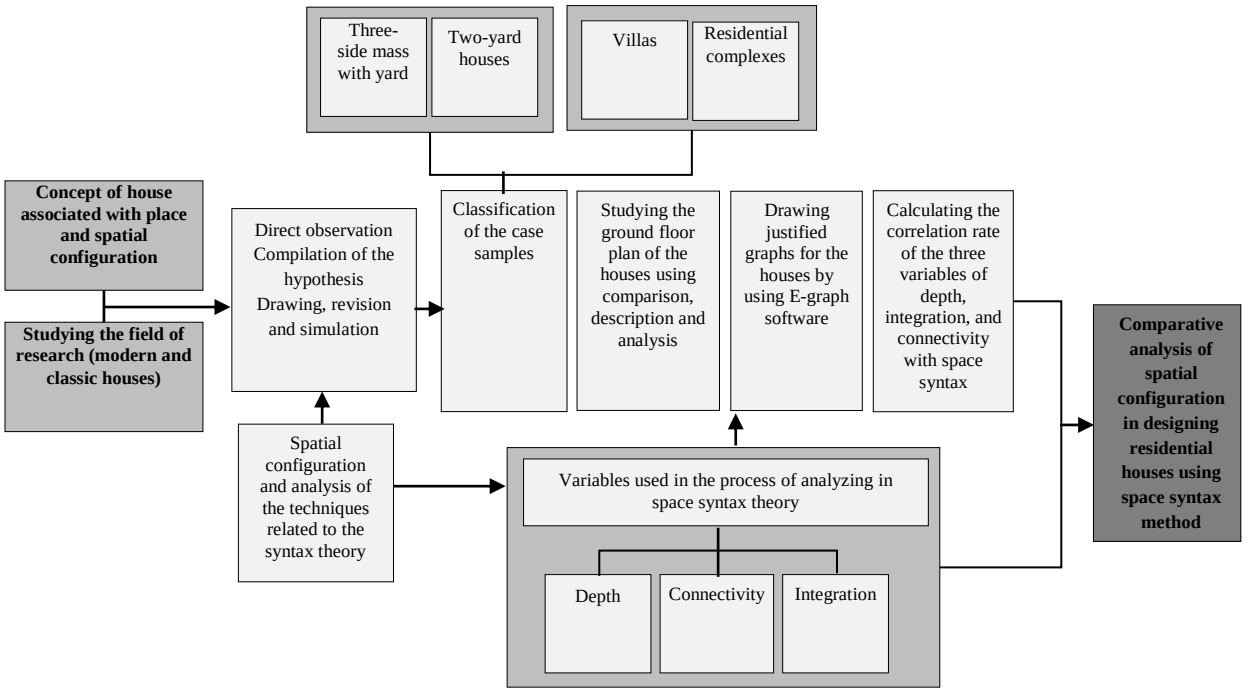


Fig 2 Conceptual model

4. Case Study

As previously mentioned, this research seeks to make a comparative study of spatial connectivity in the design of residential houses using space syntax method. One of the most important issues in the selection of traditional and modern houses was that the houses would be equal in terms of the number of spaces (different sections). For this purpose, eight housing patterns were selected consisting of four types of housing with traditional architecture and four types of residential complexes and contemporary villas in Isfahan. In the following, case examples of traditional and modern houses will be introduced.

4.1. Traditional Houses

1. Traditional house of Sayed Kazem Arabi

The house belongs to the Safavi period and on 1996, it was registered as one of the national monuments of Iran. On the east side of the house, the palaneh and the roof are being destroyed, and there are inadequate bracings on this side.

Fig 3 Traditional house of Sayed Kazem Arabi

2. House of Martha Peters

The house was built in the Safavi period and was registered in the list of historical monuments of Iran in 1974. The House of Martha Peters has a different pattern compared to its current ordinary houses, and it seems that the overall layout of the house was originally located in the middle of a garden, which has undergone some changes over time. The main part of the building is a cubic shape belonging to the Safavi period, and has four Sofehs in its middle. This space has a height of two floors and has porches on both sides of the east and west. The four-sofeh ceiling is decorated with Mogharnas and its walls are covered with decorations of plaster modeling, mirroring, gilding, and engraving of angels, which caused special features.

This space and the porch on either side were faced to the garden and the lighting was provided on its four sides. In the four corners of the main section of the house, there are rooms that are connected to the porches and the middle space. On the southern side of the building, there is a porch in the middle and two triple-door rooms on the sides, which are likely to be added later to the building.

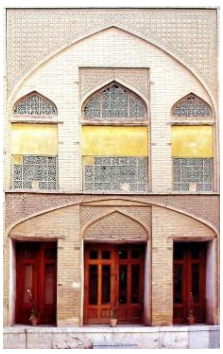



Fig 4 Martha Peters House

3. Sokisian House

This house is one of the remains of the Safavi era, and is composed of a vast, long yard and spaces on both sides of the northern and southern sides. On the southern front, the more important spaces are located, and it overlooks another courtyard on the other side. The southern yard consists of two-column ivy facing a beautiful pool. Two three-door rooms with different depths, both overlooking the main courtyard of the house, are located on the sides of the porch, and behind each of them there is another room that is connected to the second courtyard.

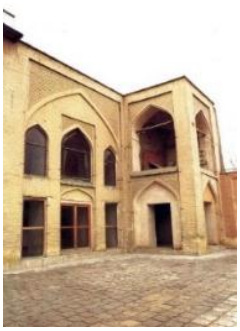



Fig 5 Sokisian House

4. Haqiqi Brothers House

The house dates back to the Safavi period, and there is also a little footprint of the Qajar architecture. It was reconstructed a few years before the Islamic revolution, and part of it has been repaired in recent years. The house is made up of a fairly large space consisting of a pool, a courtyard with brick floor and garden, and also in the north part of the building, the magnificent main room with a very beautiful sash window was built and its walls decorated with decorations of paintings and statues. The reason why this beautiful and interesting house is located among the famous attractions of Isfahan is the similarity of its gilding and flower ornaments with the architecture of Karimkhani castle in Shiraz. This work was added to the list of national works of Iran in 1974.

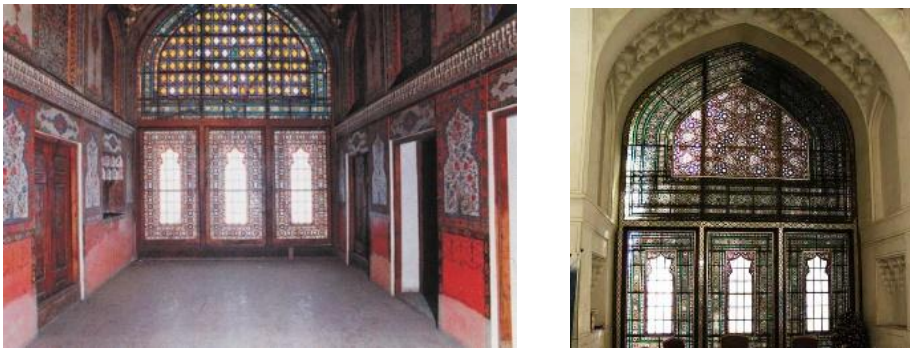


Fig 6 Haqiqi Brothers House

4.2. Modern Houses

1. Duplex Villa House – Phase Two

The house is a modern style and duplex house, located at the Imam Khomeini Street- Resalat 1. One of the challenges that made this project difficult to design was that the space was exposed to sunlight just from one side (south side). For this reason, suitable actions are taken to design the body and the land area. This project is a perfect example for defining architecture as an art for organizing the space. Accommodating private and public arenas was an architectural work of art. To a better use of light, the designer puts the main spaces in the southern part such as kitchen and bedrooms. The main space of the villa is designed to provide a sense of harmony for interior space by collecting different uses in different layers under one roof.

2. Duplex Villa House – Phase One

This villa is located on Jey Street. Most of the lighting of the villa is from the east and west, and the size of the windows is small, so it is in poor condition in terms of lighting. Access to the villa is directly from a main and broad street. The interior space, the exterior façade and the entrance of the complex have a simple design with no decorations.

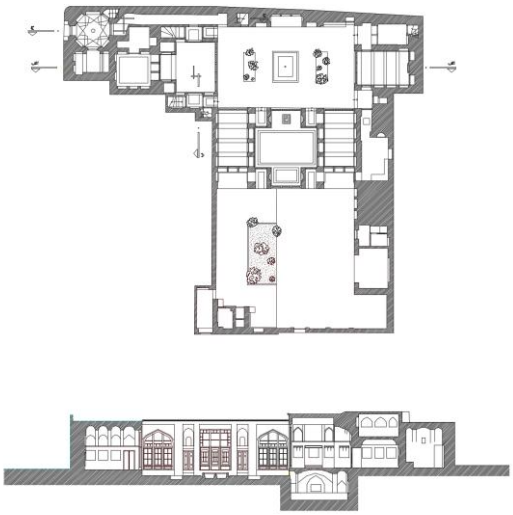
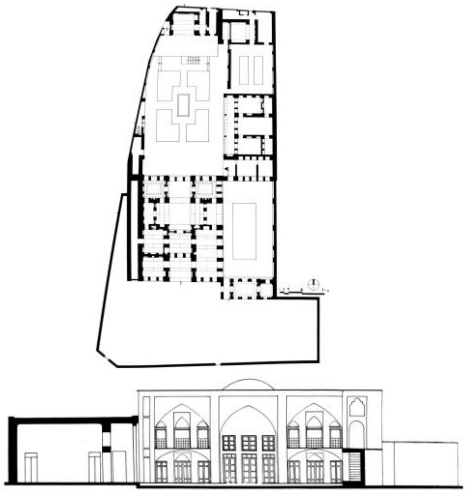
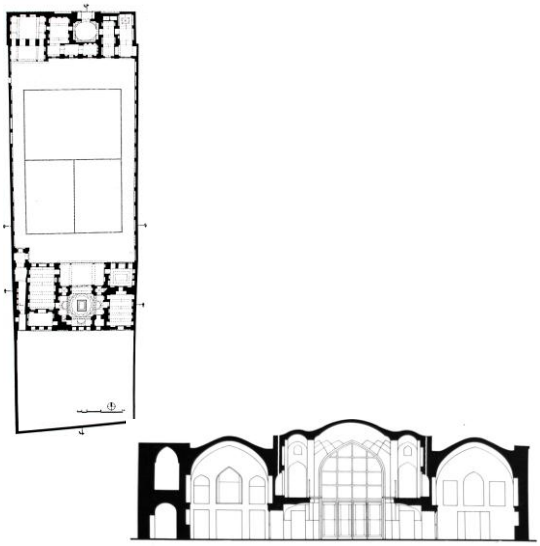
3. Sepehr Moshtaq Residential Complex

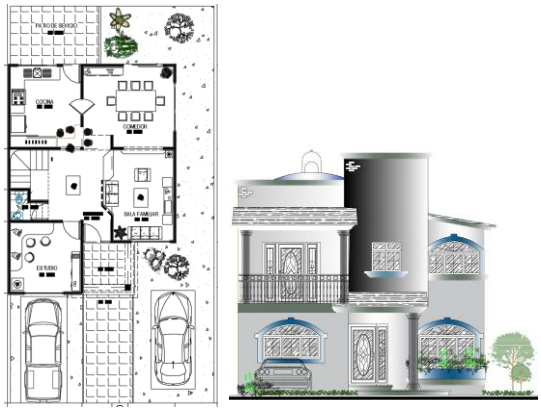
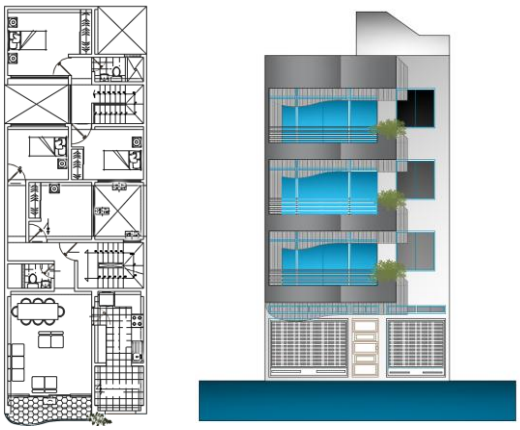
The complex is located on Moshtaq Street, along the Zayandehrud bank, and it overlooks the greenery and the river, so it has a very beautiful landscape. The project area is between 156 and 450 square meters in five floors on stilt. There are five duplex units designed to respond to the wide range of requests. This project contains luxury facilities, such as fan coil and chiller, swimming pool, sauna, Jacuzzi, smart systems, fire alarm system, etc.

4. Erison Residential Complex

Erison Residential Complex, located on Jey Street, is a four-story house. Access to the complex is direct from the main street, and access to the home spaces and their connection with each other is through the living space or the hall. The green space of the complex is located between the blocks and the architectural form of the building and its facade provides the use of ribbon windows to utilize maximum sunlight and to use larger terraces. The interior space, the courtyard and the exterior façade of the complex are very simple and have no special decoration. In general, the lack of proper yard in today's complexes has caused poor lighting and its impact on the shape and dimensions of doors and windows and the absence of the porch.

Table 1 Ground floor plan of the traditional and modern houses

Isfahan style houses	
 Arabi house	 Martha Peters house
 Haqiqi Brothers house	 Sokisian house

<table>
<tr><th colspan="2">Modern style houses</th></tr>
<tr><td> 
Duplex Villa House – Phase One</td><td> 
Duplex Villa House – Phase Two</td></tr>
<tr><td> 
Sepehr Moshtaq Residential Complex</td><td> 
Erison Residential Complex</td></tr>
</table>

5. Discussion and Analysis

5.1. Depth

1. Depth in Traditional Houses

As noted above, depth has a semantic social meaning. As the depth increases, the space becomes more private and the permeability of the space decreases. The courtyard and the porch, and then the entrance space, are considered to be the public domains with the least depth. The reason to depth of the entrance is that there are sub-entries for each home, which opened to spaces such as the storeroom. After entering the house and passing the courtyard and porch, the kitchen and Majlesi are the two spaces for which easy access have been provided. At the next level of the depth, there are the room and the windbreaker that is indicating an increase in the degree of privacy in these spaces. The bathroom and the warehouse are also among the most private spaces in the complex (Fig 7).

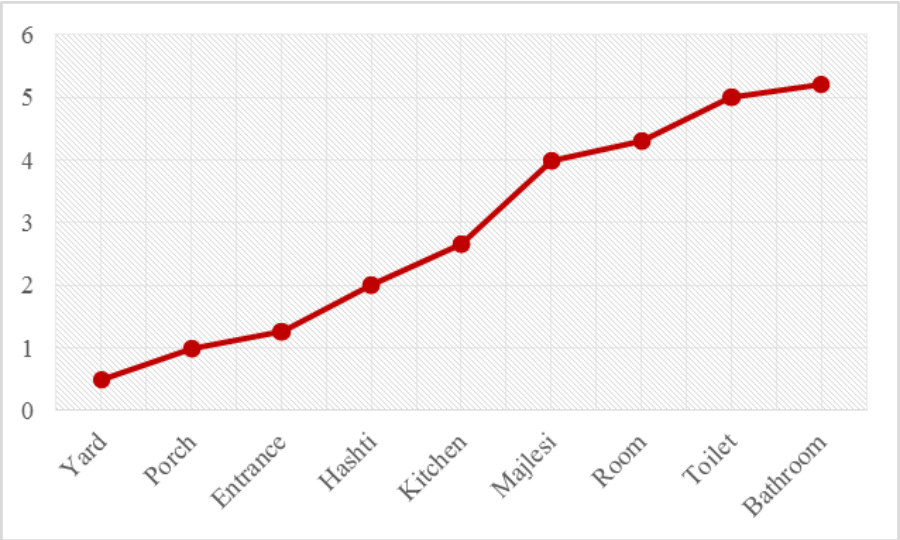


Fig 7 Depth average in traditional houses

2. Depth in Modern Houses

In modern houses, bedrooms have a low depth, while in traditional style houses they have the highest degree of depth or the lowest degree of integration. As the bedrooms integration degree has risen over the time, the privacy, intimacy and comfort of these spaces have also diminished. Nowadays, due to space constraints and lack of courtyard, in some cases, the rooms have the same role as the courtyard of modern houses. Modern private spaces are often protected only by the doors, and if the doors are open, they would show the space. In fact, privacy is not being protected in the same way all over the space, and there is no intermediary space (often a corridor) that prevents them from encountering other spaces (Fig 8).

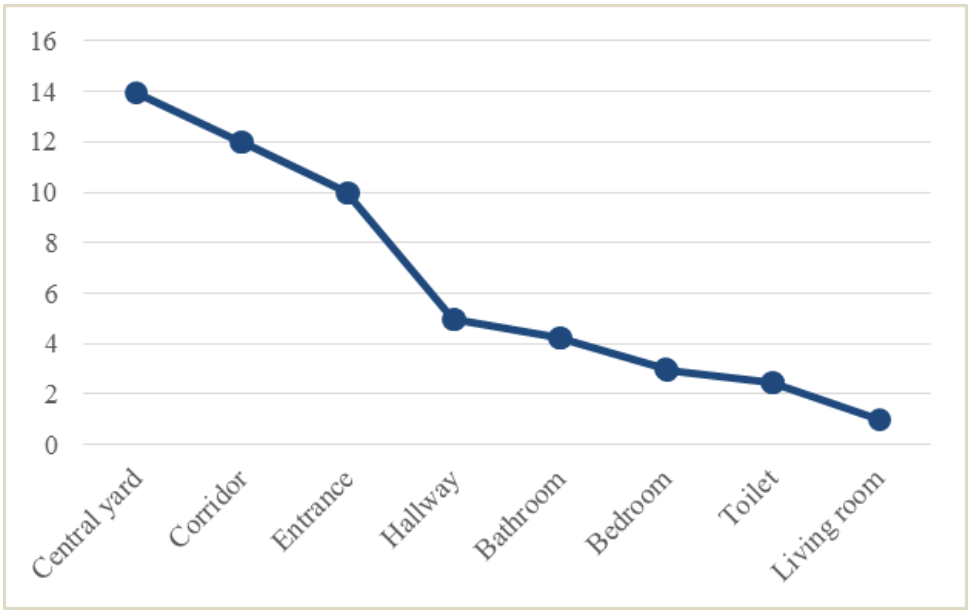
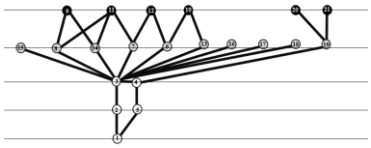
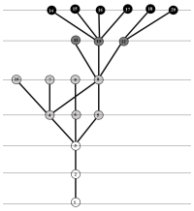
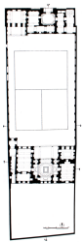
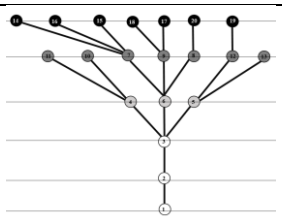
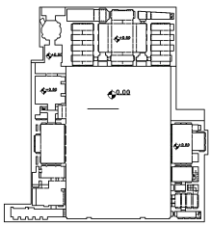
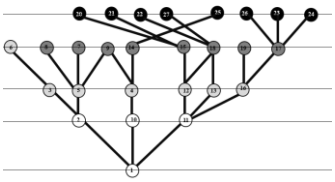
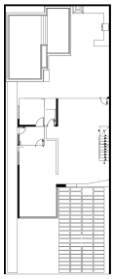
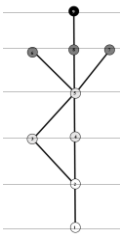
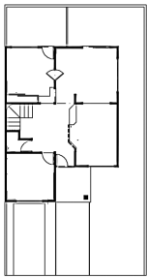
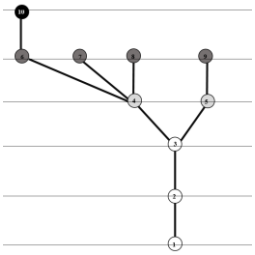
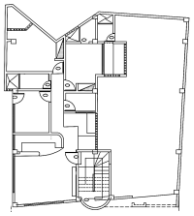
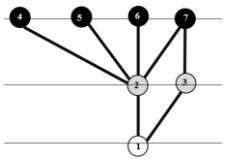
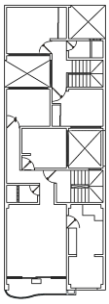
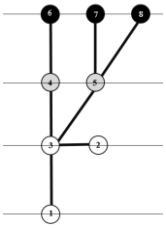


Fig 8 Average depth in modern houses

Table 2 Selected samples and graphic justification diagrams by E-graph

House	Plan	Justified Graph
Arabi House		
Martha Peters House		
Sokisian House		
Haqiqi House		
Duplex Villa House – Phase Two		
Duplex Villa House – Phase One		

Sepehr Moshtaq Residential Complex		
Erison Residential Complex		
Legend:	Spaces with zero depth ○	Spaces with highest depth ●
	Depth lines of spaces |	Connectivity between spaces —
Increasing the darkness of the color of each layer represent an increase in the depth of space, so that no-colored circles are symbols of spaces with zero depth and black circles are symbols of the most depth.		

5.2. Integration of the Spaces

1. Integration in Traditional Houses

According to the calculations, the porch and the yard in traditional houses have the highest degree of integration. Therefore, the two spaces have lots of connections with other spaces, and access to the deeper spaces takes place through these two points. In fact, they perform as the distribution space. In addition, the low depth and small integration of the kitchen reflect deployment in a shallow depth and easy access, but there is a lack of a strong connection of this space with other spaces. The most remote areas of the complex are rooms and bathrooms that tend to differentiate themselves from the system.

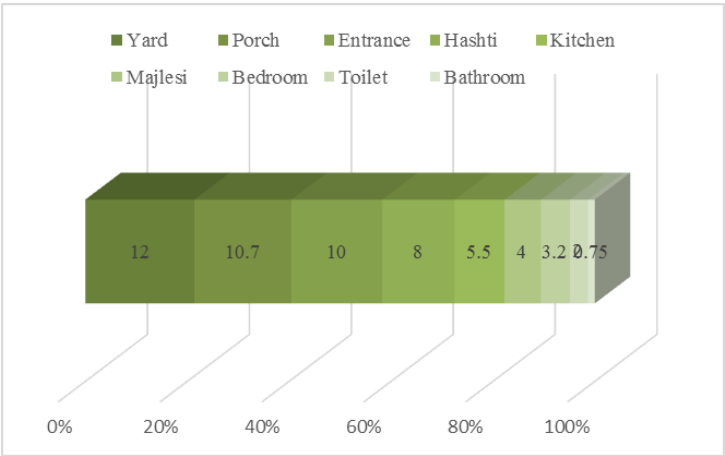


Fig 9 Integration spectrum in traditional houses

After these three spaces, the room and the kitchen have the lowest integration. Due to the low depth of the kitchen, the low level of integration in this space indicates its distance from other spaces and its indirect relation to other spaces through distribution or connecting spaces (Fig 9).

2. Integration in Modern Houses

In studying the modern house, the most integration was the connection between the living room and the courtyard. The entrance from the street i.e. the connection between inside and outside of the space was in a way that includes a relatively high integration with the interior spaces of the house, and this is more related to the living room and hallway space. This may indicate that the hierarchy of access to the public, private and semi-private spaces in modern houses is less noticeable, and also there are more tendencies to the connectivity with outer spaces. Bedrooms are also considered as the spaces with a higher degree of integration than the average; meaning that in modern homes, bedrooms are not included in isolated spaces and have a proper connection with the rest of the spaces. This may affect the privacy level of the spaces such as the bedroom, and it may not provide the tranquility and comfort needed for such spaces (Fig 10).

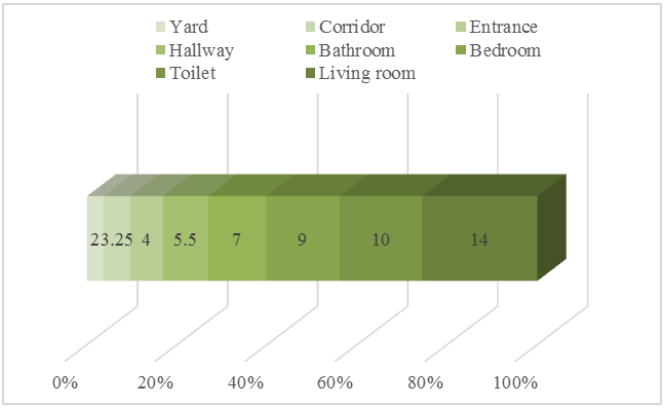


Fig 10 Integration spectrum in modern houses

5.3. Spatial Connectivity

1. Connectivity of Traditional Houses

The yard and the porch, are often of the type and the space "b" or "c", with two connections or more, and are considered to be connectivity spaces. As space is closer to the "d" type (connector of connectivity rings), it plays a more important role in the house performance, because space "d" acts as a dividing space and the background for spatial change and entry into different activity spaces. The results of the study of the courtyard and the porch spaces in traditional dwellings suggest that there is such a property for these two spaces.

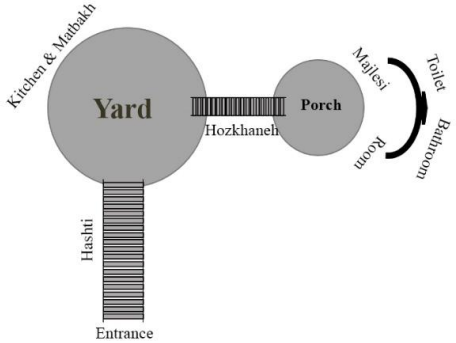


Fig 11 Schematic diagram of spatial relationships in traditional houses

2. Connectivity of Modern Houses

In modern houses, the most connections are between the bedrooms, the entrance and the living room, and they provide the most connections to the toilet, kitchen and the yard, and serve as functional spaces, which illustrate how to divide the house into the service-provider and service-receiver areas.

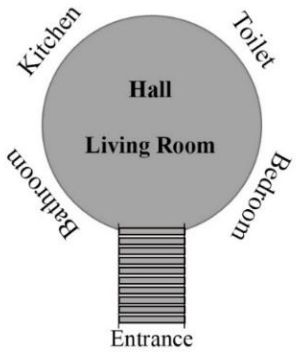


Fig 12 Schematic diagram of spatial relationships in modern houses

5.4. Calculating the Correlation of Depth, Integration and Connectivity variables on Spatial Configuration

At this level, depth, connectivity, and integration for the spaces in each house are calculated, and then the average depth, integration and connectivity for the two categories of traditional and modern houses are calculated. After that, Pearson coefficient was used to investigate the correlation between depth, integration, and connectivity and the syntax of the space.

Table 3 Average of depth, integration, and connectivity variables in traditional and modern houses

		Depth	**Integration**	**Connectivity**
Average	Traditional Houses	1.724	0.1547	3.7941
	Modern Houses	2.248	0.843	3.9311

5.5. Sample Distribution Normality Test

In this section, it is necessary to identify the distribution of the obtained data in order to select the appropriate tests according to them, and to evaluate the hypotheses. For this purpose, the Kolmogorov-Smirnov test is used. The hypotheses of this test are as follows:

(H0): distribution of the sample is normal

(H1): distribution of the sample is not normal

The hypothesis test results are presented in Table 4.

Table 4 Checking normality of the variables

Variables	**Significance level**	**Distribution status**
Space syntax	0.002	Not normal
Depth	0.000	Not normal
Integration	0.000	Not normal
Connectivity	0.000	Not normal

In this study, the connection between the characteristics of the relationships and the spatial arrangement of the house, including "depth", "integration" and "connectivity" in traditional homes, villas and residential complexes, were examined (Table 5). The results of the survey explain that there is a meaningful relationship between the two parameters of "integration" and "connectivity" with the relation and spatial arrangement.

This confirms that people living in traditional homes are more concerned with these two features as the spatial layout of the house, but the depth character is not significantly related to the spatial relationships and layout, so this feature has not been effective to change the pattern of space syntax over the time.

Table 5 Correlation level of depth, integration and connectivity variables with spatial arrangement in traditional and modern houses

			Depth	**Integration**	**Connectivity**
Space Syntax	Traditional Houses	Pearson Coefficient	0.524	0.75	0.79
		Significance Coefficient	0.415	0.00	0.00
	Modern Houses	Pearson Coefficient	0.548	0.84	0.93
		Significance Coefficient	0.461	0.00	0.00

The research findings indicate that:

1) The entrance of a traditional house represents less connectivity and integration compared to the entrance of modern houses to the outside and public space. This feature indicates that the entrance of a modern house has the same value of corridors. This balance means that the privacy space of families is gradually declining.

2) As shown in the analyses, the bedrooms in the modern houses have a high integration and a low depth, while in the traditional style houses they have the highest degree of depth or the lowest degree of integration. As the bedrooms integration rises over time, the privacy and tranquility of these spaces are diminished.

3) In the past, the courtyards played an important role in establishing a connection between different spaces. Today, due to space constraints and in some cases lack of the courtyard, the living rooms have the same role as the yards in the past and show a high degree of integration. The highest number of entries and movements is seen in the hallways and corridors.

6. Conclusion

Space syntax is a method for analyzing the architectural space with the purpose to discover social relationships in space, such as the creation of privacy and the degree of privacy and generality of the space. Examining the space syntax in eight samples of housing from traditional houses in Isfahan style and residential houses in modern style resulted in the following information:

a. Depth

In the traditional houses, the courtyard and the porch with the least depth are considered as a public space, Majlesi as a semi-public space and the rooms, the bathroom and the toilet as a private space. In the modern houses, the hierarchy of space has changed and there is the least depth level in the hall and the living room, and these spaces are considered as public spaces, and the rooms and the kitchen are considered as semi-public spaces.

b. Integration

In the traditional houses, the porch and the yard have the most connection with other spaces. The degree of integration with other spaces is low, in the sense that the most of the planes are dense and the spaces are considered as separate rooms around the courtyard, which are connected with each other by the yard or the porch.

In the modern house, the living room plays a functional role for other spaces and the highest level of integration exists in these spaces. In this style, rooms, kitchen, bathroom and toilet are located at different angles alongside the living room and the hall.

c. Connectivity

In the traditional houses, the porch is considered as a control room for entry into the private spaces of the complex. In fact, the yard and the porch are defined as the division space. Most areas of the houses are assigned to functional or activity spaces, and only 15% of the occupancy level is devoted to connectivity space.

Spaces are divided into two domains of service-provider and service-receiver, and each with a separate core.

The rooms and Majlesi are service-provider areas with the centrality of the porch and the bathroom and kitchen are service-receiver areas with the centrality of the yard. In fact, the courtyard provides access to the service-provider spaces and the porch provides access to the service-receiver spaces. Therefore, the kitchen and the toilet have a strong connection to the yard, as well as Majlesi and the rooms have a strong connection with the porch.

In modern houses, the living room is considered as a space to enter other spaces. In fact, in modern buildings, these spaces perform as division spaces. There is also direct access from rooms, bathrooms, toilets and kitchens to these spaces, and finally, the hierarchy of the spaces is lost and direct connections have been replaced.

By calculating the correlation level and the results of the survey, there is a significant relationship between the two parameters of "integration" and "connectivity with the relations and spatial arrangement. This means that people living in traditional homes often demanded to have indirect access to private spaces in the design of homes, but people living in new residential complexes and villas tend to have direct access to the interior spaces of the house.

In general, the analysis and discussion above confirm that privacy in new houses is not emphasized. Although this change may be due to new lifestyles and new technologies, an overview of the physical and mental needs of humans in the past centuries shows that many of these needs have existed throughout human history. One of these needs is the need for privacy space. Without denying the fact that the needs vary at different times, one cannot completely ignore a particular need; therefore, the revival of the architectural quality of the privacy space in traditional Iranian homes is a necessity.

A comprehensive study of this type of architecture in order to extract and redefine concepts that are not present in contemporary life will certainly help to meet the basic needs of society, in addition to increasing the degree of intimacy and privacy in the spatial organization of contemporary architecture. We suggest that each building project be simulated in its early stages to make it possible to analyze the internal behavior of its inhabitants and thus to solve the problems and to improve the quality of construction.

References

Bendikt, M. L., & Burnham, C. A. (1985). Perceiving architectural space: from optic arrays to isovists. In W. H. Warren, R. E. Shaw, & J. N. Hillsdale (Eds.), *Persistence and change*. Lawrence Erlbaum: Connecticut.

Dawson, P. C. (2002). Space syntax analysis of Central Inuit snow houses. *Journal of Anthropological Archaeology, 21*(4), 464-480.

Hansson, M. G. (2008). The Private Sphere as an Emotional Territory-A Psychological and Evolutionary Perspective. In *The Private Sphere* (pp. 33-52). Springer, Dordrecht.

Haq, S., & Zimring, C. (2003). Just down the road a piece: The development of topological knowledge of building layouts. *Environment and Behavior, 35*(1), 132-160.

Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1993). Natural movement: or, configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and Design, 20*(1), 29-66.

Hillier, B., Hanson, J., & Graham, H. (1987). Ideas are in things: an application of space syntax method to discovering house genotypes. *Environment and Planning B: Planning and Design, 14*(4), 363-385.

Hillier, B. (2007). *Space is the machine: a configurational theory of architecture*. Space Syntax.

Hoeven, F., & Nes, A. (2014). Improving the design of urban underground space in metro stations using the space syntax methodology. *Tunnelling and Underground Space Technology, 40*, 64–74.

Jeong, S. K., & Ban, Y. U. (2014). The spatial configurations in South Korean apartments built between 1972 and 2000. *Habitat International, 42*, 90–102.

Jiang, B., & Claramunt, C. (2002). Integration of space syntax into GIS: new perspectives for urban morphology. *Transactions in GIS, 6*(3), 295-309.

Kamalipour, H., Memarian, Gh., Feizi, M., & Mousavian, M. (2012). Formal composition and spatial configuration in native housing: a comparison of the division of parlor space in traditional houses in Kerman. *Maskan va Mohit-e Roustaee Journal*, 138, 3–16.

Khalesian, M., Pahlavani, P., & Delavar, M. R. (2009). A GIS-based traffic control strategy planning at urban intersections. *IJCSNS, 9*(1), 166.

Klarqvist, B. (1991). *Manual för rumslig analys av städer och byggnader*, Göteborg, Chalmers Tekniska Högskola.

Lam, K. S. (2008). An introduction of space syntax. Retrieved February 16, 2009, from http://wiki.uelceca.net.

Lima, J. J. (2001). Socio-spatial segregation and urban form: Belem at the end of the 1990s. *Geoforum, 32*(4), 493–507.

Makrí, M., & Folkesson, C. (2000). *Accessibility measures for analyzes of land use and traveling with geographical information systems*. Paper presented at the Urban Transport Systems: Proceedings of 2nd KFB-Research Conference. Lund. Institute of Technology, Lund, Sweden.

Manum, B., Rusten, E., & Benze, P. (2005). AGRAPH, software for drawing and calculating space syntax graphs. In *Proceedings of the 5th International Space Syntax Symposium, 1*, 97.

Montello, D. R. (2007). The contribution of space syntax to a comprehensive theory of environmental psychology. In *Proceedings of the 6th International Space Syntax Symposium*, Istanbul.

Moore, C., Allen, G., & Lyndon, D. (1974). *The place of houses*. Univ of California Press.

Norberg-Schulz, C. (1980). *Genius loci: Towards a phenomenology of architecture*. New York, Rizzoli.

Pirnia, M. (2013). Stylistics of Iranian Architecture. (Tehran: Soroush Danesh Publication). Thirteenth Edition.

Raeisi, I., & Habibi, A. (2008). Space syntax approach in analysis and design of Urban Space. Case Study: Down the Qazvin Quarter. *Quarterly Abadi*, 58.

Rismanchian, O., & Bell, S. (2010). Reviewing the application of Space Syntax in understanding Urban Space configuration. *Honarha-e-Ziba Journal, 43,* 49-56.

Rossler, B., & Glasgow, R. (2005). The value of privacy (Cambridge: Malden. Mass Polity).

Saremi, H., & Shahbazi, M. (2016). Studying the Effects of Residents' Behavioral Patterns on Energy Consumption Profile in Residential Buildings (Municipality No. 3, District 4, Tehran). *International Journal of Humanities and Cultural Studies (IJHCS) ISSN 2356-5926, 3*(2), 1547-1562.