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Home Architecture Data Mining from a Spatial Structure Perspective (Case Study: Jangjouyan House)

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Abstract

Information technology has led to significant advances in various sciences, including architecture, causing fundamental changes in the quantitative architectural research. In this regard, space syntax is one of the techniques used in space structure analysis that has created new horizons in digital modeling and design. From the syntactic theory point of view, space is the primary core in the state of social and cultural events. Moreover, rather than the attributes of space being individually definable, the relationship between activity and space can be perceived and defined within the existing relationships between the spaces as well as the relationships between spaces and the relationships between the addressees and social interactions. Through the desk and field studies and while getting familiar with the "Graph Theory" and the principles of space syntax (node, connection, spatial arrangement, convex space, and justified plan), this study attempts to evaluate the architecture of Qajar period from another perspective by describing its mathematical relationships in terms of total depth, mean depth, degree of spatial integration and the value of spatial control, and examine the relationship between spatial coexistence in an example of Qajar houses in Esfahan, and the House of Jangjouyan (Warriors' House) in particular.

The method used in this study is a descriptive-analytical one with a case study strategy, for which the definitions of "Gross Hopper" and" Space syntax" are used to quantify it. The present study introduces for the first time the value of control in space, which implies the adaptability of space as

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one of the indicators of flexibility. The results indicate that the courtyard positioning in the middle layers and its relationship with the intermediate spaces including the corridors, stairs, and partitions create a significant role for it, leading to its flexibility in the spatial configuration, while the location of yards in the primary layers in the contemporary homes has declined in importance and this role has been transferred to other spaces.

Keywords: Graph; Space Syntax; Spatial Configuration; Housing; Spatial Depth

1. Introduction

"Humans do not come to observe the constructions, but a wider world is hidden behind every architectural structure that humans come to see it" (Merleau- Ponty, 1962).

The meanings that the man-made environments and physical characteristics induce are the cultural and world-view principles and values of society that form the environment. The artificial environment, with its symbols, proportions, symbols, shapes, colors, and other attributes, reflects both the worldview and culture that provide its formation, promoting the required principles and values to the human beings that somehow play a part in the cultural developments (Naghizadeh, 2002: 62).

Thus, a construction requires a body, whose spirit demonstrates the spirit of culture and worldview of the community (Naghizadeh, 2002: 64). As a result, human understanding of the design problem is nothing more than clarifying the values, identifying priorities, and taking into account the goals that play an important role in fulfilling the design needs and potential factors. (Pourdeyhim, 2011: 13).

The house plays an integral role in the treasure trove of Iranian architecture as the embodiment of architecture and culture, and "one of the most important forms of social organization is the space with its dual nature, as on the one hand it is influenced by culture and on the other hand it affects it" (Ilka, Mansouri, Nasir Salami and Saremi, 2015: 166).

As a familiar subject to which humanity has a long and extensive relationship, a house a place to live and feel comfortable, which has always been considered one of the most basic and important human needs in history. Understanding the home and its place in the system of social relations between people and society is possible by taking into account all the symbolic, institutional, material and aesthetic aspects of the home, or "culture" of the home. These dimensions find cohesion and interconnection and form the "home culture" in "the anthropology of home" and with the help of the concept of culture. (Fazeli, 2008: 27).

Regarding the hardware and physical basis, housing is subject to the requirements of the time and the laws governing the material elements and human experience of the use of building materials and facilities and urban infrastructure, but regarding the software aspects, it is dependent on beliefs, values and cultures dominating the architect and the community.

Considering the native architecture of Iran reveals the role and special position of the house as an important element in architecture. The patterns are used in the design of indigenous homes in Iran, which are influenced by many factors such as climate, culture, social relations, etc. The pattern of housing architecture has also changed in contemporary architecture, with the change in lifestyle, population growth, land scarcity and other factors, (Asefi and Imani, 2016: 57) and this has led to leaving the Iranian architectural patterns. (Mahdavinejad and Shahri, 2014:32). Thus examining the old houses and analyzing the characteristics of the different types and uses of indigenous homes can reveal the common qualitative values (Asefi and Imani, 2016: 57) that can be used to meet the

challenges of contemporary architecture (Mahdavinejad, Tehrani and Karam, 2011: 205). However, more detailed knowledge of native architecture is needed regarding the developments in the field of architectural science and technology as a source of inspiration for the architects, to extract its practical implications. (Mahdavinejad, Tehrani and Karam, 2011: 206).

Locating spaces and the state of the relationship of spaces with each other are among the most important principles that can be explored and analyzed in the home culture. For this purpose, the space syntax method has been chosen as a technique for discovering the mathematical relationships in spatial configuration and interconnection relationships. It is an exploratory method that simultaneously tests the relationships between data and analyzes the degree of unity and duplication of data. In this method, no assumptions or structures are imposed on the data, and the data is allowed to determine the next steps itself.

2. Materials and Methods

Each work, including an architectural construction, is as a text, the reading of which is interpreted by the space user. From this perspective, architecture is also a kind of language (Nuremberg Schultz, 2008: 531), and since language is a system of interdependent words (Saussure, 1966: 114), an architectural work is similar to a text, whose words are the volumes, textures, and constituents, which often convey their message through the aesthetic and social codes, while they are semantically dependent. By travelling through this context (architectural), the viewer reads or views the important aspects of the work on the basis of his prefaces and presuppositions. (Shirazi, 2002: 13). Accordingly, "textual architecture" is connected to the time, thus becoming temporal and time-dependent (Raeisi, 2010: 50). The timing of the textual architecture reading process is the product of relationships that are interpreted as intertextual relationships.

Thus, the surrounding environment changes through a continuous process of transformation, and becomes so-called historical (Johansen and Larsen, 2002: 4), the transformation of which takes place through intertextual relations. Hence, "intertextuality" is a concept that implies the participation of a work in the discursive space of a culture (Culler, 1981: 114). Therefore, "intertextuality" involves the interconnection of layers of one phenomenon with those of other phenomena (of the same or non-congruent type), which results in the aesthetic and social cryptographic evolution of the textual architecture in the simultaneous and temporal relationships (Noghrehkar and Raeisi, 2011: 7).

The result of reviewing the native architecture leads to a correct understanding of the built environment and to lead to architectural and cultural patterns. Native forms and aesthetic values refer to parts of the language and are derived from symbols and social values. These symbols and symbols derive from personal and social identities and, in fact, represent social values and are the only way to protect the cultural and technical heritage of a civilization (Salingrus, 2014: 19).

Since the today's architecture of Iran is in its entire alteration from its past architecture, it should be possible to read its past architecture with the available tools to the today's architect. Reading the right architecture leads to building the right architecture. What follows from this reading can replace the unconsciousness. In other words, the past architects used their treasure trove of information, and today's architects can use the latest information in their new ways.

These transferred experiences are a kind of architectural culture heritage, and the products of this heritage reflect the temporal and spatial architectural culture of that particular land; the values that are the product of collective culture (Memarian, Hashemi Toghroljerdi, and Hamzehnejad, 2012: 248). It should be noted that the recognition of the past is not meant to be referring to the past, since this reference is principally ignored, and any emphasis on it will not lead to anything but the

imitation or staging. However, knowing and being aware of the process of developments in the past will be beneficial for the future actions. Thus, recognizing and measuring the criteria of "authenticity", "integrity" and "relative value" of historical constructions can play a valuable role in making new changes and developments (Hanachi and Fadaeinejad, 2011: 16).

Research in earlier works is bringing the collective memory to the present that has become meaningful over time and at a particular place and is one of the identifying factors; an emotion that has been going on throughout history and has been institutionalized within the individual of the community (Taghvaei, 2012: 70), having roots in typological values and can be analyzed and evaluated in two forms of hidden species or biological patterns (genotypes) and physical species (phenotypes) (Memarian, Hashemi Toghroljerdi, and Hamzehnejad, 2012: 248).

This knowledge addresses two completely different needs: on the one hand, it is a way to understand and control a complex system, and on the other hand it is a necessary tool in the design, by the aid of which the requirements can be made with consistent performance and structure.

In this way, the rules that link the patterns (nodes) are as important as the patterns themselves; similar to the words that cannot create a language without compound laws. A coherent combination of patterns creates a new pattern at a higher level, which also has additional properties (Salingrus, 2014: 12-13).

Importantly, the invention of a new template language does not require its complete replacement with an old template language. The coexistence of competing or complementary patterns is usually desirable and even necessary, especially if the new models (operating at different scales) have different positions in the language hierarchy. If these new patterns are properly connected, the richer and more stable systems will be established (Salingrus, 2014: 23).

It is to note that it would not be possible to analyze the evolution of an architecture without examining the evolution of its components or elements. On the other hand, any architectural work has the potential to be divided into two systems: the system of form and the system of meaning. Every form can exist based on the semantics, and the understanding of each meaning is made through the understanding of the form system. Hence, the meaning is the prerequisite for shaping with respect to any architectural work. The semantic system can be interpreted in two ways:

A) Discovery of the meaning: Referring to the time and place of the production of the work provides enough context for understanding the meaning of the form. In other words, it seeks to indicate the yesterday's meaning as in yesterday. In this rule, the researcher goes a step further for the required finding and removes the other semantic layers of other periods.
B) Creating the meaning: Adding other semantic layers to the work after accomplishing it. In addition to involving the primary meanings, this method also involves other concepts with respect to different times, which can be expressed in two different ways: Today's form may be the same as that of yesterday's, while its meaning may have changed over time; or the yesterday's form might have had extensions at different times up to the present day. Therefore, semantic layers would be created for the time layers.

Analysis of each architectural element in the form and meaning system has the following features and regulations based on the components:

A) Position: The system indicates the relation to the whole work in the mathematical situation of the form system. In other words, not every single element with a definite scale will have similar semantic implications in terms of different deployments.
B) Scale: This property represents the semantic differences caused by the change in the scale and size of an element. In other words, an element with a definite form at different scales has different semantic implications even with the unified deployment conditions.

C) Relationships: This attribute refers to the semantic and form transformation of an element in a composite form; i.e. the semantic and form aspects of an element in two singular and combined dimensions with other elements are different from one another, in such a way that the meaning and form provide a different meaning and form in the combined basis as compared to the singular condition.

D) Place: Place is the basis of meaning and form. Hence, understanding and perceiving each form essentially relies on the recognition of two contexts: human space and spatial human. In other words, differences in the conditions of locations make spatial humans, by which different human places express themselves in the form and meaning through these differences. In this case, a single phenomenon will have different results for different spaces. The most important feature of the relation of form and meaning to place is the identity. Human spaces and spatial human are influenced by internal and external factors in their evolutionary process, which have different dimensions.

E) Time: Transformations that form and meaning take in each architectural element in the time vector are classified into four different modes: First, form is produced in time in proportion to the evolution of meaning, and there is unity between the two dimensions. Second, the form has not undergone a change in the time and the meaning has not also encountered any transformations, in which case the form is re-emphasized due to having the semantic basis. Third, the form has left over time, but its meaning has been transformed. In this case, semantic replacement has occurred. Fourth, the form has evolved due to various reasons beyond the continuity of its place, and the meaning is left over time. In other words, a historical break has taken place and its identity has undergone a transformation. In the second and third modes, the form gets a symbolic expression and becomes timeless (Hosseini, 1999: 91).

According to Nicolaas John Habraken, the three main aspects of the social structures of a building are spatial organization, physical structure, and the light systems. He specifically points out that one of the most relevant aspects of human behavior is the "spatial organization". He also argues that the social role that has a particular space plays in the building is entirely based on its position in the transition from the public space to the private one (Habraken, 1988: 7).

The “Space Syntax Theory” or “the Space Layout”, devised by Philip Steadman, Bill Hillier, and Julienne Hanson, consists of the tools or techniques that can analyze the spatial structure of a building and help identify the considered potential of the past architecture in order to reuse them in order to adapt to the conditions and technology of the day, and accordingly achieve a pattern for the contemporary architecture design.

Understanding these relationships is developed based on Graph Theory in the form of mathematical relationships and can be explored in terms of the concepts such as depth of space, rate of integration, control value, and the choice value, which are discussed as follows.

2.1. Justified Plan or Drawing the Spatial Graph

"One of the achievements of the space syntax technique for analyzing the spatial relationships of a building is drawing a plan or the justification diagram" (Soheil, 2016: 47).

A drawing tool called a plan or justification diagram is used in order to extract the necessary information and read the hidden pattern and social relationships in the spaces. The term “justification” refers to the process of organizing the graph with the relative depth of the nodes from a space. This diagram shows the built-in communication features of the plan. In this regard, a structure based on the graph theory should be drawn for each space, which is referred to as “plan

justified structure" or "J-graph". In this structure, spaces are drawn as nodes and the relationship between spaces is drawn by lines.

The nature of this connection, which may be a door, a window or a ladder, is ignored, and only the fact that there is a connection between the spaces is recorded. Each surface or layer is displayed with dotted lines. This process converts the plan into a circular node diagram that are interconnected by lines and are accessed in different layers. Conventionally, the length of the lines and the dimensions and the size of the spaces have no effect on the graph.

Thus, the outermost space is named as the carrier or root node and is placed at the zero layer. Then, based on the different access and choices available to reach each space, a crest of the considered space is drawn to the first available space and an access level is defined with each new node and based on the type of access, for different layers to be formed. In fact, a bubble diagram can be achieved by the access levels and layers (Fig. 1) (Hillier and Hanson, 1984: 112; Ostwald, 2011-b: 739).

2.2. Depth

Organizing the living environment is possible by clearly defining the private and public areas and creating the spatial hierarchies, and defined living areas also enhance the sense of belonging and provides the identity to residential environments (Einifar and Aghalatifi, 2011: 17).

The depth of space coincides with the concept of territory; it is an intrinsic property that can provide human comfort. The territory is not only a space issue but also a social phenomenon (Shahbazi, Balali Oskoei, and Shahabi, 2017: 70). In fact, the territory is the situation and location of a community in the space; it is a prominent tool for moving through a simple space that can be seen as a supportive mechanism for the basic life requirements such as identity, motivation and security (Lawson 2002: 168). The physical, functional, social, perceptual-mental, cultural, and time factors are considered as the six indices of territory, some of which are subjective and the others are objective. However, the geographical-cultural factor is considered as the basis for other factors (Einifar and Aghalatifi, 2011: 19). The concept of depth has a social meaning. Increasing the depth indicates the separation of public and private surroundings. It means that if an individual wants to enter a building, he should pass a distance of a space from the origin in order to get closer to the private area. It indicates the social hierarchy or a social performance (Tabatabaei Malazi and Sabernejad, 2016: 77). The depth of the space is one of the most important effective factors on the quality of relationship between humans and space (Einifar and Aghalatifi, 2011: 18).

It can be said that depth is the number of spaces that need to be passed from one space to another, or to reach a specific axis or node. The depth index indicates the degree of separation of one space from another. In case of greater depth of space, it means that more space must be traveled to reach that space, and thus that space is more isolated (Masoudinejad, 2007: 11).

Depending on the depth, there are two parameters: the total depth and mean depth. The total depth refers to the spatial structure of the whole set, while the mean depth is a criterion for measuring the depth of each space relative to the extent to which the space in question is more private or public.

It is also important that increasing the depth of space, in addition to the separation, also increases the degree of spatial privacy. This indicates that the greater depth of the space complex causes the spatial hierarchy, the reduced access as well as accessibility to some other spaces, leading to greater control of space. Therefore, with increasing the depth, the controllability of the space is increased, resulting in the creation of the privacy factor in the environment (Heidari, Ghasemian Asl and Kiaei, 2017: 24).

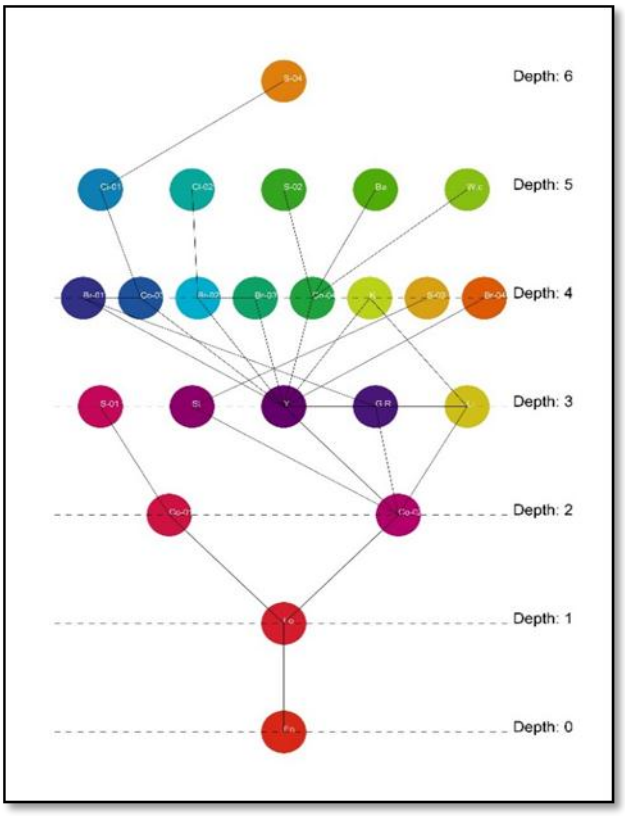


Fig 1 Spatial graph of the House of Jangjouyan from the entrance (Author)

The concept of depth in architecture is an expression of the attempt to express the conceptual and the gradual aspect of the perception process. This principle suggests a fundamental pattern of connectivity, transportation, and reception in order to reach a space such as a room, which expresses the extravagant aspect of reception in the space and emerges as a hierarchy of outside access (Zarei and Yeganeh, 2019: 102).

Depth in the architectural space also has a close concept of flexibility. Architectural flexibility is illustrated by the indexes of variability (the potential of different uses of one space), adaptability (potential to adapt to other spaces in different conditions) and variability (potential to change the spatial structure of a complex) (Kiaei, Soltanzadeh, and Heidari, 2019: 65). They are the indicators that play an important role in identifying the space efficiency (Hillier, 2007: 229).

Space performance efficiency means minimizing the influence of unrelated groups and properly organizing the related spaces along each other, which can be analyzed with the help of the concepts from space such as depth, connectivity and integration. (Peponis, 1985). Therefore, as the more public the space becomes, the greater will be the diversity of activities in it, and the more private the space, the more the diversity of activities diminishes, especially those related to the public domain of the home (Eika, 2015: 3-5).

By analyzing the set of factors that affect the degree of public aspect and privacy of the space, the degree of variability in its current activity and, consequently, its degree of flexibility can be analyzed and evaluated. One of these factors is the analysis of the influence of the space. The quality of influence indicates the access to different parts of space and has a direct relationship with

the amount of public or private aspects of the space. That is to say, increasing the influence means increasing the access to a space and thus making it more public and decreasing the influence means reducing access and thus making it more privatized (Kiaei, Soltanzadeh, and Heidari, 2019: 65). In addition to the visual accessibility index, the factor of influence can be analyzed using the spatial depth factor (Bentley et al., 1986: 162).

2.3. Total Depth (T.D)

The total depth denotes the number of trips an individual has to make from one space to another. In other words, the sum of the multiplication of the number of nodes (nX) of each surface at that depth (L) is referred to as the total depth (T.D) (Ostwald, 2011-a: 452) and is calculated as follows (Fig. 2):

$$\mathbf{TD} = (\mathbf{L_0} \times \mathbf{n_X}) + (\mathbf{L_1} \times \mathbf{n_X}) + (\mathbf{L_2} \times \mathbf{n_X}) + \cdots + (\mathbf{Lx} \times \mathbf{n_X})$$

2.4. Mean Depth (M.D)

The mean depth is the degree of depth of the node in the justification graph. By the comparison of the total depth and the mean depth, it can be concluded that the depth of a room that is above the mean range is more private than a room that its' depth is below average (Ostwald, 2011-a: 452). The method of calculating the mean depth (Fig. 2) is as follows:

$$\mathbf{MD} = \frac{\mathbf{TD}}{(\mathbf{n} - \mathbf{1})}$$

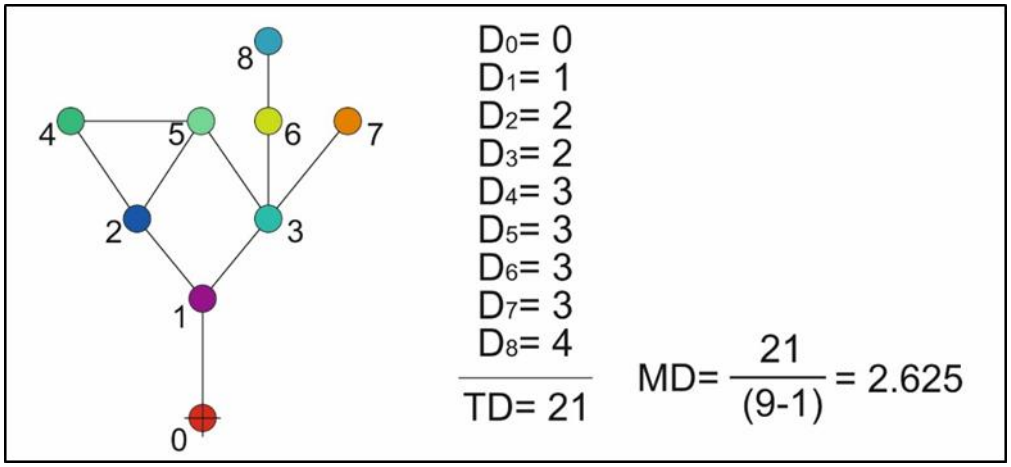


Fig 2 The graph and calculation of the total depth and the mean depth (Author)

Relative depth also defines the spatial domain as the basis for determining the degree of privacy and generality of each space, so that the mean depth lower than the relative depth value indicates the degree of public degree of the space.

2.5. Integration (i)

Dehkhoda dictionary refers to "integration" as “relative” and Moein dictionary considers it as "two or more people having interconnection and relation with each other". Both of these dictionaries seem to use the word “integration” for human relationship, while in the theory under discussion, the word “accretion” has a more significant expression than “integration”. It can be argued, however, that integration provides more weight for the overlap of human relationships discussed in space syntax (Hamedani Golshan, 2015: 86). Therefore, the important point in evaluating the interrelated structure is the spatial relationships and the continuity of its elements. (Bazrgar, 2003: 85). Integrity is a measure of accessibility. This criterion indicates to what extent the path is integrated or separated from a system as a whole (Ostwald, 2011-a: 457).

Interconnection or integration is the main concept of spatial syntax, which represents spatial cohesion (Melazadeh, Barani Pesian and Khosrozadeh, 2012: 86) and is the average number of interfaces, by which all the spaces can be accessed. In other words, the mean number of changes is the direction, from which the other spaces can be reached.

Integration is a concept of communication, not of distance, and therefore more closely related to the concept of depth than distance. In fact, the integration expresses the spatial consistency and the rate of interconnection of a space with other spaces (Masoudinejad, 2007: 15), i.e. the greater the integration in a space, that space has a higher consistency and integration with other spaces and the general spatial organization. Moreover, it has higher accessibility (Molazadeh, Barani Pesian and Khosrozadeh, 2012: 86). Evidence has shown that high precision integration axes absorb higher density of motion (Didehban, Pourdayhimi and Rismanchian, 2013: 44).

The space integration and differentiation have inverse relationship with the relative order. The lower this value, the closer will be the node to the other nodes, and in other words, the node will be more accessible. On the other hand, if the differentiation of the spaces is higher, it will indicate more private condition of the spaces (Memarian, 2002: 7-35). The degree of integration of space is shown by the (i), which is inversely related to the relative asymmetry and actual relative asymmetry. The results of the hierarchical integration of spaces show the minimum to maximum integration (Ostwald 2011-a, 464). If the relative asymmetry is in the range of zero and one, the integration results start at 1.00 and have no upper limit (Ostwald, 2011-a: 453). The lower the depth of space, the greater will be the degree of integration in that space (Hillier, 1996: 25).

The concept of integration in architecture corresponds to variability in the flexibility and can be analyzed in terms of expandability and transformability in physical bodies with the possibility of spatial integration and differentiation. In other words, if a space in a spatial configuration is associated with its adjacent spaces in such a way that it is possible to directly connect that space to each other, and if not needed, each of them can regain its distinct and original nature, then an integrated is formed between them, which can provide the basis of flexibility for the building.

Thus, increasing the integration in one space indicates increasing the likelihood of communication between that space and other neighboring spaces. On the other hand, the spaces that form a spatial configuration loop have the capability to integrate in the required conditions and, if not needed, by blocking a part of these connections, they can be used in separate spaces for specific activities (Kiaei, Soltanzadeh, and Heidari, 2019: 67-66).

2.6. Control Value (CV)

The probability of selecting an axis or a node relative to its surroundings is called “control” (Masoudinejad, 2007: 13). If the space is directly related to “n” spaces, it can control each of them

with the rate of "1/n". The control for each space is equal to the sum of the control of the spaces associated with that space (Tabatabaei Malazi and Sabernejad, 2016: 80).

Control is a parameter that determines the degree of authority of a point from other points to which it is connected. In other words, with the lower the degree of selectivity relative to a particular point, the control over it will be less (Kamalipour, Memarian, Feizi and Mousavian, 2012: 4). The rate of control can define the relative strength of the axial line in the potential absorption of its neighborhood and is calculated by the following relation, where Val (b) is the number of connections to the point "b" (Ostwald, 2011-a: 455).

$$\mathbf{CV\,(a)} = \sum_{\mathbf{D\,(a,b)=1}} \frac{\mathbf{1}}{\mathbf{Val\,(b)}}$$

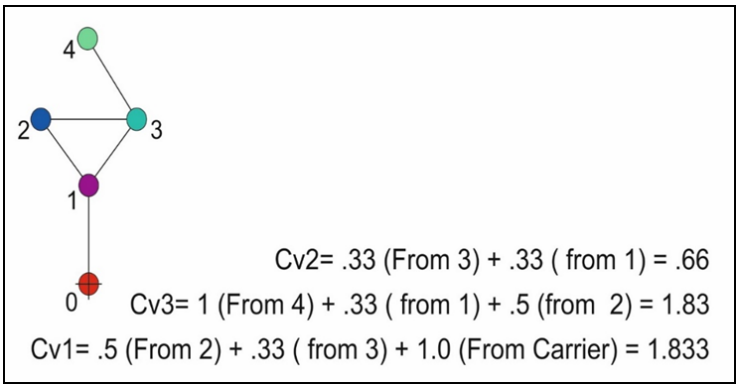


Fig 3 The graph and calculation of the control value (Author)

To calculate the CV of each node, the NCn of that node must first be obtained. NCn is the number of spaces that the node is associated with. Since CVe = 1 / NCn, the value of CVe is easily calculated for each node. Similarly, CV is the sum of CVe of nodes associated with the considered node (Ostwald, 2011-a: 456). Accordingly, there is more than one control value, and this refers to spaces that allow the required access (Shapiro, 2005: 52).

In other words, with the lower the degree of selection, the lower will be the degree of control over a given point. The adaptability index can be analyzed in the sense of control value.

3. Research Method

Data mining is the extraction of information and knowledge and the discovery of hidden patterns from a very large database. The use of data mining techniques in organizations results in a large number of laws and regulations that cannot be implemented due to limited resources and budgets.

In an informal definition, data mining is an automated process for extracting the patterns that represent knowledge, which is implicitly stored in huge databases, data store rooms and other large repositories (Ismaili, 2014: 26).

As a very influential component of urban communities and because of its wide dimensions, housing affects many other variables and is equally affected. One of the sources for recognizing the dimensions of this impact on architecture is the spatial data mining or spatial configuration (a set of relationships based on two or more features), which has direct relations to the existence and quality of each architectural work and forms a linking pattern between body and meaning.

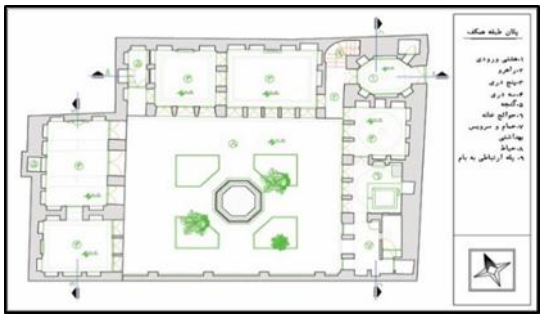
This role can be analyzed and evaluated in locating any space and its relation to other spaces to provide an approach to editing the today's architectural gene and to somehow modernize the native and original patterns of each culture and land, and maintain the architecture in the native conditions with the required adaptations to the environment.

The tool among the contemporary techniques that makes this data discovery is "Space Syntax", which can exhibit the hidden pattern of effect and relationship between the body and Exhibits socio-cultural behavior values such as the total depth, mean depth, integration, and control value, etc.

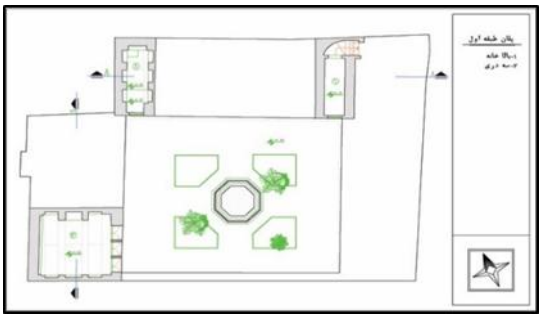
The House of Warriors (House of Jangjouyan) has been selected as a work of Esfahan's indigenous architecture in the Qajar era (as a period where the boundary between tradition and modernity in Iranian architecture was somehow the last era to embody the indigenous architectural values), which was once referred to as a model Indigenous housing and has nowadays been able to play a role in changing the way it has adapted to contemporary conditions with minimal changes.

3.1. House of Jangjouyan

House of Jangjouyan is located in District 3 of Esfahan, in Masjid Ali Lane, Haroonieh Street, next to Atiq Square, Ali Mosque, and Haroon Velayat Region, and is a late Qajar building. Its area is 350 square meters and its standing property is 240 square meters. The house consists of 22 convex spaces and has two floors in some parts (Maps 1 and 2). The building was renovated in 2009 and is currently being used as for residence (Emami, 2009: 22).



Map 1: 1st foor plan (Omran & Maskansazan "Civil & Housing Construction" Co.



Map 2: Ground floor plan (Omran & Maskansazan "Civil & Housing Construction" Co

4. Results

In order to analyze and evaluate the research findings, each node should be considered as a carrier node and a corresponding graph should be drawn. Then each data set is to be evaluated in the three modes of the lowest (maximum), highest (maximum) and average states.

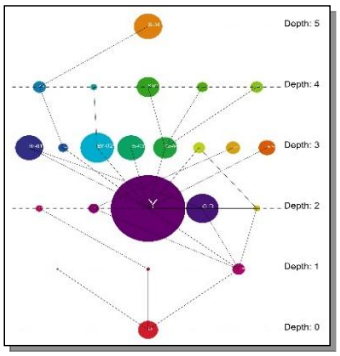


Fig 4 Spatial graph of the porch (Author)

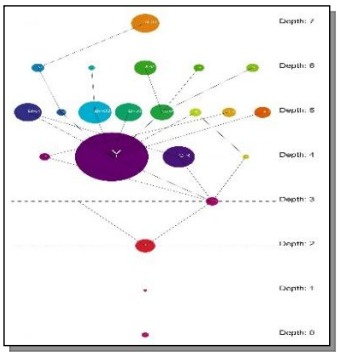


Fig 5 Spatial graph of the store room 1

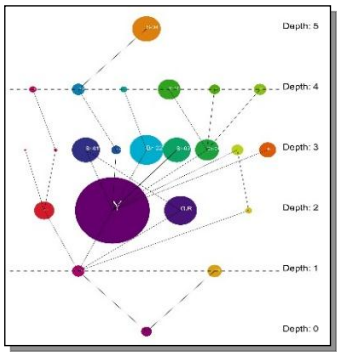


Fig 6 Spatial graph of the stairway

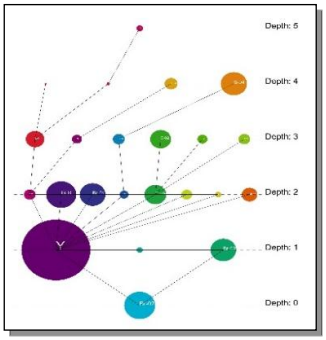


Fig 7 Spatial graph of the yard (Author)

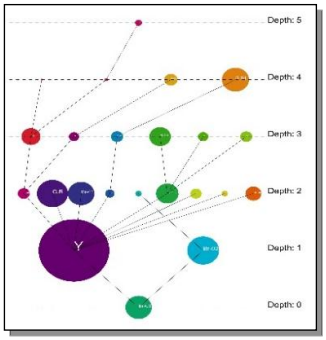


Fig 8 Spatial graph of the guest room (Author)

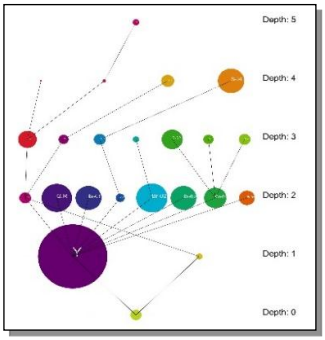


Fig 9 Spatial graph of the room 1 (Author)

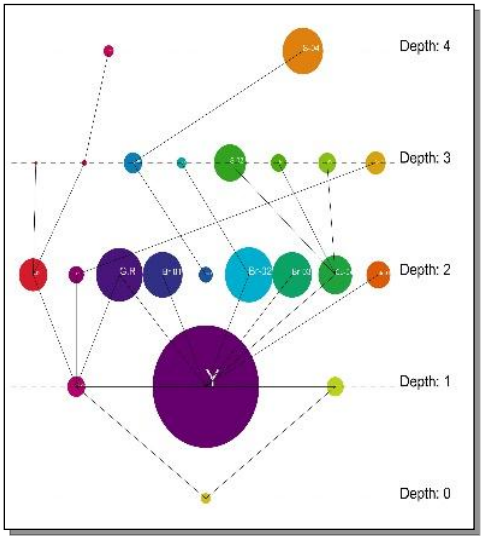


Fig 10 Spatial graph of room 2 (Author)

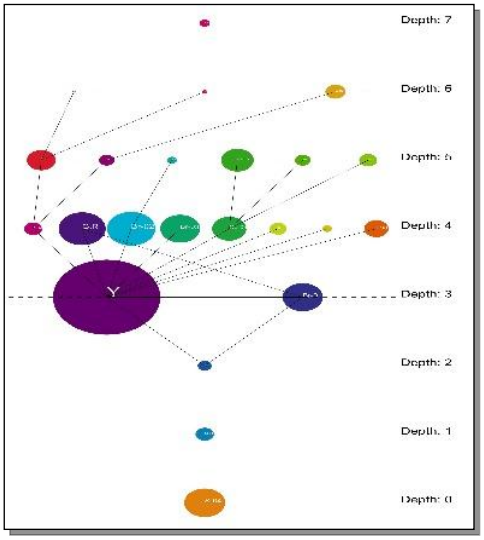


Fig 11 Spatial graph of room 3 (Author)

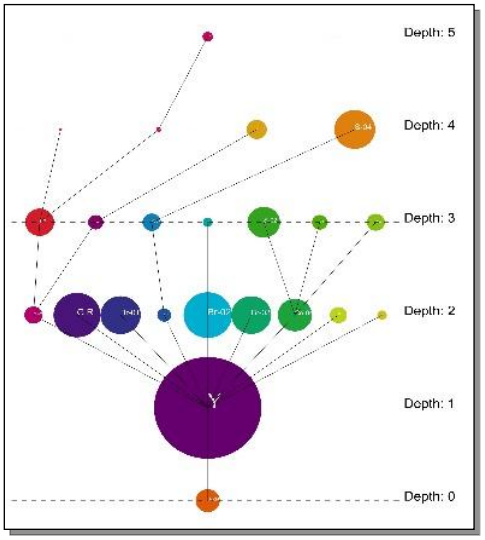


Fig 12 Spatial graph of kitchen (Author)

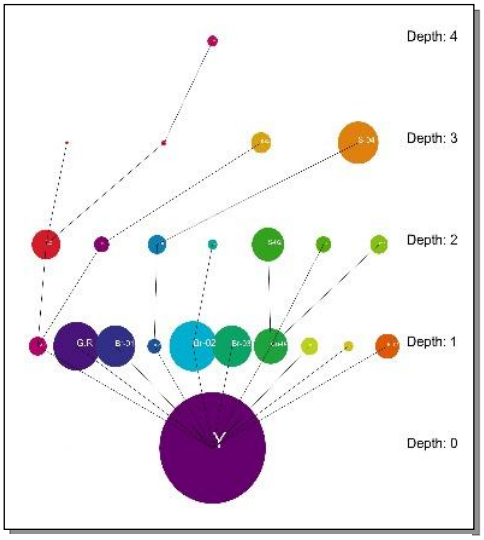


Fig 13 Spatial graph of the living room (Author)

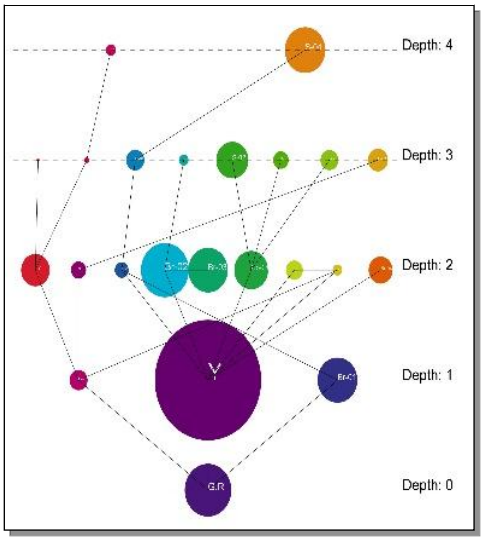


Fig 14 Spatial graph of store room 4 (Author)

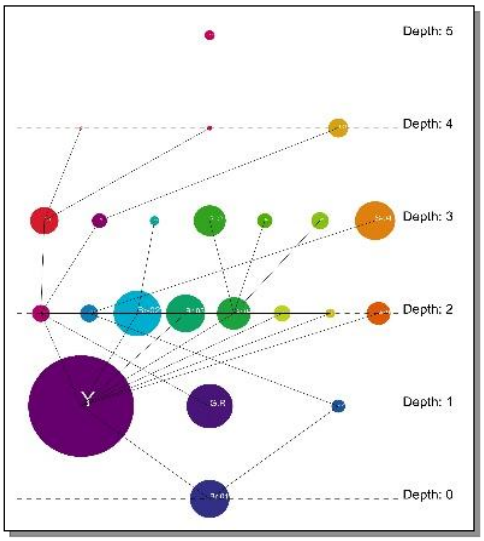


Fig 15 Spatial graph of room 4 (Author)

Table 1 No. of layers, total depth, mean depth, degree of integration and control value in the House of Jangjouyan (Author)

No.	Carrier Node	Control Value	Degree of Integration	Mean Depth	Total Depth	No. of Layers
00	Entrance	0.3	3.78	3.8	83	7
01	Porch	1.7	5.77	2.8	62	6
02	Corridor 1	1.3	3.91	3.7	81	7
03	Store room 1 (1st floor)	0.5	2.88	4.65	102	8
04	Corridor 2	1.6	9.24	2.15	47	5
05	Stairway	1.2	5.25	3	66	6
06	Courtyard	4.11	12.83	1.8	40	5
07	Guest room	0.6	7.45	2.4	53	5
08	Room 1	0.7	6.60	2.6	57	6
09	Corridor 3	0.9	6.79	2.55	56	6
10	Closet 1	1.3	4.35	3.4	75	6
11	Room 2	1.6	6.41	2.65	58	6
12	Closet 2	0.3	4.05	3.6	79	7
13	Room 3	0.4	6.24	2.7	59	6
14	Corridor 4 (1st floor)	3.1	7.00	2.5	55	6
15	Store room 2	0.25	4.27	3.45	76	7
16	Bathroom	0.25	4.27	3.45	76	7
17	Lavatory	0.25	4.27	3.45	76	7
18	Kitchen	0.4	6.07	2.7	60	6
19	Sitting room	0.8	7.45	2.4	53	5
20	Store room 3	0.5	3.55	3.95	87	7
21	Store room 4	0.5	3.12	4.4	96	8
22	Room 4 (1st floor)	0.1	5.92	2.8	61	6

Minimum	0.1	2.88	1.8	40	5
Average	0.98	5.71	3.08	67.73	6.34
Maximum	4.11	12.83	4.65	102	8

5. Discussion

According to the data in Table 1, it can be concluded that store room 1 with the total depth of 102 is the most private space and the yard with the total depth of 40 the most public space. It can also be stated that:

"Yard spaces, corridor 2, guest room, living room, corridor 4, corridor 3, room 1, room 2, room 3, kitchen, room 4, porch and stairway" with the mean depth less than 3.08 are more public areas than "store room 1, store room 4, store room 3, entrance, corridor 1, closet 2, store room 2, bathroom, lavatory and closet 1".

Accordingly, the yard with the lowest mean depth has the highest rate of entrance and the highest degree of flexibility. Thus, the degree of flexibility of each space is based on the degree of entrance and spatial depth, as shown in Table 2.

Table 2 Total depth and mean depth of the House of Jangjouyan (Author)

Bathroom	Store room 2	Closet 2	Corridor 1	Entrance	Store room 3	Store room 4	Store room 1	Space Title
3.45	3.45	3.6	3.7	3.8	3.95	4.4	4.65	Mean Depth
Room 3	Kitchen	Room 4	Porch	Stairway	Average	Closet 1	Lavatory	Space Title
2.7	2.7	2.8	2.8	3	3.08	3.4	3.45	Mean Depth
Courtyard	Corridor 2	Guest room	Sitting room	Corridor 4	Corridor 3	Room 1	Room 2	Space Title
1.8	2.15	2.4	2.4	2.5	2.55	2.6	2.6	Mean Depth

Store room 1 with the degree of integration of 2.88 is the most distant space and the courtyard with the degree of integration of 12.83 is the most integrated space with the most spatial consistency and integration with other spaces (Table 3). The degree of integration indicates the spatial variability and indicates flexibility.

Table 3 Degree of integration in the House of Jangjouyan (Author)

Bathroom	Store room 2	Closet 2	Corridor 1	Entrance	Store room 3	Store room 4	Store room 1	Space Title
4.27	4.27	4.05	3.91	3.78	3.55	3.12	2.88	Integration
Room 3	Kitchen	Room 4	Porch	Average	Stairway	Closet 1	Lavatory	Space Title
6.24	6.07	5.92	5.77	5.71	5.25	4.35	4.27	Integration
Courtyard	Corridor 2	Guest room	Sitting room	Corridor 4	Corridor 3	Room 1	Room 2	Space Title
12.83	9.24	7.45	7.45	7.00	6.79	6.60	6.41	Integration

Considerable point is the potential of the detection and precision of the software, which is introduced by comparing Tables 2 and 3 in exploring the space variability and the stairway space of lower than the mean range, as a space with lower flexibility, while other spaces are correspondingly in the tables.

From a spatial control point of view, the value of yard control (4.11) is highest and room 4 control value (0.1) is lowest on the first floor. The spatial control is another factor that shows the degree of control over each space and spatial adaptability and is in some way directly related to spatial flexibility and the functional efficiency of the space (Table 3).

The data in Table 3 indicate that the intermediate spaces such as yards, corridors, and the dividing areas (porch) play an important role in the spatial adaptability.

Table 4 The space control value in the House of Jangjouyan (Author)

Room 3	Kitchen	Entrance	Closet 2	Lavatory	Bathroom	Store room 2	Room 4	Space Title
0.4	0.4	0.3	0.3	0.25	0.25	0.25	0.1	Control Value
Average	Corridor 3	Sitting room	Room 1	Guest room	Store room 4	Store room 3	Store room 1	Space Title
0.98	0.9	0.8	0.7	0.6	0.5	0.5	0.5	Control Value
Courtyard	Corridor 4	Porch	Room 2	Corridor 2	Closet 1	Corridor 1	Stairway	Space Title
4.11	3.1	1.7	1.6	1.6	1.3	1.3	1.2	Control Value

6. Conclusion

After analyzing the concepts of the total depth, mean depth, degree of consistency and value of control in the House of Jangjouyan, as an example of Qajar native homes in Esfahan historical area, the results of the study indicate that native houses with the central courtyard, the placement of the yard in the middle layer has caused it to have a more considerable role in the organization and spatial configuration of the house. Other spaces around the yard and defining its accessibility from the middle and intermediate layers make each space have a defined territory and boundaries; on the one hand, internal relationship has provided the conditions for the spatial integration. This pattern can provide a manifestation of variability and adaptability in a structure.

On the other hand, the number of the existing uses in the physical home system and having similar spatial value imply the concept of diversity as another indicator of flexibility, which is the keyword in the spatial flexibility and hence the spatial efficiency; a space, such as a room in a spatial configuration, having the same value as other spaces, can adapt itself to other uses, including the bedroom, living room, or a guest room, in order to serve as a specific room. However, it is not possible in the contemporary space system to use the spaces such as the sleeping room to be replaced with other type of spaces. It is to note that the main share of diversity and adaptability of the spatial body of a native home is related to the presence of the climatic spaces for summer and winter.

The results of the space syntax analysis show that the yard is the mostly used space with the highest capability to create spatial consistency and the highest degree of control over other spaces. The storage room and the room in the first floor have different conditions with the least flexibility.

Overall, the placement of the courtyard in the middle layers has caused it to play a significant role in the spatial configuration, whereas in contemporary homes, the placement of the courtyard in the primary layers has diminished its importance and this role has been given to other spaces.

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