

Contemporizing the Genome of Iran's Architecture Using Hybrid Algorithm; Case Study: Semnan's Contemporary Houses

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ABSTRACT

Nowadays, the necessity for continuing and binding with Iran's historical and valuable architecture is felt more than ever before. The main issue is that it is necessary, on the one hand, for Iran's contemporary architecture to be originated from the ancient and vernacular patterns (the challenge of originality) and, on the other hand, an architectural work is required to be the child of its own time (the innovation challenge). The conceptual framework of this study has been laid on the foundation of the "theory of paramount architecture" hence it deals with the delineation of the future architecture by helping the original Iranian architecture's genotype interact with the paramount architecture's phenotype. The study primarily aims at recognizing the architectural genome latent in the plan of the vernacular houses in Semnan as a valuable part of the eclectic Iranian architectural works. Based on the study's methodology, Semnan, as the case study, and its contemporary houses from Qajar and Pahlavi Era have been selected as the study population. As for the study's sample volume, five houses have been chosen using snowball method and consultation with the experts. The article's findings indicated that there is a hidden order and a dominant pattern well-observable in the sampled houses from Semnan; an order that can be described through relying on a geometry which is based on the comprehensive justification graph of plan within the format of finding the "intersection area" of the graphs. The analysis of the spatial relations in the plans of Semnan's traditional houses during the contemporary era showcases a complex and sublime graph of the spatial relations. The architectural elements well-exhibit a considerable interaction between the designed beauties, the interaction between the filled and the empty spaces and between the latest technological applications, smart energy uses and attentions paid to the humans' spiritual and psychological needs. The study results are also indicative of the idea that the comprehensive graphs and hybrid algorithms possess the required efficiency for introducing the architectural genotype. The architects and the designers can create an eminent architecture in proportion to the time's phenotype for the today's and future users based on the extracted genotype.

Keywords: Design-Based Approach, Comprehensive Justificatory Plan's Graph, Hybrid Algorithms, Contemporary Architecture, Theory of Paramount Architecture.

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1. INTRODUCTION

Nowadays, the necessity for continuing and linking with Iran's historical and valuable architecture is felt more than ever before (Latifi & Diba, 2021). The document of the 20-year vision and the law on Islamic Republic of Iran's sixth five-year economic, social and cultural development plan have seriously put an emphasis on the use of Iran's vernacular and Islamic architectural patterns for designing the contemporary designed works, especially in the housing sector. Therefore, one of the most important opened questions asked from Iran's contemporary architecture is the contemporizing of the vernacular architectural archetypes for being usable in the process of designing and constructing architectural projects in contemporary Iran (Mahdavinejad, 2017). Like any other manmade product, architecture needs change and revolution; the archetypes, as well, should be coordinated with the new needs. Thus, updating and redefining of these archetypes are the only recommendable ways for their striving.

A glance at the cities and the lived complexes more highlights the necessity for the coordination meanwhile keeping the diversification. So, contemporizing and recreating of the patterns is a significant way for creating unity in multiplicity as well as for keeping diversity meanwhile sticking to unity (Mahdavinejad, 2020). In other words, traditional architecture is replete with secrets the discovery of which entails contemplation over and analysis of these works with its essence and tradition being dynamicity, change and modern. A review of the literature on the analysis of the magnificent Iranian architectural works, including about the orientation and expansion (Fallahtafti & Mahdavinejad, 2015; Fallahtafti & Mahdavinejad, 2021) and/or the empty and filled spaces' configurations (Saadatjoo, 2018) are expressive of the idea that there is a sort of latent order in the process of designing and implementing architectural works.

Considering the effect that houses have on the spirits of the residents as well as the effect that the houses exert on the human beings, the updating and redefining of Iran's traditional houses feature a special importance and necessity (Saadatjoo et al., 2021). The study of the living comfort's conditions in regard of the valuable Iranian architectural samples (Hadianpour et al., 2018) are reflective of the idea that all of the climatic (Hadianpour et al., 2017), cultural and contextual human needs have been met in these types of the houses. Pointing at the hidden values of the traditional architecture, many resources invite the architects to learn lessons from the traditional architecture (Valitabar et al., 2021). In some of the cases, the necessity for returning to the Iranian architectural concepts has been introduced as a key principle for the future architecture of Iran (Ansarimanesh et al., 2019). Most of these resources have underlined the

essential properties of the traditional architecture. Iran's traditional architecture is a contextual rendering of Islamic Iranian spiritual-cultural values and it can in a way be manifesting the culture of the society in the course of time. Put differently, the traditional architecture is correlated with holy issues; thus, it is recounted as being qualified for invaluableness and it is a sort of architecture featuring value and meaning. Traditional architecture is the product of the traditional method in design and construction. So, inspiration from Iranian traditional architecture is a way for taking advantage of this huge designing and construction treasure. The architectural look and the design-based approach necessitate the application of this huge treasure for Iran's contemporary architecture, as well. More than ever before, the world's contemporary architecture is currently approaching the contemporizing of archetypes as a means for getting close to the future architecture (Mahdavinejad & Hosseini, 2019). The challenge of applying the latest and advanced technologies (Mahdavinejad, 2014) and utilizing computerized progressed tools (Pilechiha et al., 2020) are parts of adopting architectural looks (Javanroodi et al., 2018) and design-based approach (Javanroodi et al., 2019) towards the contemporizing of valuable Iranian architectural patterns.

A review of the specialized literature, including in theoretical resources and practical experiences, is reflective of the idea that the automatic production of the plan (Nisztuk & Myszkowski, 2019) using the evolutionary algorithms and/or hybrid algorithms (Lim et al., 2017) in designing and optimizing forms (Eslamirad et al., 2020) sets the ground for the entry of the latest and advanced technologies into the process of designing and implementing architectural works (Pease et al., 2017). Of course, it is worth explaining that this type of architectural planning and programming has a particular position in the early stages of the architectural designing process (Li et al., 2018).

The studies conducted on the representation of the effect of geometry on the reviving of the architectural spaces showed that the geometry is a significant part of designing and that it can influence the quality of perceiving meaning and concept of the building (Mahdavinejad, 2015; Tadayyon et al., 2021; Moftakhar et al., 2021; Azadifar et al., 2021). The geometry of architecture is a factor enabling the enhancement of such a concept as livability and transferring of a sense of liveliness to the users. Studies show that the geometrical properties influence the livability of architectural works (Ahmadi et al., 2020; Javidmehr & Hashempour, 2019). Iran's traditional houses are full of specimens the vivid and hidden teachings of which can be helpful to Iran's contemporary architecture (Mahdavinejad & Javanroodi, 2014; Heidari et al., 2021) and, in order to actualize them, it becomes necessary to contemporize

the Iranian architectural genome. Therefore, a number of researches have concentrated on the search for the characteristics of traditional Iranian houses based on the investigation of lifestyle in these houses in various cities of Iran like Isfahan, Shiraz, Kashan and so forth.

2. STATEMENT OF THE PROBLEM

Originality and innovation are the two essential challenges, namely originality and innovation, with which contemporizing of the archetypes in favor of the future architecture is faced. The main issue in between is that it is necessary on the one hand for Iran's contemporary architecture to be stemmed from the vernacular and ancient patterns (challenge of originality) and, on the other hand, it has to be the-state-of-the-art and in proportion with the contemporary time's conditions (innovation challenge). Based on the study's presumption, the archetypes cannot be borrowed in an exact form though it is necessary to make use of them. The use of the genotype and the concepts concealed in the ancient architecture along with the apparent features and phenotype of the today's architecture can provide a proper response to this challenge. The research is expressive of the idea that Semnan's traditional house is in between one of the most important treasures for recognizing the values of original Iranian architecture.

3. STUDY METHODOLOGY

The primary objective of this research is the recognition of the architectural genome hidden in the plan of Semnan's traditional houses as the eclectic works selected from vernacular architecture with Islamic Iranian original values. The operational goals of the research and the executive steps thereof for the actualization of the primary objective are the followings: (1) scientific preparation and regulation of

an information bank incorporating the plans of the traditional houses from Semnan; (2) identification and analysis of the capacities of using the learning and hybrid algorithms for identifying and analyzing the residential houses' plans; (3) selection of the optimal pattern and designing a mechanism for analyzing the plans of the residential houses based on the materials learnt from the analysis of learning and hybrid algorithms; (4) analysis of the plans of the houses selected from amongst the ones in Semnan with the goal of identifying the architectural genome; and, (5) theorization and ideation regarding the contemporizing of Iranian architecture's genome using learning and hybrid algorithms and offering teachings for guiding the process of designing contemporary and future houses in Semnan.

Based on the study methodology, Semnan's traditional house has been selected as the study sample volume because, besides being in direct contact with people's lives, a house is one of the most important architectural works, as well. The study population included all of the traditional and valuable houses in the city of Semnan from Qajar and Pahlavi eras and with valuable Islamic Iranian architectural designs and plans. Using purposive sampling pattern, the study sample volume has been chosen based on snowball method from amongst the most famous eclectic works through consultation with experts and specialists; in this process, five specimens were chosen from amongst the most valuable traditional house samples in Semnan. In order to identify the genome of Semnan's traditional houses, it is necessary to use learning and hybrid algorithms for analyzing the graphs so that the genotype of each of the houses can be extracted separately. Then, within an interactive process format, finding the "intersection area" is the process that should be conducted in a comparison of the obtained graphs to eventually apply a dominant pattern for introducing the architecture's genome.

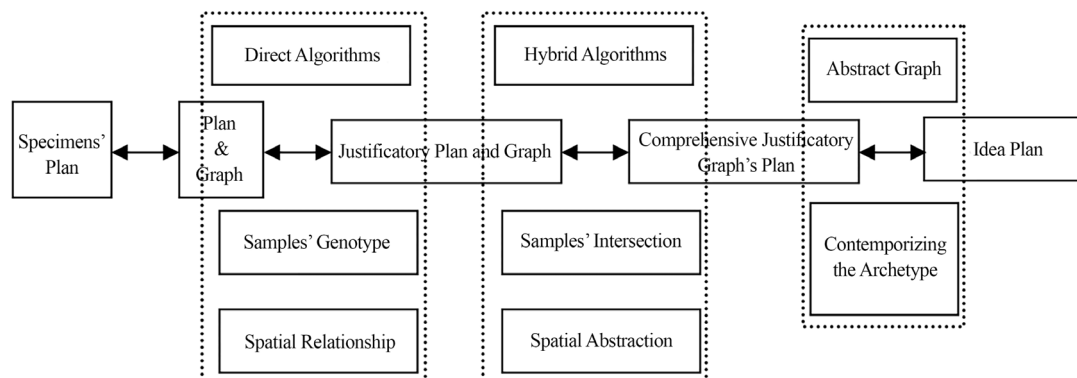


Fig. 1. The Inference Mechanism Based on the Study Methodology

The methodological studies indicate that Depth Map Software and Space Syntax technique are two

of the most well-known methods for perceiving the relationship latent between the various spaces of the

building. This relationship is expressed through the delineation of the space syntax graph or justificatory diagram. In between, the studies by Bill Hillier regarding the space organization and spatial regulation have a particular position (Hillier, 1993). He showed that there is a sort of hidden geometry identifiable in the spatial relations between the architectural elements, social structures and behaviors and activities of the users (Hillier, 1999). The space syntax method is focused on analyzing the permeability, control and hierarchy (Ostwald, 2011; Rahbar et al., 2022). The goal of generalizing the theory of space syntax is the extraction of an interaction and easing of the mathematical calculations for obtaining the logic of (1) permeability; (2) co-association and (3) the degree or rate of spaces' control. Put differently, the generalized space syntax theory has been developed to create a mathematical-geometrical ground in line with the theoretical-operational analysis of the spaces' interrelationships. In terms of the technique's type, the application of the justificatory graph is a scientific-analytical method that uses the language of space syntax or space arrangement for expressing the relationships that eventually give a graphical model for the spaces' interrelationships parallel to analyzing the spatial configuration and permeability of the buildings.

In 2010, in a new edition of the book "the trend of the

architectural thoughts", the theory of generalized space syntax was applied for expressing the method of spaces' interaction and discovery of the spaces' social logic in the famous works in the world's architectural history (Mahdaveinejad, 2021). The space syntax graph was used for analyzing the effect of yard in the formation of the traditional Iranian houses' configurations in Kashan (Hajian et al., 2021). The other researchers also could utilize the capacity of the mathematical-geometrical patterns for analyzing the various architectural and urban planning subjects (Ziaee et al., 2020). These are some cases indicating the competencies of this instrument for analyzing the architectural works. The experience gained in Insite Laboratory, Virginia University (Bassett, 2020), in the form of determining the vivid ad hidden relationships between the elements of buildings' plans has been reported easier when using the hybrid algorithms. In the applied samples, the space syntax method is used for analyzing the interior spaces as well as their spatial interrelationships. This method is usually applied for designing the contemporary architecture in line with the prediction of the spaces and their interrelationships. The essence of this method is a sort of reverse engineering and, based on the relationships existing between the plans of the valuable buildings, the new specimens are planned and programmed.

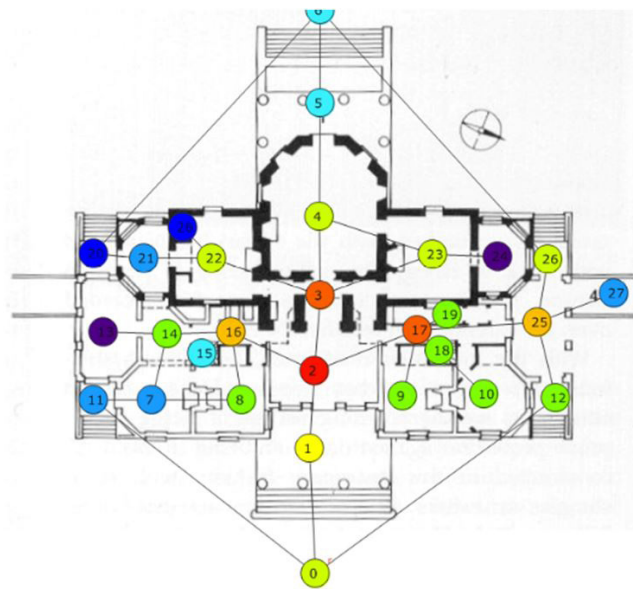


Fig. 2. The Specimen of the Selected Method in the Study's Methodology for Analyzing the Hidden Relationships Between the Various Parts of the Architectural Plan
(Bassett, 2020)

The use of the justificatory graphs for contemporizing the vernacular housing patterns in Tehran sing numerical methods (Esmaeilian et al., 2021) showed that these graphs, though not being comprehensive, have a good capability but the mathematical-

geometrical expression can accelerate and corroborate the process of architectural designing (Mahdaveinejad & Refalian, 2012). The later studies indicated that there are many limitations in the direct and non-combined application of the plans' justificatory graph

for the analysis of the architectural works (Lee et al., 2018). In order to make up for this shortfall, the use of hybrid algorithms possesses a particular stance (Rahbar et al., 2019). In the later experiences, other abilities were added to the mathematical-geometrical approach in the analysis of the spaces (Herthogs et al., 2019) to the extent that this approach could be applied as a successful method (Shams et al., 2020). The critical approach to these methods and the limitations in the common graphs (Schwaller et al., 2020) underline the necessity of revising them and using the comprehensive justificatory graph of the plan.

4. ANALYZING THE CASE STUDIES

Based on the study's methodology and in order to identify and discover the genotype in an architectural work, it is necessary to extract the spatial relations and the guideline governing the contextual interrelationships.

Representation of the extracted spatial relationships enables the introducing of the work's genotype and the building's phenotype can be practically extracted through the adoption of an architectural look and a design-based approach based on the identified genotype. In order to ease the display of the spaces' titles, use has been made of abbreviations so that the delineation of the related graphs can be done with more exactness and in better controllable conditions. Five specimens of the valuable and historical houses in Semnan were carefully analyzed. These five cases are the followings: (1) Nazemian House; (2) Kalantar House; (3) Ranjbaran House; (4) Tadayyon House and (5) Taherian House. To be short, a specimen of the drawn graphs' plans and finally the movement algorithm of objects in 3D space are introduced to eventually report the results based on the five analyzed buildings.

Table 1. The Guide for Naming Micro-Spaces in the Plans of the Traditional Houses Along with Their Abbreviations

Entrance (E)	External yard (Y0)	Winter-dwelling room (Rw)	Guest room (Rg)	Western edge room (WR)
Corridor (C)	Internal yard (Y1)	Summer-dwelling room (Rs)	Interior room (Rp)	Eastern edge room (ER)
Veranda (Ds)	Wind-catching room (W)	Kitchen (K)	Servants' room (Sc)	Storage and patio (Sr)
Porch (I)	Stable (SL)	Restroom (WC)	Stairway (St)	

5. NAZEMIAN HOUSE AS THE CASE STUDY

Nazemian House is a building from Qajar Era and belonging to Nazemis as one of the noble families as well as a family with high positions in the then government. At first and after entering the main entrance of the house and passing through the corridor, the first central yard was entered but it is generally named yard and it includes a stairway to the rooftop and two other entrances. On the left side of the house's entrance, there is a room wherein the servants of Nazemian's house reside; in the corner of the first yard, there is another entrance which is called the house's main entrance. This entrance features an indirect space and, a corridor is reached when passed it; on the right side, there is another entrance which opens to the pit of the house's garden. In the periphery of the garden pit, the house's main part has been positioned and it includes two storeys of rooms atop of one another and a belvedere storey with a pond in the middle. This presence of water through the passing of a ditch from the middle of the house for also filling the cistern provided the residents with climatic comfort in the spaces. Having passed the corridor, one finds oneself in the external yard which is the place for the residence and hosting of the guests

in this house. In the southern edge of the external yard, there is a summer-dwelling section on the first floor of which there are built two rooms. There is a five-door room specially for hosting the guests with the other room being smaller and simpler. In the basement of the summer-dwelling room, as well, there are two rooms the bigger one of which has been built within a 2-m elevation from the yard's floor and it provides a cold and pleasant environment for the guests. In the northern section of the house and on the first floor, there is the winter-dwelling section of the house and it has one winter-dwelling porch and two columns with gypsum-made ornamentations and two three-door rooms connected to one another. In the basement part, there is a cistern which is filled with ditch water and supplies the household with water during the year. There is also another room for the guest therein. In the western side of the house, there is a warm sun-facing room wherein a stool-like wooden frame is placed and it can be understood from the way it is designed that it is the only common spaces of the house between the internal and external yards. In the corner of the external yard and on the southwestern side of the entrance, there is the interior section of the house. The cooking part of the house and two other rooms are still usable in the winter-dwelling side of the internal yard (MCTH, 2020). Nazemian's house

has embedded most of the classical spaces of Iranian traditional architecture in a unique manner and it is a perfect sample of Iranian residential architecture. The historical investigations relate the age of the building's initial core to the Safavids' era; although the building lacks a slate or inscription by which the exact date of its construction can be figured out, the

age of the building's current form is typologically related to the late Qajar Era and early first Pahlavi era. The house's placement along one of the most important historical axes of the city and also along the mosque's orientation and towards the city center is indicative of the significance of this house.



Fig. 3. Eye-Catching Combination of the Open and Semi-Open Spaces in the Architecture of Nazemian House in Semnan



Fig. 4. Nazemian House was Registered under the Number 2766 on 9th of August, 2000, in the List of Iran's National Artworks



Fig. 5. The Capitals of the Main Porch Copied From the Neoclassical Style of Capital Making which was Trendy During the Late Qajar Era and Early Pahlavi era



Fig. 6. Aesthetical Functions and Climatic Performance of the Basement of the Basement



Fig. 7. The Natural Geometry of the House that does not Seek for Eligibility in Following the Euclidean Perpendicular Geometry



Fig. 8. The Role of Yard as the Structuralizing Element and a Factor of Coherence in Architectural Designing



Fig. 9. The Interaction between the Closed, Open and Semi-Open Spaces in Nazemian House in Semnan



Fig. 10. The Use of the Linear and Planar Transparent Elements for Bestowing Depth to the Plan and Bringing about Spatial Diversity in Nazemian House

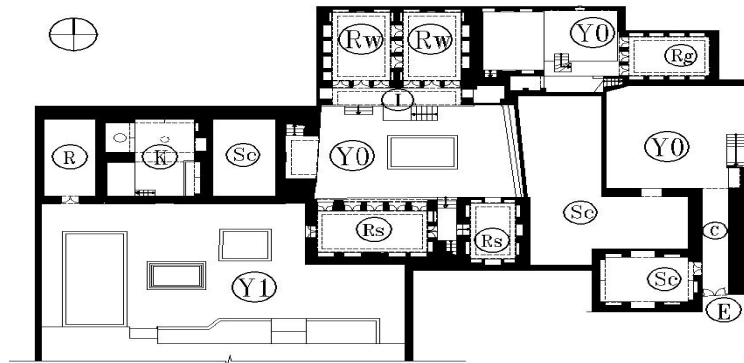


Fig. 11. The Architectural Plan of Nazemian House in Semnan (MCTH, 2020)

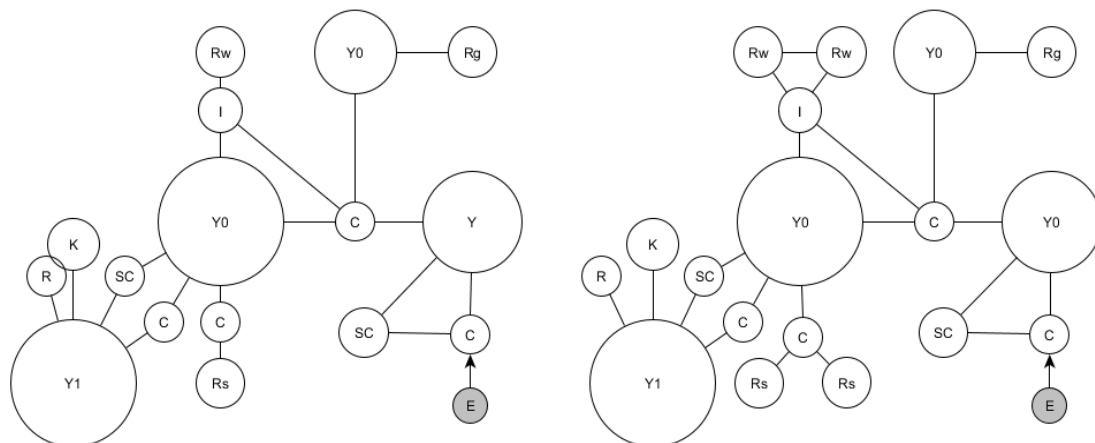


Fig. 12. Exhibition of the Micro-Spaces and Spatial Communications in Nazemian House in Semnan through the Use of Tree Graph

Table 2. Extraction of Communications in Nazemian House in Semnan from Tree Graph

Rg-Y0-C	I-Y0-C	Sc-Y0-C	R-Y1-Sc	K-Y1-Sc	Y0-C-Y0	E-C-Y0
C-Y0-C	I-Y0-Sc	Sc-Y0-Sc	R-Y1-C	K-Y1-C	Y0-C-I	E-C-Sc
Rs-C-Rs		Sc-Y1-C	Rw-Rw-I	K-Y1-R	Y0-C-Y1	
			Rw-I-Rw		Y0-Sc-C	
			Rw-I-C		Y0-Sc-Y1	
					Y0-I-Rw	
					Y0-C-Rs	

6. ANALYZING THE RESULTS

The study findings indicated that there is a hidden order well-observable and recognizable in the eclectic samples of traditional houses from Semnan; it is an order that can be described through relying on the geometry based on the plan's justificatory graph. The analysis of the spatial relationships in the plans of the architectural spaces in Semnan's traditional houses from Qajar and Pahlavi Eras showcases a complex graph of the spatial relationships. The graph of these relationships has been extracted in the form of translatable codes in machine language and this reflects the success of the study's general idea in analyzing the traditional housing in Semnan. The implementation of the simplification stage and omission of the repeated spaces using learning and hybrid algorithms in the graphs enabled the displaying of more precise dimensions of the genome in Semnan's traditional house. The execution of the simplification stage via elimination of the reiterated

spaces provides for contemporizing and its application in the designing of the future houses in the city of Semnan.

In order to accomplish the study's intended objectives in Semnan's traditional houses within the format of the studied samples, the micro-spaces and their interrelationships were categorized in such a way that a sort of summarization can be carried out in the generality of the graphs without influencing these spaces. After extracting the codes of the graphs' internal relationships, the graphs' internal relationships were classified based on triple groups of the spaces (R-R-R). The notable point is that the dual relationships (R-R) are numerous and the existence of a very large number of diversities in them causes inability in finding an exact commonality between them in practice. On the other hand, commonalities can be rarely found in the quadruple relationships (R-R-R-R) and they cannot be practically guiding towards architectural look and design-based approach.

Table 3. Finding the Intersection Areas of the Plans' Spatial Interrelationships between the Five Case Studies Investigated Herein Based on the Extracted Genotype

No.	Spatial relationships	Common cases	No.	Spatial relationships	Common cases	No.	Spatial relationships	Common cases
1	Rp-C-K	3	17	Y1-Y0-C	2	33	WR-Y0-C	2
2	Ds-C-Rp	3	18	Y1-C-St	2	34	WR-Y0-ER	2
3	Rp-C-Rp	3	19	Y1-C-K	2	35	WR-Y0-K	2
4	Y0-I-Sc	3	20	Y1-C-Rp	2	36	WR-Y0-I	2
5	Y0-C-I	3	21	Y1-Rp-C	2	37	Rw-I-Rw	2
6	Y0-I-Rs	3	22	ER-Y0-I	2	38	Rw-Rw-I	2
7	I-Y0-C	3	23	ER-Y0-C	2	39	Rg-Rg-I	2
8	I-Y0-I	3	24	ER-Y0-K	2	40	Rg-I-Rg	2
9	Y0-ER-ER	3	25	Ds-C-Rg	2	41	Rg-Rg-C	2
10	Y0-C-Y0	2	26	Ds-C-K	2	42	Sc-Y0-C	2
11	Y0-I-Rw	2	27	Ds-C-Sr	2	43	Sc-I-C	2
12	Y0-C-I	2	28	Ds-C-Ds	2	44	Sr-K-Rg	2
13	Y0-C-Y1	2	29	E-C-Sc	2	45	K-Y0-C	2
14	Y0-I-Sr	2	30	E-C-Ds	2	46	K-Y0-I	2
15	Y0-I-St	2	31	E-C-Y0	2	47	I-Y1-SL	2
16	Y0-C-St	2	32	E-Ds-C	2	48	C-Y0-WC	2

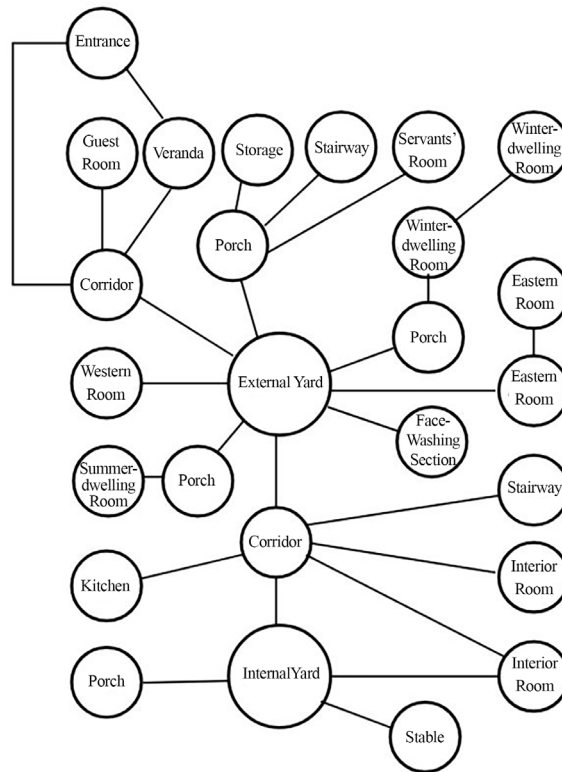


Fig. 13. The Cumulative Graph Obtained for All of the Spaces in the Five Studied Samples without Filtering Based on the Hybrid Algorithms and Comprehensive or Generic Simplification Introducing the Genotype Extracted from the Study Sample Volume

Table 4. Rating the Spaces Based on the Justificatory Comprehensive Graph of the Plan for the Extracted Genotype

Row	Spaces	Privacy	Centrality	Contextual Scale	Performance Scale
0	Pre-entrance	1	0	1	1
1	Entrance	1	1	2	3
2	Veranda	2	4	2	4
3	Exterior pre-space	2	2	1	2
4	Exterior section	2	1	3	2
5	Interior pre-space	3	4	2	3
6	Central yard	4	5	5	5
7	Main porch	5	4	3	4
8	Dais	5	3	4	4
9	Large hall	6	2	3	3
10	Kitchen	6	3	3	2
11	Storage	7	1	3	1
12	Northern porch	5	2	1	2
13	Small hall	6	0	1	1
14	Procurement sector	7	1	2	1
15	Face-washing sector	6	2	1	1
16	WC services	7	1	2	2

7. CONCLUSION

The analysis of the selected graphs indicates a sort of organized relationship between the various parts of the plan in the chosen residential houses from Semnan. In case that use is made of the pattern of a

comprehensive justificatory graph of the plan (or justificatory graph of the generic plan) for offering the spatial manifestation of Iranian architectural genome in Semnan's traditional house, a comprehensive graph will be attained.

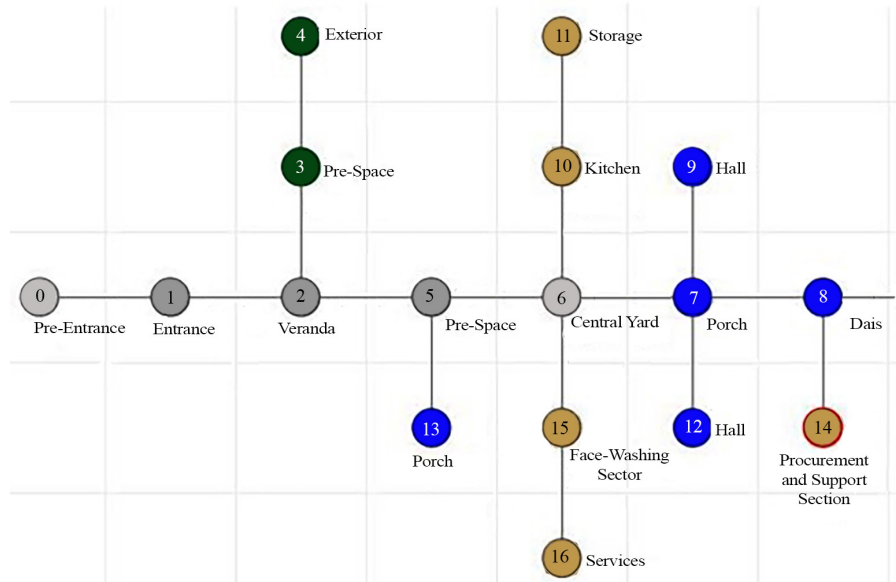


Fig. 14. The Final Graph Introducing the Genotype Extracted from the Study Sample Volume Using Hybrid Algorithms

The study results indicated that Semnan's traditional house is a valuable sample of Iranian traditional architecture and that a hidden order can be accordingly offered within the format of a comprehensive justificatory graph of the plan and it would be a graph introducing the genome of Iranian architecture in Semnan's traditional houses. The validations and controls made herein indicate that the obtained graphs can be well-introduced as the genome or the dominant graph of the generic plan in the traditional houses of Semnan. The obtained results regarding the description of the genome of Semnan's traditional houses can be applied, on the one hand, by architects

and designers in the process of designing and constructing architectural projects and, on the other hand, in other researches as the data bank. The abstract graph of the hidden geometry related to Iranian houses in the sample volume studied for Semnan can provide a pattern capable of being utilized in the contemporary specimens, as well, and as a pattern for the future architecture. The results obtained from the description of the genome of Semnan's traditional house can be applied, on the one hand, by architects and designers in the process of designing and constructing architectural projects and, on the other hand, in other researches as the data bank.

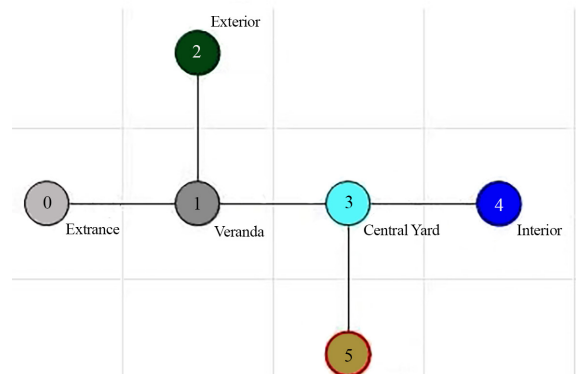


Fig. 15. The Abstract Graph of the Hidden Geometry Pertaining to Iranian House in the Sample volume Studied for the City of Semnan

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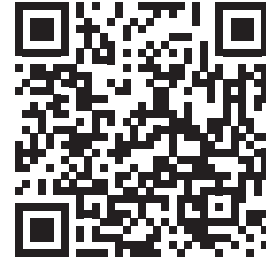
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