Journal of Environmental Sciences Studies

Journal home page: www.jess.ir

Qualitative indicators of sustainable housing and architectural genome based on genetic algorithms

Mohammad Ali, Mansour Yeganeh*, Mohammadreza Bemanian

Digital Architecture and Artificial Intelligence Lab. Department of Architecture , Tarbiat Modares University, Tehran, Iran

*Corresponding Author, email: Yeganeh@modares.ac.ir

Received: (2023-2-14)
Accepted: (2023-5-25)

Abstract

Examining housing indicators is one of the different means and methods of knowing the characteristics of housing, with the help of which one can know the effective parameters in housing and facilitate any planning and decision-making about housing. The ever-increasing demand for housing has led to more attention being directed toward the quantitative aspects of housing. As a result, quality indicators of housing have received less attention. While the qualitative indicators of housing play a more colorful role than the quantitative dimensions due to responding to the social-cultural needs of the people of the society. In the reasonableness of housing, attention should first be paid to qualitative indicators such as content, meaning, and concept, and then to quantitative indicators such as form. The residence or living space should be efficient in terms of quality indicators. The stated qualitative indicators include material and spiritual aspects. The material aspect is defined and formed by creating an environment with appropriate access and facilities, temperature, humidity, and light, etc. The spiritual aspect is formed in order to respond to the spiritual needs of the users and is created through the creation of spaces in accordance with the way of life of the people of the society, which is derived from their culture and social customs.This research has been studied with the descriptive-analytical research method. The results show that the recognition and reference to the basic concepts and principles of sustainable and native house building and the correct application of their principles on the one hand and the use of new knowledge such as the genetic algorithm to facilitate access to the architectural genome of native and sustainable houses on the one hand on the other hand, the main solutions are to get rid of problems and weaknesses in this field.

Keywords: Genetic Algorithm, Sustainable Housing, Modernization, Architectural Genome, Quality Indicators

1.Introduction

Housing quality indicators are divided into two cultural-social and physical parts based on the presented categories.The set of socio-cultural indicators includes smaller indicators such as culture, identity, privacy, arrangement and spatial communication(Cormen et al., 2009, P5). Each of the stated indicators contains concepts such as spatial arrangement, spatial organization, functional spaces, spatial relations, hierarchy, introversion and permeability(Zare, Yeganeh, Dehghan,. 2022). The set of physical indicators also includes smaller indicators that contain concepts such as building form, physical enclosure, plan geometry, mass and space system, building

orientation, and number of floors.According to the presented categories and concepts, it is possible to see that the indicators and concepts presented in the qualitative section of housing in the socio-cultural category are completely consistent with the genotype-forming indicators, and the concepts presented in the physical category are completely consistent with Phenotype forming indicators(Yeganeh, 2012, Yeganeh 2015).Throughout history, houses have undergone many and significant changes in order to meet human needs. Always Responding to the increasing growth of the population has led to the formation of houses that have fundamental problems and weaknesses. One of the most important reasons for these problems and weaknesses can be considered as the neglect and non-use of the basic physical, cultural, social, religious and identity structures and patterns of residential architecture or the architectural genome. Perhaps recognition and reference to the basic concepts and principles of home and home building and employmentThe correctness of their foundations on the one hand and the use and application of new knowledge such as the genetic algorithm to facilitate access to the architectural genome of sustainable houses, on the other hand, are the main solutions and solutions to get rid of the problems and weaknesses in this field that have plagued contemporary architecture. Is. Considering the fact that among the methods of recognizing the genome of house architecture; It is possible to refer to 1- covering a variety of identification methods, 2- examining the concept, indicators and quantitative and qualitative standards of the house, 3- knowing the elements that make up the architectural genome of native houses, and 4- methods of applying the genetic algorithm.

1.1.Genetic algorithm

The algorithm includes all well-defined and specific calculation methods that receive values or a set of values as input and produce values or a set of values as output. Therefore, an algorithm is a set of computational steps that transform inputs into outputs. An algorithm is a tool for solving specific computational problems. The general statement of the problem specifies the relationship between the desired inputs and outputs. As a result, the algorithm expresses a specific calculation method to achieve the relationship between the inputs and outputs of the problem in question. (Cormen et al., 2009, P5)An algorithm means solving the problem in a systematic way and in order to generalize that method to similar problems. (Ekhlasi, Mofidi Shemirani, Anbari Roozbahani, 2013, p. 32) The meaning of solving a problem in a systematic way is to follow the order of the steps of creating an algorithm. Any change in the order of the steps of creating an algorithm, including increasing or decreasing it, leads to the formation of a new algorithm with a different result, and such results can achieve better, similar or worse results than the original algorithm. In general, changing the stages of creating an algorithm and using random variables can lead to the emergence of unknown and different solutions with the main purpose of creating that algorithm. The fundamental concept of the word algorithm is based on the method and logic of problem-solving. It is essential to know that achieving a problem-solving method is different from solving it. (Ekhlasi et al., 2013, p. 32)In another definition, an algorithm can be considered a specific set of clear, clear and defined instructions that can perform a specific operation through a specific hierarchy. For example, the algorithm can take a number of numbers, calculate their average and provide the answer. Algorithms are used for calculations, information processing, and correct and logical decisions. The algorithm has sections such as data entry, information processing, and finally the output of the calculated answers. (Khabaz, 2015, p. 85) The use of an "algorithm" leads to a step-by-step calculation operation and at the end of the steps, the correct and logical result is presented to the user.Taking into account the concepts that were presented earlier in order to express a specific definition for the term algorithm, the ultimate goal of creating an algorithm can be considered to be finding a logical solution to solve a problem. As a result, according to the concept of algorithm and its direct relationship with problem-solving, the

categories of problem-solving algorithms are described below.

1.2. Problem-solving algorithms

1. Determined algorithm: In this algorithm, progress is without probability and coincidence, which means that the algorithm starts from a value and finally reaches a certain value. (Yang & Karamanoglu, 2013, P 6) The more complex the problem becomes, the more difficult it is to solve.

2. Heuristic algorithm: In this algorithm, discovery means "trial and error" to achieve problem-solving. (Yang and Karamanoglu, 2013, p. 6)

3. meta-heuristic algorithm: intensification and diversity are two key elements for any meta-heuristic algorithm. The intensification element is also known as exploitation and uses local information in the search process to generate better solutions. The diversity element can be called discovery. This element fully explores the search space and helps generate diverse solutions. (Ibid., p. 12) This algorithm has the ability to solve complex problems. Meta-heuristic methods as optimization algorithms have the ability to solve complex non-linear and multi-objective problems with linear or non-linear constraints and discrete and continuous variables. (Cuevas et al., 2019, P 7)

- The most used meta-heuristic algorithms

The three main groups of meta-heuristic or meta-heuristic algorithms that have the ability to solve complex problems are categorized as follows.

- Evolutionary algorithm

Evolutionary Algorithms (EA) are a group of optimization algorithms and are rooted in the foundations of evolutionary biology (Sadeghian and Hosseini, 1400, p. 20), in other words, they are based on the concepts of biological evolution. (Triggle et al., 2007, p 106) and focus on cyclical processes and work on large populations of responses. In general, in this method, to achieve the optimal answer to a problem, several options are produced and these options are evaluated based on the criteria designed for a good option, (Khabaz, 2015, p. 98)Accordingly, a "population" of possible solutions to solve the problem is first created by scoring each solution using an "objective function" that shows the degree of desirability of each of the ways to solve the problem. (Triggle et al., 2007, P 106) The solutions in an evolutionary algorithm are similar to organisms that evolve within a species and according to their adaptation to the environment, in the search space in order to optimize the objective function and answer a problem. They evolve. (Simoncini & Zhang, 2018, P 2) Then each population evolves over time and identifies more optimal solutions. (Triggle et al., 2007, p. 106)In the next step, among the generated options, the desired options are selected and the rest of the options are removed (out of the cycle or die). Based on the quality of the selected options, multiple new options are generated and re-evaluated so that the most favorable options are selected for the next round. This process is repeated until the final desired options are reached. The evolutionary algorithm has in a way simulated Darwin's famous theory of Survival of the Fittest in the field of computer science in a way where only the strongest (generation weapons) survive and the weak are eliminated. (Khabaz, 2015, p. 98(

The key elements of an evolutionary algorithm are the problem statement, selection of stochastic variation operators, selection of population, and alternative solution which are described below.

a .Statement of the problem: looking at the metaphorical statement of evolution, presented in the form (-) of the link between phenotype and genotype becomes the connection between the statement of the problem and its coding. The two main elements of problem coding are the way of presenting solutions and the design of the objective function. The selection of these elements has an important effect on the dimensions of the search space and the shape of the objective function, which can be considered as a map for the search space. Solutions can be coded in different ways. The objective function is derived from the problem statement and can be exact, like the famous traveling salesman problem, or approximate and experimentally defined, like the protein structure prediction problem.

b .Random change operators: Inspired by evolution theory, random change operators are divided into two categories: crossover operators and jump operators. Crossover operators are functions that take two solutions as input, while jump operators are functions that take a single solution as input. The basis of the idea of crossover operators is to randomly receive two desirable solutions and combine the good features of each of those solutions, as a result, a better solution can be achieved. In this method, a cut point is randomly selected to determine which part of the two solutions should be exchanged. Mutation operators usually randomly select a position and change its solution and value.

c .Selection and replacement strategy: two factors of how to choose new solutions and also how to choose the new generation of solutions that replace the old solutions affect the dynamics and convergence of the search in the heuristic algorithm. The two main approaches in choosing and replacing new solutions are sustainable and generational plans. In the stable design of the heuristic algorithm, two solutions are selected for the new combination mutation. The mutation and solution results are directly inserted into the initial population if they meet the prerequisite criteria. In the generational exploratory algorithm, some solutions are selected to form a transition population, and from this transition population, a set of new solutions will be created with mutations and new combinations. The new set of solutions completely or approximately replaces the initial population according to some conditions specified by the user. (Simoncini & Zhang, 2018, P 2-3)

2. Materials and Methods

2.1. Cycle of achieving the criterion determined in an evolutionary algorithm In general, it can be said that this cycle includes stages that start with the selection of the initial population and end with achieving the necessary criteria and replacing or producing a new population. The mentioned steps include:Valuation or quantification of the initial population (first stage) Evaluation of solutions (second stage) Beginning of a cycle during which, in each iteration, a subpopulation is selected (fourth stage) Subpopulation to generate new solutions through operators Random changes are used (5th step) Evaluation of all subpopulation solutions (6th step) Finally, the initial

Algorithm 1 Evolutionary algorithm

1: $\mu \leftarrow InitializePopulation()$
2: $EvaluateFitness(\mu)$
3: **while** $Continue()$ **do**
4: $\quad \lambda \leftarrow Selection(\mu)$
5: $\quad \lambda \leftarrow StochasticVariations(\lambda)$
6: $\quad EvaluateFitness(\lambda)$
7: $\quad \mu \leftarrow ReplacePopulation(\mu, \lambda)$
8: **end while**

population is replaced with part or all of the newly created population. The repetition cycle continues until reaching the set criterion for stopping. (Seventh stage) (Simoncini & Zhang, 2018, P 2)

Figure 1: the cycle of achieving the criterion determined in the genetic algorithm (Simoncini & Zhang, 2018)

Among the different types of evolutionary algorithms, the genetic algorithm is the most well-known algorithm. (Triggle et al., 2007, p. 106)

2.2. Genetic Algorithm (GA)

re than 30 years ago, John Holland proposed Genetic Algorithm (GA) as a paradigm for dealing with computationally complex search spaces. (Tabrda, Almedia, Santos, Eloy, Kwiecinski, 2018, P938) are evolutionary (EA) and work with a similar method to search and find the optimal answers of a subject. In short, a genetic algorithm consists of two parts: generating options and evaluating them. These actions take place in the process of an algorithm

1. Generate an initial population of options

2.Evaluating the compatibility of options with favorable conditions

3.Repeating the following cycle until the operation is interrupted (time limit, reaching the desired level of compatibility, ...)-

Choosing the best options for reproduction-

Cultivating and producing (like) new options (using techniques such as change, interference, etc.)

Evaluating the degree of compatibility of new options with favorable conditions-

Replacing the undesirable options of the population with the produced desirable options

Production of new options is based on the combination and genetic mixing of previous options. Since the successful options survive, stronger genes are also replicated in later periods and in the underlying structure of response populations. In the completion of this production process, the measurement engine (Fitness Function) with the definitions of the state of the desired option, after each production, checks the quality and the degree of their proximity to the desired conditions in order to be able to select more successful options with the options Replace the existing one. Assuming that the initial population and the algorithm process are focused on generating architectural options and evaluating them based on design criteria, it seems that this method, after repeating it for the appropriate number of times, has produced a population of desirable options that is a more suitable answer. are given to the design factors and the continuation of the design process can be done on the best selected options.(Goharian, daneshjoo, Yeganeh. 2021, Ashtari, Yeganeh, bemanian. Vojdani Fakhr. 2021). More than 30 years ago, John Holland proposed the Genetic Algorithm (GA) as a paradigm for dealing with computationally complex search spaces. The classical approach to genetic algorithms can be described by the following algorithm. Determining the appropriate number of members (N) for the evolutionary population is an important parameter in the genetic algorithm. The higher the number of members in the initial population, the greater the chromosomal diversity of the generation and subsequently the greater the exploration in the search space. The lack of diversity may prevent wider exploration and the algorithm may easily get stuck in a local solution. (Tabrda,Almedia, Santos, Eloy, Kwiecinski, 2018,P938)

Genetic algorithm is an optimization algorithm inspired by natural selection. A search algorithm that is based on population and follows the concept of survival of the fittest. New populations are generated by repeatedly applying genetic operators to individuals in the population. Chromosome representation, selection, crossover (combination), mutation, and fitness function calculation are the key elements of genetic algorithm. The genetic algorithm execution method is as follows

Input:
Population Size, n
Maximum number of iterations, MAX
Output:
Global best solution, Y_{bt}

begin
Generate initial population of n chromosomes $Y_i \ (i = 1, 2, ..., n)$
Set iteration counter $t = 0$
Compute the fitness value of each chromosomes
while $(t < MAX)$
Select a pair of chromosomes from initial population based on fitness
Apply crossover operation on selected pair with crossover probability
Apply mutation on the offspring with mutation probability
Replace old population with newly generated population
Increment the current iteration t by 1.
end while
return the best solution, Y_{bt}
end

Fig 2: classic genetic algorithm

.

An initial population (Y) of n chromosomes (the number of chromosomes) is randomly initialized. (Katoch, Chauhan and Kumar, 2021, P8094; Yeganeh, 2017) In fact, most living organisms store their genomes on several chromosomes. But in genetic algorithms, all genes are usually stored on the same chromosomes. Therefore, chromosomes and genomes are synonymous in the genetic algorithm. (Sivanandam and Deepa, 2008, P17) The fitness of each chromosome is calculated in Y. Two chromosomes named C1 and C2 are selected from the Y population according to their fitness. A single point intersection operator with intersection

3. Results & Discussion

Selection is an important step in genetic algorithms and determines whether certain sequences will participate in the reproduction process or not. The importance of the selection stage is so much that sometimes the selection stage is known as the reproduction operator.
The task in choosing a roulette wheel is that all possible chains are allocated on a wheel or a part of it according to their suitability. Then this wheel randomly moves and selects certain solutions that contribute to the formation of the next generation(Yeganeh, Ansari, Bemanian. 2012).

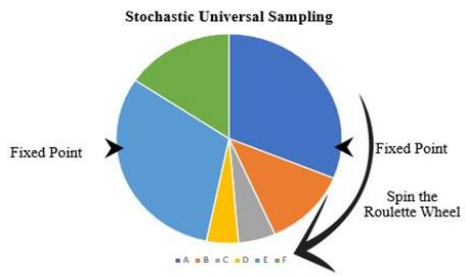
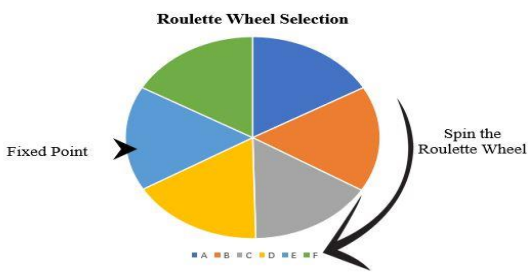


Figure 3: Roulette Wheel in Genetic Algorithm (author)



Although this process suffers from many problems such as errors due to its random nature, De Jong and Brindle modified the roulette wheel selection method to eliminate errors by introducing the concept of determinism in the selection method. Rank selection is a modified form of roulette wheel selection. In this method, the ranks are used to determine the fitness of the members. Ranks are assigned based on the fitness of each member so that each member of the initial population has a chance of being selected based on their rank.

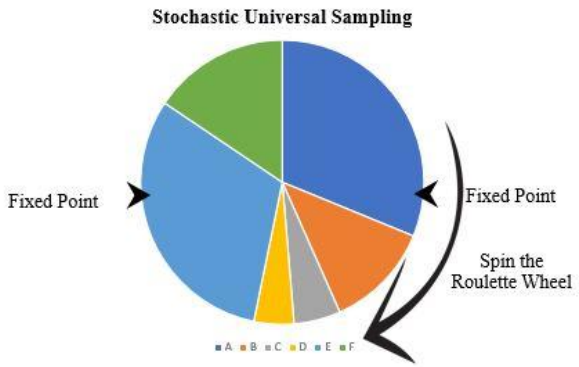


Figure 4: Selection of Rank in Genetic

Chromosome	Fitness Value	Rank
A	8.1	1
B	8.0	4
C	8.05	2
D	7.95	6
E	8.02	3
F	7.99	5

Algorithm (Author)

3.1.Tournament selection method

Members are selected in pairs based on their fitness from a random roulette wheel. After selection, members with higher fitness are added to the next generation set. In this selection method, each member is compared with all other members (n-1) if it reaches the final population of solutions.Random inclusive sampling selection methodThe random inclusive sampling method is formed from the development of the roulette wheel selection method. This selection method uses a random starting point in a list of members of a generation and selects new members equally at equal intervals. This method gives everyone an equal chance to be selected to participate in the next generation mix. As the problem size increases (higher complexity), the traditional roulette wheel selection method performs relatively better.

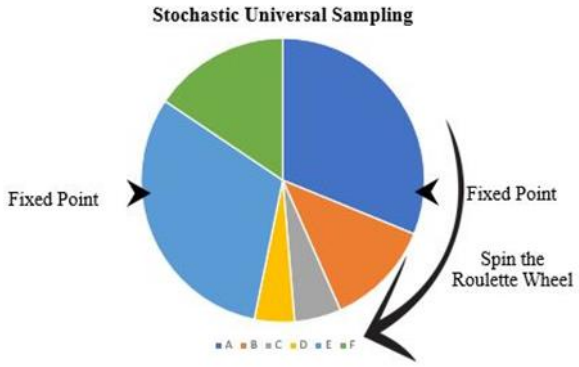


Figure 5: Stochastic universal sampling selection in genetic algorithm (author)

3.2.Boltzmann selection method

The Boltzmann selection method is based on entropy and sampling methods that are used in Monte Carlo simulation and helps to solve the premature convergence problem. In this method, the probability of choosing the best course is very high, while it is executed in much less time. But there is a possibility of data loss. It can be managed through elitism. Elitist selection was proposed by K. D. Jong (1975) to improve the selection performance of the roulette wheel. Elitism ensures that members of the elite in one generation are always reproduced in the next generation. If the member with the highest fitness is not present in the next generation after the normal selection method, the elite member is automatically placed in the next generation.

Table 2: comparison of selection methods in genetic algorithm (Katoch, Chauhan and Kumar, 2021)

Disadvantages	Advantages	selection method
Risk of premature convergence, dependent on the variance of the fitness function	Easy implementation	Roulette wheel
Slow convergence, need for sorting, high computational cost	Free from bias, maintaining diversity	Rank
Loss of variety due to large tournament size	Preservation of diversity, parallel execution, no need for sorting	Tournament
High computational cost	Obtaining the global optimum	Boltzmann
Early convergence	Fast method, free of bias	Stochastic universal sampling
Losing the best member due to intersection and mutation operators	Keeping the best member of the crowd	Elitism

4. Conclusions

The growth and development of the city and urbanization, along with the creation of facilities and welfare for human life, has caused an increase in environmental destruction and pollution. Therefore, the theory of sustainable urban development was proposed with regard to the negative effects of the growth of cities and it has proposed solutions to minimize urban problems. Among these solutions is the effort to create sustainability in urban housing. Housing, as the most important use in cities, which occupies a high percentage of the city's area, determines the quality of life and well-being of the people. How to design and build housing affects the environment, society, culture, economy, and also the daily life of people, their health and safety. Therefore, housing sustainability is an important step in achieving sustainable urban development in various social, economic, physical and environmental dimensions. As a complex and multi-dimensional subject, architecture should have the opportunity and possibility of processing and diverse information. And parametric architecture has induced a new collective movement, on the other hand, this progress and development led to the creation of new issues in the field of design and components, and the form and image of architecture has been strongly influenced by this design, and it has entered a new phase of form finding and space design and spatial relationships. In the process of parametric design, they avoid flexible geometric principles, and parametric design, unlike the architecture of single styles, is not in the form of overhanging the structure as the ruling element in architecture, and the mutual relationship and understanding of two factors It shows a better feeling of the design and implementation process. One of the most important problems faced by architects in the gap between the initial design and the final design is organizing and defining uncertain forms. The use of genetic algorithm, like other computational systems, is inspired by natural systems, while other fields are computational tools based on The principles of biology have been adopted in the architectural design process. There has not been an extensive evolution, only recently there has been a significant change in the way architects have discovered techniques to deal with complex problems. By using architectural genome based on genetic algorithms, it is possible to continue architecture.

References

1. Alami, B., Pourdihimi, S., and Mashaikh Fereydoni, S., "Structure, Form and Architecture". Iranian Architecture Quarterly, Spring and Summer 2015, No. 9, p. 131
2. Appleyard, D., 1979. Home, Architectural Association Quarterly, No 2, PP 2-20
3. Arnold, Christopher and Reitherman, Robert. (1981). Building Configuration and Seismic Design the Architecture of Earthquake Resistance, Building Systems,\Development, Inc., San

Mateo, California under a grant from the National Science Foundation, Washington, D.C.P 103
4. B Ashtari, M Yeganeh, M Bemanian, B Vojdani Fakhr . 2021.A Conceptual Review of the Potential of Cool Roofs as an Effective Passive Solar Technique: Elaboration of Benefits and Drawbacks. Frontiers in Energy Research, 624
5. Babazadeh Eskoui, S., Tofan, S., and Jamali, S., "Upgrading the theoretical foundations of the concept of privacy in contemporary housing from the perspective of environmental psychology, a case study of Milad residential tower in Tabriz". Bagh Nazar Scientific Journal, Winter 2018, No. 16, p. 63
6. Barati, N., "Recognizing the concept of home in Persian language and Iranian culture". Khayal Quarterly, Winter 2013, No. 8, p. 25
7. Cooper Marcus, C., 1974, The house as symbol of self. In: Lang, J.T. (ed.) Designing for human behavior: Architecture and the behaioral science, Dowden, Hutchinson. P
8. Cormen, T. H., Leiserson, C. E., Rives t, R. L., & S tein, C. (2009). Introduction to algorithms. Third Edition, Cambridge, Massachusetts London, England: MIT press, ISBN-13: 978-0262033848
9. Dorigo, M., Ant Colony Optimization,. Thesis, MIT Press, Cambridge
10. Dosti, Sh., "Privacy and Privacy in Traditional Iranian Houses". Iranian People's Culture Quarterly, Summer and Autumn 2017, No. 53-54, pp. 117-120
11. Ebrahimi, A. and Tamali, M., "Orientation in architecture and its role in the formation of historical houses in Tabriz". Architectural Quarterly, February 2017, No. 5, pp. 1-4
12. Falahat, M. and Shahidi, S., "The role of the mass-space concept in the explanation of architectural space". Bagh Nazar scientific journal, Mehr and Aban 2014, year 12, number 35, pp. 30-34
13. Goharian A, Daneshjoo K, Yeganeh M . 2022. Standardization of methodology for optimizing the well aperture as device (reflector) for light-wells; A novel approach using Honeybee & Ladybug plugins. Energy Reports 8, 3096-3114
14. Hayward, G., 1975, Home as an environmental and psychological concept, Landscape, 20, PP 2-9
15. Hikmatnia, H., Mousavi, M. and Zarafshan, A., "Investigation and analysis of quantitative and qualitative indicators of housing in Taft city and its future planning". Journal of Geography and Regional Development, Fall and Winter 2014, No. 5, p. 127
16. Hillier, B., Leaman, A., 1974, How is design possible?, Journal of Architectural and Planning Research , Vol 3, No 1. PP 4-5
17. Hosseinpour, R., and Kaynejad, M., "Analysis and evaluation of design methods in the functionality of small-scale housing, case example of Mehr Shahr Pardis housing". Scientific Quarterly Journal of Construction Engineering and Housing Sciences, Winter 2017, twelfth period, number 22, page 4
18. Ikhlasi, A., Mofidi Shemirani, M., Anbari Roozbahani, N., "Algorithmic design approach and native architectural solutions of Iran in the use and control of daylight: how to use past architectural solutions in the direction of designing contemporary transparent facades" . Arman Shahr Architecture and Urbanism Quarterly, spring 2013, volume 7. p. 32
19. Jafariha,R., 2017, Different Ways of Organizing Space Based on the Architectural Models of Traditional Houses: A New Approach to Designing Modern Houses: (Case Study: Qazvin's Traditional Houses), Space Ontology

International Journal, Vol 6, Issue 4, P 18

20. Kartika Sari, I., Nuryanti, W. and Ikaputra, I., 2020, Phenotype, Genotype, and Environment, Case study: Traditional Malay House, West Borneo, Indonesia, Preprint, P
21. Luna Watkins. Spatial-functional analysis of the central area of the ancient settlement at Tayma, North-Western Arabia, during the Nabataean, Roman and Late Antiquity periods. Archaeology and Prehistory. Université Panthéon-Sorbonne - Paris I, 2020. P3
22. M Shahbazi, M Yeganeh, M Bamanian. Meta-analysis of environmental vitality factors in open spaces. Motaleate Shahri 9 (34), 61-76
23. Mahdavi Mehmandoost, M., "Meaning in housing, rereading the narrative of yesterday's housing for today's life". Two Quarterly Journals of Architectural Thought, Winter 2016. Year 1, Number 2, p. 100.
24. Montazeral Hajjah, M., Nokar, B., Sharifnejad, M. and Fatuhi, Z., "Measurement of physical indicators affecting the aesthetic component in contemporary urban developments (case study: prepared areas in Yazd city)". Scientific and Research Quarterly of Urban Studies, Winter 2017, No. 29, p. 48
25. Mukok, S., 1996. viewpoin on sustainable urban Development in sub-saharan Africa cities, vol 13, No 4 ,PP 265-271
26. Norberg Schulz, C., 1996, The phenomenon of place, In: Theorizing a new agenda for architecture: an anthology of architectural Theory, Nesbitt, K (ed), Princton Architectural Press, New York. P 422
27. Proshansky, H., 1978, The city and self-identity, Environment and Behaviour, No 10, PP 147-83
28. Qalambardzfouli, M., Naghizadeh, M., and Majdi, H., "Explaining the basics of factors affecting housing quality indicators". Hoyt Shahr magazine, winter 2017, year 12, number 36, pp. 102-100
29. Qalambardzfouli, M., Naqizadeh, M., and Majdi, H., 2017, "Explaining the basics of factors affecting housing quality indicators". Scientific Journal of City Identity, Year 12, Number 36, Page 99
30. Rafiei, M., "Urban housing in Iran: the future perspective of sustainable development". Bolton Housing Economics, 1376, No. 23, p. 24
31. Rahmane, A. and Abbaoui, M., 2021, The Architectural Genotype Approach in Contemporary Housing (1995 to 2010), The Case Study of Setif, Algeria, Engineering, Technology & Applied Science Research, Vol 11, No 1. P 6811
32. Shahzamani Sichani, L. and Ghasemi Sichani, M., "Analysis of the geometry of the early century housing plan in Isfahan based on spatial organization". Urban Management Quarterly, Winter 2016, No. 49, p. 139
33. Sheikh Bahai, A. and Yeganeh, M., "Comparative analysis of the influence of religious culture on the patterns of spatial relationships in the house (case study: Muslim and Zoroastrian houses in Kerman)". Quarterly Journal of Architecture and Sustainable Urbanism, spring and summer 2019, year 6, number 1. p. 137
34. Sheikh Bahai, A., "Reviewing the principle of introversion in Iranian housing based on the theory of space syntax (case study: traditional houses in hot and dry climates)". Urban Management Quarterly, Spring 2018, No. 54, p. 76
35. Sifian, M. and Mahmoudi, M., "Privacy in traditional Iranian architecture". Hoyt Shahr magazine, autumn and winter 2016, first year, number 1. pp. 1-9
36. Simoncini,D. and Zhang, K. Y.J., 2019 Population-Based Sampling and

Fragment-Based De Novo Protein Structure Prediction, Encyclopedia of Bioinformatics and Computational Biology,Academic Press, Reference Module in Life Sciences. doi:10.1016/b978-0-12-809633-8.20507-4. P 2-3

37. Sivananda, S.N. and Deepa, S.N., (2008), Introduction to Genetic Alghorithms, Springer, Berlin, Heidelberg, New York, ISBN 978-3-540-73189-4. P 16-17
38. Tabatabaei Molazi, F., and Sabernejad, J., "Analytical approach to the syntax (arrangement) of space in the perception of the spatial configuration of native housing in Qeshm (a case study of Laft village)". Housing and Rural Environment Journal, summer 2015, number 154 P. 78
39. Tabrda, B. Almedia, A. Santos, F. Eloy, F. and Kwiecinski, k., 2018, Shaper GA: Automatic Shape Generation for Modular House Design, GECCO Conference, At: Kyoto, Japan. P 938
40. Tabrda, B. Almedia, A. Santos, F. Eloy, F. and Kwiecinski, k., 2018, Shaper GA: Automatic Shape Generation for Modular House Design, GECCO Conference, At: Kyoto, Japan. P 938
41. Triggle, D. J. and Taylor, J. B., 2007, Comprehensive Medicinal Chemistry II . 2nd Edition, Elsevier Science, ISBN-13: 978-0080445137. P 106
42. *Vaughan, L. 2007. The spatial syntax of urban segregation.Progress in Planning, No 67, P 208*
43. *Wehmeier, S., 2005, Oxford advanced learner's dictionary of curcurrent english, Oxford University Press, Oxford, P 744*
44. *Wojczynski, M. and Tiwari, H., 2008, Definition of Phenotype, Advances in Genetics, Vol 60. P 76*
45. *Wright, F. and Fessele, K., 2017, Primer in Genetics and Genomics, Article 5—Further Defining the Concepts of Genotype and Phenotype and Exploring Genotype–Phenotype Associations, Biological Research for Nursing, Vol 19, No 5. P 576*
46. *yeganeh, Mansour, Bemanian Mohammadreza, Ansari Mojtaba, Architecture as an Organism, 2012. International Conference on Industrial Engineering and Operations Management*
47. *Yeganeh, Mansour,2015. "Educating designing an architectural model based on natural principles and criteria." International conference new perspectives in science education. 2*
48. *Zare, Z. Yeganeh, M. Dehghan, N. 2022. Environmental and social sustainability automated evaluation of plazas based on 3D visibility measurements, Energy Reports, Volume 8, 2022, Pages 6280-6300, ISSN 2352-4847, https://doi.org/10.1016/j.egyr.2022.04.064.*