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Investigating Fractal Geometry in Iran's Bazaars with an Expansion Approach and Adjusting to the World's Modern Architecture (Case study: Qom, Kashan, Tehran's Timcheh)

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Abstract

Fractal geometry is a concept that has attracted the attention of architects and designers all over the world; this is because modern architecture tends to be inspired by nature, and natural elements are primarily the source of inspiration for designers in fractal geometry, the inspiration of nature and natural elements is an important task. Naturalism is likely related to the current era. An interesting and important point is that Iranians have paid a lot of attention to the nature and utilization of natural elements for a long time ago; and this interest is shown in a variety of ways in their life, such as using fractal geometry in different shapes and forms of inspired elements from nature. This usage is The highest point in Bazaars, Mosques, Kar-bandi format, Moqarnas, and Shamseh. Because of this, this research tries to investigate the utilization of fractal geometry in Iran's Bazaars and Timcheh through sample analysis with field and library studies by analytic and descriptive methods. This research wants to answer the following questions: Is there any consistency among fractal geometry conditions? Could it be generalized to society? If the answer is yes, what are the methods of updating and expanding it in this situation? Therefore, after some accurate investigations, we will conclude that the traditional usage of fractal geometry in Iran's Bazaars and Timcheh can be modernized and expanded. Moreover, some methods to achieve it are presented.

Keywords: Natural elements, Fractal geometry, Bazaar, Timcheh.

1 | Introduction

Iranians have been interested in knowledge and art for a long time ,and geometry is fundamental among them. Some examples of this are Khayam ,Avicenna ,and Abou Reyhan Birouni. On the other hand, they tried to use theoretical sciences as practical sciences and use them to help other people. This thing, besides

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Iranian essential interest in the natural elements in different fields such as architecture, was how natural dements geometry (such as lotus, sunflower, peacock feather,…) came to Iranian architecture, and since the observance of symmetries was an important task in Iranian architecture, this point was also observed in natural elements geometry, and this is exactly what we see in fractal geometry. (natural elements geometry and observance of symmetries). Thus, fractal geometry was used in Iran's traditional architecture, especially in the Islamic era of architecture and high points. This usage is in Bazaars and their Timches and Mosques, which we will explain in the following section.

1.1|Statement of the Problem

The Bazaar was the most important communication axis between cities of Iran in the past, and it is one of the most important urban elements, as well as its beating heart. That can be the center of the economic, cultural, and social… exchanges. This urban element has a historical background, and its role and different functions during this land's history show its importance among Iranians; it was always in the spotlight, and architects used to try to exhibit the most beautiful, diverse, and complex works in Iranian Bazaar.

This Bazaar is an Iranian urban element; it's original and traditional, entangled with this country's culture, and was effective in their different field of life. Besides the other functions, which were known as people's meeting sites and caused social and cultural exchanges, it can recall the rich Iranian culture to other nations' cultural exchanges. As Tabriz Grand Bazaar is a world heritage site registered in UNICCO and gets worldwide tourist attention, its necessity of protection and keeping this important urban element is revealed and caused within trying to declare it to the others. Necessary and appropriate actions will be taken. In addition, its development and the modern world of architecture will be provided and will get back again with its realization. Considering this point and given that, unfortunately, there isn't any noteworthy research to achieve this goal, the lack of it is felt tangibly and retires with secreting and checking it out, fundamental research should be done and considered in this case.

The method in this study is in the form of field study and direct presence in the location and Bazaars and Timches observation and photographing of them finally, these photos were transformed into AutoCAD files, and the Bazaars and Timches that were more special in pattern were chosen and were studied. In addition, library resources were used. For this purpose, document and written and available information, including specialized books, previous research and related papers, architecture magazines, travelogues, and maps, were examined and evaluated accurately, and analytical and descriptive methods expressed the result.

Each research depends on its subject importance, level, capacities, and limitations. It follows some goals that whit checking and analyzing sources and existing conditions present findings, and it would have worthy and noteworthy output.

This principle is also considered in this research, and writers are following these goals.

Fractal geometry's artistic effects are identified in Iran's traditional architecture, in the form of Bazaars and Timches, which is a great sample of this glare.

I. Comparison of these effects (fractal geometry used in Bazaars and Timches architecture) with today's architectural conditions.

II. Development opportunity study in current condition due to current vision of architecture.

III. Presenting approaches and suggestions to development and modernization in a possible way.

IV. Introduction of Iranian architecture and rich culture to cultural exchanges with the world.

Considering the mentioned point, the same questions are created, such as:

I. Can we find any specific patterns in the geometry of architectural elements in Bazaar and Timches?

II. Can we achieve fractal architecture using these patterns?

III. Is this pattern's origin in nature and natural elements?

IV. What was the application of these patterns in the past, and how does fractal geometry appear in architecture at the current time?

V. How can we develop these patterns and traditional applications?

VI. How is it possible to develop and adapt this traditional pattern and application in the current situation of architecture?

With accurate studies, these hypotheses are ahead of us:

I. All designs and patterns are in the form of fractals.

II. A specific number of these designs are inspired by natural elements like sunflower, Zardak Flower, Pine fruit.

III. Symmetries are observed in all of them.

IV. The forms that were inspired by nature that lead to fractal plans and elements that can push us to fractal in form so it can provide a domain for contextual or parametric architecture.

2| Fractal Geometry

2.1|Definition

Fractal is a geometric and nonlinear structure that is made by expanding each part in different directions and in a certain ratio, and that initial structure is finally made. However, this expansion is irregular in appearance and often accompanied by changes in scale, direction, and turning; all of its components are seen the same from far and near distances and express that each component is wide, and the same irregularity is regular [1].

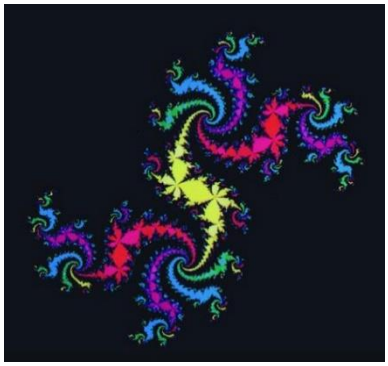

Fig. 1. Fractal figure sample.

2.2|Etymology

Fractal is taken from a Latin word (Fractious) or (Fracture) and means a broken stone irregularly. This word was first expressed by Benoit Mandelbrot, a Polish-French mathematician who lived in the US.

2.3|Background

Since human beings lived in nature from the beginning, their life and thoughts were affected by nature, and this influence caused their familiarity with nature and, finally, the genesis of fractal forms. Therefore, we want to root and study the background of fractal geometry. We should return to the past and follow its track in various civilizations and world areas, from Iran, India, Asia, Africa, and Europe [2].

For example, we can consider zigourats[1], which are several thousand years old and fractal or semi-fractal. Memorial and religious monuments in the southwest of Asia also have fractal structures. In Africa, circular chained houses of clans [3], residences in the south of Zambia, and a logon in Cameron [4] are noteworthy samples with fractal structures.

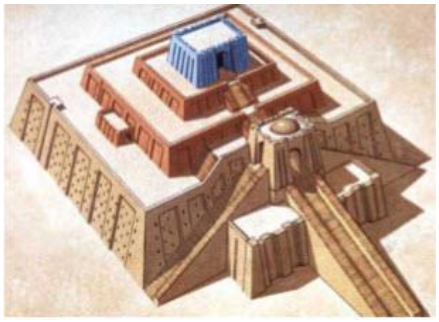

Fig. 2. Our Zigurat.

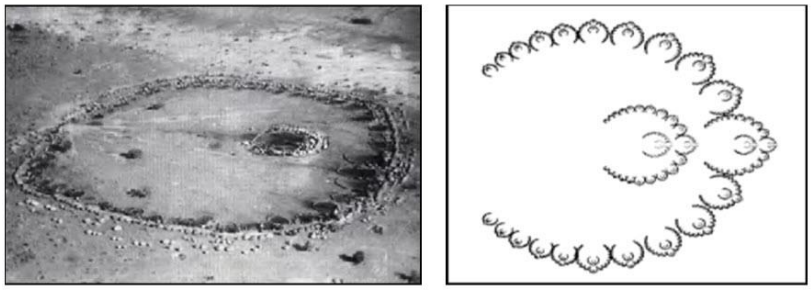

Fig. 3. Circular chained houses of African clans.

In Iran, we also perceive many fractal samples from ancient times until now. Lotus is counted as one of the fractal figures in ancient Iran. In addition, we have some fractal plans from different periods in Iran's history [4].

Khayyam's triangle in mathematics is another fractal sample that transforms into triangles with smaller scales but the same as the big triangle [5].

However, Iran's highest point of fractals is related to the Islamic era. Muqurnesses, which Iranian intuitive architects create, are examples of fractals formed to create a sense of unity in plurality [6].

These samples and some cases like them all expressed fractal entrance background to human life and is continued in the current time because more explanation requires separate research. To make the long story short, the important point is that none of them, even current samples like Sur Pinsky triangle, Koch's snowflake, Pierre Lay's self-similar curves, and Cantor's collections, … are presented in the codified and distinct form and new and independent topic. But Benoit "Mandelbrot" was the first one who, in 1977, expressed it in a distinct and independent branch called fractal [7].

In his research on England's beaches, Mandelbrot found that the length measured in the scale is more than its measure in the small scale. This irregularity caught his attention and led to the founding of fractal geometry. Because of this, Mandelbrot is known as a founder of fractal geometry.

3 | Characteristics

In his book about fractal and fractal elements, Mandelbrot mentioned, " Why is geometry often senseless and soulless?" One reason is its lack of ability to describe the shape of a cloud, a mountain, a gist line, or a tree. Clouds are not spherical, mountains are not conical, gantlines are not circular, skin is not flat, and thunder and lightning do not move in a direct lane [8]. So, he expressed Euclidean geometry's weakness in describing and explaining phenomenon diagrams and natural elements and introduced fractal geometry to describe and explain them. We can conclude that the first characteristic of fractal geometry is phenomena and natural elements' geometry better describes and explains; the other characteristic is irregular dimension complexity and depth. As Ostwald and Vaughan [9] mentioned in their book: in gammon fra, CTAL word is used in two themes, First to describe a kind of irregular dimension and second, an intense geometrical set.

Another characteristic that can be mentioned is being nonlinear and forming complex forms from a simple process, which is what James Harris [10] has stated. Fractal geometry is a nonlinear part.

Revolution…one of the most amazing and fundamental characteristics of fractal geometry is that a simple process makes complex forms [10]. He stated some other characteristics: consistency, genteelism and structure, organizational dimension, recursive/distributed Quality, and Diagram [10].

The other characteristic is the following:

I. They seem irregular but they are regular.

II. They are similar in details in their structure in each scale, and the irregularity amount is equal from a far and near distance [11]; on the other hand, they are self-similar, and each individual is like the general (Karl, Boull) also mentioned it: "fractal geometry is selfsimilar structures official study [12].

III. They are simultaneously evolutionary.

IV. A repetitive rhythm in fractal figures pushes them to balance [13].

V. They do not have the correct dimensions and magnifying extreme.

VI. They have fractal dimensions. This is a decimal number, not an integer [12].

VII. Dynamic processes make them. (Some processes that are membric and their behavior depend on the past).

4 | Application

Fractal elements are used in many themes, from physics to music combinations [12]. But their primary application is in the following points:

I. Architecture and urban design.

II. Mathematics.

III. Physics and material science.

IV. Computer graphics.

V. Digital photos processing.

VI. Geology and faults study.

4.1 | Comparison between Fractal and Euclidean Geometry

I. Euclidean geometry is linear, while fractal geometry is not linear.

II. Euclidean shapes do not show many deep details, whereas fractal geometry inhibits unlimited information [12].

III. Euclidean geometry is capable of describing artificial crafts. It is incapable of describing nature-made crafts, and fractal geometry is incapable of describing artificial crafts and is capable of describing nature-made crafts [15].

IV. Fractal geometry is more irregular than it can be expressed by euclidean geometry [13] and Euclidean geometry is regular.

V. Static and stationary functions create Euclidean shapes, while dynamic and floating functions create fractal shapes.

VI. Fractal geometry has high capacities in certain complex structures, but Euclidean geometry's capacity is limited and usually full of repetitive information.

5 | Fractal effects in mathematics and nature

5.1 | Fractal in Math

The Euclid system was the only possible system and the only description of the word [14] until the 19th century when Mandelbrot changed visions by founding fractal geometry. In math and science, a fractal is a complex geometric figure with similar details in its structure in each scale [11]. Its pants can be expanded to extremes by repetition. This is traceable by fractal dimension measurement. However, because this repetition is to an extreme point, this prevents us from drawing a fractal figure completely. Now, for a better understanding of this statement. We mention some examples of the most famous fractal effects in matches.

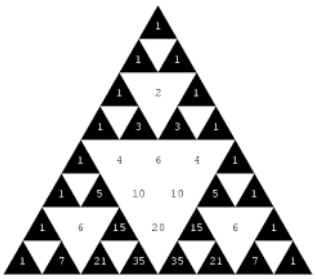

Fig. 4. Khayam-Pascal's triangle which we get to serpinski by omitting even numbers.

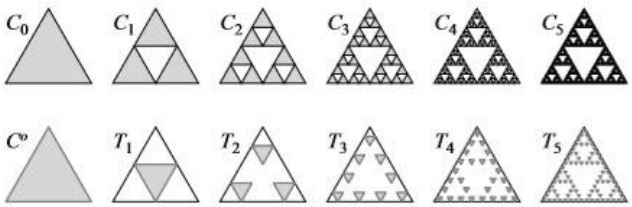

Fig. 5. Serpinski triangle.

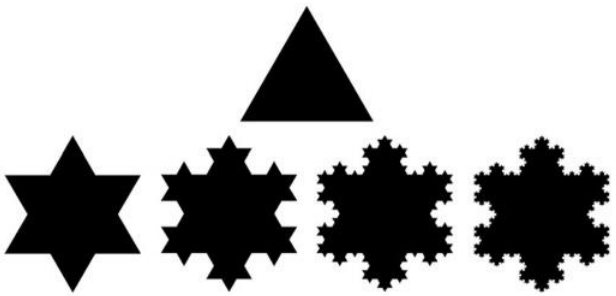

Fig. 6. Kock's snowflake.

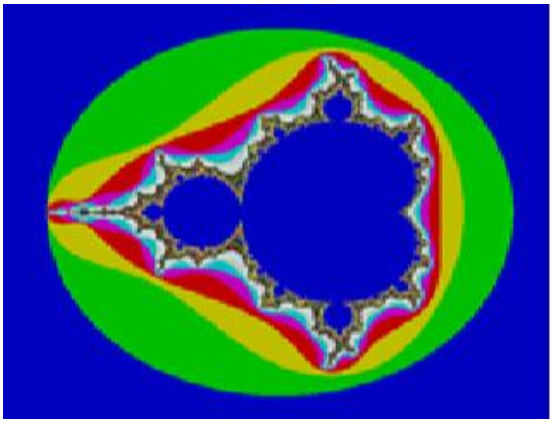

Fig. 7. Mandellbrot complex.

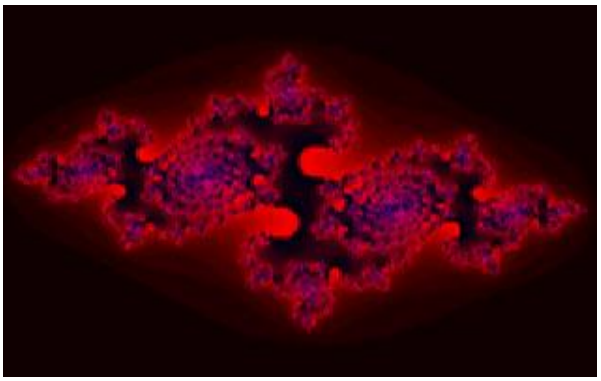

Fig. 8. Julia's complex.

5.2 | Fractal

As we know, a fractal is nature's geometry. Not only is the physical shape of nature fractal, but also the way nature changes over time [12]. So it's evident that lots of natural elements are fractal formed.

Leaves, trees, branches, mountain hillocks, river flood levels, wave patterns, and neural relumes [12], clouds, rain and snow, thunder and lightning, cactuses, sunflowers, corn, cabbage, and lots of other examples are examples. *Fig. 9* shows some samples.

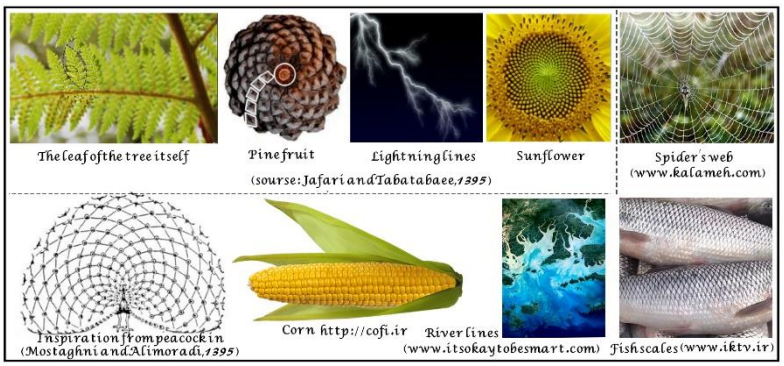

Fig. 9. Fractal samples in the nature.

6 | Fractal in Architecture

Human beings were influenced by nature and natural elements during their lives because, as quoted by Frank Loid Right [15] nature's inspiration treasure is infinite, and it is so rich that it does not finish as whatever is taken by humans. On the other hand, we know fractals are some parts with dominant geometry [16]. So, considering that fractals are the dominant geometry in nature and natural elements, nature itself was also an inspiration resource, and now it is its resource. We can understand why Fractal geometry during architectural history was considered to an extent by architects and designers. The following examples are evidence of this: (example of a fractal in architecture).

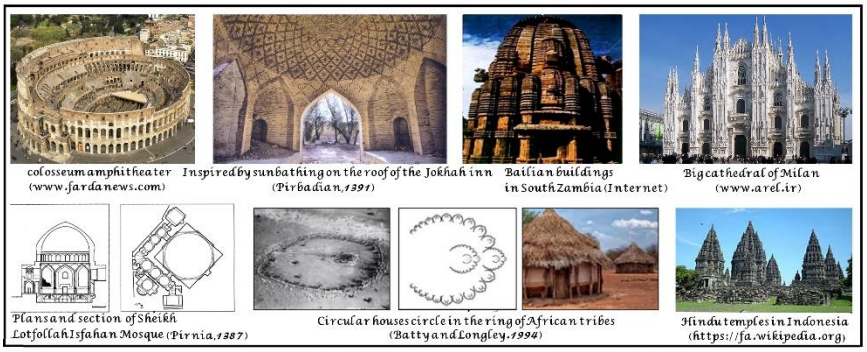

Fig. 10. Fractal samples in old architecture.

Fig. 11. Fractal samples in modern.

6.1 | Fractal in Architecture Study Conclusion

Fractals are applied and unable in architecture in plan, elements, cortex, and form.But the important point is that fractals were used in plan and architecture elements more than cortex and form in the past.

But as architecture progressed and human knowledge increased, technology came to architecture, and we have seen fractal deployment in the cortex and form improve. This peaked at parametric architecture occurrence and bionic style tendency, whose target is inspiration and nature modeling. As far as we can count, parametric and bionic architecture is one of the most popular types in modern architecture.

7 | Fractals in Iran's Architecture

As we stated in the introduction, Iranians were interested in art knowledge long ago. Considering their naturalist origin and their inspiration from natural elements,it is obvious that we see their manifestation in their consequences, including architecture, as if we see lots of samples from this manifestation.

On the other hand, we know that the fractals approach is some natural complex figures geometric modeling and its unionism. [17] Iranian traditional architects followed this goal and pictured it in their designs. Another point is that one of the sensible characteristics of Iranian architecture is the balance and coherence of design, and this is exactly what exists in fractal geometry. (of course, every balance and coherence is not fractal) so, considering these points, we can imagine a very long background for fractals in Iranian architecture. Based on our research, we can see fractal or semi-fractal samples in Iranian architecture, such as ziggurats like Chagazambil.

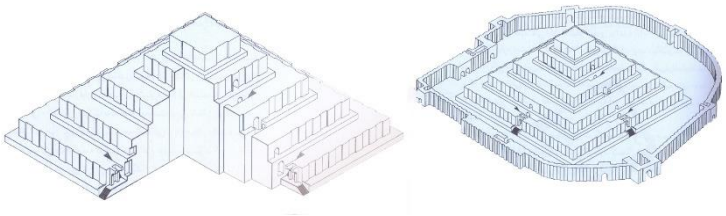

Fig. 12. Chagazanbil Zigurrat and 3d section of its temple.

In some ancient castles and fortresses, we can see fractals in form or plan, including Madi Fortress in Hamedan and Girl's Castle in Firuzabad, Fars. In addition, we can see some of their plans or fractals with the birth of cities. The best samples can be related to Samarkand and Bukhara's plans.

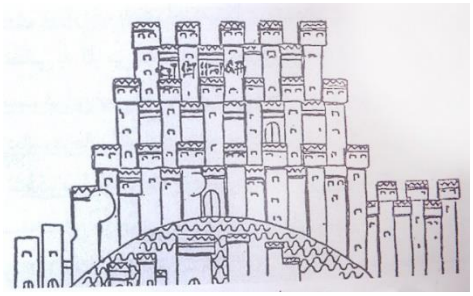

Fig. 13. Madi Fortress.

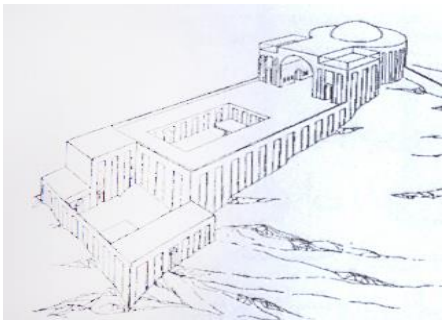

Fig. 14. Girl Castle.

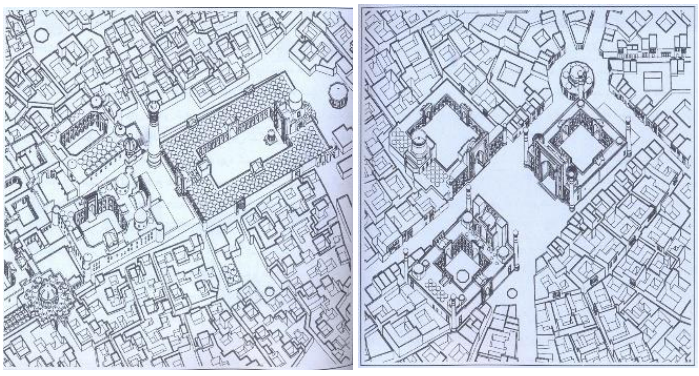

Fig. 15. Bukhara (left) and Samarkand plan (right).

But fractal application climax in Iranian architecture is related to Islamic era architecture. It is usually included in architectural elements and plans. We can find it in bazaars, mosques, houses, caravan-serais, and sometimes in schools and Bathrooms. (of course, fractal figures are seen frequently in this period of tiles and decoration, but we do not consider them because they are not part of our subject) in this era, because of Iranian architects' dominance of geometry and their naturalist origin, we see some designs that nature and natural elements inspiration (like lotus, chamomile, sunflower, peacock, spider web, pine fruit, …) are mixed with geometry beautiful elegance at the highest port of perfection and such blazing wich each spectator will be bewildered of watching them. The mosque's contribution was greater among them because its social place and applied elements were more prominent and wealthy.

But all the mentioned examples (Bazars, mosques, houses, caravan_serais, schools, and bathrooms) are at some level in variety and application range. However, there were more contributions from the bazaars and mosques, and we see the best sample in both elements. If we want to state some samples, it should be bazaars and mosques until the intended goal is presented in the best way. But since they are evaluated, Bazar is less. This contributed to research because this urban element is older and thriving in the past. Still, unfortunately, it is going to be forgotten these days, and in the modern world, we. However, it is necessary to pay more attention to this important element and modernization, syncing it with the world's modern architecture by doing this research. Until it gets its high place again, we chose our studying samples from less-considered bazaars that are being forgotten. But it is necessary to introduce the Bazaar and its details first.

8 | Bazar

8.1 | Definition

Bazar is one of the most important urban buildings [18]. Bazar's first literature refers to a crowded and busy place that is especially able to determine economic, social, and political fate. The world bazar is very old originally [19]. In Pahlavi and Midle-Persian, it was called varchar, which was not only for trading goods. vachar was generally called (an association place) hang-out place. Each city's people gather together in Vachar several times each year. And investigate their social problems [20]. Therefore, a bazar was an association and trading place, nots and strikes center, broadcasting information, communication, introduction place, and sometimes a secure place [19].

Bazar was used as the main communication path in the city in the past, and it was counted as the city center. Important urban spaces, such as the urban grand mosque, great theology schools, Daral Zarb, and most important symbols and spaces, were located near or a short distance from Bazar [20].

8.2 | Bazar's Different Elements

I. Raste marker order: (the main bazar paths which were parallel or crossed over).

II. Raste the line: (it means guild and was located in different parts of the main order.

III. Corridor (against the line, different stuffs were beside similar stuff).

IV. Serai (it was a trading company which stuff samples were delivered there and distributed to the other parts).

V. Khanbar.

VI. timche (was an indoor place and the center of several trading companies, and it means a circular, wide, and well _set place; time is called to the smaller times).

VII. Gheisarieh (means a long serai and a place for artisans and transients).

VIII. Shop (like bakery, pharmacology) [19].

8.3 | Bazar Architecture

Bazar architecture is considered Bazar in order or outdoor in general [18] . As architecture, the space in the middle is surrounded by rooms and chambers. This middle space is sometimes a yard or an indoor space. Sometimes, the building is formed by two or more middle spaces. Some indoor and some outdoor rooms are located around them. A mainline and some linked buildings form each bazaar. This line, which is sometimes direct and sometimes in herbal form, may meet different branches but is always formed by a simple foursquare with two rooms on the sides [21].

In buildings, especially in main spaces, the design geometry is perfect, which is governed from components to the whole. The geometry is formed by emphasizing centers and axes and asserting two perpendicular axes, using pure figures, different types of symmetry, repetition, and firm and decisive effects by repeated emphasis [21].

But bazaar architecture's perfect effect rises from yard outdoor space companionship with indoor space. When people suddenly step (time and time) from dark, busy, and crowded spaces into a pleasant yard or wide indoor and decorous. Space, they feel as if they are relaxing [21].

We can state that yard outdoor spaces, and Timche indoor spaces are two main elements at Bazar, which are more credit than other spaces, and we can see the glamorous effect of Bazar architecture.in them, but since our goal is to study fractal geometry in Bazar, this geometry is Tims and Tandimches. We will concentrate on them to understand them better and more tangible. We state some cases, for instance, and recent natural elements and geometric patterns that are comprehensible.

9 | Fractal Elements Study in Bazaars in the form of Case Sample Analysis

9.1 | Big Tim-Qom

Big Tim is the most important Bazar in Qom bazar which belongs to Qajar era in Bth century . This Tim or Timcheh is connected te bazar and outside only from one side.so it is not passage way and is a quiet spase next to bazars active way [21].

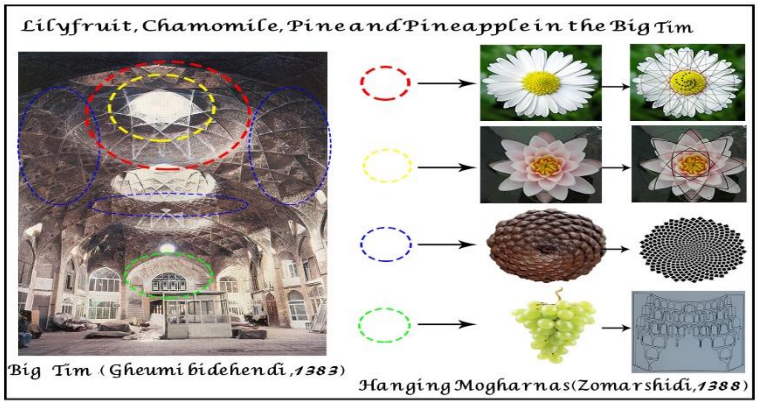

Fig. 16. Natural patterns in Big Tim.

9.2 | Sadr-Azam Timcheh -Qom

According to local people this Timcheh was been built by mirza Ali Asghar Khan,Azam Atabak, Amin ol soltan,naseredin Kings prime ministers order and is built by Hassan Qom masterarchitect.so it is more than one centure old [21].

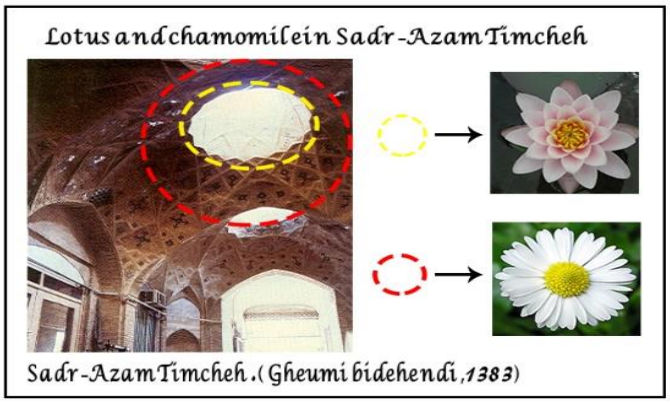

Fig. 17. Natural patterns in Sadr-e-Azam Timcheh.

9.3 | Shin Serai-Qom

this building is located between Qom bazars order and (shin)alley and is formed by one serai in the middle and two corridors in east and west of serai. The serai has a sample and small approve which one floor height which symbols of the second half of Qajars rise or architecture is completely felt in [21].

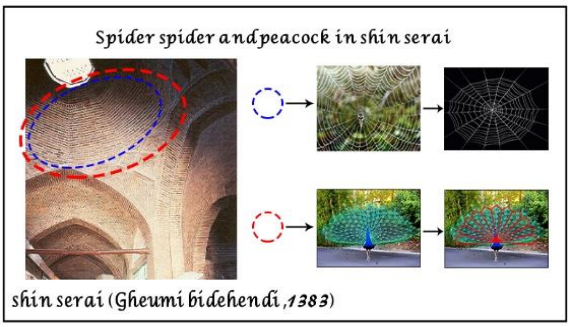

Fig. 18. Natural patterns in Sheen Serai.

9.4 | Aminoddoleh Timcheh-Kashan

It is one of the most important building which is perfect sample of Timcheh, has been built by FarrokH Khan Aminoddoleh Qaffaris order in 1285 in Naseredin Kings era.It has a porch and a middle space and chambers are in two floors around them [21].

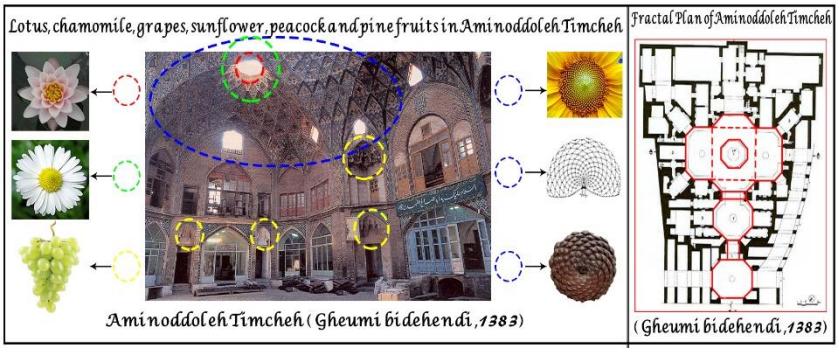

Fig. 19. Natural patterns in Amin-o-Ddoleh Timcheh.

9.5 | Sabbaq Timcheh–Kashan

Sabbaq Timcheh interns of combination and spatial management is one of the simple examples and the same time is toyal Qajar Timcheh. designers strength and appropriate ground made the possibility.

That has been appeared the meaning of Timche specially in terms of spaces stability in a simple a pure way [21].

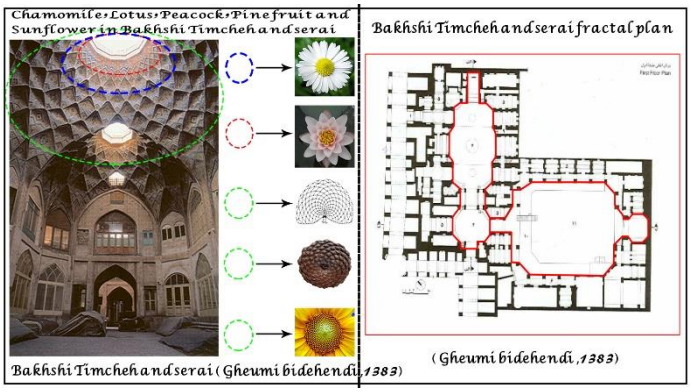

Fig. 20. Natural patterns in Sabbaq.

9.6 | Bakhshi Timcheh and serai- Kashan

One of the highlighted sample of Kashans Bazar building is Bakhshi Timche and serai complex which is built in Qajar era and the fonder of it was Haj Hossein Bakhshi.Timches middle space –the most important. spase of this complex – has long shape which is wider in the middle [21].

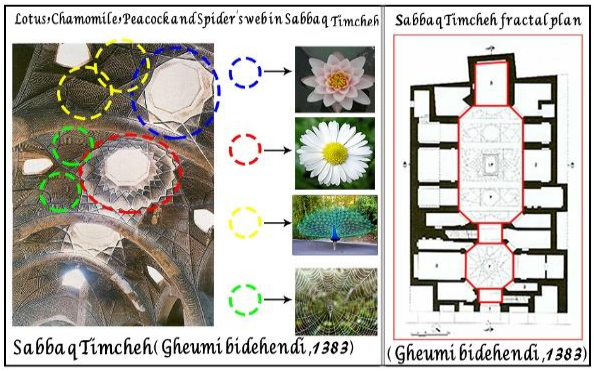

Fig. 21. Natural patterns in Bakhshi Timcheh and Serai.

9.7 | New serai-Kashan

There is a building in the beginning of Kashans Qeisarieh bazar which its design is same haw different and it should be conted as Qajar eras innevations. the first unconventional thing in this serai design is its uniform decagone base, se that the designe is bound to this figure inaddition to apron, basin and garden even in outer environment [21].

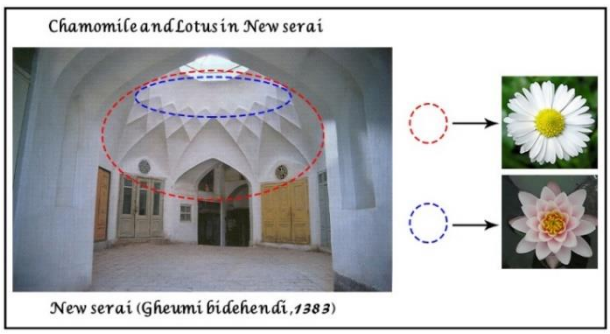

Fig. 22. Natural patterns in New-Serai.

9.8 | Mahdieh Timcheh-Tehran

this Timche which is one of the oldest buildings in Tehran bazar and belongs to Qajar era, is located in the building of shoemakers Bazar and near sabze meydan. And is terminated toshoemakers bazar from west and to Aminolmolk bazar form south and to mercerss bazar from north middle spase at this Timche is two floor and a by a Kashkool base which has attached body and roof together by a little wider and a beautiful detailes karbandi web [21].

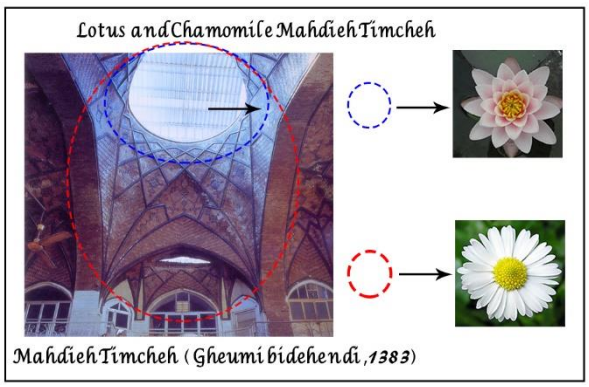

Fig. 23. Natural patterns in Mahdieh Timcheh.

9.9 | Amir complex-Tehran

Serai, which was built in 1267 by Mirza Taghikhan Atabaks order, is one of the detailed complexes that has remained from the Qajar era. This complex terminates at the shoemakers' bazaar from the west, the tailor's bazaar from the north end, and the Amir Bazaar from the east. This complex's main elements include a big eastern-western apron. Two markets in the north and south of the apron, a corridor along the longitudinal axis operon, and two small yards on both sides of the apron and chambers are formed around these centers and axis [22].

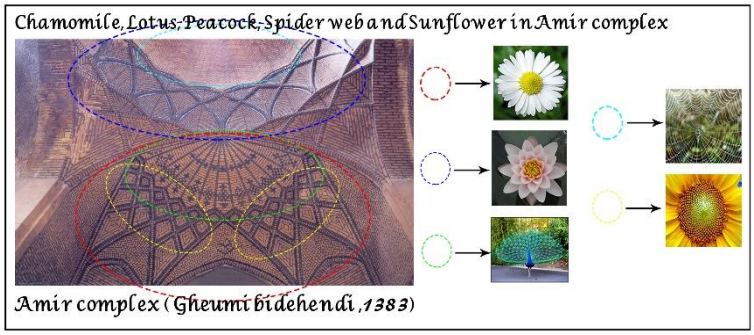

Fig. 24. Natural patterns in Amir complex complexTimcheh.

9.10 | Hajebodoleh Complex-Tehran

This complex, located on the southern side of Aminolmolk bazaar, is a complicated combination of a serai, two Timchehs, and several corridors. The three main centers of the complex, the big Timcheh, Serai, and the small Timche, make an eastern-western axis along Aminolmolk bazaar, which attacks two northern-southern orders at Grand Bazaar in the east and Shoemakers Bazar in the west. The small Timcheh west of the Serai is the most beautiful and delicate port [22].

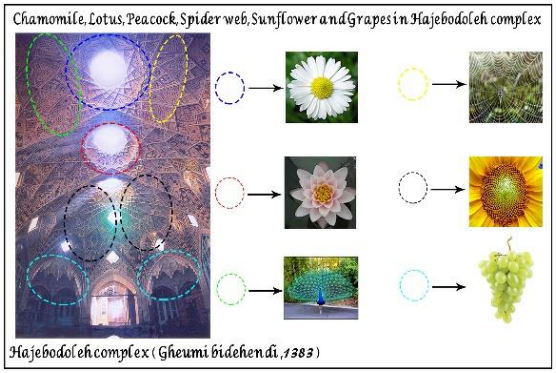

Fig. 25. Natural patterns in Hajib-o-doleh complex complexcomplexTimcheh.

10 | Sample Studying Analysis

We can conclude in two types by observing the preceding sample and checking similar cases. There are some natural elements such as sunflower, pine fruit, and even peacock geometrical designs in the mentioned samples, which other researchers stated is not new because of this. However, some elements are not extracted in any books, magazines, or scientific papers, and these simple sessions of geometric fractals are stated here for the first time. Because of its use, this research is innovative. The impressions are as follows:

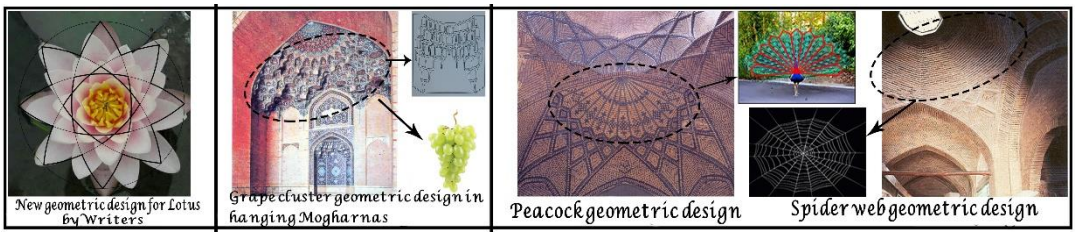

Fig. 26. New writers and innovative conception of Fractal natural elements in Iranian architecture.

Of course we could consider fish scales as a fractal element in karbandi and this is what is not stated anywhere and it is innovative but it is a little out of mind and at the same time there was not any background of it in Iran's culture,we decided not to state it.

Fig. 27. Fish scales recognition in Karbandis.

I. The second group of conclusions is that in this architecture, elements are taken from nature and have the fractal form:

   i. More unity in the plurality sense is seen.

   ii. Naturalist sense of Iranian architects and their natural elements inspiration is completely seen, which is considered in fractal architecture.

iii. The human get familiarity with these elements because of cultural backgrounds, and their understanding and imagination are more tangible.

iv. In addition to original beauty, geometry has added to their attractiveness and made their charm double.

v. These fractal figures and elements have a special algorithm and are not created and expanded accidentally. These points would rather be done according to mathematical principles and rules; this is exactly what we see in fractal geometry. Fractal components have fractal dimensions and will be expanded according to their formulas.

vi. These designs are more expandable, and a little creativity and accuracy can develop them.

11 | Innovation

This study pioneers a systematic approach to analyzing the fractal geometry of traditional Iranian "Timcheh" structures within bazaars and aligning them with principles of contemporary global architecture. By integrating fractal analysis with a developmental perspective, the research introduces a framework that revitalizes traditional architectural patterns while preserving cultural identity in modern design language.

The core innovation lies in presenting an adaptable model that bridges indigenous spatial patterns with the functional demands of today's architecture, offering potential applications in urban regeneration and the design of modern commercial spaces.

12 | Conclusion

In this day and age, modernity has passed geographic borders. It is going to the front with an incredible speed, and every country and nation that can not adapt its culture and tradition in all themes, including architecture with modernity, is sentenced to disappearance. Iran is no exception and has no solution to keep and revive its worthy architectural treasures except adaption.

This requirement caused us to try to realize this goal in the form of this research and within fractal elements and geometry study in Iran's architecture, especially in Islamic era architecture, which we see the highest point of fractal elements effect; we tried to evaluate and modernize the possibility to expand and if possible, study the realization ways and present some suggestions.

Research has determined that because the modern architecture trend is naturalism and fractal and bionic architecture are some of its obvious samples, they were inspiring models for Iran's traditional architecture.

Therefore, considering nature's origin has not changed over time, and its traditions are always lasting, we can conclude that there is the possibility to expand and modernize based on architecture possibility to expand and modernize based on nowadays architecture.

Considering this point, our suggestions as researchers are:

Fractal is used dependently in Iran's architecture, while in modern architecture, fractal is used more in crust and form and as an independent element. So, one way to modernize fractal's traditional usage is to remove it from being a dependent architectural element and give an independent identity through its transition to the crust and form. Such that they do not depend on other aspects.

The best sample in this case is "Parasol Metropal" in Sevil, which, if we look at accurately, we find out there are some forms like Iranian Islamic kar-bandi and, at the same time, is independent itself.

Fig. 28. Karbandi pattern in Parasol Metropol.

Another way is to have a creative and modern conception and rebirth and revive them by adjusting them to world architecture's modern condition, thus showing some contextualist effects of architecture. Azadi Tower is an obvious sample that Hossein Amanat sketched using a foursquare form, which is open, creative, and modern.

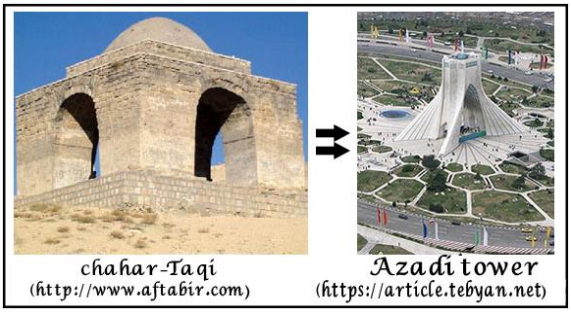

Fig. 29. Azadi tower's pattern from chahar-Taqi formMetropol.

Another modern conception of the traditional pattern is seen in Figure 30, designed by Zigurrat's inspiration.

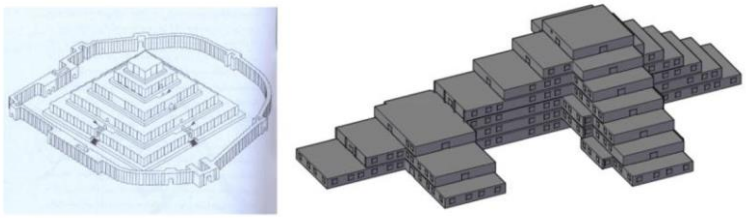

Fig. 30. Zigurrat form inspiration in design.

We can also sketch an iconic from natural elements. The Lotus temple in India is one of these samples inspired by the lotus.

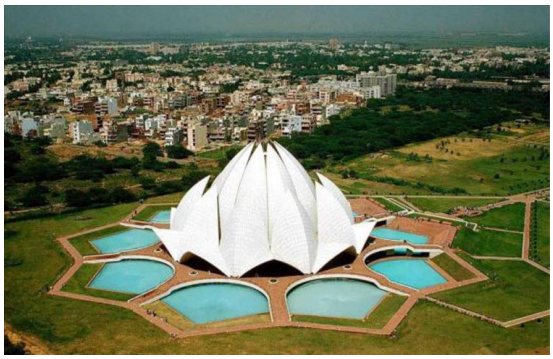

Fig. 31. Lotus temple in Indian.

Complex, new, and elegant designs coordinate with the human naturalist soul. This knowledge makes the creation of every repetitive design possible. Artists from all regions and cultures retell their ancestors' artistic

treasures through a fractal view and look for a creation that coordinates with their ecosystem but matches their era's interests, conditions, and knowledge.

Author Contributions

Conceptualization, methodology, and investigation were collaboratively developed. Data collection, analysis, visualization, and writing tasks were shared equally. All authors contributed to the review and editing process and approved the final version of the manuscript.

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Data Availability

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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