Fractal house and heritage

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Abstract:

Twentieth century was a failure in matter of architecture and urban design in Algeria and particularly in Algiers, the capital. "Modernist" principles were experienced by French colonizers everywhere. Unfortunately, they are revealing many problems caused by disconnection, simplification, reduction and lack of complexity. Sprawled urban territory has made neighbourhoods non liveable spaces: quality of life disappeared completely. Now very serious social problems are emerging and development cannot take place.

Scientists are changing their ways of thinking and many new methods are being tested. All fields are working as teams and trying to share new ideas about managing cities and use sustainable development principles.

In our thesis, while observing heritage architecture (a restored eighteenth century house), we found out that it was designed with a strong analogy to laws of nature and cosmology. Magic square, peer and odd numbers, golden number, golden proportions, connections to cosmos and relation to human body structure characterize this architecture. Body and spirit, it is actually alive and durable. Three century old, it is still comfortable. Spaces are in right measure, optimizing and allow many different uses over time. Mathematical beauty and fractal geometry could be demonstrated. Symmetry of scale, iterations, high level of complexity and harmony between parts (holistic method) appear through observation. Finding the whole in a part (the city in the house) is not a common thing today. This house is typical and unique: it **belongs** to this particular city. Like a living cell or a galaxy, it looks like a sponge, a lung or a bone. It is part of universe; it is understandable through new sciences that are emerging in this starting century.

While talking about natural organisms, we found out that columns in the heart of the house have screwed forms. They recall DNA molecule. Rooms around centre have a spiral arrangement. Tiles also show spiral forms, etc. We find also numbers of Fibonacci (series) that are present in many flowers or fruits and DNA. Our house is mathematically definitely alive and sustainable.

Keywords: Complexity, fractals, belonging, geometry, sustainability, heritage, emergence.

Theoretical framework

In order to be able to understand the complexity of heritage architecture, we had to look for modern sciences that are helpful and efficient. Among them, fractal theory (Benoit Mandelbrot, 1980) or fractal geometry has the advantage to correspond totally to our objectives. This new vision of the world makes us put aside Euclidian geometry which is limitative and insufficient. Instead of dimensions 1, 2 and 3 only, fractals use fractions. Objects could have dimensions between 1 and 2, or between 2 and 3. Benoit Mandelbrot, in the eighties, wrote a book where he explained complexity of natural forms and using computer science, he could modelize them and talk about particular kind of dimensions (Sierpinsky carpet, "flocon de Koch", etc). The mathematician Karl Menger has invented the model called "Menger's sponge" (dimension, 2, 7). This model is a process of infinite iterations of centers (fig. 1). Volume tends to zero and surface tends to infinite (fig. 3). Cube is the most stable form of all (fig. 2). In this paper we will be working with this object in order to demonstrate numerous properties of traditional house in Algiers.
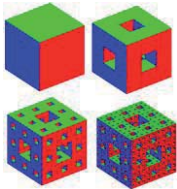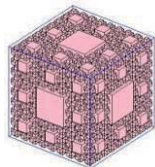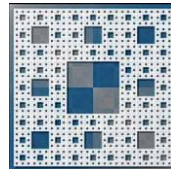
Fig. 1   Fig. 2   Fig. 3

Problematic

Today, throughout the scientific world, researchers are strongly concerned with urban renewal related to sustainable development. They are trying to find new strategies and new methodologies in order to solve crisis at several levels. Cities are growing in all directions without any limit and quality of life is decreasing fast. Urban landscape is no longer manageable and its development can't be predictable. Hopefully, people have understood, now, that cities, as complex systems, have to be organized through complexity. "New" sciences have emerged since the birth of computer science. Scientists are convinced that all fields of knowledge have to be connected and have to work together, aiming to solve problems. Mathematics and philosophy are coming back and helping in this quest. In Algeria, one hundred and thirty two years of colonization have destroyed a whole society. Algerian people have lost identity and culture. Today, they lack references when they try to build cities and architecture. They borrow occidental models and think that they represent modernity. Unfortunately, they are wrong models, completely inadequate and based on simplified patterns which don't have any qualities for the future. Urgency for housing is a pretext. People have been building huge sets of buildings that are destroying natural landscape and causing an ecological disaster. Units are very expensive and are not sustainable. At the beginning, when a family finds a housing unit to live in (fig. 4), every body is happy. A few years later, family members are separated, every day life is unbearable, elevators are always broken and socio-psychological diseases

appear slowly. Actually, we don't know how to build habitable neighbourhoods. New landscapes are composed of collective housing (fig. 5) or individual houses that are expensive but without any convenience or architectural quality. Old city is no longer habitable and French city is so expensive that offices and shopping activities are concentrated there. We call it: "city centre" because it is the only part that have urban wholeness, architectural significance and intelligible language. There is a positive feeling there. It is the only urban qualitative place today for public life.

In the universities, scientists are thinking about new strategies but there is a big gap between theory and practice. Politics and inhabitants are disconnected. It is very difficult to build ethical laws in these conditions. Hopefully, researchers are mobilizing energies and research teams are working hard to make sustainable solutions emerge progressively.

The only place where it is possible to find complex, ecological, ethical, aesthetical, optimized architecture is heritage. Many properties are not revealed yet but a lot of architects are searching. Until now, astonishing qualities are showing that cities of the past are the best lesson of architecture and excellent resources for learning about sustainability, efficiency, optimized systems, high environmental qualities, cultural balance, spirituality, durable patterns, social timeless rules and beauty. We decided to penetrate that period of history where society was civilized and knew how to dwell, to build and to be. Through valuable traces, we tried to dig deeply looking for the essential which is not visible with the eyes. Treasures for the future are certainly in timeless lost pattern languages rooted in eternal tradition and wise modernity.

Fig. 4

Fig. 5

In order to expose the most important properties of Algerian heritage, we will choose Algiers, the capital in the Ottoman era (18° century). After a big earthquake, in 1715, the destroyed city was rebuilt almost entirely. The whole city grew on the base of specific rules that generated a particular architectural language. All houses followed the same rules but took local forms according to the site place. At that time the large system of Algiers was composed of two sub systems: The compact mineral city and the spread out vegetal city (network of gardens), both visually connected (fig. 6).

Fig. 6

Fig. 7

The two systems were so connected that it was impossible to separate them. Very

often, the owner of a house in mineral city (winter house) had a second (summer house) inside a garden (fig. 7). The house that we are presenting is in this case: "Dar" Abdeltif. "Dar" in Arabic means large house. This word comes from the verb: "daara" which means "to turn". "Daira" means circle. Therefore, each house is based on a "movement" around a centre.

Conceptual study through eleven properties:

Remark: we will be noticing that these eleven properties are strongly linked inside a set of systems. No separateness makes this house more complex than others.

3. 1. **The turning house:**

Several aspects show the spiral or helix movement. T-shaped rooms are arranged in spiral form around a courtyard. Between the court yard and rooms, there is a gallery with arcades. Arcades are punctuated with twisted columns (fig.8). On the top of the capital of each column, there are eight spirals (fig. 8). Spirals are sculpted on doors and recall the form of the plan (fig. 9). Some of the ceramic tiles have a spiral design on them. Spiral is a very old famous form chosen to express beauty. It comes from natural forms (snails, galaxies, sun flower (fig. 11), pine apple) and could be constructed with golden number (1, 618) and "suite" of Fibonacci (mathematician). Twisted columns are analogous to DNA molecule (fig. 10). This remarks show the high level of aesthetical value of people at that time. They used to use science of nature at all scales in the way of building. Also, Muslims during the pilgrimage turn seven times around the "Kaaba" (tawaf, fig. 40). From macro to micro scale, the spiral has been structuring the dynamical aliveness. Ethics and aesthetics meet.

Fig. 8   Fig. 9   Fig. 10   Fig. 11

3. 2. **The house "cube":**
All houses at that time are designed basically as cubes. This form is symbolic. The "Kaaba" (fig. 12) in the "haram" of Mecca is a cube and the centre of all Dar el Islam. The cube is a non separable form. The center of islamic houses in North Africa is an empty cube. The void IS the most important part of the house and the center of interest.

3. 3. **The courtyard house:**
All houses have a heart (fig. 13) or center called "west ed dar". It is analogous to spiritual place in Mecca. In nature (micro scale) we find centralized forms (algae (fig. 14), digit (fig. 15)). Architecture is inspiring. Builders were observing nature. This courtyard is the most important connector in this highly complex architecture. Galleries connect all the spaces of the house to the courtyard. This element doesn't

exist systematically in houses of Islamic territory elsewhere (Tunisia and Morocco, sometimes there are no galleries around the courtyard).
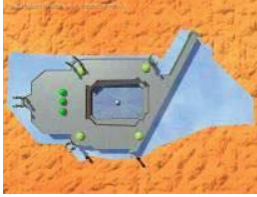

Fig. 12   Fig. 13   Fig. 14   Fig. 15

3. 4. **The house "sponge":**

The natural sponge (fig. 16) is a soft "body" full of voids. With this kind of structure, it attracts water and absorbs it. Interior surface is infinite even if the volume is small. The model of Karl Menger describes the natural organism. This traditional house has the properties of this model. It is organized on the basis of interrelated cavities (fig. 17).

Fig. 16   Fig. 17   Fig. 18   Fig. 19

In summer, when temperature is very high, this house, with such an interior complex form, makes air circulate efficiently, get hot while rising towards curved ceilings (fig. 18) and finally gets out from small openings (fig. 18 and 19). Water works in natural sponge, air works in house. No need for air conditioning here. When it is 40° C outside, inside it is around 18° C. Energy is saved and space is well arranged.

3. 5. **The house "bone":**

Bone is spongious (fig. 20) even if it looks tough. Inside it is full of voids (fig. 21) while rather strong. The structure is highly complex. Our house has also a strong thick wall as a protective skin and is full of compartments or cavities. It looks like an interior sculpture.
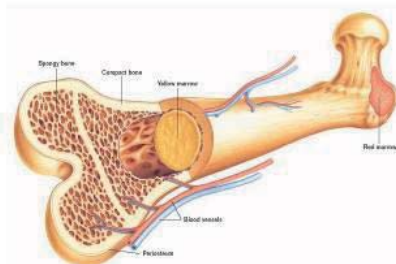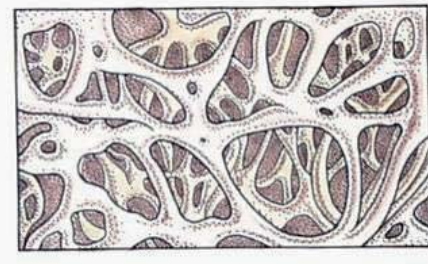

Fig. 20   Fig. 21

"In all things, perfection is finally attained not when there is nothing to add, but when there is nothing to take away." Antoine de St Exupery.

3. 6. **The cosmic house:**

Keith Critchlow, in "Islamic Patterns", explains all the cosmological approach of islamic philosophy that generated arts. In Islam, art and architecture are not separable. He shows magic squares (fig. 22) of all orders. Our house is conceived on order 3. Magic square and Menger's sponge are related. The form has a center

and numbers. On the cross, numbers are odd and on the four angles they are even. In sacred book (Qur'an) odd numbers are magics. Five is very special: Five pilars of islam, five daily prayers, five fingers in members, five openings in face, five senses, etc. Five is in the center. We have found (in our Phd research) that all courtyards measure 1/5° of the surface of the house. It is a specific rule. 1, 3, 7 and 9 turn around five. Each number has a historical and cosmical meaning. Magic squares are very old (India, China, thousands years old). Islamic civilization took a lot from what existed before (mesopotamian, Indian, Greek) and added its own amount of science and knowledge (El Khawarizmi invented algorithms that are used to generate fractals figures today, fractions, and algebra). When genius people were building such houses, they had a high level of spirituality and some of them were practicing 'tassawouf" which is a mystical attitude. Twentieth century has eradicated this religious behaviour especially in colonized countries. In all fields, a tendancy to simplification arouse. Today, people are becoming aware of the lack of spirituality. We notice that it is emerging again everywhere in the world.

Fig. 22

3. 7. **The natural house:**

In this house, the floor of the courtyard is built with hexagonal marble pieces. It is an analogy to honey bee design (fig. 23). Buiders name it "periodic" pavage. It is an optimization of the use of the material. It is interesting to think about: "why bees construct hexagonal cavities for honey (fig. 24), eggs or pollen storage" (fig. 25)? For sure it has a very smart explanation.(In Qur'an there is a whole sourate about bees.) This truth was noticed by mathematician Pappus in the antiquity. Ethics and aesthetics meet.
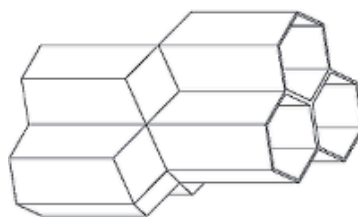

Fig. 23   Fig. 24   Fig. 25

3. 8. **The optimized house:**

In the whole house, we could not find a millimeter of unuseful or negative space. Three- dimensional design makes this house intelligent. Every thing is at the right place. Complexity makes all places connected and intelligible. Remarkable strengh is in all connectors: galleries, entrance room, stair cases, porch, and centers at all levels. These "in between" makes the inner quality of such a design. A huge energy goes from the courtyard towards all rooms. These rooms are complex: they can

allow a family to inhabit. They are kinds of small appartments (T shaped in order to design a center that is connected to the courtyard). Storage spaces are inside walls or in stairs volume. The amount of variable daylight is regulated with the center. Rooms are not too deep. They receive sunlight from all sides. Christopher Alexander (1979) talks about the quality without a name, in his book, "The Timeless Way of Building" (1979). Actually, every property added to the other one makes a very strong system of interrelated phenomenons. It is this situation that gives us the sensation of beauty.

3. 9. **The spacious house:**

Since surface tends to infinite whatever the volume could be, it is a sensation of unfolding inside each space (fig. 27, 28, 29, 30). We could imagine a mental morphogenesis where the whole precedes parts like in the embryo. Inside the body, after the enveloppe, heart is the first important step. Then each part, autonomous and also a whole itself, will grow depending to the whole and other parts. DNA gives all informations. Every thing is registered there. In one special house, all parts are special but they use laws of all houses in this city. The part is inside the whole and the whole is inside the part (fig. 26).

Fig. 26   Fig. 27   Fig. 28   Fig. 29   Fig. 30

A famous saying of the prophet Muhammed (PBUH) states: "Four secrets of happiness: A good wife, a good neighbour, a spacious house and a good mount". Besim Hakim (1986, architect and historian) said that spaciousness is a matter of design morphology. In a house where surface grows infinitely, we perceive spaciousness, we feel it. Feeling is essential inside a building. When we talk about a generous person, we say she has a big heart.

3. 10. **The house of interiorities:**

This house system is made only of interiorities. The vegetal city is inside the large city. The garden is inside the vegetal city. The house is inside the garden. The courtyard is inside the house. All parts of the house are ordered according to the symmetry of scales. The concept of belonging is very important in such society. French colonizer destroyed interiority (fig. 31 and 32) as a need and a value. They introduced the occidental concept of exteriority (fig. 33) which did not exist at that time. They broke thick walls to put openings (violation of intimacy). They built new models of architecture and urban organization. After independence (1962), people forgot how to build in adequation with their actual values and needs. They have been valuing intimacy but they continue to copy exteriority (fig. 34) of the colonizer, even if they still inhabit the interior of the house. In traditional houses, the façade is inside. Four walls are richly decorated with ceramic tiles and galleries are limited with elegant columns. Arches are typical to Algiers. Interior life in comfortable interior spaces made houses contain thousands of activities. The volume evolves inwardly

with the family. It is powerful and efficient. It has all qualities of adaptability. It could last three centuries and continue to prove its potency.

| Fig. 31 | Fig. 32 | Fig. 33 | Fig. 34 |

3. 11. **The house lung:**

The lung is a fractal structure (fig. 35). It looks like a complex tree. But it has a remarkable ability: it contracts and expands. Our house, when it is built in compact mineral city where pieces of land are small, keeps its whole language but it contracts. Instead of four galleries we can find three or two or one. The same is for rooms. It is important to mention that a 40m 2 house has the same language as a 600m 2 house in a large property: entrance transition, courtyard, T shaped rooms, galleries, niches and terrace with its room. In a large house, spaces expand, surface increases but principles are kept.
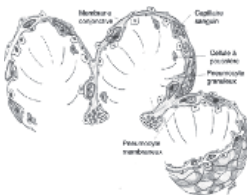

| Fig. 35 | Fig. 36 | Fig. 37 | Fig. 38 |

On the right drawings, one shows contraction and the two others show expansion.
Remark: the universe has been in constant expansion (fig. 39) (Edwin Hubble, 1929) and rotative move (fig. 40).

| Fig. 39 | Fig 40 |

Conclusion:

This house symbolizes constant move and it breathes. Air is circulating with convenience. It is sane. People inside are in good health because exchanges can occur in good conditions. The analogy with lung, bone and sponge helps us understand the sustainability in such a complex system. Optimization is one of the most important qualities. Since we can understand this living organism through modern sciences, we have all the tools for the elaboration of future rules in modern

architecture. Heritage helps us recover identity and appreciate the work of our ancestors and build our own local building laws. They have to be evolving with expected needs. New technology is not in contradiction with all our reasoning. If we work hard to establish strong ethical specific principles in our territory, we could allow future promises of new aesthetics to emerge. People would not copy randomly other models. They would help appropriate solutions to emerge locally. Globalization would not be frightening anymore. Cultural values have a big impact on architectural forms.

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