Handling Architectural Complexity by Combining Genetic and Syntactic Approaches

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The Case of Traditional Settlements in North Africa

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Abstract
This paper examines ways in which a genetic approach might contribute to space syntax research and allow for a holistic understanding of architectural and urban systems. The genetic approach has proved its usefulness in studying architectural systems and the definition of genotypes. Previous works tend to validate the idea that the evolutionary vision of architectural and urban entities, perceived as complex systems, might contribute to explain the dualities of continuity/discontinuity and ancient/new and phenomena of style and identity in the architectural production.

On the other hand, space syntax research gives a wide understanding on the relationship between spatial configuration and people's use and behaviour. Moreover, it has been demonstrated that building forms are embodied in social norms of societies. Linking the two theories leads to question whether there are any interrelationships between parts and whole both in genetic and syntactic terms allowing for the formulation of a common system combining architectural and syntactic properties.

Thus, the study explores case studies of selected traditional north African settlements called "medina", starting by the medina of Algiers in Algeria. Through the use of the genetic approach, the architectural system of the medina was defined together with its various subsystems and compartments. Syntactic properties were calculated using axial and visibility graph analysis (VGA). The analysis of the compartmental program of the subsystems, their frequency and their constitution revealed the existence of two sub-systems: the parent and the adapted subsystems, the latter resulting from the cross breeding of the former. The study also allowed for a chronological identification of the different subsystems forming the medina.

The syntactic analysis conducted, either for a given subsystem within its taxonomic class or by comparing several comparable subsystems, revealed that such evolution may be dealt with in the first place by keeping the same program, the continuity perceived in the evolution of the physical configuration is assured by means of adaptation by change transformation of syntactic relationships between the different elements so as to produce potentially adaptable spaces for a needed program. The other way is the change of the compartmental program elements by transforming one or several compartments according to historical, contextual and usage constraints.

The analysis also revealed that the syntactic properties of the parts tend to articulate with the whole in the same logic as genetic programs do but by giving a different kind of information on the socio-spatial knowledge of the architectural complex system.

1. Introduction

The ancient medina of Algiers, also known as the Kasbah, is a triangular-shaped town engraved into the hills in front of the Mediterranean Sea. The triangle is constituted by the sea at its base and the citadel at its summit. The striking beauty of the town has been celebrated by painters, architects and poets. (Missoum, 2003). It is one of three famous ancient cores besides those of Tunis and Fez in Morocco. Old Algiers shares many similarities with the medina of Tunis; the two of them bearing the fingerprints of the Ottoman presence in North Africa which lasted from the sixteenth century till the advent of French colonisation. The medina of Algiers, like its Moroccan and Tunisian counterparts, has always been described as a complex urban entity. However, although largely acknowledged, such complexity has rarely been approached outside the traditional historical and formal descriptive approaches. Most studies so far have been concerned with social, historical or archaeological aspects, stressing the priority to preserve a valuable architectural heritage for the forthcoming generations. Few attempts have been made to analyze the link between physical aspects and social ones and to find out whether culture is embodied in the physical structure.

2. The ancient medina of Algiers

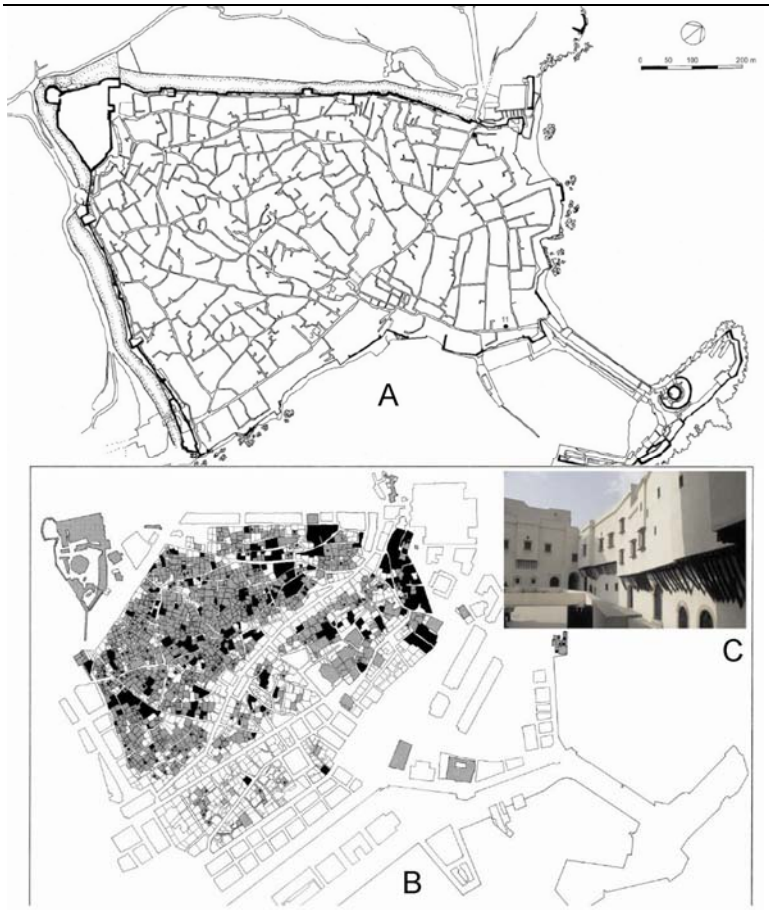

Figure 1

The medina of Algiers before the French occupation (A),the situation today with some houses (black coloured) are in ruins (B) and an experience of rehabilitation (C). Composition by the author, after Missoum (2003)

Founded by the The Zirid dynasty in the tenth century over the remains of the ancient Phoenician and Roman settlement under the name of 'Djezair Beni Mezghenna', the Kasbah was ruled by successive dynasties until the arrival of the Ottomans in the sixteenth century, becoming the capital of Algeria. (Missoum, 2003) The recapture of Spain by the Christians in the fifteenth century caused a flow of the Andalusian population, phenomena that added to the diversity of the population and richness of architectural and urban solutions. There is little knowledge about the

pre-ottoman city, however, the walls of the Berber settlement might have corresponded to the later Ottoman walls, but the density was considerably lower than that of the post-sixteenth-century period. Many of the streets are former Roman paths or filled ravines which served as open sewer at the Berber time. The fortified Medina, which was built on a hill, then presented 7 Gates (Bab). (Missoum, 2003) (Figure1). The Kasbah was divided into two zones the upper (private) city, called Al-Djabal or "the mountain," and the lower (public) city, called Al-Wata or "the plains. Administrative, military, and commercial settings occupied the lower part, inhabited mainly by dignitaries and rich families, whereas small neighbourhoods occupied the upper city. Along the main streets, are concentrated souks and warehouses. The street network is characterized by a functional hierarchy, revealing three types of streets: those of the lower town, large and crowded, accommodating commercial and military functions; those of the upper town neighbourhoods, narrow, irregular catering for privacy and safety, often with dead-ends; and transversal streets ones liking the two sections. The medina of Algiers contains, besides its street pattern, a great number of religious and public buildings, among them come, in the first place major mosques and a multitude of smaller neighbourhood ones. Zawyias (small mosques), medersas (religious schools), fountains and hammams (public baths) were scattered around the city. Small markets (swika) constitute interfaces between neighbourhoods. There were also leisure spaces like sabats (vaulted sitting spaces), qahouet (cafés), passengers, merchants and visitors' facilities like foundouks (hotels), and military facilities like Palaces, bordjs (citadels, towers) and military barracks that are located not far from the ramparts. After the French occupation, many projects, based on the Haussmanian urban tradition, were elaborated, which would later change drastically the face of the city. The fact that Algeria was one the earliest conquests made the new masters in a rather uncomfortable position of explorers; hence they mostly proceeded by trial and error according to Celik (1997). This explains why Algiers, unlike Tunis or Fez, experienced a huge upheaval, which marks are visible today. However, this is paper sets out only to explore pre-colonial Algiers in order to understand how it worked as a coherent whole and as a physical response to cultural, social and environmental needs.

2.1.The house of the Kasbah

The house of the Kasbah is a highly introverted structure with a spinal column constituted by Wast-eddar (the courtyard, the upper gallery and the terrace). Four types of houses can be found in Old Algiers: the Common House, with or without chbek (a lattice which sometimes covers the courtyard), is the most common house constituted by a courtyard surrounded by rooms and accessible through an entrance device called skifa. The upper floors contain the main rooms, all opening onto the arcade. A stairway leads to the roof terrace which contains one or more rooms and a terrace that communicates to the neighbouring houses. The large house, although organised following the same scheme, is far more complex because of the spaces added to the main structure. The most striking example is the skifa; a simple single space in the common House to a series of articulated ones in the large house. The third type is the aali house, a small house, without courtyard and often with hanouts (boutiques) at the ground level. The fourth type called Dwira is a medium between the smallest, the aali house and the simple house. It serves often as an extension for the large houses.

3. Approaches dealing with the medina

Geographers tend to question issues such as centrality and its relationship to urban growth and the shift of the city centre from the medina to new and more equipped areas. Social and cultural parameters, supposed to be at the outset of medinas, have been the domain of sociologists and anthropologists. Historians and archaeologists advanced theories about the origins of the medina and the potential Mediterranean influences. (OREF, 1984) All the above cited approaches and others adopt an anti-physicalist attitude and tend to ignore physical dimensions architectural and urban structure. Only morphologists, most of them architects, tried to give an alternative reading of the medina by stressing its structural parameters like spatial organisation and the decomposition of urban tissues following perceptual assets of limits and continuity – discontinuity and so on. In his work on the medina of Tunis, Berardi sets out to undertake a new reading of the urban structure of the city and concludes that such a coherent and ordered system, with all its variations, cannot be the result of random historic circumstances. Drawing from structuralist methods and

urban semiology, Berardi contends that “the aggregation of discrete elements gives rise to various combinations: groups like the Souk or the house result from operations exerted on discrete elements, gaining in complexity as the aggregations grow. The souk, for example, when multiplied, results in an enclosure which can be transformed into a foudouk by addition or from a foundouk back to a souk by subtraction. A serial combination of souks gives the complete pattern market alleys”. (Berardi, 1969). In a similar way, Santelli, undertook a comparative study of several medinas in the Maghreb and drew up a structural model starting by basic units which he defines, respectively for public buildings and for housing. (Santelli, 1982) However, these approaches reflect the dichotomy between the physical dimensions of space and its cultural assets on one hand and between parts and whole on the other. This underlines the need for a complex approach that regards the medina as a complex system.

4. Towards more appropriate approaches: « genetic » and « space syntax »

4. The genetic approach: application to architecture

Traditional evolutionary analogies refer to evolutionary adaptation, form, function, environment and time. According to Steadman (1979, 1983), the notion of ‘transformation’ diverges from that of ‘evolution’ in the fact that transformation might consist of a systematic permutation or combination of parts and elements. Among the architectural analogies comes the Durand’s system of composition involving the setting up of principal and subsidiary axes for the building, around which pre-designed elements -the basic molecules or cells of the structure- are then arranged and disposed following d’Arcy Thompson’s theory of transformation. The latter supposes that ‘any material form could be transformed into any other’. (Steadman, 1979, 1983) Recent research findings have confirmed the validity of a genetic approach to architectural creativity. (De Biasi, 2000) By studying notes, sketches, models, plans, technical drawings,) and by reconstituting their phase by phase chronological series, the different ways followed in the thinking process, the different tasks in the design studio, it is possible to uncover profound mechanisms of the design process. The P.O.M system is an evolutionary model of design put forward by Tzonis (2001) and intended to deal with the problem of representing architectural knowledge, the basic concepts and structures which capture information contained in precedents, principles and rules of architecture. After fitting this knowledge into a reasoning mechanism, Tzonis translated it into a framework, which aims to represent design explanation as well as design generation. The framework of the P.O.M. system relies on four main concepts, which are: ‘performance’, operation’, ‘morphology’ and ‘context’. According to Zarzar (2003), ‘performance’ refers to the conditions that a building is intended to bring about; morphology refers to the formal aspects of a building or an urban area; ‘operation’ refers to the process that comprises the use of a building and the role of form in the process and finally ‘context’ refers to the state in the external world. Through the many examples given by the author to validate its model, like the Unité d’habitation of Le Corbusier the P.O.M. system has provides a good description of the features to be transferred, adapted and/or recombined. (Zarzar, 2003) Zarzar, however, criticized Tzonis’ model over a number of issues, namely over the adaptation and fitness to the environment. Building on Tzonis’ model, Zarzar built her own model by applying the concept of d-genes (meaning design genes to distinguish them from biological genes) which are subdivided into regulatory and structural. The regulatory d-genes transference means the transmission of order and configuration whereas the structural d-genes are concerned with materials and techniques. Another example, equally drawn from Le Corbusier’s projects is that of the ‘Piloti’. It is contended that in the re-use of the precedent ‘savage hut’ leading to the emergence of the ‘piloti’ needs the definition of the role of the context, which imposes scale and plot constraints. Regulatory d-genes impose, in this case, the transference of structural d-genes as an instruction towards a structural solution, not in timber but in concrete as imposed by context. As can be seen, the P.O.M. model revisited bears a great potential of applicability. However, the main problem in analysing ancient urban structures is the lack of traces in the design of these entities. If archives allow for the exploration of the evolution phases, they do not do so for the genetic material (namely project drawings and sketches), which is, in most cases, non-existent. In modern design, architects have developed habits consisting of recalling parts, which combined, give different wholes. In the highly complex systems of medinas, the relationship between whole and parts is overriding. Hence, an appropriate genetic model is yet to be built.

4.1. Toward a genetic approach methodology

The construction of an evolutionary model implies an analogy between the human system and the architectural system. A system is defined as a set of elements which interact between them and with the external environment. From such a definition architecture can be represented as an artificial system. The fundamental concepts of a system can be summarized in the following:

1. One or several parts of a system constitute a sub-system which, on its turn, may be broken down into other sub-systems. The topology of a system can only be perfectly defined if its description comprises entities called components.
2. The system, being an object, is defined regarding an environment.
3. Systems are not immutable entities. Their fundamental priorities concern their evaluation capacities. The evolution depends both on the system structure and on the external environment. (Chevallier, 1998)

In the present study, architecture is apprehended in an evolutionary viewpoint that supposes the dynamism of the system, with an input, an output, intrinsic (adaptation, reproduction, crossover and/or- mutation) and extrinsic relations. (Benhsain, 2008) A dynamic open system informs us on the relationships it has with the external environment and especially about relationships between subsystems or objects. That is a dynamic open system. In this study, the exchange with the external environment, that is extrinsic relations, will not be studied, only intrinsic relations will be treated. In order to study the evolutionary character of the system, an input which represents the state of the art in the background knowledge of the morphogenesis of the city, is defined which in a first step. The second step consists in adapting this input to the components of the system. Architectural objects diverge from each other by progressive modifications, due to artificial selection that defines the evolutionary mode of the architectural system. The evolution is modelled by adaptation and transformation: historical constraints, the influence of the context, laws of usage and local abilities among other aspects define user needs by adapting the programs of architectural responses; the latter change progressively to define a new and original architectural system. The genetic program is defined once the genotype and phenotype are defined.

5. Space syntax

5.1. The analysis model

The methodology consists of applying Space Syntax, which is a set of techniques for describing and analysing relational/configurational properties of manmade environments (Hillier and Hanson, 1984, Hanson, 1998, Bafna, 2003). The current study introduces the concept of ‘compartment’ which relates to the notion of ‘sector’ put forward by Amorim (1997, 2001). In a series of papers exploring the sectors’ organisation of samples of modern houses designed and built in Brazil between the fifties and the seventies, Amorim uncovered the hidden idea of sectors and demonstrated that the understanding of buildings as a collection of functional sectors was pervasive enough to establish a paradigm for housing design: the sectors paradigm. (Amorim, 2001) As a result, he found that sectors were phenotypically arranged, but expressed by a few genotypes. The same author explored further the sector concept and demonstrated the role of sectors in guiding depth distribution in buildings. Among the other space syntax studies dealing with genotype issues and graph and shape transformation, come those of Conroy Dalton and Kirsan (2005) and Heitor, Duarte and Marques Pinto (2003). However, whereas the first deals with graph matching and similarity, the latter is concerned with the formulation, evaluation and generation of designs, combining shape grammar and space syntax.

The present paper re-examines the idea of combining spatial transformation and adaptation by character inheritance and syntactic properties. But, instead of applying it to one building type, it is across different building types that it is applied and justifies the use of the word ‘genetic’ instead of ‘shape grammars’. Likewise, and despite the fact that the study draws heavily on the sectors paradigm, the analysis of buildings with different programs, composing subsystems of a grater entity which is the system (the city as a whole) imposes the recourse to the notion of ‘compartment’ instead of ‘sector’. A spatial analysis is carried out between sets of buildings having

the same function and between sets of buildings supposed to have undergone transformations and adaptations to accommodate other functions and to acquire a new identity. The aim is to uncover configurational properties embedded in the different configurations and to compare the results with the provisional conclusions of the genetic analysis. Classical syntactic analysis was carried out starting with simple j-graphs used to determine visually salient features and to show the articulation of the main program or compartment in genetic terms with other programs, taking into account the Depth parameter. The latter, needless to say, is an important configurational property of spatial patterns and indicates how many steps one must pass through to arrive at a particular space in the configuration. This is a crucial feature in ancient buildings. Other syntactic properties like Relative asymmetry, integration and control were also measured. A visibility analysis was also undertaken in order to explore ways in which parts articulate with each other and with the system as a whole; it is important to know whether syntactic like visual integration and relativised entropy measures vary with growing complexity and change in the nature of articulation between components. (Turner et al, 2001) This is to test the consistency and pervasiveness of common themes underlying the spatial organisation even when there are substantial differences in the manifest morphology. Agraph© was used for j-graph calculations and DepthMap© for performing visibility graph analysis.

6. Definition of the architectural system of the medina of Algiers in the Ottoman period

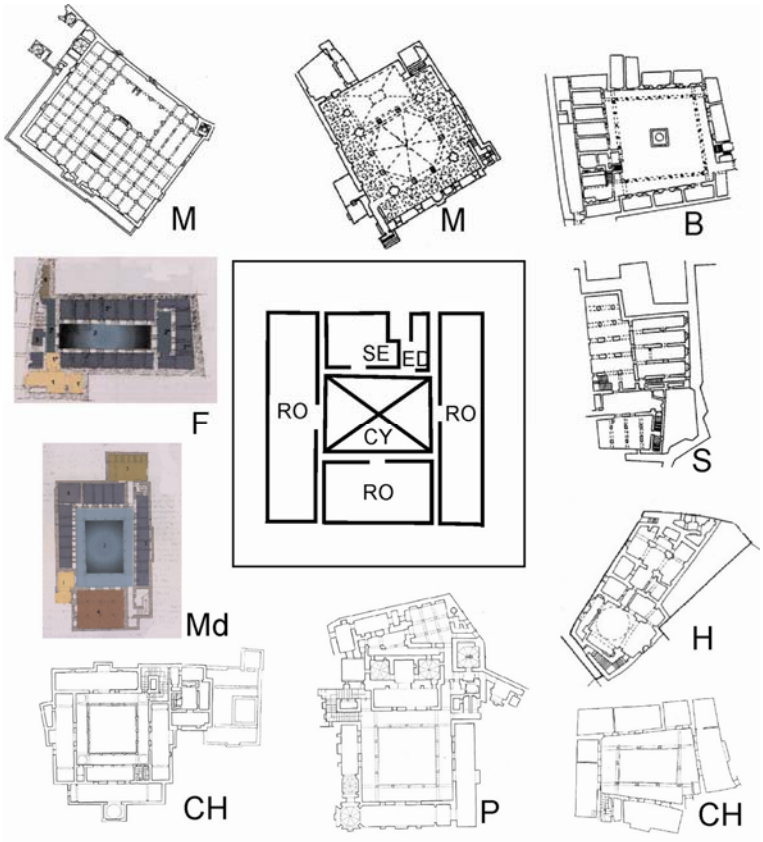

Figure 2
Some of the subsystems composing the medina system: the deconstruction of the basic subsystems gives out a few discrete elements.

Working as a system, the medina of Algiers witnessed the integration of new buildings without eliminating the existing ones. During the ottoman period, new systems with new programs were inserted like cafes, jails, and barracks, alongside the existing bakeries, hammams (baths), souks (markets), mosques, zawyias (small mosques and schools), M'sids (schools) Sabats (covered street sections), Foudouks (hotels), Cafes, Makhzan (depots), Palaces, Citadels, and diverse

urban equipments. These elements together with the big houses and the small popular ones form the system of the medina. The main argument is that the elements cited above act as interacting subsystems with one or more parts of a system constituting a sub-system. It is frequent that one part be subdivided into smaller parts. The topology of a system will be properly defined only when its description contains only primary parts which cannot be further broken up, called compartments. (Figure 2)

- Entrance device (ED): designates squabble-like entrances designed as buffer spaces between exterior and interior. There's a variety of skifa in the medina of Algiers, with corridors, sitting places, and sometimes with room for male guests.
- Courtyard (Cy): open space surrounded by a covered archway and walls or living spaces like rooms or cells in the case of schools (medersas) or military barracks.
- Room or cell (RO): the room is the living space in houses and takes several forms and dimensions, as shown in the diagram below. In Public buildings, it is designated by cell.
- The definition of the compartments will inform on the objectal relationships between the different subsystems.

6.1. Analysis of the compartimental program and evolution of the subsystems

1. The two most frequent compartments are the courtyard (Cy) and the entrance device (ED).
2. The courtyard is only missing in the hammam and the cafe, regarded as leisure places.
3. The mosque is the only sub-system which does not contain an entrance device.

6.1.1. Analysis of the mosques subsystem

Every subsystem contains in its compartmental program: a primary program; present in equivalent subsystems; a secondary program, which completes the primary program but not present in equivalent subsystems; and finally a distinctive program containing one or more compartments which identify the subsystem. The example of the mosque is illustrates this trend: All the mosques of the medina of Algiers contain in their primary program a prayer room (Pr), a courtyard (Cy) and a gallery (GA). Secondary program items like ablution spaces and services (SE) are not present in all the mosques. The minaret is a distinctive feature not present in all the mosques. (Table 1). The compartimental program of the mosque slightly changed from the pre-Ottoman to the Ottoman period by the introduction of new compartments and the tendency, for the prayer room, to evolve from hypostyle types towards centred Ottoman ones and from transversal to longitudinal distribution. However this tendency does not eliminate distinctive features, originating in a contextual model belonging to the medina of Algiers.

6.2. The syntactic analysis

The syntactic analysis is mainly carried out to uncover relationships between subsystems and test the evolutionary and adaptive trends discovered earlier. (Figure 3)

The evolution of the mosque from the pre-Ottoman to the Ottoman period shows that the primary compartment, namely: the courtyard, the prayer room and services, is still there but losing some of its attributes; the courtyard is no longer a must and the prayer room is no longer the main structuring space. The prayer room becomes, in some entities, the most accessible space. The justified graphs reveal the shift from linear deep structures to shallower ones. The move of the integration core from the courtyard or the prayer room space nearer to the centre of the prayer room illustrates this tendency. The variation of RRA for the courtyard follows a steep decrease from 1.18 in Djamaa Lekbir, the most ancient mosque in Old Algiers, to 0.32 for Sidi Ramdane mosque which still belongs to the pre-Ottoman sample. This probably explains the specific character and the complexity of the plan of this old mosque, as can be seen in figure 2. Then RRA undergoes little variation across the whole sample, demonstrating that it is always the most integrated space, even for the prayer room centred Ottoman mosque. The exception is probably Bitchin in which the courtyard RRA and the prayer room RRA meet at 0.45 value point, showing equal level in integration for both. The case of the prayer room is it varies from medium values (0.45), (0.54) and (0.59) to relatively higher ones (0.85), (0.94) culminating in a high value (1) for El-Djadid mosque, justifying the trend towards more segregation for both the courtyard and the prayer room but the

variation is very slow reflecting the process of adaptation. The visibility graph analysis showed that the courtyard, very important feature in most of the mosque types found in literature is still a very integrated space in the Casbah of Algiers but does not exert the sort of prominent visibility control of all of the spaces constituting the mosque system. Furthermore, because probably of the process of densification and the scarcity of land, most of the space is devoted to the prayer room. The context seems to have played a great part in the layout shift from hypostyle to ottoman type. Thus the role of the context in adapting compartments was carried out in regard of the whole system and was realised under the control of the context as was demonstrated by Tzonis in his P.O.M. system

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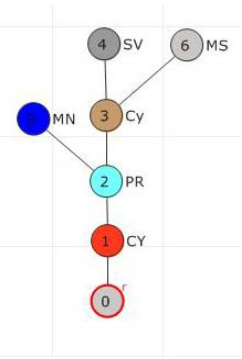
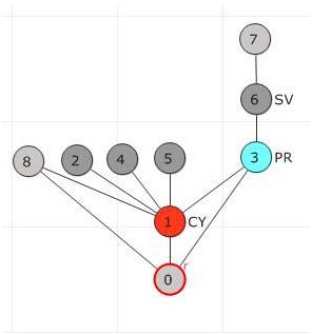
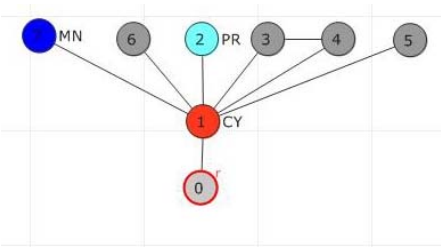
<tr><td> 
</td><td> 
</td><td> 
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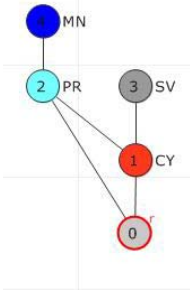
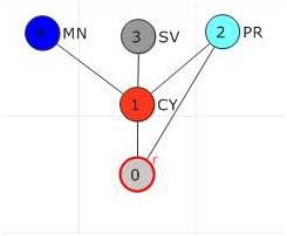
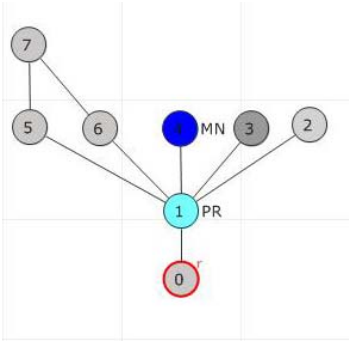
<tr><td> 
</td><td> 
</td><td> 
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<tr><td>Bitchin mosque</td><td>Ketchawa mosque</td><td>Djamaa El Djadid mosque</td></tr>
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Figure 3
Justified graphs of the mosques sample

6.3. Evolution Of The House's Subsystem

Several types of houses exist in Old Algiers, despite the fact that all seem to belong to the same house system with its variants. The most common type is the Common House, with a Wast-a-dar (courtyard) with rooms articulated around, the rooms may be simple or large with kbous (a contiguous sitting place) whereas the courtyard may open or covered by a grill. The house system might have had for input ancient Mediterranean, middle-eastern and local influences, namely concerning the centred courtyard. There is no structural difference between the simple "popular" house and the big "master houses" except from the point of view of surfaces or in the adjunction of a small adjacent house for different purposes, or more commonly a hammam (bath) and a bakery acting as a heater for the hammam. However the most striking feature, although simply a result of a program reduction concerning the courtyard, namely the aali. It is a very small house often built on existing house skifa or on the top of a shop. It may serve as lodging for strangers or for other purposes. The compartimental program of the house seems to evolve in terms of proportions and surface by resorts to adaptation when it comes to fit in an irregular urban context, often the adaptation takes the form of eliminating items like rooms or services but rarely, almost

never, a space like the courtyard or the entrance device (skifa) which remain the genes of the primary program. These remarks must be corroborated by a syntactic analysis. (Table 2).

House	House type	ED	GA	Cy	Se	RO	Qb	HM	BO
House 1	Common House1	X	X	X	X	X			
House 2	Common House2	X	X	X	X	X	X		
House 3	Large House3	X	X	X	X	X	X	X	
House 4	Large House4	X	X	X	X	X	X	X	X
House 5	Small house (Dwira)	X	X	X	X	X			
House 6	Very small house 'Ali	X	X		X	X			

Table2
The houses Subsystem

In larger master houses, with increasing complexity, one might expect more deep structures to show up. This is not the case; the shallow structure of the house structure remains almost unchanged. More rooms articulate around either the courtyard in the ground floor level or around the upper gallery in the first floor but they are that deep away. However, the entrance device is very much deeper in big houses, often subdivided in a multitude of other spaces such as sitting places or comfort amenities like private hammams, private ovens or cowsheds. (Figure 4) Except from the case of the smallest unity in the housing stock: the Aali type, syntactic parameters remain unchanged or undergo very little change. However, in terms of control, both the courtyard and the entrance device (main components of the main compartment system) diminish as the systems increase in complexity. (Figure 5)

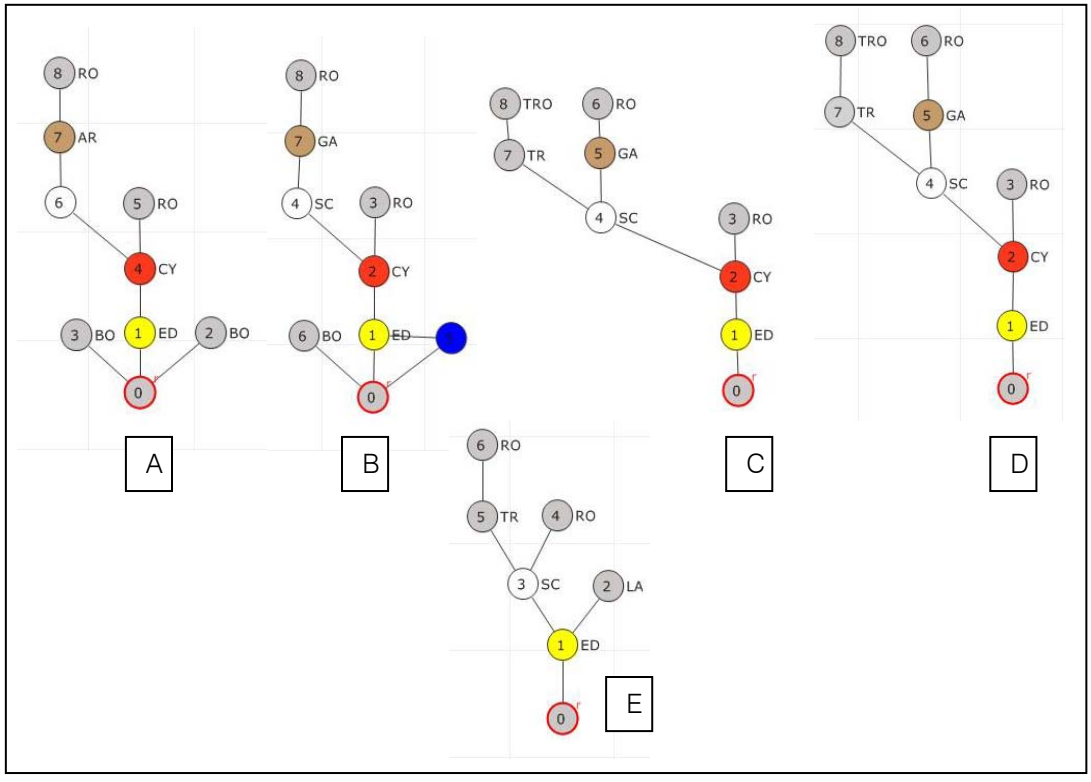

Figure 4
Justified graphs of the houses' system: the two large houses (A and B) and the two common ones (C and D) are variations on the same theme, the small aali house (E).
The order survives despite the increasing complexity

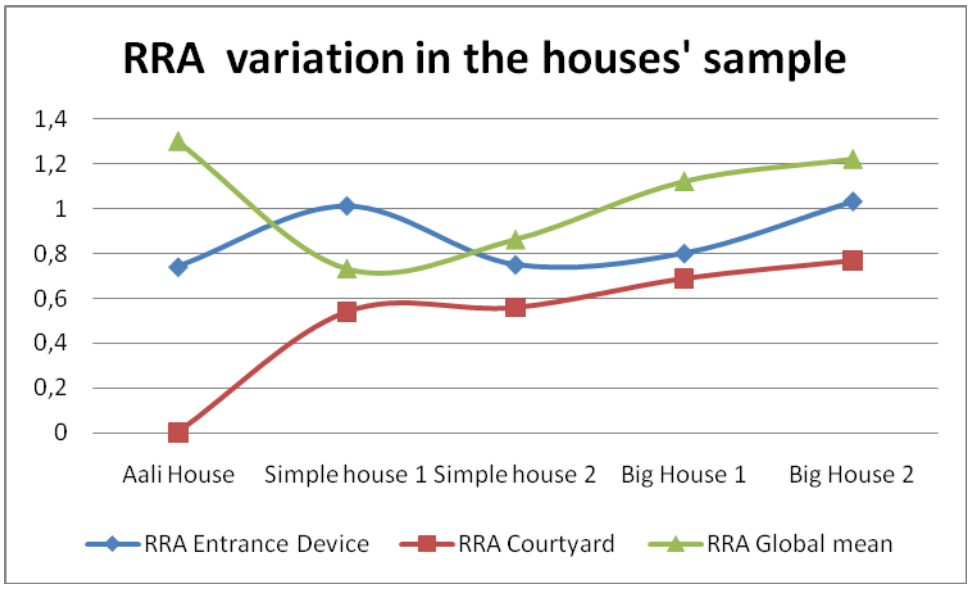

Figure 5
RRA variation in the houses sample: As houses become larger, the control value of the key spaces, the entrance device and the courtyard, diminish

6.4.Evolution of subsystems with similar primary programs

According to architectural historians, foundouks, barracks and maristans are different in their dimensions but have a rather similar plans. Some barracks were, at the outset, lodgings for merchants or travellers, before their reconversion by the military authorities into barracks. Saadaoui has demonstrated this in the case of Tunis. (Saadaoui, 2001) The other fact is that the foundouk was founded well before the maristan and the barracks. (Table 3). This table reveals the adaptive character of the primary program of the three entities.

6.5. Synthesis

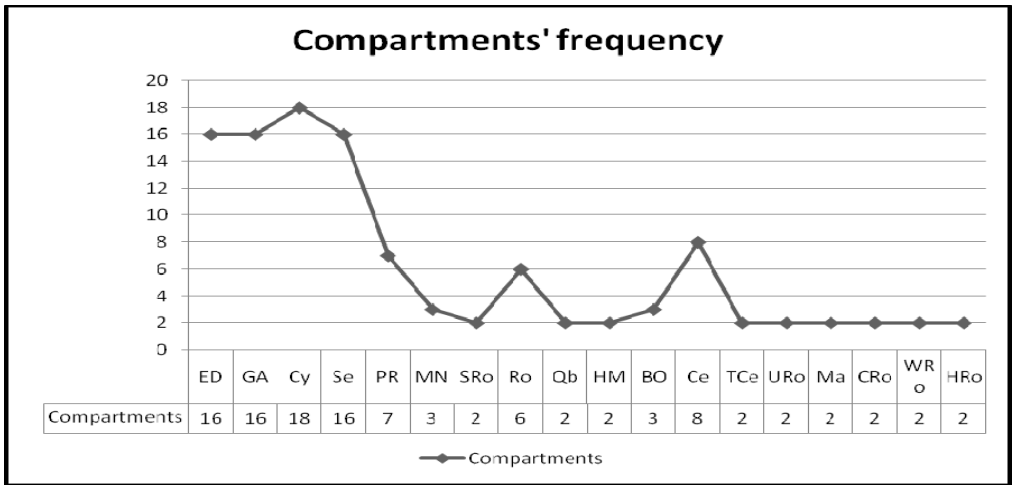

Figure 6
The compartment's frequency in the system's compartments

The frequency analysis revealed that the existence of three distinct groups. The first high frequency group comprises the compartments that constitute the specificity of the medina of Algiers; the second group comprises medium frequency items represented by basic modules such as rooms and cells, basic constituents of most of the buildings and specific features like private hammams and minarets; the third group comprises very specific items like the ones present in particular buildings. (Figure 6)

The most important feature resides in the fact that two types of sub-systems:

1. Genitor subsystems constituted by the mosque, the foundouk, the dar and the hammam.
2. Adapted subsystems constituted by the medersa, the foundouk, the zawyia the barracks and the cafe.
3. The crossing over of the genitor subsystems gives variants of adapted subsystems. Ex. The medersa is the result of the crossing between the mosque and the foundouk. (Table 4).

Mosque	PR	GA	Cy	Se		Ma	MN		
+									
Foundouk	ED	GA	Cy	Se	Ce				
=									
Medersa	ED	GA	Cy	Se	Ce	Ma			

Table 4
Evolution of the Mosque's Subsystem

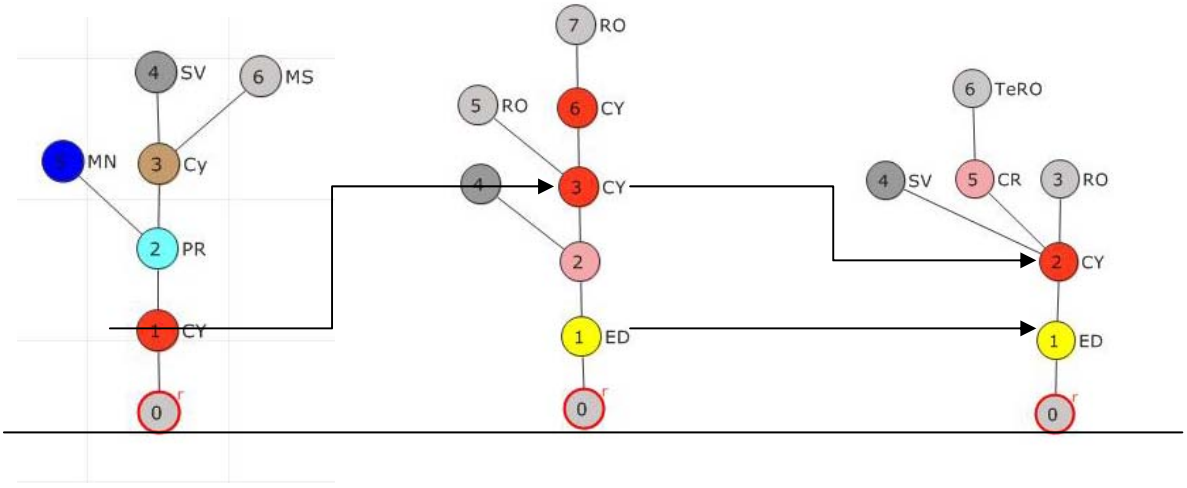

Figure 7
Compartments' justified graphs of the set mosque-foundouk-medersa. The combination of the pair mosque-foundouk left to right) gives the medersa (far right)

Other examples confirm crossings and filiations between subsystems. Another example is the adaptation of the foudouk which can give either the maristan or the barracks. The application of a systemic approach has revealed hidden relationships. The occurrence and recurrence of genes (compartments) described as primary, because of their structural order; they constitute an interface between subsystems and between subsystems and the whole system of the medina. Among the crucial features revealed comes the fact that they are considered as necessary for the survival of the system as a whole. The second set of compartments appears as necessary but not crucial for the survival of the system whereas the third set seems rather incidental. Now let us trace the evolutionary process of the first equation: Mosque + foundouk=medersa Justified graphs (Figure 7) reveal inherited characters from both instances (mosque and medersa); the deep character of the foundouk's courtyard is replaced by the mosque shallow and integrating one whereas another character, not present in the mosque, namely the entrance device, is inserted in the medersa, giving its own identity to the latter. The courtyard is best integrated in the medersa, in agreement with the tendency of the global mean value of Real relative asymmetry (RRA). This seems to indicate that the inherited character undergoes a contextual adaptation. Visual integration confirms the above results showing that the courtyard in the medersa is a key space, articulating the other spaces and the carrier of social activities taking place in the medersa and confirmed by historical studies, such as

praying or studying. In the foundouk, the courtyard takes the form of a narrow alley which purpose is solely to link and communicate the cells (rooms) to the main spaces. Homogeneity of accessibility is shown by entropy outputs to place the medersa as the easiest space to move around and the foundouk the worst. (Figure 8).

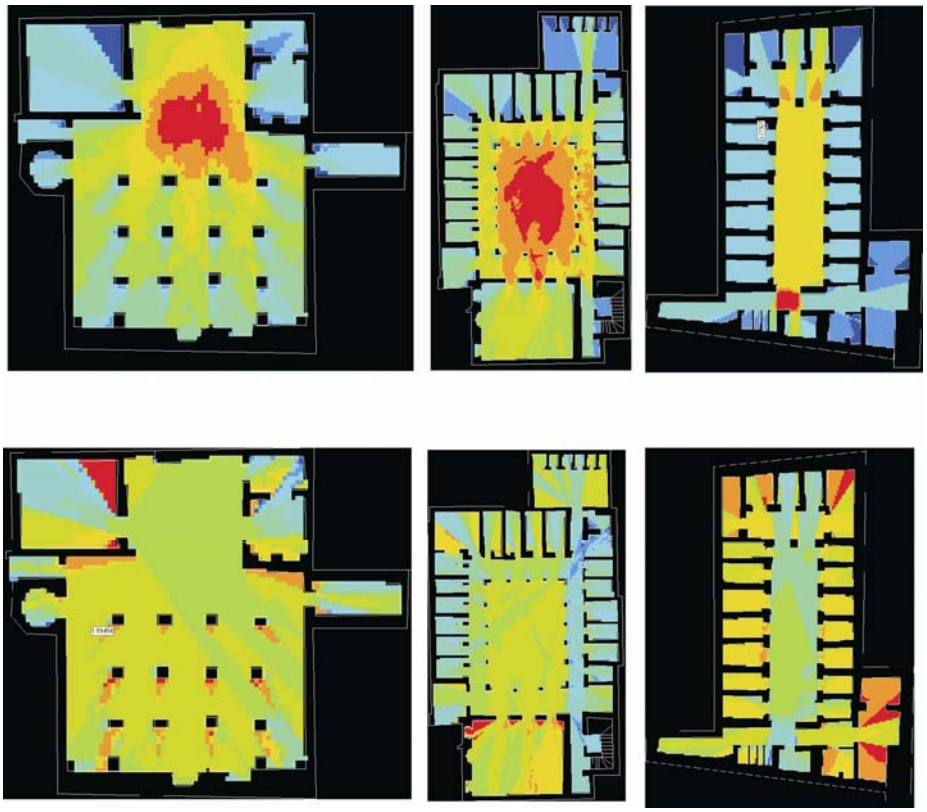

Figure 8
VGA of the mosque-foundouk-medersa transformation

7. Conclusions

In this paper, a sample of buildings (houses and other public and religious buildings) in The medina of Algiers has been analyzed in terms of their genetic and syntactic characteristics. The provisional conclusions reached by applying the genetic approach which revealed patterns of change and adaptation in subsystems in order to accommodate new functions and therefore create new facilities were not mere games like it would be the case in contemporary design by analogy with precedents, as shown by Tzonis. The occurrence of inheritance and evolutionary process is done in connection and in harmony with the system as a whole, respecting its equilibrium and balance between the input and the output. Space syntax analysis through the measure of syntactical properties uncovered hidden aspects, namely the pervasiveness of a genotype constituted by the dorsal spine (entrance, courtyard, upper gallery and terrace) forming a highly introverted, yet open on top of the roof structure. One of the most striking hidden dimensions is that a more extraverted genotype would threaten the system's survival; the dwellings would no longer be associated the way they were; eluding by the same way, the dense compact structure of the city. The application of visibility mapping enhances the previous findings and shows that despite the sometimes substantial change in programs, syntactical relationships vary very slightly. The Integrated core remains the same showing that these spaces seem to be consistently placed where they can command multidirectional views and the accessibility measure of the buildings assessed by means of relativised entropy does not vary that much from buildings with low number of spaces to those with higher ones.

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