Unveiling the structure of the Marrakech Medina:
Architecture History as a precedent for Contemporary Architectural Design

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ABSTRACT

The population increase that occurred in North African and Middle-Eastern cities, has led to an uncontrolled urban growth that produced urban environments lacking the spatial richness from their historical vernacular towns. In order to alert and to change this context this paper illustrates work in progress for a design project at the city of Marrakech in Morocco.

It describes from a historical and analytical point of view, research carried out at the *Zaouiat Lakhdar* quarter of the Marrakech Medina. The goal is to create the basis for a computational tool that could capture spatial features of the existing architectonic fabric and apply them at contemporary architectural scenarios. The methodology used is explained from the initial historical analysis and fieldwork realized in *situ* to the identification of social, religious and geometric set of laws and its codification into two different types of generative rules. These were than applied either at the urban level, or at the domestic level. At the urban scale the system generates options for new urban neighborhood layouts, and at the domestic level, proposes different housing typologies taking in consideration architectural precedents. Results from a class will be showed.

The ultimate objective of this project is to illustrate how fruitful can be the interdisciplinary dialogue between history, culture, computation and architecture. It outcome is proved as a dynamic design process able to infer on the organization of a Design Studio, and in the formalization of a computational design methodology that contributes with architectural solutions to the building of the local environment.

Keywords: Islamic Architecture, History, Generative Systems, Design Studio

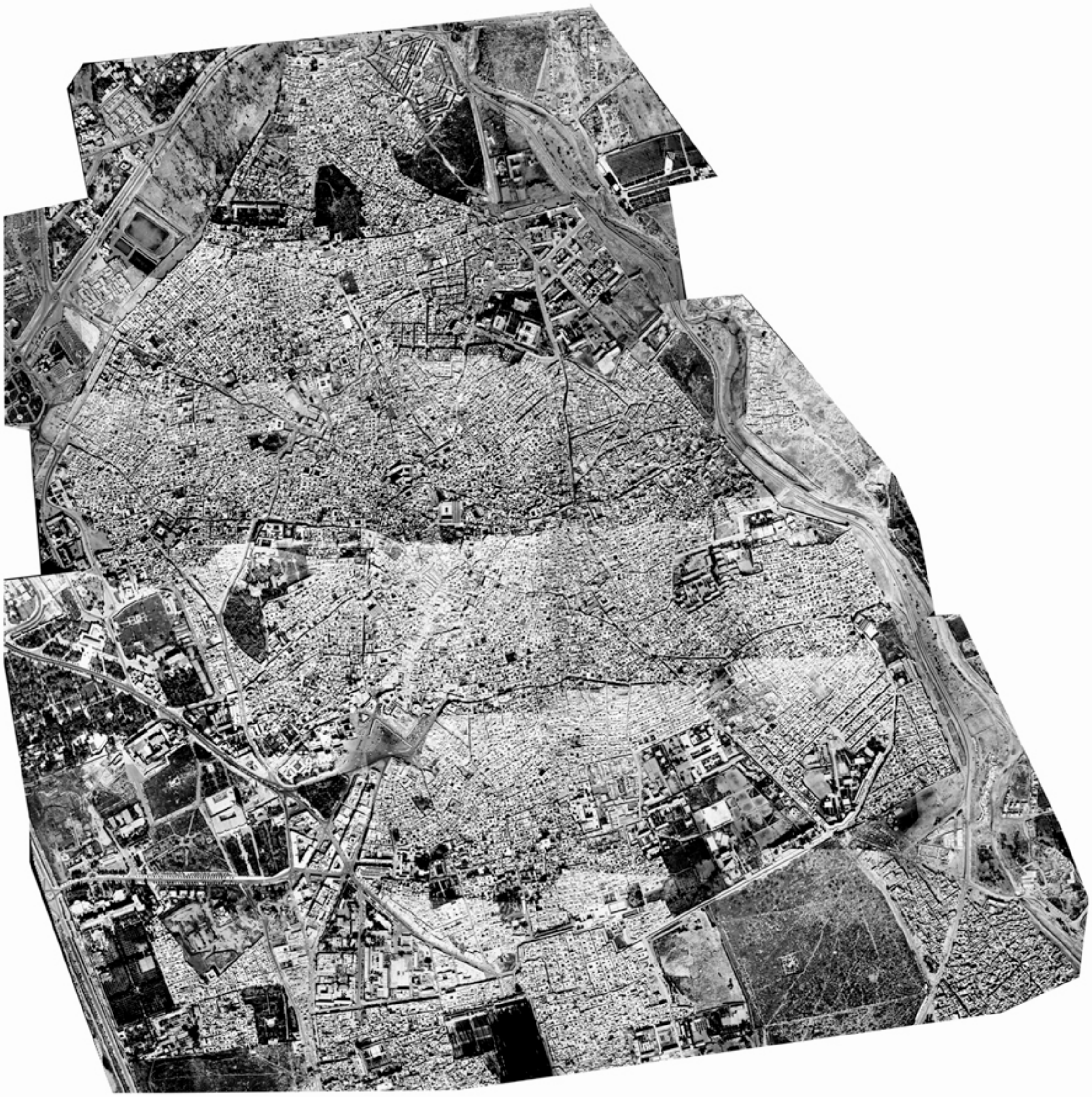


Figure.1. Satellite image of the Marrakech Medina (Quickbird)

Introduction

The main goal of this research is twofold, by one hand attempts to do an architectural reading of the Marrakech Medina**,** identifying the main structures that organize architectural and social space, and on the other hand, to develop a computational model that could be used as a tool for new urban planning. This tool should generate urban neighborhood plans with similar features to existent ones while improving the environmental performance of these new design solutions.

The aerial view of the Marrakech Medina (Fig.1) suggests an organic and almost chaotic city growth. However, a more detailed analysis unveiled a well-established order with repeated urban patterns. Such patterns are not geometrically but topologically similar, meaning that they can differ in the values of parameters like the angles and dimensions of the inner structure of allotments. Consequently, it was possible to encode the identified patterns into a reduced number of parametric schematas, thereby causing the urban grammar to be developed as a parametric shape grammar (1998, Knight).

At the outset, it was considered that it was necessary to deal with both the urban scale and the domestic scale. As such, the development of two independent grammars was foreseen: an urban grammar that would account for the layout of the urban allotment *structure*, and a housing grammar that would account for the functional organization of the patio houses.

Historical Context

Cities of Muslim origin, such as Marrakech, share specific culture and social values which are embedded in their everyday system of social organization, and therefore, in architecture as well. In this section, we identify and put forward a succinct contextualization of these cultural and religious values, which have to be taken in consideration in any interpretation of Islamic architecture.

Social and cultural characteristics of urban planning and architecture, as well as many aspects of Islamic social behavior are related to the Islamic law, *shari´ah*, and certain principles found in urban environments of Islamic cities are a tribute to *shari´ah*. They are clearly founded in the basic source of the *shari´ah*, the Qur´an and the *sunnah* (life of the prophet), while others stem from traditional building codes related to, inheritance and endowment laws. This set of religious and public values and rules determine many of the social patterns of Islamic society and its urban and architectural spatial configurations.

An utmost Islamic condition is that a strong social relationship is underlined by the concept of brotherhood, which has frequently been mentioned in the *Qur´an*, and that family is the most fundamental element of Muslim society where strong family ties are expected to last. This partially explains the organization of domestic architectural spaces that are close to each other and contain a multifunctional space surrounding a courtyard. It also partially explains the unsolved familiar [tribal] problems found in certain areas which can lead to spatial arrangements such as the closing of a *Derb*, the change of its direction, the destruction of a house for its division, or decisions about land division among family members and disputes of inheritance goods.

Contrary to what happens in the Western world, Islamic societies do not have an explicit urban code that guides the planning and design of urban environments. Islam through its *shari´ah* has provided principles that determine the way of life of Muslim communities and individuals, which in turn shapes the urban environment. Oleg Grabar says in his study on traditional Muslim urban environment: "it is Islam which gave resilience to the Muslim city and to its bourgeoisie, not because it was necessarily aware of all urban problems but because it had the abstract form in which all of them could be resolved."(Grabar, 1976) These laws, which are constantly applied in everyday life, form a dynamic set of rules that actuate in a "bottom up" fashion to shape the urban tissue. This deserves to be preserved, but at the same time, encoded in more contemporary ways of living within the Islamic culture.

The current study was based on previous work in which it was hypothesized that the Marrakech Medina urban tissue, like other Islamic cities, was organized as a spatial progression from public space to progressively more private realms, until reaching the privacy of the patio house. The patio is the place where the outdoor activities of the family take place. The patio is also the means to provide daylight and ventilation to the house, contrarily to traditional European configurations in which the main external space is the street, and buildings are lit and ventilated primarily through street-facing facades. External facades in the Marrakech Medina are mostly closed, with very little openings. Because privacy, lighting and ventilations requirements are not significant, street width can be considerably reduced, thereby generating very narrow and deep street canyons.

Figure.2. Drawing of the Marrakech Medina with its urban fabric and external walls.

Marrakech which was chosen to be the capital of the Almoravids, had already in 1107, 100.000 inhabitants. It was in the 12th century that Ali Ibn Youssouf founded the mosque with his name, and it is in front of the Ibn Youssouf complex that the *Zaouiat Lakhdar quartier* (one of the oldest in the Medina), is located. Since its foundation Marrakech built its religious spaces displaced in the city main *quartiers* (Fig. 4).

Figure.3. Localization of major Mosques and religious buildings within the Medina space.

These architectural structures have different *quibla* orientations and due to this fact organize their surrounding urban fabric differently. Their identification and characterization is key to better understand the existent variety of religious spaces and their taxonomy. Historical maps suggest that the limits of Marrakech neighborhoods, and in particular of the *Zaouiat Lakhdar*, could have been defined by the organic way in which the city grew. Factors like the pre-urban paths that inhabitants used to get to key-points like the market space and exit city doors, remained intact carving in this way the major axes of the city. Between these axes, and related to neighborhood mosques, *quartiers* like *Zaouiat Lakhdar* began emerge. The land was progressively purchased by families and divided in allotments into different zones in top-down fashion.

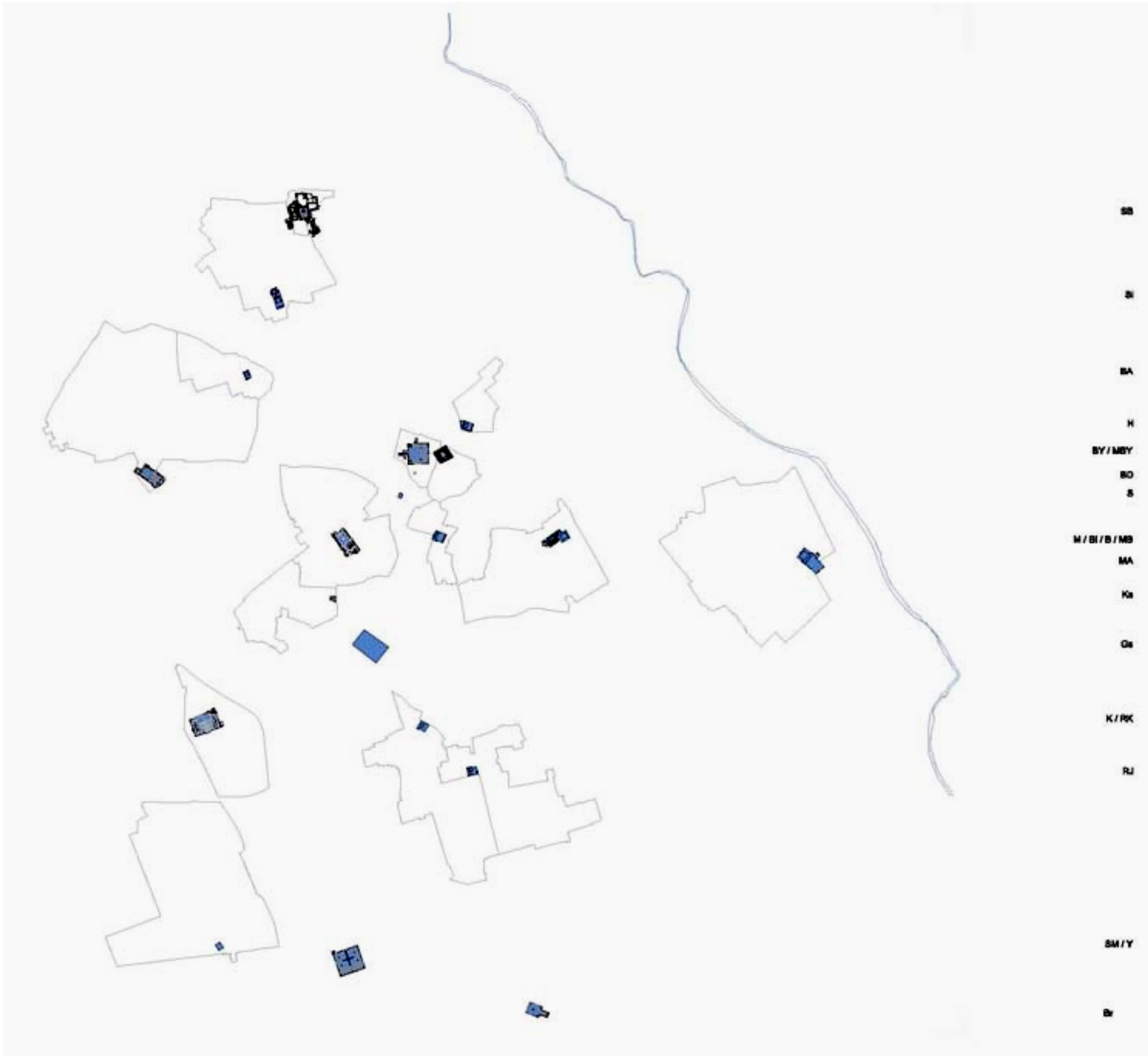


Figure.4. Localization of major Mosques and religious buildings within its *quartier space.*

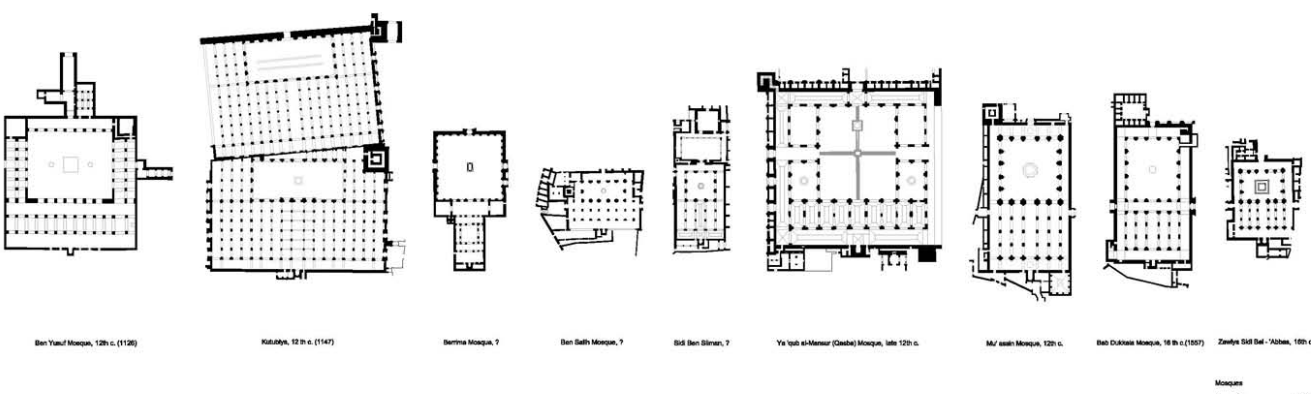


Figure.5. Drawing plans of the most important Mosques in Marrakech.
i) Ben Yusuf Mosque (1126), ii) Kutubiya (1147), iii) Berrima Mosque, iv) Ben Salih Mosque, v) Sidi Ben Slimanm,
vi) Ya Qub Al-Mansur Mosque (1190), vii) Mu Assin Mosque(12th c), viii) Bab Dukkala Mosque (16th c), ix) Zawlya Sidi Bel Abbas (16 th c).

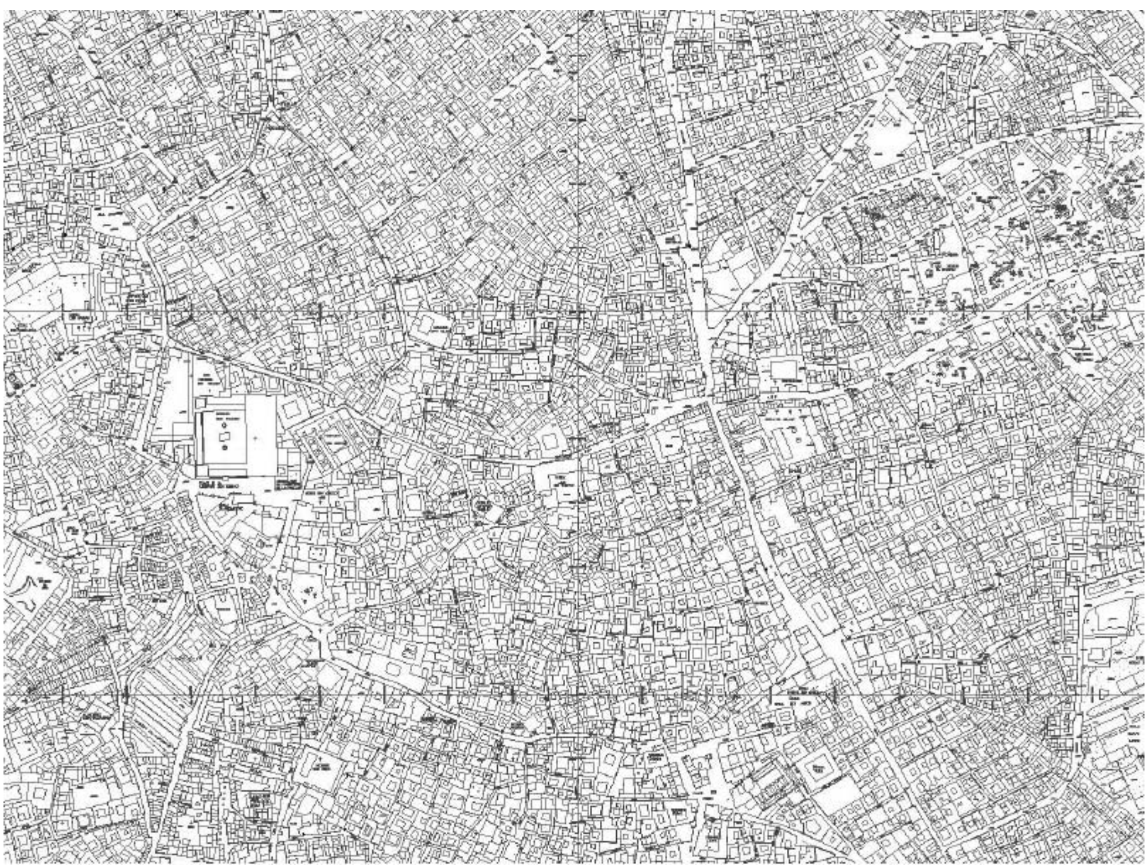


Figure. 6. Aeral photograph of the North area of the Marrakech Medina (1917) and detail of the Ben Yusuf religious complex (1917).
Figure. 7. Drawing plan of the Medina city fabric, with Ben Yusuf Mosque at the far left.

Fieldwork

To collect information that permitted to infer the design rules that could inform the design of the grammar, and its computer implementation, a field trip to Marrakech took place in the beginning of 2005, following previous work realized *in situ*. Fieldwork in the Medina and particularly at *Zaouiat Lakhdar*, consisted in surveys of the site based on laser measurements, digital photos, and detailed hand drawings. These surveys permitted to acquire rigorous information regarding the taxonomy of the urban fabric, length and width of the *derbs*, the height of the *sabbats*, and the location and size of openings and doors. A second source of documentation consisted in drawings obtained at the Agence Urbaine de Marrakech and at the Inspection Général des Monuments, such as an aerial photo of the city taken in 1917, the plan of the Medina in digital format, and the city strategic plan indicating the functional uses foreseen for each of the historical neighbourhoods. A third source consisted in interviews and visits to local houses, which permitted to gather information regarding the genesis of the neighbourhood and the reasons for certain spatial configurations. The analysis of these sources led to the elaboration of a more accurate site plan, (Figure 16, 17, 18) where the identification of the *quartier* building blocks were identified and classified.

Figure. 8. New urban dwellings on the southern east part of the Marrakech medina
Figure. 9. Spontaneous urban dwellings at the southern east part of the Marrakech medina

Inferring and structuring the grammar

The Medina is composed of many neighborhoods and although these might look similar, they are quite varied in terms of morphology, scale and street layout. For example, the *Mellah*, which used to be the Jewish quarter, has an orthogonal gridlike urban pattern with alleys that lead to other alleys and streets. The unique characteristics of *Zaouiat Lakhdar* made it the most appealing so it was selected as the model for the development of the urban grammar, which will generate *quartier* allotments As such, the corpus of existing designs was restricted to a single design. To overcome this limitation, the strategy used to infer the grammar was to divide the neighborhood into sectors thereby creating a corpus of several partial designs. The methodology used to develop the computer model encompassed three steps: i) analysis of previous work carried out to infer basic shape rules; ii) development of an experimental computer program encoding these rules; iii) field work to collect additional information to correct, complete and detail the rules. We believe that a bottom-up approach will reflect more honestly the organic character of the urban fabric and will eventually yield more complex design solutions (Fig. 21).

Figure. 10. South entrance to the *Zaouiat Lakhdar quartier* in the Marrakech Medina. An intermediate space.

Figure. 11. One of *Zaouiat Lakhdar´*s longer *derbs* with zenital light and narrow interior spaces.

Figure. 12. Private spaces. Interior of two patio houses located at two different *quartiers*.

Figure. 13. Private spaces. Interior of two patio houses located at two different *quartiers*.

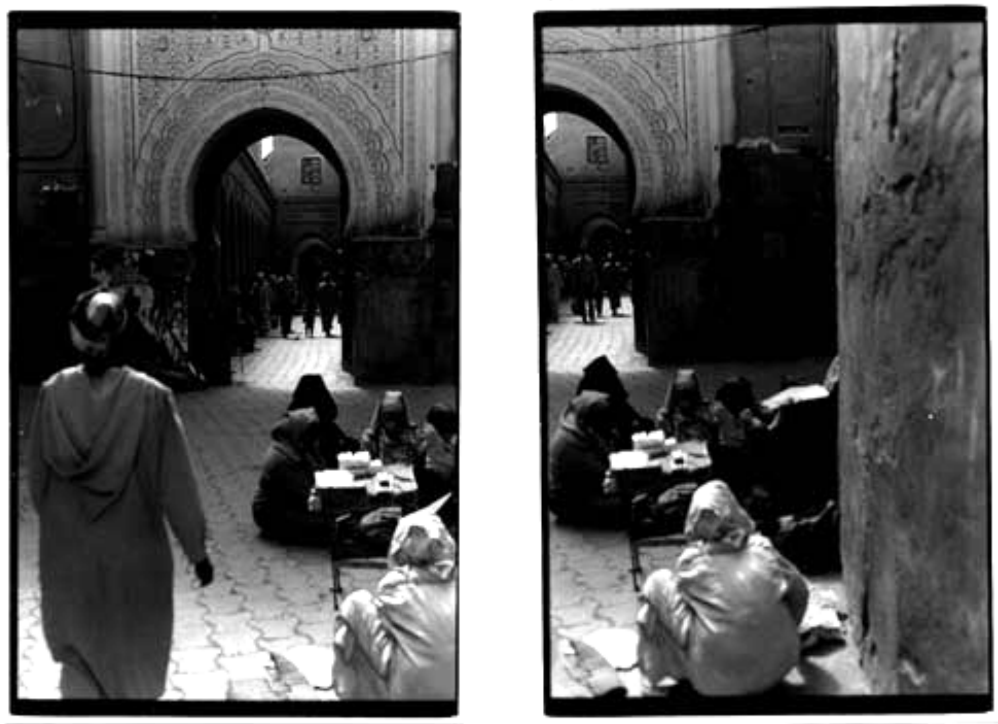


Figure. 14. Semi public spaces. South entrance to Zawiya Sidi Bel-Abbas religious complex (16 th c.)

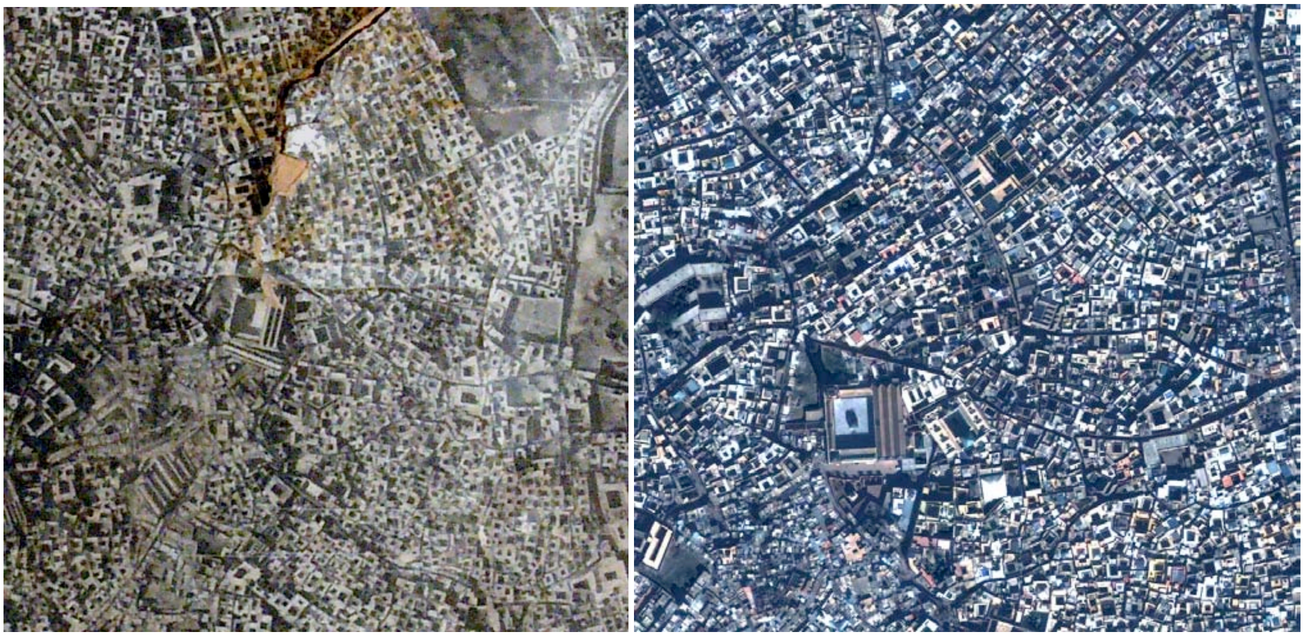


Figure. 15. Aeral photographs of the Ben Yusuf religious complex and surrounding area of the Marrakech Medina . 1917 and 1985.

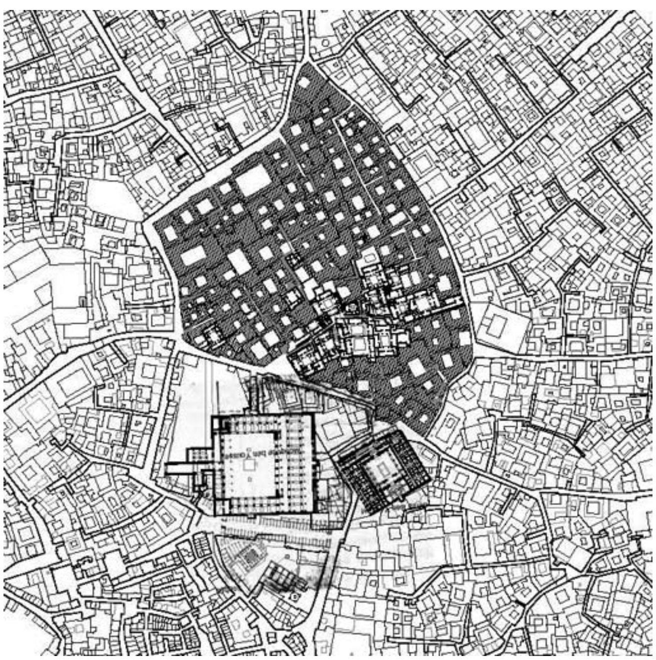


Figure. 16. Plan drawing showing the interior *derb* structure of the *Zaouiat Lakhdar quartier*, with its cluster of houses hosted by nine different *derbs*. Plan of the Ben Youssef Mosque and Medersa.

Figure. **17**. Plan drawing showing the interior *derb* structure of *Zaouiat Lakhdar quartier,* with individual courtyards and network of related entrances.

Figure. **18**. Plan of *Zaouiat Lakhdar* displaying the superimposition of drawing information (collected *in situ* with official data).The drawing shows discrepancies that were corrected.

Figure. **19**. Plan of *Zaouiat Lakhdar* based on collected information showing the location of *derbs, sabbats,* house entrances, houses, and *patios.*

Figure. **20**. Final plan with hypothetical family property division constituting specific housing clusters. Patio houses with the same color are accessed by the same *derb*. The *Zaouiat Lakhdar quartier* has nine *derbs, which* hold 142 courtyard houses organizing each *derb*. The main *derb* crosses horizontally from West to East and holds near to 34 houses, a few dating from the early XVI century.

Experimental program

Following the initial hypothesis, several attempts were carried out to simulate spatial urban growth. The idea was not so much to reach a final model but to explore the design potential of constructing one. A simple shape grammar composed of ten parametric rules was developed. Then, it was encoded into an experimental computer program implemented in AutoLisp. Growth is defined by the successive and iterative application of rules, with one iteration corresponding to a single rule application. Finally, the program was run with 50, 100, 200, 500 and 1000 iterations, (Figure 21). These iterations showed a few implementation problems. The first was that growth became too slow preventing the polygon representing the neighborhood to be completely filled in. The program was implemented in a way that rules were blindly applied, that is, a rule was applied and then a test was carried out to check whether it yielded a valid result.

As growth evolved, it became gradually slower to a point at which most rule applications were not valid. Consequently, it became gradually more difficult to fill in the whole polygon. At 1000 iterations, there were still too many empty spots. Because of stack overflow, it was not feasible to increase the number of iterations, but the observed behavior suggested that growth would stop before the whole polygon was completely filled in. The second problem was that the *derbs* grew in all directions. Growth was constrained by restrictions imposed on the length and on the angles between consecutive trusses of *derbs*. Although angular values were restricted to intervals, the successive use of different values originated *derbs* that followed a wide range of directions. However, *derbs* tended to follow predominant directions in *Zaouiat Lakhdar*. The third problem was that the distance between two “parallel” *derbs* was not controlled. In later versions of the program, a minimum distance was defined so that lots with adequate dimensions could be inserted. Results then showed that number of lots also had to be considered in determining the distance between *derbs*. The fourth problem was to guarantee that the limits of adjacent lots matched. In the last version of the program, the growth of *derbs* was followed by the placement of rectangles on both sides representing lots.

Running the program showed that assuring that the limits of lots matched represented a big challenge in the development of the grammar and its computer implementation. Furthermore, the proportion of the lot is confined to the interval between 1:1 and 2:3 meaning that its geometry may vary from a square to a rectangle in which the length cannot exceed 1.5 times the width. Not all lots are quadrilaterals as some may have more than four sides. However, it is possible to identify a main quadrilateral shape, which is then used for matching the schema on the left-hand side of rules.

The figures bellow illustrates some results of the computer iterations. The experiment starts with a single polygon (dark blue), which is replicated using blind encoded rules. The result shows a organic spatial growth where space is re(defined) at each step of the interaction. Configuration varies and produces richness in spatial variety. It is possible to observe the branch of *derbs* each one with its cluster of courtyard plot houses. The automated generated design solutions respect the inferred rules from the existing urban fabric and propose new urban configurations that could easily be taken to another architectural level of study.

Figure 22, 23 and 24, instead show initial plot of the formal structure of a grammar underlying some of the Marrakech Medina houses and its computer implementation.

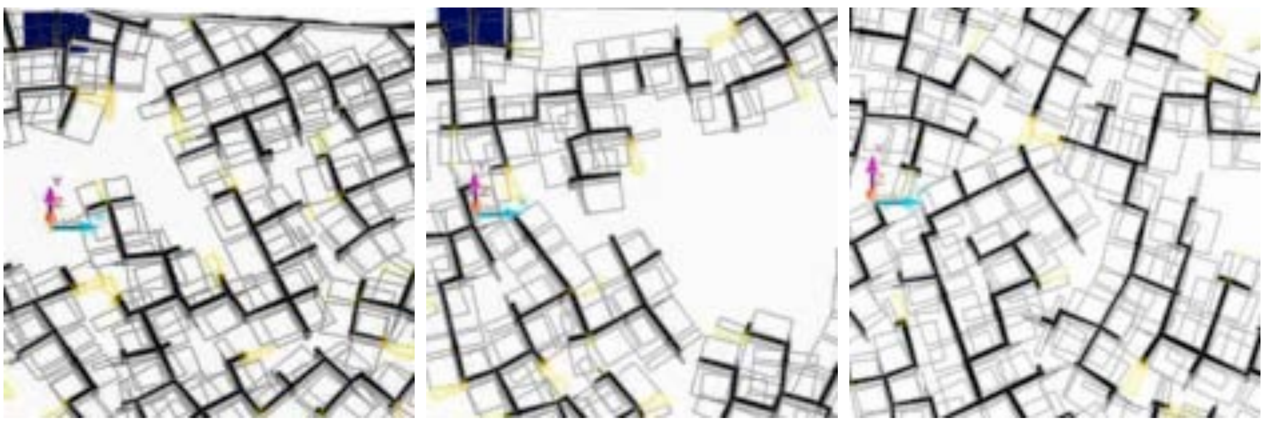
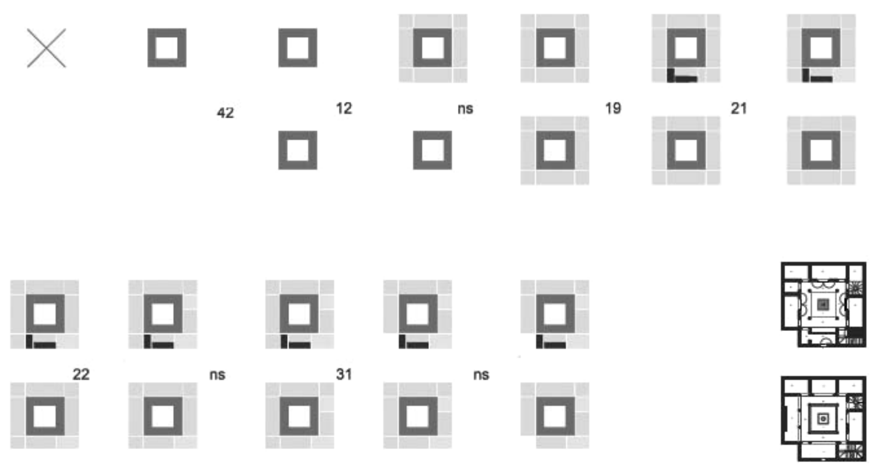


Figure. 21. From left to right: output of an experimental computer program encoding a basic urban grammar for the Marrakech Medina after 100, 200, 500 and 1000 iterations. Computational space.



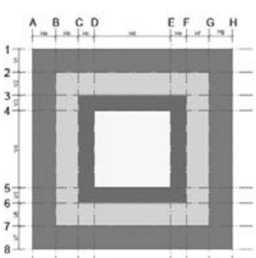


Figure. **22**. The initial pattern of the formal structure underlying some of the Marrakech Medina houses with two or three functional spatial rings around the patio.

Figure 23. Partial example of color grammars applied to house formation displaying rules for the insertion of functional rings and stairs.

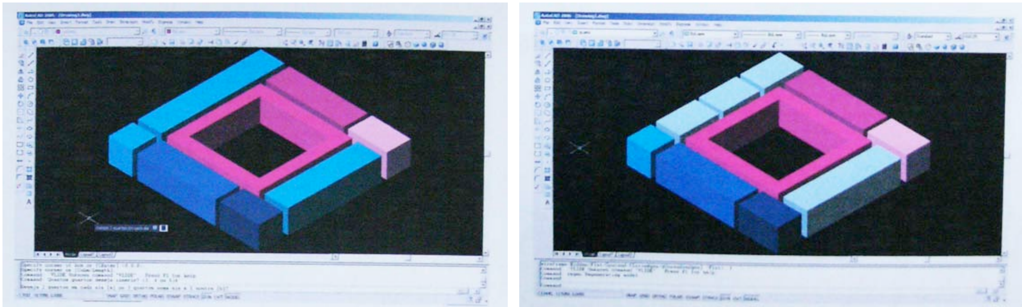


Figure. **24**. Autocad interface designed to allow user friendly input of functional data for the generation of a house.

Conclusion and further work

The research described in this paper constitutes one step towards the development of a computational model that could be used as a design aid in new urban planning and design of new neighborhoods that have similar spatial features and yet are improved from the environmental viewpoint.

We argue that the need to rethink urban planning suggests the critical use of tools as those described in this paper. Moreover the explained methodology is particularly appropriate for use in design studios, introducing in this way the complexities of the built environment. Further work encompasses the need to build a larger multidisciplinary platform to study the urban and natural landscape of the Marrakech Medina and at the same time to promote a design studio where students could access this tools in a real design context.

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