The Digital ArchiMusic Patterns in Alhambra

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***Abstract*—This paper is a part of an ongoing research project that is seeking to clarify the interrelationship between the architecture of the Alhambra and Andalusian music at that time. Despite that Alhambra was built long ago before the recent digital age, but it contains some phenomena's that points out to the relationship between 2D and 3D patterns and the type of music at that time. The term "digital" was never known at that time, but the basis of digital knowledge did exist, even if tools and equipment's did not. This research paper is seeking to clarify this theoretical basis that proves the interrelationship between architecture and music and to proof that both were stemming from one integrated cosmological source.**

***Index Terms*—Alhambra, Architecture, cellular automata, genetic algorithms, music.**

I. Introduction

In the art and architecture of a traditional society the principles of the tradition inspire man's creative energies and integrate the whole of society into a totality. In such a society the distinction usually made today between the sacred and the profane is either transcended by a metaphysical knowledge that pierces through all veils of separation or it is removed through the integration of all aspects of life into a sacred unity outside of which nothing exists.

In fact, all Islamic art comes into being as a result of the wedding of both formal sciences and the crafts. The sciences referred to mean not only the processes of nature but knowledge of the laws and principles which govern things and which are themselves related to the metaphysical order. As to the crafts, they are not just ad hoc ways of making things hut are externalizations in the world of forms of the realizations of science; thereby they possess their own laws and regulations. Both these orders of knowledge—that connected with the sciences and that connected with crafts—are embodied within the craft guilds, which are the organizing bodies that bring traditional art into being.

The guild is often directed by a master who is both a Sufi and a craftsman who possesses a conscious knowledge of the principles governing his art. The knowledge needed to produce this art is explored through such sciences as alchemy, and the realizations of the knowledge are crystallized in the artifacts produced. The created works are like arts of nature, at once functional, cosmic, and imbued with a nobility of expression that seeks the truth through the way [6].

Natural symbols, such as the processes of nature, form certain systems of order that are symmetrical or rhythmical, or both [1]. Man, through his art forms, emulates these orders by creating geometric forms which are symmetrical with respect to their center and which symbolize "unity within unity," the first principle of Islam. The complementary system is nature in its profusion of rhythms expressed in infinite patterns—simultaneous, staggered, or harmonious cycles with no beginning and no end—a system symbolizing the inexhaustible multiplicity of creation, the effusion of being that emanates from the One: "multiplicity within unity."

The music of the reed is symbolically seen as the externalization of an interior movement, just as musical tones work through wind instruments from the inside out. He who hears the music is aware of the inner space and the' harmonious encounter of its motion with its outer shell.

It is widely known that music was taught in Andalusian colleges. Ibn Farnes (d.888) was the first to introduce it as an integral part of the department of the quadrivium consisting of the four subjects in the upper division of the seven liberal arts: arithmetic, astronomy, geometry, and music. Zariyab (789-857) was also renowned for his teaching of music in Spain as well as for his establishment of the first conservatory in the world. In the Arabian schools in Andalusia the art of organizing was taught, as we know from a contemporary Spanish chronicler, Vergilius Cordubensis. Mensural music was known to the Arab theorist Al-Khalil (d.791), but his *kitab al "iqa"* (*Book of Rhythm*) has not come down to us. It was known to Al-kindi, to Al-Farabi. In 1252, Safi al-Din al-Urmawi developed a form of musical notation, where rhythms were represented by geometric representation [5]. Al-Urmawi's most important work are two books in Arabic Language on music theory, the Kitab al-Adwār and Risālah al-Sharafiyyah fi 'l-nisab al-ta lifiyyah. The Kitab al-Adwār is the first extant work on ***scientific music theory*** after the writings on music of Avicenna (full name Abu Ali al- usayn ibn Abd Allah ibn Al-Hasan ibn Ali ibn Sina 18 June 980 -16 August 1037) [2].

II. Evolutionary Models

Our approach to fitting the digital and the theoretical has dealt with the problem of any new pedagogy: beginning with a new taxonomy for digital architectural theory. This has occurred in order to create the theoretical foundations of new processes of design that, in turn, are transforming our accepted traditional models and logic of design.

Together with the accompanying technological and media developments, the foundations of architectural education appear to be in need of a make-over from the bottom-up.

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In an evolutionary model of design, form emergence is considered to be the result of an evolutionary process. Evolutionary techniques have been part of a long research tradition exploring computational mechanisms of form generation. Form generation is derived from an internal genetic coding that replaces traditional interaction with the form itself. There also exists a significant body of theory dealing with problems of emergence and the behavior of complex systems as related to evolutionary models.

III. Ideological Roots

Ibn Al-Haytham says: "Proportionality alone may produce beauty, provided that the organs are not in them themselves ugly, though not perfect in their beauty. Thus when a form combines the beauty of the shape of all its parts and the beauty and the beauty of their magnitudes and their composition and the proportionality of parts in regard to shape, size, position and the other properties required by proportionality, and moreover, when the organs are proportionate to the shape and size of the face as whole-that is perfect beauty" [8].

IV. Plane and Space Geometry

At Alhambra, and in the case of the imaging geometry, the kinetic type offers two particular versions of the same generic proposition: plane kinetic geometry on the walls, panels and floors, and space kinetic geometry developed in the patio.

Most of the geometrical panels covered with polychrome ceramic tiles depict images of movement, and are hence classified in the kinetic category. But here the term imaged must be understood as a visual expression, obviously not as iconography or a figurative picture. That is to say that the perceptual content of these ornaments and their formal structure constitutes visual manifestations of the principle of movement "Fig. 1".

Perhaps the simplest examples in terms of geometrical design, but also the most radically kinetic ones from the strictly aesthetic point of view, are to be found in the baths, where the ceramic sets that adorn the walls follow a standard model of kinetic organization. The panel displays repeated elementary geometrical figures, all of the same shape and painted alternately in contrasting, vivid, primary colors that are regularly arranged on the surface In order to fill it completely, often leaving a white space between each figure In this way, the white patterns radically oppose the black and colored figures, producing a dramatic contrast with each other, strengthened by the play of bright, juxtaposed primary colors. In addition to this the simultaneously contrasting colors and black and white values, the repetition of the forms and their arrangement, systematically placed in alternation with, in some cases, a variation of linear direction, creates a strong linear and chromatic rhythm, an animation of the pictorial plane and a vibration of the surface which are all fundamentally effects of the principle of movement. A skillful dynamic mechanism is thus built by means of the basic two-dimensional elements of line, color, light and dark values which actually sets the geometrical patterns in motion [8].

V. Music, Architecture and Mathematics

In music, twelve tone system is a logical step (according to Shoenberg) in the evolution of the tonal system, as it was an attempt to put all twelve pitches in the chromatic scale on an equal footing. The development of computer technology in recent years has offered composers a way to incorporate new outside-of-time structures to the compositional process. These structures are drawn from a discipline as old as mankind: mathematics "Fig. 1".

The connection between music and mathematical models is made through a process known as mapping. Mapping consists of establishing a correspondence between the mathematical model data (usually numerical) and a set (or sets) of musical outside-of-time structures (such as scales. Rhythmic values, dynamics etc.) . Mapping thus creates an intimate link between a new process (the mathematical model) and established musical structures. The choice of those outside-of-time musical structures for the mapping process is ultimately determined by the composer.

Aesthetic and value judgment are not applicable to these outside-of-the time structures, since they are mere abstract constructs from which actual works of art are engendered. They are comparable to the marble stone out of which Michelangelo caved La pieta. Marble (the sculpture prime matter) is moot to any aesthetics or values judgment, while the artist's work upon it or the product is subject. We must be fully aware that music is not just science; it participates in both science and art. Mathematical science is that which considers abstract quantity and it has these divisions: arithmetic, music, geometry, astronomy. Music is the discipline which treats numbers in their relation to those things which are found in sounds [3].

In more recent times, music and mathematics-the one art, the other science ,linked together by the common factors of logic- have found true conjugality in our age of the computer, by whose agency the two fields have been consciously and practically integrated. The recent advent of software programs for algorithmic composition reflects man's ancient endeavor to furnish him ever more proficient tools.

It is realized that music and mathematics had a very close relationship, maybe because music is the most abstract form of art. In this regard it was possible to create an algorithmic-music generator, that is, it creates melodies using mathematical formulas. Based on this, we could deal with the inverted operation, and generate form in architecture out of the music composed at the construction period, taking into consideration that those shapes are stemming out and also using mathematical formulas [7].

In simplified terms, an algorithm is a process that solves problem in a step by step fashion through redistribution, recursion, or branching. The solution must be found a finite number of steps. In application to music, algorithms may be thought of as procedures that test potential compositional material from its appropriateness within a given context.

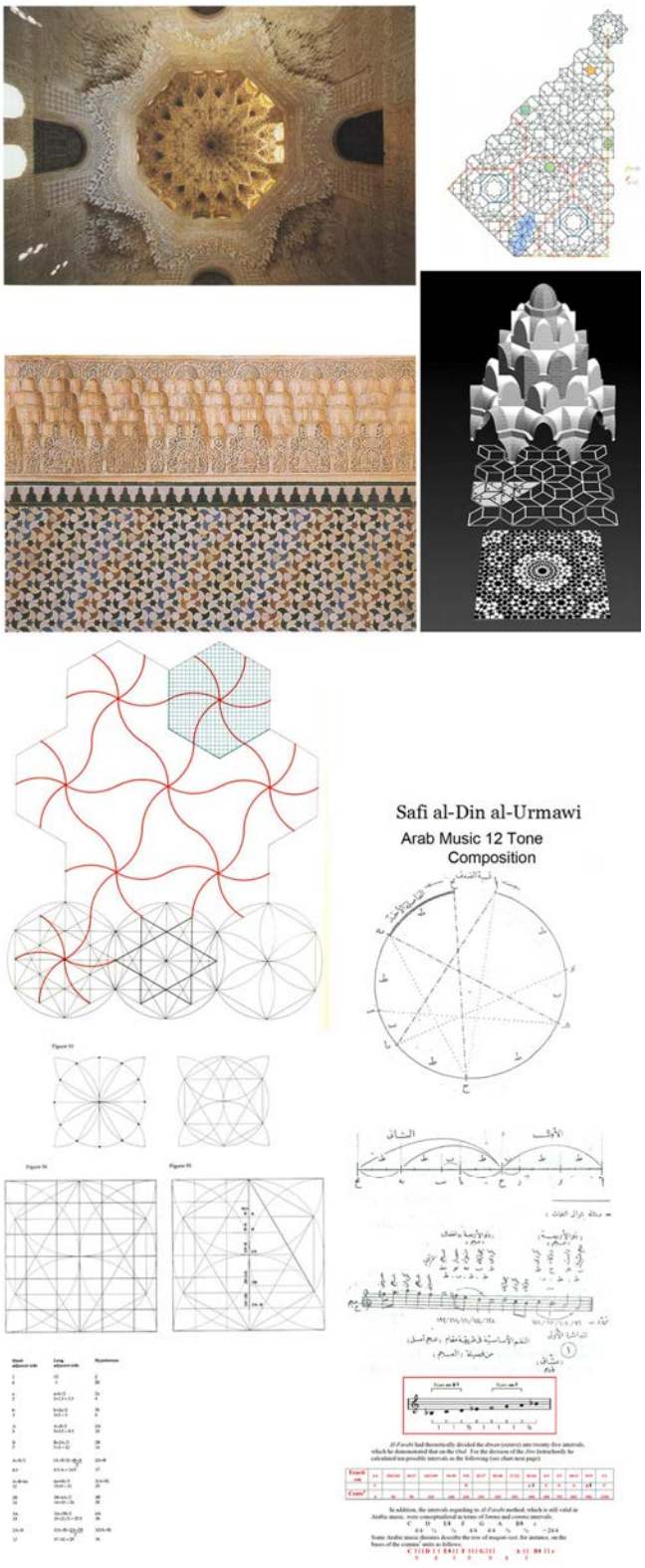

Fig. 1. Music, architecture and mathematics. Hall of the two sisters at Alhambra. Safi al-Din al-Urmawi developed form of musical notation, where rhythms were represented by geometric representation.

"An algorithm is not only a step-by-step problem solving procedure, a series of lines of computer codes or a mechanist linguistic expression, but it is also an ontological construct with deep philosophical, social, design, and artistic repercussions".

A. Aalgorithmic Composition and Cellular Automata

Cellular automata are very rich source for algorithmic composition. Cellular automata are discrete dynamical systems, which is to say that the space, time and properties of the systems can only have a finite number of states. A cellular automata consists of regular array of cells in one, two, three or more dimensions "Fig. 2". Each cell is said to have neighbors which are cells with some specified spatial relationship. In the simplest two dimensional grids of squares, a cell might be defined as having four edge-neighbors, or eight including those in the diagonal. In three dimensions, a cube cell might be considered to have six face neighbors, or up to twenty-six if those adjacent to the edge and vertices are also counted.

Depending on the behavior desired by the designer any geometrical shape can be parameterized in different ways, therefore, a geometrical model can be subject to more than one parameterization schemas creating different ways to perform design transformations. The parametric schemas will let the designer create different instances based on the transformations that the parametric model allows. Parametric models schemas generate different design instances based on the kinds of transformations that the parametric model allows .All instances created by one parametric model form a ***family*** of designs i.e.; *Arches, Columns Capitals, Cornice, and Domes*, despite the fact that one particular instance from a parametric model can be exactly the same as another instance from another parametric mode "Fig. 2".

B. Behaviour of the Cellular Automata

The behavior of the cellular automation is controlled by transition rules which determine the state of each cell at each moment in time in time in relation to the previous state of the cells and of its neighbors. The rules of the individual cells are referred as "local" and the overall behavior as "global" (totalistic rules).

Mapping two-dimensional cellular automata in zellij patterns at the Alhambra involves the automata's evolution to a space-form generation. On the other hand, mapping two-dimensional cellular automata to Andalusian music involves transcribing the automata's evolution to a musical event space. Each generation will be mapped to the members of our choice of musical event space. Since each generation involves a collection of cells, a direct correspondence must be made between each possible configuration of cells in the lattice and the event space [3].

The evolution of the automation recognized in the 2D zellij patterns and in the 3D of the muqarnas compositions in Alhambra. On the other hand, in Andalusian music the evolution of the automation can be mapped to a polyphonic ensemble of the musical instruments used at that time.

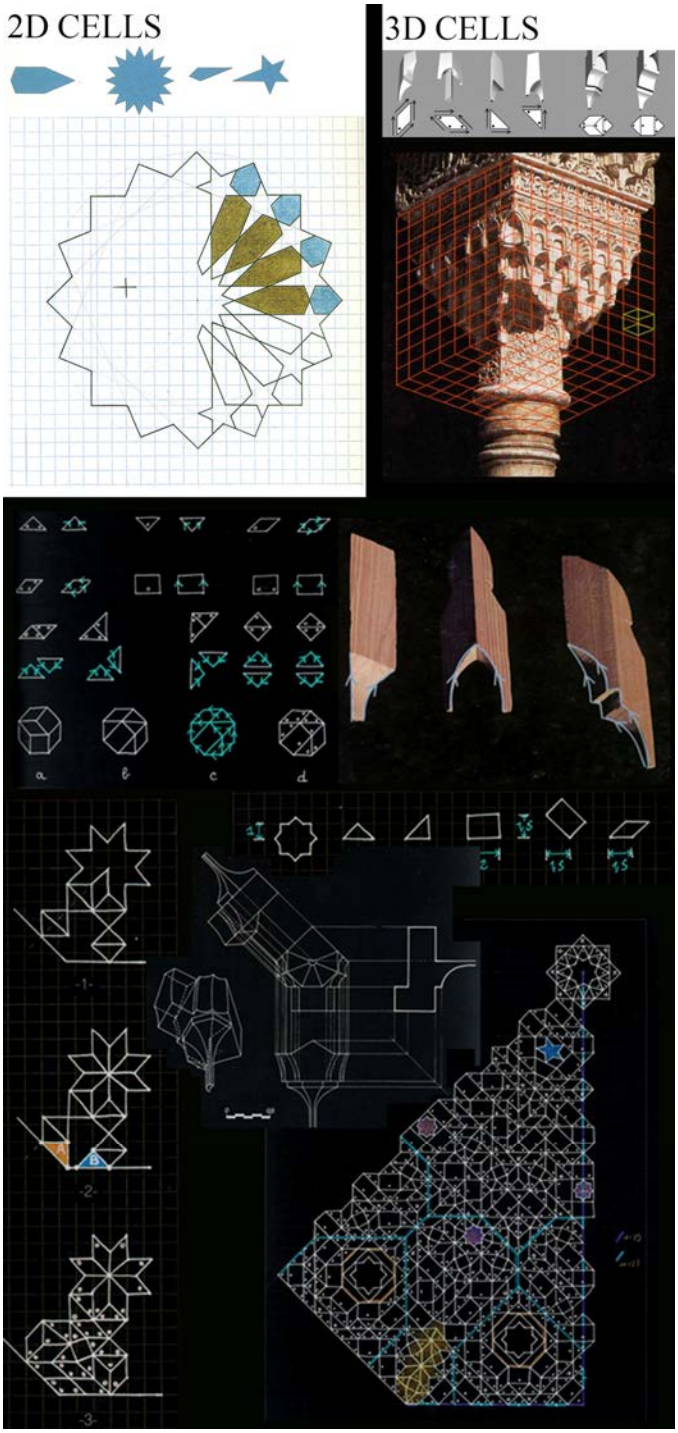

Fig. 2. Muqarnas used at the in the columns capital in the court of the lions and also at the hall of the two sisters, Alhambra.

C. Rule and functional based knowledge

Dealing with muqarnas we are mainly dealing with ontology-based approaches. The main decomposition is into *cells, features, and parameters*. Cells could be defined as "***a component*** of the artifact being designed". Features are associated with cells, and can be either geometrical or functional (among others). Parameters are properties of features of cells. Classes of cells and features are organized into an inheritance hierarchy.

A Muqarnas composition depends mainly on grouping of ***components*** (cells) that affects *relative orientation*, *relative position*, aspect ratio, length, and *size* ***constraints***. In principle, each ***component*** has an algebraic equation representing it. Each ***constraint*** also has an algebraic representation.

VI. Conclusion

Through this research we may be a step forward to grasp the concrete interchangeable relationship Andalusian architecture and Andalusian music. We are looking further to have the software that can generate architecture through music, and generate music to architecture. In both operations, style and character will be an essential issue in the design of this process system. Based on the artistic relationship between architecture and music, we shall try to settle a mechanism for a pattern recognition audio-visual system that can that can turn a certain style of architecture to a collection of melodies that truly reflects the character of that architecture. In this regard, future research will be trying to settle the methodological basis that will be able to "translate" Andalusian musical compositions into graphical images that have the distinct style and character of Andalusian architecture. This could happen by taking all our composition parameters (scales, durations, voices, algorithms, etc.), and from them creating an interference pattern which has fractal structure. At that time, every pattern could be uniquely mapped to each composition.

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