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ADAPTING DIGITAL ARCHITECTURE VOCABULARY TO REFORMULATE GEOMETRIC COMPOSITIONS OF ISLAMIC FACADES - CASE STUDY: PROPOSED MODEL FOR ISLAMIC FAÇADE THROUGH DIGITAL VOCABULARY

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Abstract

Islamic architectural facades characterized by many distinguished vocabularies that formed its character; as arches, ornaments, al-Muqarnas and mashrabeya etc. However, during the modern era, the Islamic heritage regions faced many changes and transformations of its character, either by new buildings that were built according to modern or unplanned styles, or by random and unplanned developments. However, recently and with the beginning of the twenty first century and with the great breakthrough in the digital tools and techniques, it facilitates new horizons in the architectural form generation. Accordingly, the research focuses on how to investigate the positive impacts of digital technologies on Islamic Architecture. In addition to how to utilize the digital thoughts, vocabulary, and techniques to create and develop a heritage inspired vocabulary that can compromise with the traditional Islamic architecture theme. Through this, the research aims to achieve a systemization of digital design strategies to facilitate the generation of Islamic-inspired façade, to create a new Islamic architecture that can be applied within Islamic heritage regions to connect the modern buildings which located in these regions with the existing Islamic reference. To achieve that, the research starts with studying and discussing the main elements that formed the Islamic facades, to stand on the methods of formations of each element and its function of the Islamic façade, whether it is an intrinsic function or aesthetic function. Consequently, standing on the main digital theories that lead to new architectural vocabulary that can homogenate with Islamic vocabulary, through studying the concept of each digital theory, accordingly how it can be applied theoretically to create a modern façade with an Islamic spirit. The research ends with a case study for a proposed modern building that resembles most of the recent buildings in Al-Azhar Islamic region in Cairo, and how through applying some selected digital theories can result in developing and renovating this facade to match the heritage Islamic surrounding in a new digital way.

Keywords

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ABSTRACT

Islamic architectural facades characterized by many distinguished vocabularies that formed its character; as arches, ornaments, al-Muqarnas and mashrabeya etc. However, during the modern era, the Islamic heritage regions faced many changes and transformations of its character, either by new buildings that were built according to modern or unplanned styles, or by random and unplanned developments. However, recently and with the beginning of the twenty first century and with the great breakthrough in the digital tools and techniques, it facilitates new horizons in the architectural form generation. Accordingly, the research focuses on how to investigate the positive impacts of digital technologies on Islamic Architecture. In addition to how to utilize the digital thoughts, vocabulary, and techniques to create and develop a heritage inspired vocabulary that can compromise with the traditional Islamic architecture theme. Through this, the research aims to achieve a systemization of digital design strategies to facilitate the generation of Islamic-inspired façade, to create a new Islamic architecture that can be applied within Islamic heritage regions to connect the modern buildings which located in these regions with the existing Islamic reference. To achieve that, the research starts with studying and discussing the main elements that formed the Islamic facades, to stand on the methods of formations of each element and its function of the Islamic façade, whether it is an intrinsic function or aesthetic function. Consequently, standing on the main digital theories that lead to new architectural vocabulary that can homogenate with Islamic vocabulary, through studying the concept of each digital theory, accordingly how it can be applied theoretically to create a modern façade with an Islamic spirit. The research ends with a case study for a proposed modern building that resembles most of the recent buildings in Al-Azhar Islamic region in Cairo, and how through applying some selected digital theories can result in developing and renovating this facade to match the heritage Islamic surrounding in a new digital way.

Keywords: Digital architecture, Islamic vocabulary, Heritage Regions, Digital Era, Architectural Paradigm.

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ملخص

تتميز الواجهات المعمارية الإسلامية بالعديد من المفردات المميزة التي شكلت طابعها مثل العقود والزخارف والمقرنصات والمشربيات وما إلى ذلك. ولكن مناطق التراث الإسلامي واجهت خلال العصر الحديث العديد من التغييرات والتحولات في طابعها، إما من خلال المباني الجديدة التي تم بناؤها على الطراز الحديث أو غير المخطط لها أو تلك التى بنيت بشكل عشوائي. ومع ذلك، في الآونة الأخيرة ومع بداية القرن الحادي والعشرين فقد وفرت التطورات الهائلة في الأدوات والتقنيات الرقمية آفاقا جديدة في أدوات التشكيل المعماري. وبناءً عليه، يركز البحث على كيفية تقصي الآثار الإيجابية للتقنيات الرقمية على العمارة الإسلامية، بالإضافة إلى كيفية الاستفادة من الأفكار الرقمية والمفردات والتقنيات لإنشاء وتطوير مفردات مستوحاة من التراث يمكن أن تتعارض مع موضوع العمارة الإسلامية التقليدية. من خلال ذلك، يهدف البحث إلى تحقيق منهجية لاستراتيجيات التصميم الرقمي لتسهيل توليد واجهة مستوحاة من العمارة الإسلامية ، لإنشاء عمارة إسلامية جديدة يمكن تطبيقها في مناطق التراث الإسلامي لربط المباني الحديثة الموجودة في هذه المناطق مع مرجعيات مفردات العمارة الإسلامية. ولتحقيق ذلك يبدأ البحث بدراسة ومناقشة العناصر الأساسية التي شكلت الواجهات الإسلامية للوقوف على أساليب تشكيل كل عنصر ووظيفته للواجهة الإسلامية، سواء كانت وظيفة جوهرية أو وظيفة جمالية، وبالتالي الوقوف على النظريات الرقمية الرئيسية التي تؤدي إلى مفردات معمارية جديدة يمكن أن تتجانس مع المفردات الإسلامية، وذلك من خلال دراسة مفهوم كل نظرية رقمية، وبالتالي كيف يمكن تطبيقها نظريًا لخلق واجهة حديثة بروح إسلامية. ينتهي البحث بدراسة حالة لمبنى حديث مقترح يشبه معظم المباني الحديثة في منطقة الأزهر الإسلامية في القاهرة، وكيف يمكن من خلال تطبيق بعض النظريات الرقمية المختارة أن يؤدي إلى تطوير وتجديد هذه الواجهة لتتناسب مع المحيط التراثي الإسلامي بطريقة رقمية جديدة.

الكلمات المفتاحية: العمارة الرقمية، مفردات العمارة الإسلامية، المناطق التراثية، العصر الرقمى، الطراز المعمارى.

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1. INTRODUCTION

As the 21st century has conveyed new era for architecture, so searching for creative and innovative forms became one of the most motivating focuses to contemporary architects in recent years, and computer has played essential role in achieving this new paradigm in architecture. Digital architecture is considered the architecture of the 21st century and distinguished by its extremely varied manifestations and characteristics that simulate various principles and theories. Complexity in masses and shapes to fluidity, moreover geometric shapes that known as parametric geometry and many others, in which the relationship among them are examined and applied through computer software. Despite this, remains the absence of mutual discourse methodology between digital and traditional approaches to create a modernized vocabulary has challenged contemporary historical Architecture, while the digital architecture theories with the role of computer can assure the simulation of historical rich ideas, vocabulary and characteristic (Nejad et al., 2014).

By concentrating firstly on the design of Islamic façade with its unique and distinctive way, through studying the main elements that formed the identity of Islamic facades, in which its features were designed to support different aspects starting from psychological, ecological, societal and religious demands convenient to all the requirements of that era. (Singh and Saxena, 2021). In this context, the question arises as to find and highlight the link between the design of Islamic façade elements and the design methods of digital architecture and how it can have a great role in the possibility of achieving a new historical architecture with its great and rich vocabulary to reach a new Islamic feature through the wide variations in the digital techniques. In addition to being able to compromises with the traditional Islamic vocabulary, elements and characteristics and can still also have the same imaginative and expressions within the same spiritual traditional Islamic way.

2. ISLAMIC ARCHITECTURE FACADES ELEMENTS AND VOCABULARY:

Formation of Islamic architecture facades utilizes a set of rules and principles that created this vocabulary. Islamic vocabulary combines between fixed (religious beliefs) and variable (the form) principles, that formed the Islamic architecture and assure its distinctive characteristics. For example, from the religious beliefs that affected the form in Islamic architecture was the privacy principle, which is one of the most important principles that affected the form through many aspects specially the external openings that led to covering external openings with different treatments. Consequently, it's important to determine the main elements that formed the Islamic facades and its basic principles to stand on deep understanding for Islamic elements and vocabulary to reach a conscious attitude and full awareness of their meaning and way of designing, to enhance rethinking and reformulating Islamic compositions through digital techniques. (Hillenbrand, R. 2003),
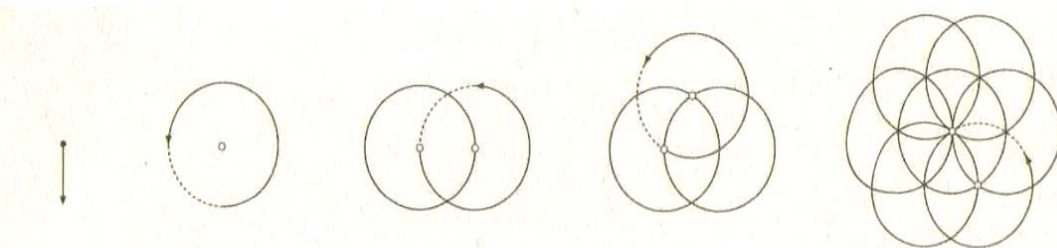
2.1. Geometric Ornaments

Fig.1: From unity to cell through circle center interlocking (Sutton 2007, 3)

Islamic ornaments are one of the main elements that formed Islamic architecture identity and ideology. When we analyze its composition, we can in Islamic pattern the most notable and basic theme in forming its geometry find that repetition. Islamic ornament formation methodology is mostly based on one or two basic shapes, by interconnecting these basic shapes many diverse and complex patterns can be generated. (Alani, 2015). Origin Start of any of any Islamic geometric pattern shows a kind of symbolism, as example; the center of the circle (Although not visible in itself), the center provides the

basis for the rest of the pattern. This center/unity corresponds to the concept of Tawheed in the Islamic tradition, as shown in figure 1. Correspondingly, it is the basic concept and the first pillar of faith. In Islam, God is the absolute power from which the universe originated. Although the names may vary (center, unity, or absolute), in both geometry and Islam, it is the unseen reality that is the most obvious. (Azad, 2020).

slamic Ornamental designs are mostly generated by the repetition of the basic shapes circle which is the main, square and triangle. Pentagon, octagonal, hexagon decagon, and Islamic stars are from the shapes that also have a significant role in generating Islamic ornaments and patterns, but furthermore most of these shapes can be formed from the interlocking of the Islamic basic shapes. As stated previously, what is significant about Islamic ornaments is repetition that can generate a surface of geometric pattern, as shown in figure 2. (Azad, 2020).
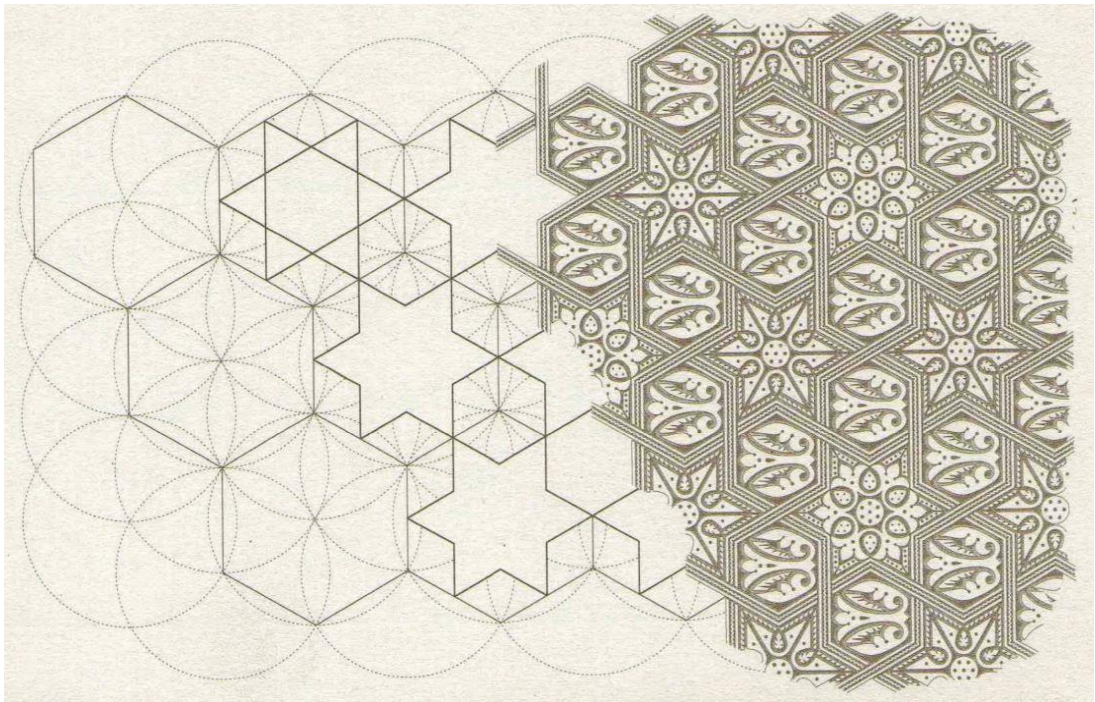
Fig.2: Simple to complex (from circle to hexagon transforms into another shape by joining the midpoints of the hexagons). (Sutton, 2007, 3).

2.2. Al Muqarnas

Muqarnas is an organization of three-dimensional decorating masses that used in Islamic architecture with various forms. Muqarnas is complicated shapes, geometry, and repeated structures that characterized by symmetry-repetition-diversity-accumulation - diversity in scale. Muqarnas is mostly used in domes, niches, arches in facades to determine the entrance. According to the use of Muqarnas; its size, module in addition to the deepness of its composition is varies and adjusts to the size of the area covered or to the required purpose, Figure 3, for example in ceilings it serves a clear architectural purpose as a transition element from ceilings to walls (e.g. from circle to square or vice versa), or provides the structural delusion and spatial balance of ascending movement in domes. (Bloom, 1988).

Fig.3: On the left Main entrance portal (iwan) of Mosque-Madrassa of Sultan Hassan, Cairo, Egypt. On the right muqarnas vault of entrance portal, Complex of Sultan al-Mu'ayyad, Cairo, Egypt (Sutton, 2007, 3).

The three-dimensional effect of the muqarnas decoration is achieved by interlacing and repetition of patterns. The Muqarnas are made of small 3d pieces or cells which are simple in shape combined in successive layers together produce this complex surface. These cells are the structural blocks on which Muqarnas were built and expanded to fill the area between consequent layer lines, as in Figure 4. Muqarnas 3d cells are roofed like a staircase consists of facets and a flat roof. Both facets together with their roof are called one cell. Adjacent cells, which have their bases on one and the same surface parallel to the horizon, are called one tier, and from tiers to complex surface as stated before. (Von, V, 2006).
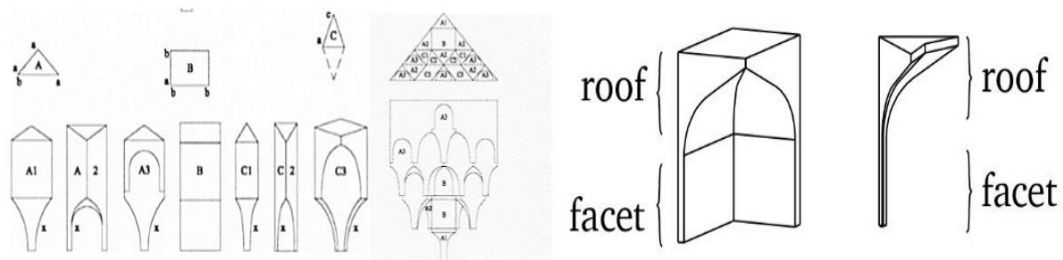
Fig.4: Simple elements of Muqarnas (roof and facet), Plans, Elevations, Sections. (Garofalo, V. 2010).

2.3. Arches

The arch in Islamic architecture as an opening or frame has three purposes in its achievement: the first is the functional, to form openings or a set of arrangements of arcades that formed and surrounded Islamic plazas and courts. The second purpose is a structural purpose which may be a load bearing with a profile based on the segment of a circle or series of segments. The third is the aesthetic and symbolic feature as it can be used as a decorative element in the Islamic facades. Mostly arches in Islamic architecture are used in regular repetition rhythm, shown in figure 5, which appeared in the opening's rhythm of Islamic facades or in the repetition rhythm the arcades. (Edwards, C. and Edwards, D. 1999)

Fig.5: Left photo arches repetition in the Great Mosque of Kairouan, (www.khanacademy.org). Right photo the repetition in arches with different scales in Al-Azhar Mosque entrance, (islamicart.museumwnf.org).

There are different types of Islamic arches as shown in figure 6, the variation in their shapes depend on the number of the arcs segments and the changing the positions of their center. (Almaimani, A., Nawari, N. 2016,)
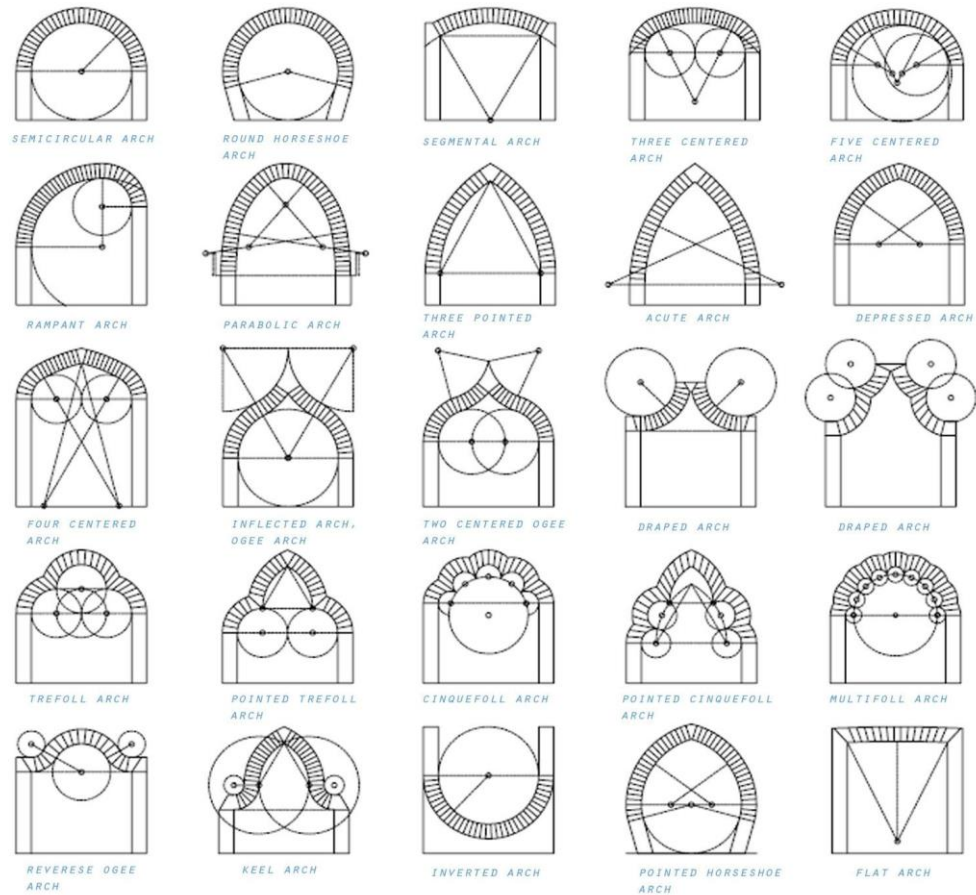

Fig.6: Some of the Islamic arch types (Almaimani, A., Nawari, N. 2016).

2.4. Wooden Treatments of Islamic Facades

Islamic wooden treatments are considered a porous structure that have several distinct types according to their wooden latticework designs differ from region to region, figure 7. Wooden languages in Islam offers a lot of aspects according to human needs that Islamic architecture was concentrating on, (i.e., religion, privacy, environmental, spiritual, and ornaments), which can be further sorted into the following aspects: (Embi. R., Abdullahi. Y., 2012)

- Physical aspects: adding a touch of details in terms of color, aesthetics, and another level of ornaments in the facades.
- Psychological: Achieving a kind of porous through indirect connection between the interior spaces and outdoor spaces.
- Environmental aspects: provide shade from the summer sun while permitting the flow of cool air from the road. This allows for greater air circulation within the room without causing discomfort. The wood itself removes moisture from the air.
- Social and Spiritual needs: The wooden ornaments allow the user to use the space confidently, insure Islamic practices and worship.

Fig.7: Wooden treatments (mashrabeya) in Beit El-Sennari (www.meashots.com).

2.5 During the Study of Islamic Facades Geometric Composition, The Research has Revealed That:

▪ By decomposing Patterns and motifs in Islamic architectures to its constructional non-repeating components, it's found that it is based on a fundamental unit or cell, which is formed from a starting point or smaller cells. Once the fundamental unit is achieved, a surface geometry can be able to reconstruct.

▪ Islamic geometric patterns have simple governing rules for creation and have infinite number of possible patterns.

▪ Islamic formations depend on the repetitive sequences.

▪ Patterns is used to enhance cultural characteristics and determining its identity.

So, the research will study digital architecture vocabulary and techniques to develop Islamic elements and vocabulary using parametric algorithms.

3. REFORMULATING ISLAMIC GEOMETRY COMPOSITIONS THROUGH DIGITAL METHODS AND TECHNIQUES:
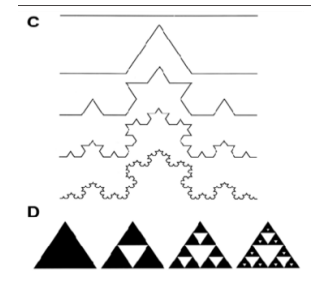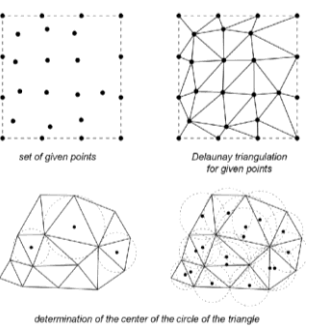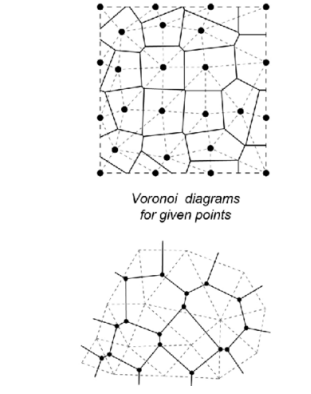
The notable changes in today's architecture are predictable consequences of the sweeping technological advances of the 21st century. The architecture of 21st century or digital architecture is characterized by various features and compositions that resemble Islamic architecture formations which have been studied previously in so many characteristics. Consequently, digital architecture can be exploit in achieving new contemporary architecture that can homogenate and compromise with the Islamic architecture and be a way to develop facades of modern buildings in the traditional Islamic regions. In this context, the research will illustrate the most convenient theories that matches with the Islamic compositions that have been illustrated before.

3.1. Fractal Geometry

Fractal geometry is inspired from structural irregularity of nature system. Fractal appears in phenomena of nature system through all its scales, from its particle to cosmological unit. From its examples, the structures of the ground surface, snow crystal shape, discharge phenomenon of electricity, and distribution of the cosmic galactic system, human, and plant cells, and many other. Fractal has varied principles and theories that can be useful in applications of new Islamic architecture. Fractal geometry is developed by means of algorithm that developed in cellular formations in a numerical formula and achieved in a repetitive operation process. Namely, fractal has a creative attribute in which small change in parameters incorporated in creating various complex patterns, with substantial change. (Lee M. 2014). Many theories and classifications have discussed the fractal types according to varies visions and from these theories, the research will concentrate on three theories that can correspond the Islamic concepts of geometric patterns as studied in the following table:

Table 1. Fractal Theories.

Fractal Theories		
Theory name and Concept	**Concept of application method**	**Example**
Fractal Self Similarity It's a repetitive process in which that the figure can be decomposed into some number of disjoint pieces, each of which is an exact copy of the entire figure but may differ in its size. (mellor B, 2013)		 Repetitive hexagon by different scales (Busygina. E. behance)
Delaunay triangulating Fractals It is a triangle mesh that is formed from either a set of random **points** or from a group of adjacent circles in which the vertices of each triangle intersect with the circumference of each circle at different points forming an acute angle triangle. (Rokicki, W. 2016).		 Delaunay Fractals Pattern
Voronoi Fractals It's a step more after the Delaunay triangulation through either defining the voronoi cell from a given point, or from the centers of the circles which determine the vertices of the convex polygon of voronoi which form form a new grid of "irregular voronoi diagram". (KNZLE, A. 2020).		 Voronoi diagram with different attractor points.
Conclusion	Fractals mostly depend in its design on a starting point to reach a fractal fabric as in Islamic geometric patterns.	

3.2. Geometric Folding

The process of folding is bases on transforming a two-dimensional surface into a three-dimensional sculptural object, which includes three important aspects for the architectural design, creation, and performance.

- Folding paper is a design method to build geometric models, by transforming the two-dimensional sketching into a three-dimensional modelling as shown in figure 8, which can give into wide possibilities of unpredicted results.

- Geometric folding is an effective structural model that can support itself due to the stability of its folds.

- Most of geometric folding has an effective adaptability with different environmental aspect. (Hemmerling, 2010)
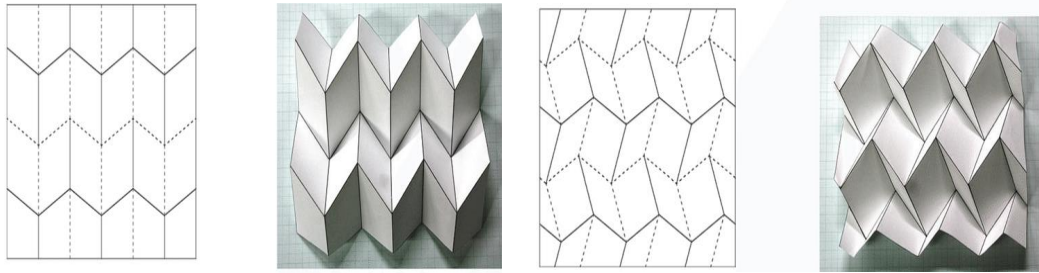
Fig 8: Transforming 2d surfaces into geometric 3d modelling through folding (Lynn, G. 2004)

These spatial parametric patterns and models can be used through different building aspects such as in form and building mass designing, or as a structure element in building ceilings or columns or as a façade pattern and material. In that respect the morphogenetic process of folding results in a highly useful in detailed design model that provides a high degree of freedom for the designer through different patterns.

3.3. Porosity

Pore means "a minute opening". Porosity or "the state of being porous", it is one of the natural phenomena that is found in different aspects in nature and living creatures as in biology and in organic chemistry porosity is defined as: "the characteristic of living body to have a large number of small openings that permit matter to pass through". It is also ca be found in the geological transformation that occurs in ground and rocks due to the atmospheric effects. In porosity, the forms, the sizes and the distribution of pores are usually random as shown in figure 10. Their functionality is related to circulation and filtration with respect to the external environment. The concept of porosity was transferred to architecture design either in form or facades solutions, to guide the creation of a porous morphology in architecture as a kind of reformulation of natural characteristics.
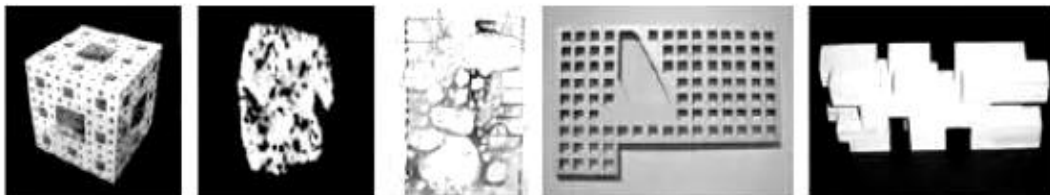

Fig.10: Organic and modular porosity, Early design schemes, Steven Holl Architects, New York, NY (Kotsopoulos. S., 2018)

Modular porosity in façades is a kind of surface fragmentation through pixilation technique, that can give an aesthetic preference within traditional architecture facades specially found in Islamic facades patterns. The porosity concept was part of a wider hypothesis, the "permeability hypothesis" that also found in Islamic Architecture (Wooden Treatments) as shown in figure 11, in which a porous morphology would have positive effects at building facade scale: better air circulation and light penetration, better accessibility and visibility at an urban scale, and better communication between interior and exterior at a building scale with a great achievement of privacy aspects for the internal building spaces. (Kotsopoulos. S., 2018)

Fig.11: Levels of modular porosity (Kotsopoulos. S., 2018)

3.4. Lofting (Riplles)

The term lofting originates from early shipbuilding. The ship large wooden framework called a loft, which was built to hold the external ship surface while it was assembled. The process of lifting the ribs (cross-sections) of the external surface into the loft became known as lofting. In Architecture, Lofting is one of the significant techniques for 3D object creation. Shape objects are created to serve as a path with any number of varied cross-sectional shapes either varied in shape or in height and area. (www.designstrategies.org). as shown in figure 12 which shows different shapes for lofting sectioning between regular and irregular.

Fig.12: On the left United National Movement building in Tbilisi, on the right Tampere art museum' in Finland by 3GATTI (www.designboom.com)

This technique can reformulate the repetitive cross section of Islamic Arches, as shown in figure 13. Accordingly, first create two or more spline objects. One of these splines will be the rail, which is referred to as the path. The rest of the splines are the cross-sections of your object, which are called shapes. As you arrange your shapes along the path, 3ds Max generates a surface between the shapes.
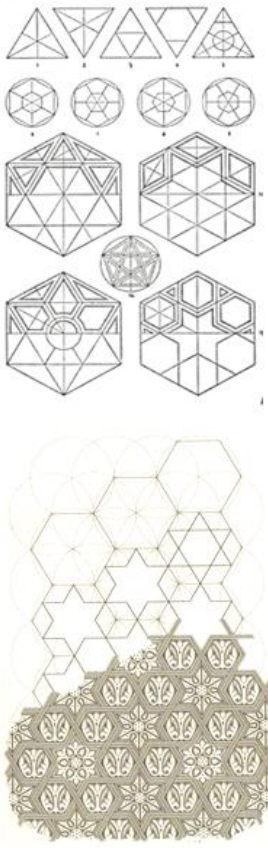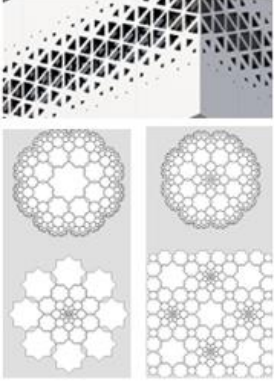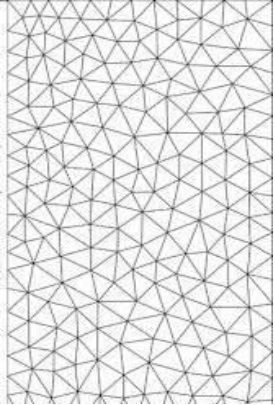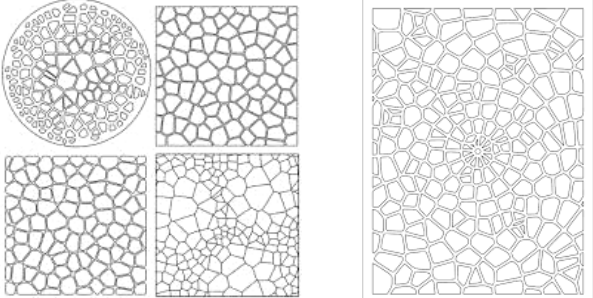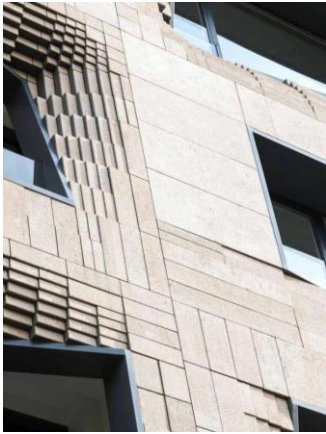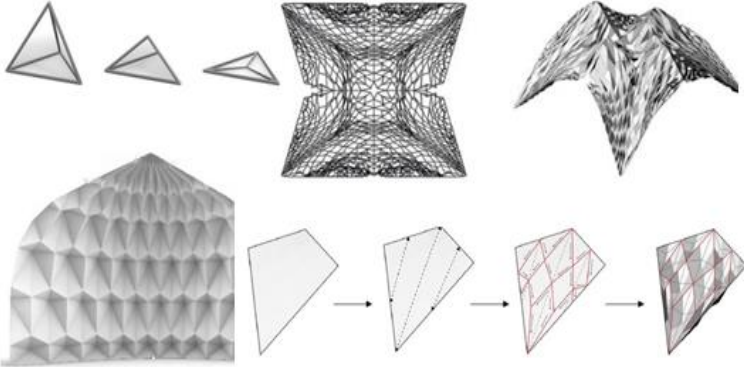

Fig.13: The Chamber Church aims to create a spatial container that both respects the past and looks towards the future (architizer.com)

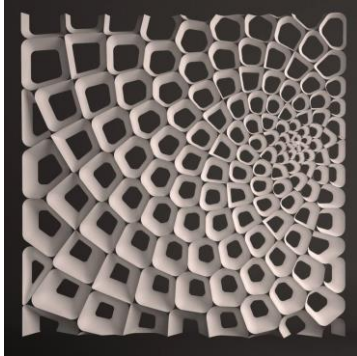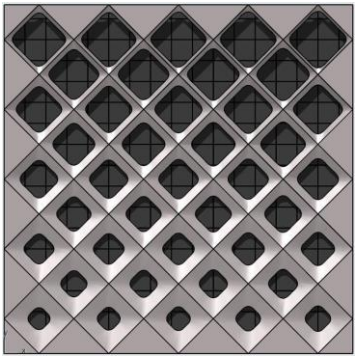## 4. A Comparative Study Between Islamic Facades Vocabulary And Digital Methods And Techniques

Through the following analytical table, the research will analyze how Islamic architectural facade elements and vocabulary can be reformulated through digital methods:

Table 2: Digital reformulating Islamic geometric compositions. (by the researcher)

Islamic Geometric Compositions	Digital Reformulating	
Geometric Ornaments	Fractal Self Similarity	Fractal Delaunay
	First photo self-similarity using triangles, second photo self-similarty using ismalic star only. (P. Webster, 2013)	Abstract geometric pattern using fractal texture of delaunay triangulating, (www.shutterstock.com)
	Fractal Voronoi	
Interlocking of the Islamic basic shapes forming infinite no of ismalic geometric patterns.	• Round gradient Voronoi 2d pattern • Voronoi 2D pattern. • Voronoi 2D pattern with rounded corners. • Voronoi diagram with 3 attractor points • Round gradient Voronoi 2d pattern with round corners and offest. (www.craftsmanspace.com).	

Al-Muqarnas	Fractal Self Semilarity	Fractal Voronoi
Concept of Muqarnas in Islamic architecture depend on small 3d pieces or cells which are simple in shape combined in successive layers together produce this complex surface. These cells are the structural blocks on which can be reformulated and developed through digital vocabulary by different methods and theories.	Al- Muqarnas effect by using self-similarity square pattern with different depth points in soft stone project – Iran (architizer.com).	Organic Voronoi fractal scheme expansions that allowed to grow multiply like fractal cells of Muqarnas in petroleum research center by Zaha Hadid (Elgohary, A.-2019).

Geometric Folding
Examples from 2D pattern towards 3D formation; digital through geometric folding modelling forming al-muqarnas. (Alaçam, S., 2017).

Islamic Wooden Treatments ➤	Porosity	
Porosity is one of the main characterstics that distinguish islamic wooden treatments.	Porous can be achieved by many shapes in digital theories as the following, permeable, honeycomb screen, net riddle, sponge pore opening, hole aperture, and many others, it addition it can be a step more after achieving fractals pattern by its different theories, as shown in the photos. (Kotsopoulos. S., 2018)	
Islamic Arches ➤	**Lofting (Ripples)**	
Arches used as openings or in determining the main entrances of islamic building which in many cases depend on the repetitive concept.	Lofting adopts the structural form of a series of arches in islamic architecture, with different heights, which can make a formal language and spatial structure of Islamic facades. At the same time, it also responds to the traditional idology of Islamic architecture from a structural point of view. (www.archdaily.com).	
Conclusion	From this analytical study we can conclude that Digital vocabulary featured with many characteristics as complexity, rhythm, geometric, changing and growth compositions, which shows a great ability in dealing with Islamic visions in forming vocabulary and compositions, which can be exploited to develop the modern facades within the Islamic context in the tradition Islamic regions.	

5. CASE STUDY: APPLYING DIGITAL VOCABULARY IN ISLAMIC GEOMETRIC COMPOSITIONS

Through the following practical study, the research will apply digital vocabulary that has been studied in the previous theoretical and analytical study on a proposed façade of three-story building. Through practical study, the research can assure that digital vocabulary and theories are able to compromise with Islamic architecture facades designs. Consequently, it can be achieved and applied on modern buildings which located in Islamic heritage regions to reach a new contemporary style that can homogenate with Islamic architectural vocabulary and compositions but with a new digital style.

5.1. Practical Study Sample

Choosing and designing the sample depended on two main aspects. The first aspect; analyzing Islamic façade and standing on their main elements. The second aspect; designing a basic model of a modern three-story facade, which contains the main elements of the façade that we concluded from the first aspect, in addition to, its simulation to the modern facades that are located within heritage Islamic regions, shown in figure 14.

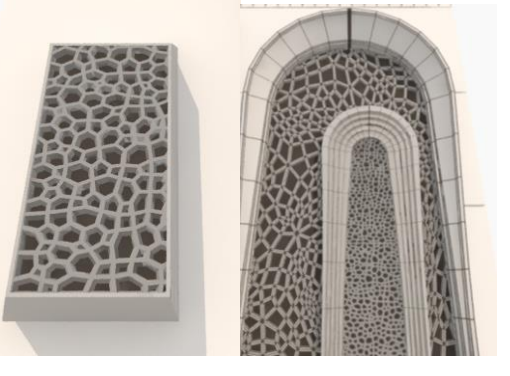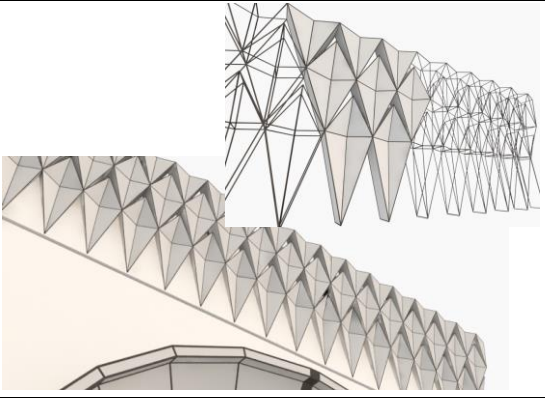Fig.14: Proposed modern façade model of three story with simple and basic elements
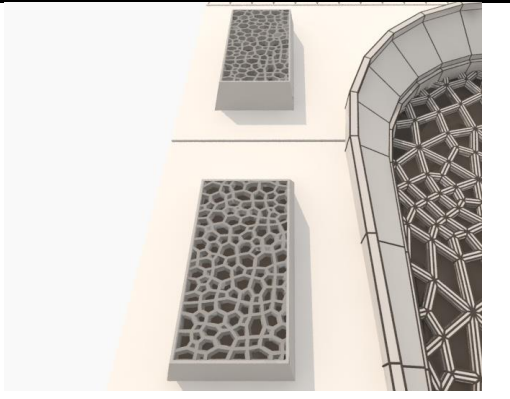
5.2. The Practical Study Tools

The practical study chose 3ds Max program as study tool to apply digital techniques, according to its general features as a computer graphics program for creating 3D models, animations, and rendering photorealistic images. In addition to its modelling techniques such as, Polygon modeling includes multi sub-object levels, navigating and a rich modifier stack and creating commands like; loft, mesh topology, edit poly, inset, morph, Boolean, NURBS and modifier list, like; twist, bend, FFD, sweep, etc. and also its accuracy with complex forms.

5.3. Practical Study Digital Vocabulary Application

The practical study chose some of the digital vocabulary that have been studied previously to be applied on the proposed façade.

Table 3: Practical Study Digital vocabulary application - By the researcher

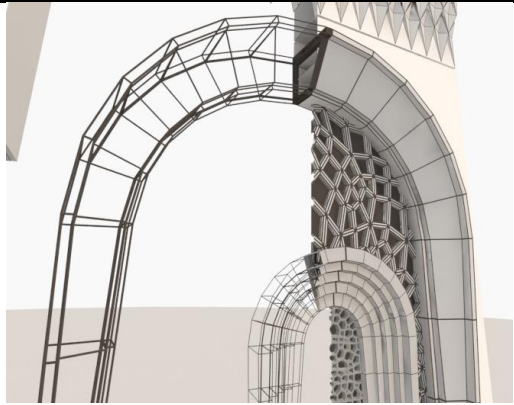| Practical Study Digital vocabulary application		
Geometric Ornaments		**Fractal Voronoi**
The Islamic ornaments applied through Voronoi diagram with multiple attractor points in entrance and Voronoi 2D pattern with rounded corners in openings		
Commands used:	Applying (Edit Poly) on a multi-face plane, then apply (Mesh topology) to create the Voronoi pattern, after that applying (Inset) to create struts.	Applying fractal voronoi on openings, also in the entrance area as ornaments to determine the entrace area..
Al-Muqarnas		**Geometric Folding**
Applying Islamic muqarnas through geometric folding from 2D hierarchized triangulating pattern that transformed to 3D formation by moving specific lines and points		
Commands used:	Creating 2d Sp-line triangulated pattern. Moving vertices and giving it extrude, then apply 3d array with different scales.	Applying geometric folding as a Muqarnas on the top of the building façade.
Practical Study Digital vocabulary application		
Wooden treatments		**Porosity**
Porous techniques applied on Voronoi patterns to simulate porosity treatment of Mashrabeya and Islamic wooden treatments.		
Commands used	Applying (delete mesh) on Voronoi editable poly, then applying (bevel) to create the opening thickness.	Applying porosity on the Voronoi pattern of the openings to ensure the Mashrabeya concept and the entrance arched pattern.

Isalmic Arches		Lofting
Applying Lofting by using three sections with different scales and shapes, to simulate the tradition arched entrances with its upper ornament, but in an abstracted and modern way.		
Commands used	Applying (loft) using three cross-sections as a loft shape, and apply it on an arched path.	
		Applying lofting on two scales in the entrance area to determine the entrance as in Islamic architecture and to ensure the concept of repetition of arches in Islamic designing.

5.4. The Proposed Digital Facade

By applying the previous techniques, the research proposed an integrated modern façade which homogenate with Islamic tradition façades, which proved the research hypothesis that digital techniques and vocabulary can be used to develop the modern facades in Islamic region.
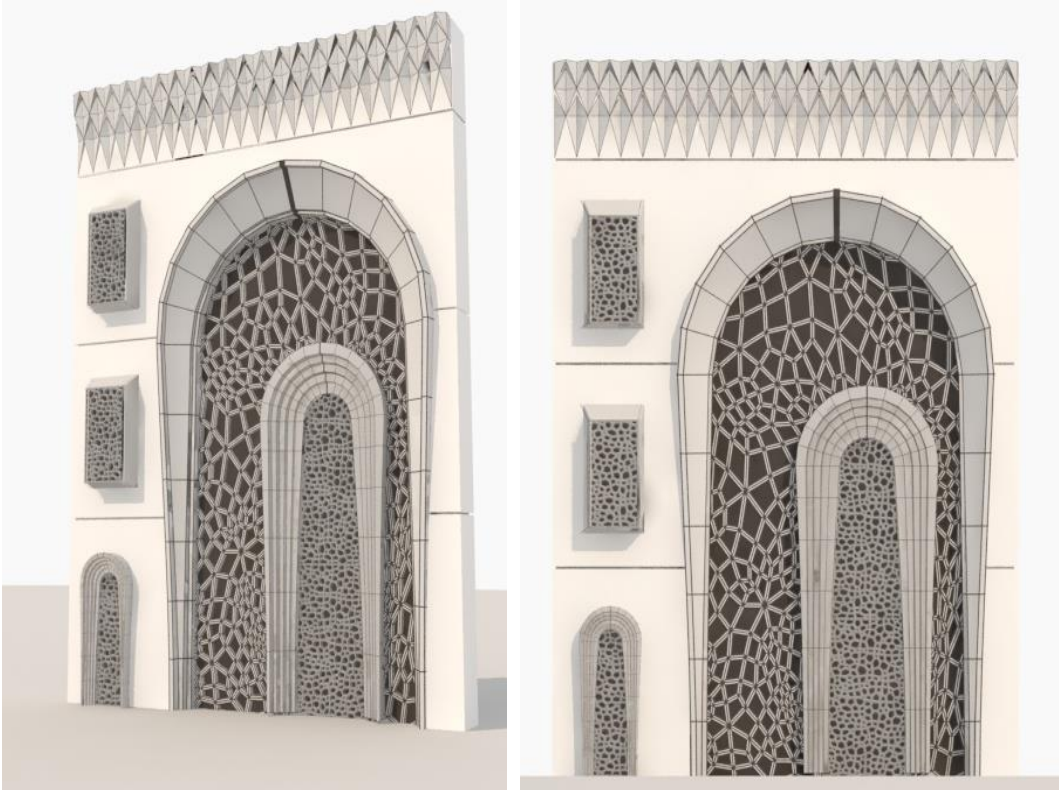

Fig.15: The integrated proposed Islamic façade model and elevation after applying digital vocabulary.

6. CONCLUSION

The research can be considered as a step to achieve a systemization of digital design strategies to facilitate the generation of Islamic-inspired façade, to develop the modern architectural output which located within the Islamic heritage regions -particularly in the façades design - through digital methods and techniques. Consequently, the research proved the great impacts of digital theories and its new architectural vocabulary in creating a new Islamic architecture that can be applied on modern buildings facades to transform it homogeneously with its Islamic heritage surrounding. In this context the research proposed sequenced steps of the facades' development as the following:

▪ firstly, stood on the main elements that formed the surrounding Islamic facades.

▪ Secondly, analysing the modern facades (that will be developed).

▪ Then selecting the suitable vocabularies from digital theories, which can help in achieving the features and compositions that resemble Islamic architecture formations.

▪ applying the elected vocabularies to get new integrated façade alternatives.

▪ finally evaluating the new façade designs to stand on the most suitable proposal which homogenates with the surrounding facades.

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