

ARABIC CALLIGRAPHY AND PARAMETRIC ARCHITECTURE

Translation from a calligraphic force to an architectural form

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Abstract. This paper describes an on-going research that unites two distinct and seemingly unrelated interests. One is Arabic calligraphy and the other is parametric architecture. The effort is to integrate these interests and, in doing so, balance cultural issues with technological ones, traditional with contemporary and spiritual with material. Moreover, this paper is inspired by Arabic calligraphy and its influence on Zaha Hadid's designs; it is invigorated by parametric systems and their capacity as a source of architectural forms. This paper will observe the rising importance of computation technologies to architecture, which has always been a form of negotiation between 'function and fiction' and 'force and form'. The paper proposes a Parametric Calligraphic Machine that simultaneously produces, connects and separates calligraphic surfaces, calligraphic images and calligraphic reality. Therefore, the goal is to examine this hypothesis in order to produce a set of techniques, tools and methods that inform the three-dimensional design process of Arabic calligraphy's contemporary possibilities by addressing a process description rather than a state description of creating calligraphic images and calligraphic surfaces. The theoretical approach highlights issues pertaining to *calligraphy, spatiality, translation, generative systems, parametric design, visual structure, force and form.*

1. Introduction

The motivation for this multidisciplinary research (Fig. 1) can be traced back to thoughts, speculations and ideas developed during several years of engagement in architectural design and theory at the University of Edinburgh and the Architectural Association, as well as during the author's professional work at Zaha Hadid Architects in London. The research's cross-disciplinary

main propositions unite the interests of Arabic calligraphy and parametric architecture, and have a mutual understanding of speculation analysis that deals with discovery and predictive theory, as well as a creativity synthesis that deals with the experimental explorations and invention of both disciplines.

Arabic calligraphy is one of the most typical expressions of the Islamic spirit and a fundamental decorative element of all forms of Islamic/Arabic art, ranging from architecture to decoration design. Calligraphy integrates a cultural language with the language of geometry and combines sacred meaning with creative making (Moustapha & Krishnamurti, 2001). Therefore, there has been extensive interest in the study of Arabic calligraphy as a medium for design from an objective and/or subjective point of view.

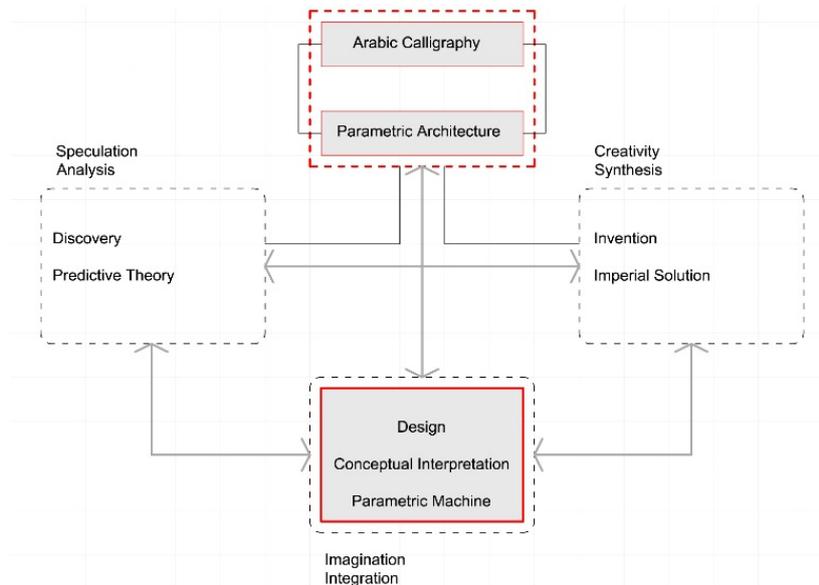


Figure 1. The research's cross-disciplinary main propositions (adapted from Philips, 2000).

Furthermore, calligraphy is a *visual structure* and has a visual order, and has shown an impressive ability to regenerate itself. A calligraphic composition is composed of components (letters) and formational rules (letter arrangement rules), defining an overall *visual structure* where letter flexibility and fluidity present indefinite possibilities for designing two-dimensional calligraphic expressions. Arabic calligraphy's visual structures and its conceivable spatial dimensions make it a dynamic and versatile language for the conveyance of form and space as well as meaning. During the calligraphy compositional

process, letters and their relation arrangements are formed, and the visual system transformed and redefined. There is a rhythmical and poetic interpretation of calligraphy in Arabic culture, which demonstrates itself in architecture through the decorative surfacing of sacred architecture with the complex patterns displayed in Arabic architecture and arts. However, this interpretation and representation occurs only in two-dimensional visual structures. The challenge, therefore, is to determine how to translate these calligraphic visual structures into three-dimensional objects and how to inject them into the real context. The challenge of translating these calligraphic visual structures into three-dimensional objects is associated with the current state of architecture in the Arabic region; this indicates that there are serious challenges at different levels, which are affecting both the 'making' of Islamic/Arabic architecture and the 'meaning' of its cultural identity. However, this research, by using Arabic calligraphy as a catalyst, will attempt to identify and discuss briefly the challenge of integrating and interacting the culture identify of Islamic/Arabic architecture with global contemporary and avant-garde movements in architecture.

2. Translation from a *Force* to a *Form*

In his book, *Notes on the Synthesis of Form*, Christopher Alexander (1964) examined ways to infer form from the diagram of forces. This concept, borrowed from D'Arcy Thompson who referred to the form as a 'diagram of forces', was later further advanced in Alexander's article 'From a Set of Forces to a Form.' Questions asked in this article included, 'Given a system, how can we assess the forces which act upon it and arise within it? Given a set of forces, how can we generate a form which will be stable with respect to them?' (Alexander, 1966: 98). Alexander believed that the concept of force had the potential to articulate the complexity of a given system. He defined force as "an inventive motive power which summarises some recurrent and inexorable tendency which we observe in nature" (1966: 96). Alexander argued that the notion of force allows us to summarise and outline all forces embedded within a given system.

D'Arcy Thompson, in his book *On Growth and Form*, analysed variations in the morphology of animals' shapes using deformable grids, which shaped curvilinear lines according to changes in any given form (Fig. 2). These terms relate to the influence of a force on a form through a natural *system*. In this context, the term 'deformation' indicates a system that

regulates and orders an object through a combination of forces (Lynn, 1999: 29).

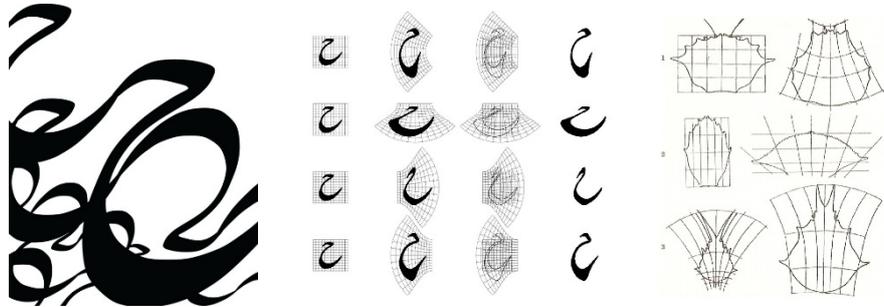


Figure 2. Study of the transformation of Arabic letter 'Haa' through the deformation of a flexible grid. Inspired by Thompson (1992) (right).

The present paper will focus on the concept *translation* between forces and forms in the Arabic calligraphy *visual structure*, by translating calligraphic expression into architectural spaces based on algorithmic means through computational experimental studies. In his article, 'Translations from Drawing to Building', Robin Evans stated, 'It can be argued on the common antilogy that would have architecture be like language but also independent of it. All things with conceptual dimension are like language' (Evans, 1996: 154). According to Evans, buildings are translations of drawings. However, Arabic calligraphy as a source of drawings could be described as a diagram. Furthermore, the importance of translation and representation becomes increasingly apparent in architecture; moreover, much research has been undertaken in the area of non-symbolic, especially diagrammatic, representation systems. Evans identified translation as 'the interpreting of the meaning of a text and the subsequent production of an equivalent text, to translate is to convey. In another words, it is to move something without altering it' (Evans, 1996: 154). In general, diagrams are important representations of design thinking and design communication in the design disciplines, and drawings are considered the principal form of representation; they translate ideas from conception to completion.

A diagram of Arabic calligraphy visual structure is a form of representation that involves a high level of visual abstraction with a low level of visual perception that does not affect the informative dimension. Alexander characterised design as matching program requirements with a corresponding diagram (Alexander, 1966). He called a diagram 'any pattern which, by being abstracted from a real situation, conveys the physical

influence of certain demands or forces' (1966: 85). Furthermore, Deleuze and Guattari (1988) described diagrams as abstract *machines* that have embedded within their structure the ability to generate potential forms – physical or visual. “They are not representations; they construct the process through which the generation of form will be possible. Therefore, they are the visualisation of a mechanic process, which combined with territorialised elements (such as program, regimes of signs, and regimes of bodies) produces form” (1988: 142-144).

By understanding and reflecting this methodology in the process of translating calligraphic forces into architectural forms, it is noted that *Calligraphic Information*, required for producing the *Calligraphic Formation* that is susceptible to *Calligraphic Transformation*, could be associated with generative and parametric systems used to produce two- and three-dimensional paradigms. The paper will present a Parametric Calligraphic Machine that supports a novel approach to calligraphic compositions by manipulating and controlling the algorithmic script ‘*Calligraphy of the Algorithm*’, based on an actual Arabic calligraphy preference, ‘*the Algorithm of Calligraphy*.’

3. The Visual Influence of Calligraphic Forces on Zaha Hadid’s Forms

The author observed, during his professional employment at Zaha Hadid Architects, that Hadid’s thinking and creativity had been heavily influenced by the place of calligraphy in her Arabic culture. Arabic calligraphy inspired Zaha Hadid’s architecture; for example, she allowed Arabic calligraphy to influence her design strategy and style. Hadid stated that she realised there was a connection between the logic of maths in architecture and the abstraction of Arabic calligraphy, and mentioned it in the press as a fertile subject for scholars to investigate, with consideration given to creating forms and surfaces based on contemporary design elements that employ algorithmic means.

Hadid and her partner, Patrik Schumacher, share a design goal to achieve spiritual meaning with aesthetic making in their buildings. It can be argued that during the past two decades, the defining feature of avant-garde architecture has been the media representations and design processes pioneered by Zaha Hadid, which have resulted in the production of spectacular paintings and drawings. Her curved gestures, influenced by Arabic calligraphy, allowed her paintings and drawings to reflect the notion

of deconstruction and fragmentation in space (Schumacher, 2002). The influence of Arabic calligraphy on these drawings and paintings challenged the sensibilities of Hadid's contemporaries, who found them hard to interpret. Some scholars felt they were merely graphics (2002). But this dilemma around two-dimensional drawing has been a predicament of architecture ever since its inception as a discipline distinguished from construction (2002). As Robin Evans pointed out, '[A]rchitects do not build, they draw.'

One of Hadid's significant moves was to translate the dynamism and fluidity of her calligraphic hand into equally fluid tectonic systems, producing controversial relations between angular and curved forms (2002). Using her calligraphic skills, she shifted significantly from isometric and perspective projection to literal deformations of space. The curvilinear contours of Hadid's designs echo the cursive flow of Arabic calligraphy.

Both Hadid's designs and contemporary calligraphic visual structures share design principles with space and landscape design, since all have common visual design guidelines. The influence of calligraphy on Hadid's designs is apparent; both Arabic calligraphy and Hadid's designs have several strengths as a form. These include changing relationships between curves and lines, the ability to stretch or compress elements and the ability to fit equally well into large or small spaces. The concept of 'scale' is vital in both phenomena; they are highly flexible and full of dynamism, energy and sometimes rhythm, which makes Arabic calligraphy, as well as Hadid's designs, a responsive device for aesthetic expression. They both have the quality of adapting to all purposes and moods.

Both Arabic calligraphy and Hadid designs have creative tension, where boundless flexibility combines and meets with the following of rules. The flexibility and dynamism of the written sensibility of Arabic calligraphy, as well as the visual sensibility of Hadid's designs, offered an exceptional probability for the malleability of constituent letters and the elements of a word or design. Moreover, the flexibility of the written language of Arabic calligraphy and the visual language of Hadid's designs allows designers to stretch letters and design elements almost in any direction, which creates a work of art. Indeed, both Arabic calligraphy artists and Hadid follow the same rules in their use of space and surfaces.

4. Understanding Arabic Calligraphy as a Surface

Continuous surfaces play a significant role in Hadid's design principles. In Islamic/Arabic architecture, calligraphy and geometric patterns flow through the interior surfaces of sacred buildings, establishing this *continuity* (Blair, 2006). These surfaces become the visual ornamentation that convey the meaning of the text; they are particularly noticeable in most sacred buildings, providing the comprehensive decoration that seems to cover every surface of the building. In such architecture, surface and calligraphic ornamentation are responsible for representing the building's meaning and making. These surfaces, covered with calligraphic ornaments, deliver a timeless message about the society's belief system.

Traditionally, the technique of producing Arabic calligraphy emphasises a two-dimensional surface, not a three-dimensional form, and horizontality rather than vertical order. The main principle of calligraphic visual structure is *continuity*, rather than interruption or disconnection. This continuity in shape and geometry has been noticed in the continuous evolution and development process of the art of calligraphy; Hillenbrand stated that it could 'well be argued that the art of beautiful writing – for that is what "calligraphy" means – has, alone of the major Islamic visual arts, continued its creative evolution without a break from the first Islamic century until the present day' (Hillenbrand, 2006). As a metaphor, this *continuity*, either as a state description of *continuity* of surface (in space) or process description of *continuity* as calligraphy development (in time), is very important in understanding calligraphic continuous surfaces, which could constitute a new era of design in Islamic/Arabic architecture.

For the author, such concepts hint towards a different and more contemporary approach to the appearance and representation of Arabic calligraphy in architecture, one in which the surface of calligraphic ornamentation is not a representation of reality. Instead, calligraphic ornamental surface effects have constructed a different reality, a virtual reality that has become a significant aspect of architectural creativity. In other words, Arabic calligraphy is not considered an inferior simulation of reality, but rather a creative and symbolic reproduction that produces a unique reality of its own. When such calligraphic ornamentations are re-interpreted as ornamentation applied to the surfaces of buildings, the non-hierarchical simulative operation continues to affect different mediums. Consequently, it is possible, as a creative act, to argue that the design

elements will merge and integrate to form a folded continuous calligraphic surface. The surfaces of calligraphic ornamentation are visual boundaries between the inside and outside of the form. In order to identify this virtual reality, a new approach should be followed and computational thinking should be implemented.

5. Parametric Architecture and Computational Exploration

The rapid development of the computational design technologies of mass reproduction has been an important issue for this paper. This ongoing research is derived from two fields, *Arabic Calligraphy* and *Parametric Architecture*, and the awareness of the crucial role that parametric design plays in exploring new boundaries for architecture and space making. Today, Muslim/Arab architects and artists are formulating different responses to image, surface and their (re)production in the information age, and parametric design plays a significant role. Many theorists in architecture have discussed the notion of expressiveness and representation in architecture through the use of computational and parametric methods.

'Parametricism' is an avant-garde architecture and design movement introduced in 2008 by Patrik Schumacher. However, there is a difference in computational thinking between *Parametric Design* or *Parametric Architecture* and *Algorithmic Architecture* or *Algorithmic Design*. Scholars may also argue that there is another field, called *Generative Design* or *Generative Architecture*. The author shares the opinion of Wassim Jabi, who defines *Parametric Design* as a process based on algorithmic, mathematical and logical thinking that enables the expression of parameters and rules that together, define, encode, clarify and control the relationship between design intent *force* and design response *form*, which differentiates it from both algorithmic and generative design.

The fact that it is a *process* is clear (Fig. 3). It is a strategy of thinking, not 'just a tool', and it should not be the *purpose* of a design. It is actually a fundamental shift in thinking of the process of design. The main shift is from a high fidelity in the manifestation of design concepts to a high fidelity in the expression of the logic of design concepts. It is also a shift from a focus on the shape of a given form to a focus on the internal mechanics and forces that define the form (Jabi, 2013).



Figure 3. Abstract translation of transforming the Arabic letter ‘Haa’ to a square.

The relation between architecture and its integration with Arabic calligraphy, as well as the rise of the information society and digital culture, stresses again the role that architecture plays in Islamic/Arabic culture. The question then follows: what can Islamic/Arabic architecture achieve today and in the near future by merging parametric thinking with Arabic calligraphy as a catalyst? The use of parametric architecture to produce new and spectacular forms is only one aspect of a larger picture that later leads to unfolded perception, just as ‘the invention of the perspective at the Renaissance was linked to broader issues than the mere research of geometric regularity’ (Picon, 2000, 55). What should be the exact scope of parametric architecture’s involvement with architectural design and Arabic calligraphy?

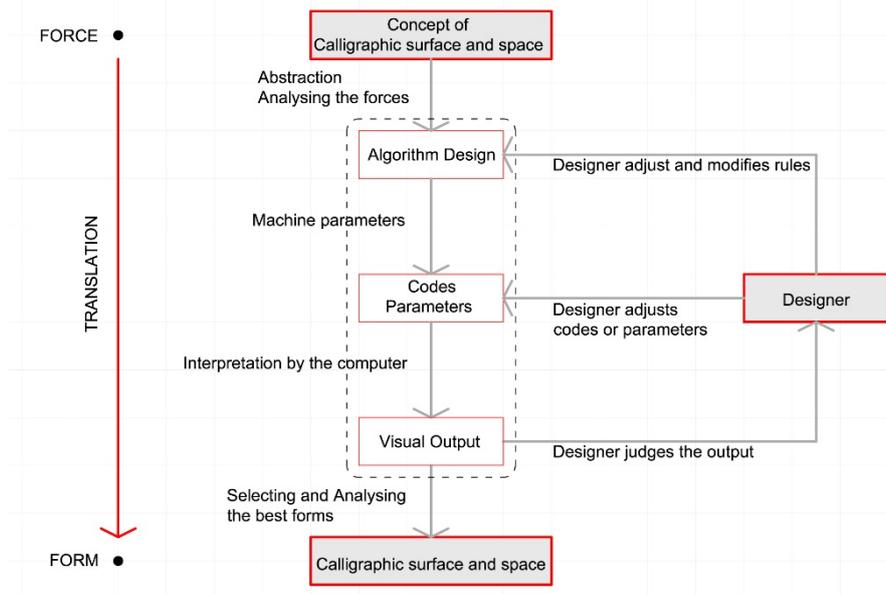


Figure 4. Parametric Calligraphic Machine design process and methodology.

The author’s ongoing research will unify these polar opposites through the hypothesis of ‘architecturising’ Arabic calligraphy and the theory of parametric design, which have both been widely used to produce two- and three-dimensional forms, and will use this new design thinking and new design outcome in architectural contexts. The scope of this paper is to

explore the intentions and influences underlying the argumentative relation between *Parametric Architecture* as a design system and *Arabic Calligraphy* as a design medium within the framework of architectural design generally and algorithmic design specifically (Fig. 4).

In his book, *Notes on the Synthesis of Form*, Alexander examined way to deduce form from a diagram of forces; his question of how to generate a form that will be stable with respect to a set of forces (Alexander, 1964) could be answered using a parametric machine that represents the influence of specific forces in any given context on a design. The outcome – a Parametric Calligraphic Machine for designing and visualising calligraphy-based forms – will be a significant contribution to the design process and will influence the way people create new forms of architectural spaces. This machine will translate Arabic calligraphy forces into architectural forms. The concept of the machine also supports transformations of Arabic calligraphy visual structures, thus producing new, yet arguably visual forms.

6. Parametric Calligraphic Machine Design Framework

In order to design the Parametric Calligraphic Machine, a series of experimental computational studies have been designed. In these experiments, Arabic calligraphy is applied as a design medium for conceptual inspiration; this inspiration began with the idea of defining a parametric architectural language. Investigations and explorations started with an exploration of the different visual possibilities within a single letter from its two-dimensional abstraction, proportion and perspective quality into three-dimensional interpretation.

The next step is to apply algorithmic means to the design process, which will be based on a series of algorithmic design experiments. In this sense, the proposed parametric system can be a completely automated process or a user-controlled one. John Frazer (1995) in his book *Evolutionary Architecture* discussed that we are inclined to think that final transformation should be process-driven, and that one should code not the form but rather precise instructions for the formative process. As such, the MEL (Maya Embedded Language) programming language was employed to create the Parametric Calligraphic Machine by designing specific programming scripts. Moreover, the basic structures and processes of MEL scripting will be introduced in order to understand, clarify and illustrate some of the mechanisms, relationships and connections behind the forms generated.

This process involves designing the algorithm of a certain calligraphic letter (rule) that enables the expression of parameters and rules that together define, encode, clarify and control the relationship within the calligraphic letter by adjusting the initial parameters and shapes, steering the derivation process and finally selecting the best variant (Fig. 4). A distinct machine was created for each case study. The machine introduces, explains and articulates the use of scripting in creating a space based on calligraphic visual structures. However, experiments examine the intellectual power of an algorithm and consequently parametric architecture (Terzidis, 2003).

7. Machine Design Review

This paper does not address the MEL scripts and code used in creating these machines, since the experiments are still ongoing. The machines and their visual outputs represent and constitute the beginning, rather than the end, of a narrative. Later research will be conducted in order to determine principles or a strategy to work with complex parametric systems using a more sophisticated method. The proposed Parametric Calligraphic Machine supports novel approaches to calligraphic compositions by manipulating and controlling algorithmic scripts based on actual Arabic calligraphy preferences (Fig. 5). The main concept surrounding the Parametric Calligraphic Machine can be attributed to the abstraction of the algorithm versus the concrete of form (Fig 6); therefore, most experiments ended up producing abstract forms.

Furthermore, adjustments had to be made to constrain the algorithm, which subsequently reduced many qualities of the spatial feature (Fig. 5); the experimental process was begun without precise knowledge of the way it would develop. On the other hand, producing an algorithmic project cannot be approached in the same way as an architectural project (Terzidis, 2003). From the outset, it demands a fundamentally different way of thinking. Parametric calligraphic surfaces and spacers are nevertheless a stimulating intellectual exercise. Moreover, the experiments examine the ability of an algorithm to encode and respond to new types of data and information, and to extend certain limits of the design process. The machine's scripts create parametric design processes. They give an indication of the potential and a point of reference for assessing the value of algorithms in the design process.

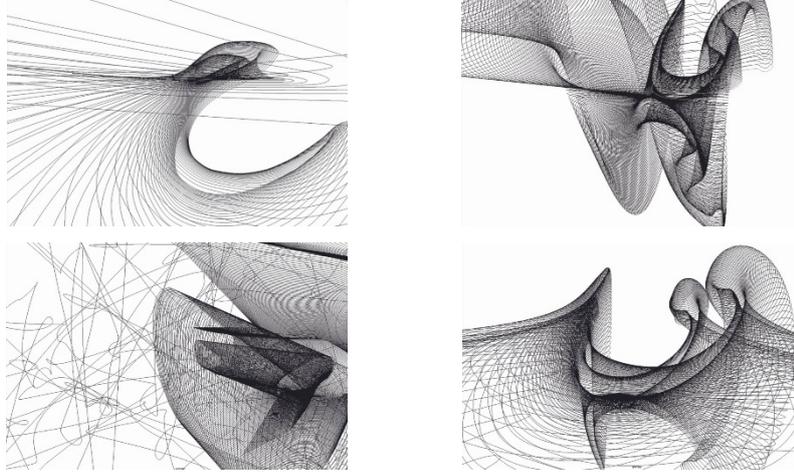


Figure 5. Forms and surfaces produced by the Parametric Calligraphic.



Figure 6. Ongoing three-dimensional calligraphic experiments to produce forms and surfaces.

The algorithms for these experiments were designed based on calligraphic letters' formational rules through a systematic development of the algorithm; the algorithms for these experiments allowed swift and accurate exploration of many variations. The machines translate the dynamism and fluidity of calligraphic context into equally fluid tectonic systems, producing controversial relations between angular and curved forms. Moreover, these algorithms are seen as linguistic expressions. An expression in a computer language is arguably a description of the desired behaviour of a virtual machine. 'The basic linguistic elements used in algorithms are constants, variables, procedures, classes, and libraries and the basic operations are arithmetical, logical, combinatorial, relational, and classificatory arranged under specific grammatical and syntactical rules' (Terzidis, 2003: 38).

Although algorithms in some experimental studies are effectively controlled, the final result was limited to a repetition of elements. However, it must be stated that algorithms offer many precise variations on a theme, though the main problem with them is that some designers find the numerical relationships too limiting (Terzidis, 2003). Parametric machines as diagrams can be understood in two ways, as a descriptive device and as a generative device (Eisenman, 1998). The machines produced designs different to what architects had designed previously, generating a process description form based on algorithmic calligraphic forces.

The questions still to be answered after completing these experiments are:

- How can these calligraphic forms and surfaces be utilised in real architectural designs, and how can they be handled spatially?
- What kind of design strategy and principles will calligraphy as a continuous surface offer? What kind of spatial possibilities might such a surface create?
- Did these calligraphic machines extend the designer's vision into a spatial design? Will the machines suggest a cognitive inventive process?

8. Conclusion

The author concludes this probationary part of the ongoing design experimentation as its theoretical basis; this preliminary investigation has, perhaps, raised more questions than it has been able to answer. The challenge that has persisted throughout the process is ascertaining how to crystallise this relationship with the abstraction of mathematically generated forms. Nevertheless, this ongoing research is in a position to formulate a contemporary hypothesis about the relationship between Arabic calligraphy and parametric architecture and will be able to develop studies further and provide a better insight into the relationship between the theory and application of the Parametric Calligraphic Machine.

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References

- ALEXANDER, C., 1964. *Notes on the Synthesis of Form*. Cambridge: Harvard University Press.
- ALEXANDER, C., 1966. From A Set of Forces to a Form. In: G. KEPES, ed. *The man-made object*. London: Studio Vista.
- BLAIR, S., 2006. *Islamic Calligraphy*. Edinburgh: Edinburgh University Press.
- DELEUZE, G. and GUATTARI, F., 1988. *A Thousand Plateaus*. Minneapolis, MN: University of Minnesota Press.
- EISENMAN, P., 1998. Diagram: An original Scene of Writing. In: B. VAN BERKEL AND C. BOS, eds. *Any no 23: Diagram Work.23*.
- EVANS, R., 1996. *Translations from Drawing to Building and other Essays*. London: Architectural Association.
- FRAZER, J.H., 1995. *An Evolutionary Architecture*. London: Architectural Association.
- HILLENBRAND, R., 2006. Figural Calligraphy in the Muslim World. In: J. PEACOCK, ed. *Ten Poems from Hafez*. London: Sylph Editions.
- JABI, W., 2013. *Parametric Design for Architecture*. London: Laurence King Publishing Ltd.
- LYNN, G., 1999. *Animate Form*. New York: Princeton Architectural Press.
- MOUSTAPHA, H. AND KRISHNAMURTI, R., 2001. Arabic Calligraphy: A computational Exploration. In: *Mathematics and Design, Third International Conference*. Geelong: Deakin University.
- PHILIPS, E., 2000. *How to get a PhD: a handbook for students and their advisors*. 3rd ed. Buckingham: Open University Press.
- PICON, A., 2000. *From Poetry of Art to Method*. Los Angeles: Getty Research Institute.
- SCHUMACHER, P., 2002. *Graphic Spaces, Aspects of the work of Zaha Hadid* [Online]. Available at: <http://www.patrikschumacher.com/Texts/graphic.htm> [Accessed August 2008].
- TERZIDIS, K., 2003. *Expressive form, a conceptual approach to computational design*. New York: Spon Press.
- THOMPSON, D.W., 1992. *On Growth and Form*. Cambridge: Cambridge University Press.