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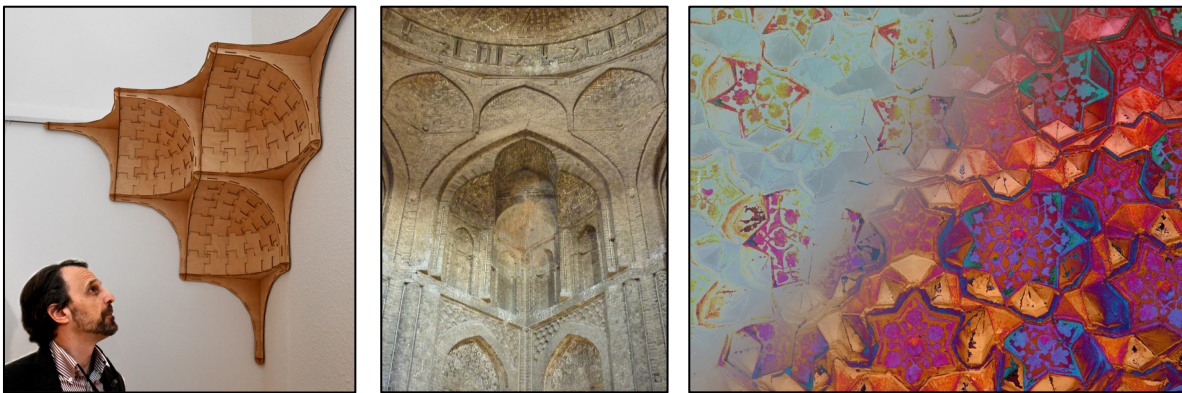
## Algorithmic Aesthetics: Redefining Traditional Islamic Art

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### Abstract

The recent exhibition, “Reverberating Echoes: Contemporary Art Inspired by Traditional Islamic Art,” organized by the Center for the Arts & Religion at the Graduate Theological Union afforded an opportunity for me as curator to reconsider the definition of ‘traditional Islamic art.’ This effort led to the identification of an algorithmic aesthetic of pattern that characterizes artistic production in all media from the 9<sup>th</sup> through the 12<sup>th</sup> centuries in what were then Islamic lands, centered in Baghdad, but extending from Spain across North Africa through the Middle East and Iran to Central Asia and the Indian Subcontinent.

### Reverberating Echoes



**Figure 1** (left) Chris Palmer with Muqarnas, wood, 1998. Photo: Peg Skorpinski/GTU, 2017.

**Figure 2** (middle) Squinch and transition zone in Masjid-i Jomeh, Isfahan, built by Taj al-Mulk in late 11<sup>th</sup> century. Photo: Beverly Willcox <https://beverlywillcox.wordpress.com/category/iran-october-2014/>.

**Figure 3** (right) Mamoun Sakkal, Bokhara Muqarnas, manipulated digital photograph, 2007.

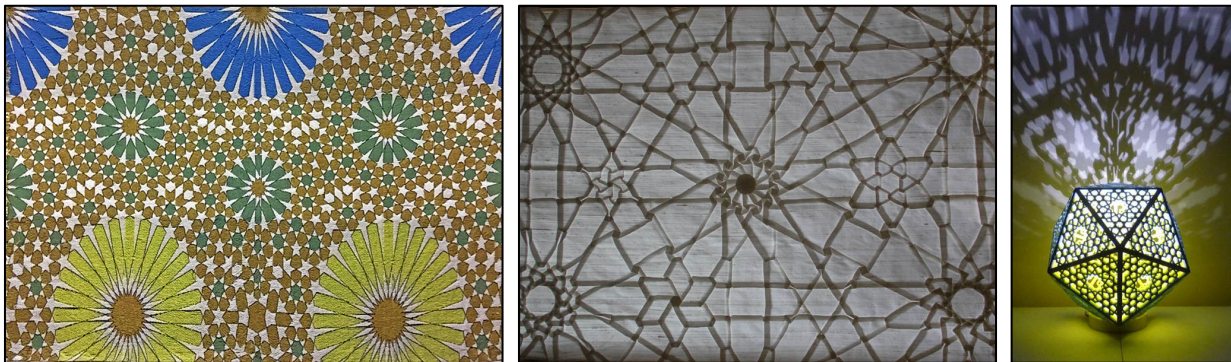
A recent exhibition, “Reverberating Echoes: Contemporary Art Inspired by Traditional Islamic Art,” organized by the Center for the Arts & Religion at the Graduate Theological Union highlighted the work of seven American artists, each of whom is inspired by traditional Islamic art [1]. As curator, it was my responsibility to identify the artists and select from their works. Considering the arc of a narrative I wished to convey, the process afforded me an opportunity to reconsider the definition and raise the question, “What is ‘Traditional Islamic Art?’” [1:21-27].<sup>1</sup> Typically, within the Western academic study of art history, patterns in Islamic art are treated as decorative and ornamental, categorized as non-representational in contrast to figural imagery that is representational. Working with Islamic textiles and Oriental carpets as curator at The Textile Museum for many years, I came to recognize patterns as both technologically significant and as intersections of art and mathematics [2]. And my research as a historian of Islamic art led me to consider such patterns as deeply meaningful within their original cultural contexts

<sup>1</sup> In general, recent studies of Islamic geometric patterns, such as those by P. R. Cromwell in the *Journal of Mathematics and Art* and elsewhere, tend to omit reference to cultural context. It is not the intent of this brief essay to dismiss these studies, but rather to consider more broadly the cultural expressiveness of geometry between the 9<sup>th</sup> and 12<sup>th</sup> centuries. All photographs are courtesy of the artists unless otherwise credited.

and expressive of geometry at a time of intense mathematical inquiry [3, 4]. The curatorial process of selecting works for display in “Reverberating Echoes” led to my identification of an algorithmic aesthetic of pattern that characterizes artistic production in central Islamic lands from the 9<sup>th</sup> through the 12<sup>th</sup> centuries, which served to influence the development of art locally in Baghdad, capital of the Abbasid Empire, and throughout what are today Iraq, Iran, and Syria. But this algorithmic aesthetic also served to influence the arts and architecture of more distant lands under Muslim rule, extending to Fatimid Egypt and across North Africa to Umayyad Spain, and from the Arab Middle East and Iran, to Central Asia, and the Indian Subcontinent [6].

The thirty-five works selected for the exhibition echo historic aesthetic concerns, many of which are expressive of mathematical ideas [1:29-113]. The representation of space in two and three dimensions, through tilings and tessellations, grids and lattices, polygonal networks, and modular repetition of forms are among the topics explored.

Two works in the exhibition illustrate the use of *muqarnas*, an architectural feature that originated in Baghdad in the 11<sup>th</sup> century and spread rapidly throughout the Islamic world (figs. 1-3) [5,18]. A key contribution to the history of architecture, the *muqarnas* is a modular three-dimensional structure that takes many forms; initially it comprised segments of intersecting barrel vaults (fig. 2), which sustained the load of a dome above a square plan [10]. Chris Palmer’s sophisticated minimalist architectural model (fig. 1) uses an ingenious finger panel system that he devised, requiring neither adhesive nor the use of nails [1:54-55]. Constructed of flat pieces that overlap, each curve is achieved by means of a spiraling central three-fold symmetry, converging to four-fold symmetry at each corner; the resulting structure is a symmetrical three-dimensional form that is modular. Mamoun Sakkal’s digital manipulation of a documentary photograph (fig. 3) highlights the stunning visual effects of a complex late example of *muqarnas* in the Madrasa of Abd al-Aziz Khan in Bukhara [1:34-35].



**Figure 4** (left) Nathan Voirol, Star Pattern 7-Fold Symmetry, Jacquard weave, cotton and viscose, 2010.

**Figure 5** (middle) Chris K. Palmer, Shadowfold Zillij Dodecagrams, folded, uncut silk, 2010.

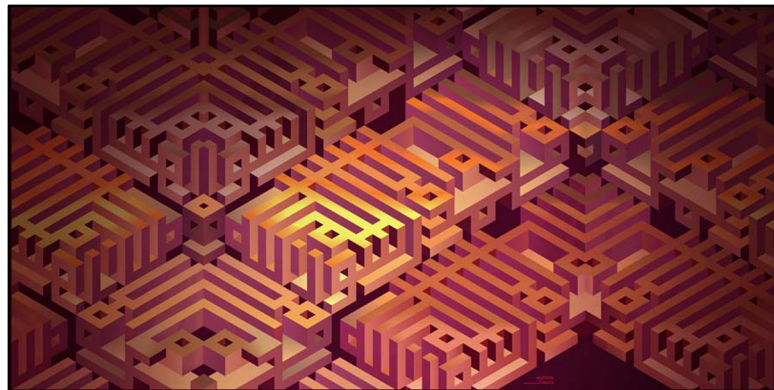
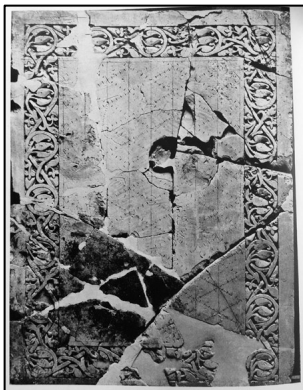
**Figure 6** (right) Phil Webster. Screened Icosahedral Lamp, 3-D printed composite with LED light, 2013.

Patterns related to traditional Islamic tilings and tessellations appear in the works of Nathan Voirol, Chris Palmer, and Phil Webster (figs. 4-6). The examples illustrated demonstrate different approaches to polygonal networks in a variety of media. In Nathan’s Jacquard weave (fig. 4) the pattern of polygons and stars creates a polygonal network that is integral with the interlaced structure of the weaving itself, reflecting the technology of pattern-weaving on an automated loom. The tiling in Chris’s work (fig. 5) is effected through the algorithmic folding of an uncut piece of silk. Phil’s icosahedron addresses other engagements with traditional Islamic art: that of Platonic solids and the use of light as a medium, pertinent to the translation of the classical Greek scientific corpus into Arabic and the experimental studies of optics and visual perception undertaken by Ibn al-Haytham (d. 1040) and Arab interest in Euclid’s *Optics* [8, 17]. The effects of light are also studied in the drawings of Hooman Koliji [9 and 1:65-81]. Chris’s work captures light in the folds of cloth [13]; Phil’s lamp projects light through the 3-D printed screens of each equilateral triangular face of a regular polyhedron of 20 sides [1:57-59].



## Design Algorithms

Design algorithms establish a formal means of repeating a unit; they may work through the use of grids in the plane or on a sphere or polyhedron. In every case, replication is technology-dependent. In both traditional Islamic art and the contemporary works selected for the exhibition, there is considerable experimentation with new technologies in the creation of patterns based on design algorithms. New technologies today include digital media (fig. 8), 3-D printing (fig. 6), laser-cutting, CNC milling, and weaving automated by computer (fig. 4) [1:15-20]. But reverberating echoes from the past are also present in historical technologies that were newly introduced in Islamic lands before the Mongol conquests in the 13<sup>th</sup> century. These include the introduction of paper-making after the Arab conquest of Samarqand in 751 CE, calligraphic reforms that focused on the writing of Arabic in proportional scripts based on geometry of the circle, advances in the chemistry and application of glazes for use in architecture from the 11<sup>th</sup> century on, and experimentation in enlarging the scale of woven patterns [1:16-17]. Weaving on a drawloom facilitated the mechanical repeat of a design, which may also have influenced the production of patterns in other media. The introduction of grid-based patterns may date from this period as well [11, 19]. Exceptionally early evidence for the use of marked-off grids is seen on plaster in an unfinished balustrade panel (fig. 7) from an Umayyad palace dating from the 8<sup>th</sup> century [7]. Bricks served as modules for patterning in the plane, a feature observed on tombs and other monuments in Iran before the Mongol conquests [3, 4]. The setsquare and “perfect compass” referred to in historical Arabic and Persian textual sources may also have had an impact on algorithmic approaches to geometric design [12,15].



**Figure 7** *Khirbet al-Maffjar, Palestine, unfinished plaster panel with marked grid, 8th c. [7:pl.LXI].*

**Figure 8** *Mamoun Sakkal, Steps and Shadows wide 2, digital medium, 2014.*

Mamoun Sakkal works as a graphic designer with a focus on Arabic typography and a strong interest in the history of Islamic calligraphy [1:31-41]. In *Steps and Shadows wide 2*, by means of line and color and the ingenious use of an oblique grid, he has achieved the illusion of three dimensions in a digital medium without reliance upon linear perspective (fig. 8). Diagonal axes intersect to create a rhombic grid in which two lines of Arabic script repeat the Islamic profession of faith, “There is no God but God: Muhammad is His Messenger.” In the central cluster, the name of God is highlighted in yellow. The letters are prismatic in appearance, each line bending at right angles as if on intersecting horizontal and vertical planes. The square Kufic style of writing references calligraphy of fourteenth-century Samarkand, in which glazed ceramic lettering exists on multiple levels. Representing the spatial dimension by means other than linear perspective also has a long history in painting and manuscript illustration in Islamic lands.

If we define a pattern as *the repeat of a unit according to an organizing principle* (such as symmetry, or fractals), the process of repetition is algorithmic. The word, *algorithm*, derives from a Latin corruption of the name of al-Khwarezmi (d. 850), the mathematician working in Baghdad who established the framework for the development of algebra [16]. Halving and doubling, squares and square roots, and

arithmetic operations enhanced by the use of zero and by means of Hindu reckoning introduced to the Islamic world in his time – all of these functions have visual counterparts in the arts. According to Roshdi Rashed, al-Khwarezmi’s successors “undertook a systematic application of arithmetic to algebra, algebra to arithmetic [and] trigonometry, algebra to the Euclidean theory of numbers, algebra to geometry, and geometry to algebra” [14:352], ushering forth an exceptionally fertile period in the history of mathematics that is not yet fully recognized. Design algorithms in architecture and the arts, visually articulate these major advances in mathematical thinking in the Islamic world of the 9<sup>th</sup> through 12<sup>th</sup> centuries, as expressed in Islamic geometric patterns, floral arabesques, pattern-woven textiles, *muqarnas*, and proportional systems of Arabic calligraphy. These algorithmic aesthetics of traditional Islamic art and architecture continue to find visual expression in contemporary art, as exemplified in the exhibition, “Reverberating Echoes,” described above, highlighting the works of participating artists Chris Palmer, Nathan Voirol, Phil Webster, Hooman Koliji, and Mamoun Sakkal, as well as figural works by Nazanin Hedayat Munroe and Manzar Rassouli.

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