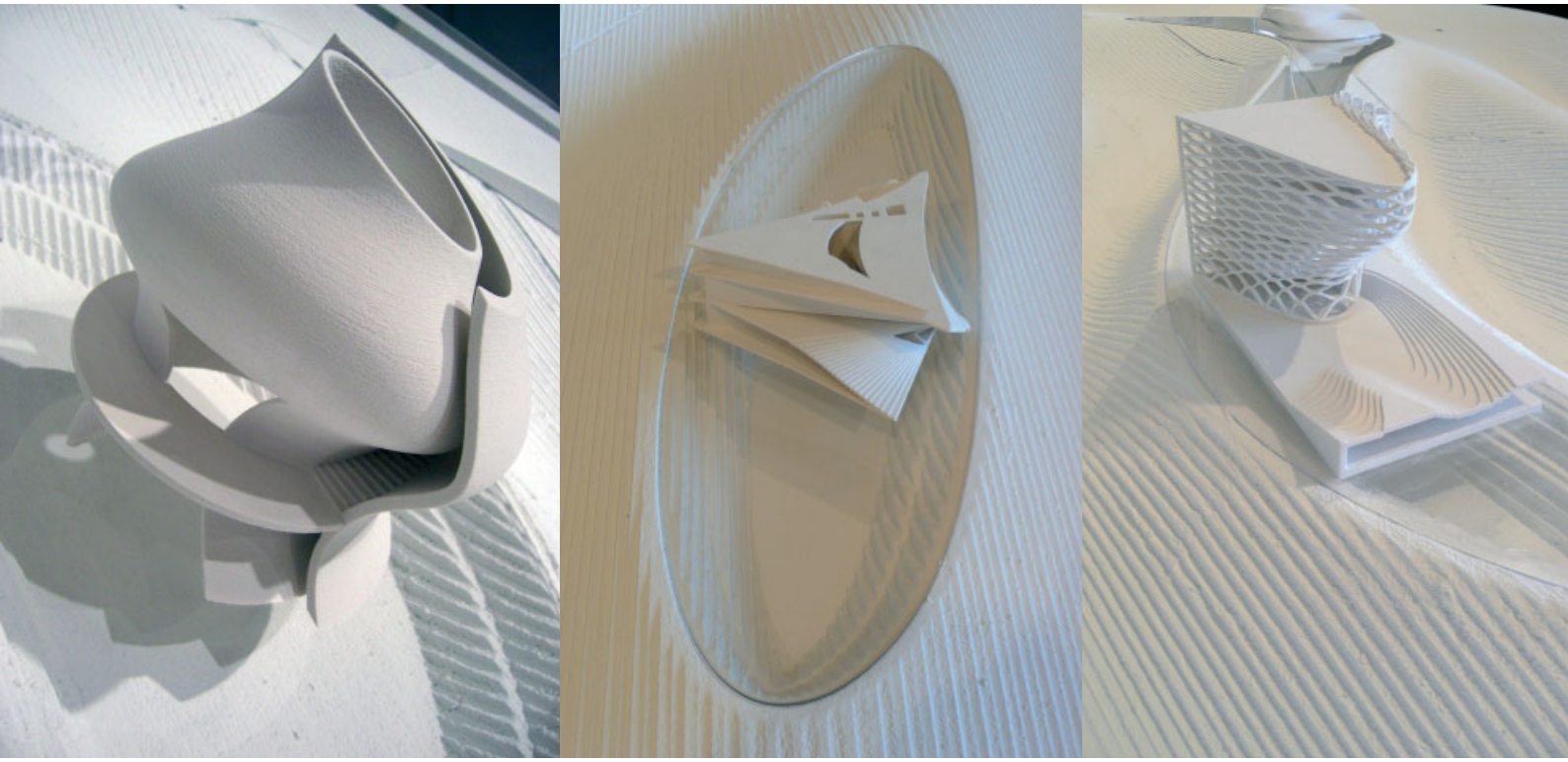
Baroque Parameters

Andrew Saunders describes how students on Rensselaer School of Architecture's Rome programme were encouraged to explore the geometry and mathematics that underlie the architecture of the Baroque through parametric design.

Re-Interpreting the Baroque, Rensselaer School of Architecture Rome Program (studio coordinators Andrew Saunders and Cinzia Abbate in collaboration with Jess Maertterer), Rome, 2007
Sinusoidal landscape designed by Andrew Saunders and fabricated by Rensselaer students Michael Visovsky, Erica Voss, Andrew Chardain, Michelle Schrank, David Holbrook, Chelsea Anderson and Patty Clayton.



Rapid prototype model of a parametric variation of Baroque geometry by (from left to right) Rensselaer students Andrew Diehl and Jenna Lettenberger, Stephanie Mendelson and Morgan Wahl, and Andy Zheng and Christine Eromenok.

> *Though few modern scholars make use of the fact, or even seem to realize it, Baroque architecture was above all mathematical.*
>
> – George L Hersey, *Architecture and Geometry in the Age of the Baroque*, 2001, p 4.[1]

Scripting: The Return of Mathematical Intuition

One of the most promising aspects of parametric design is that it promotes a distinct and disciplined bottom-up process of modelling geometry. A scripting-based approach to parametric modelling utilises features of programming within a native modelling environment. Geometry can then be generated by flow control (skipping and repeating lines) and variable control (logical and mathematical operations – data storage).[2] The ability to model with mathematical operations allows unprecedented accessibility to the generative possibilities and comprehension of equation-based geometry.

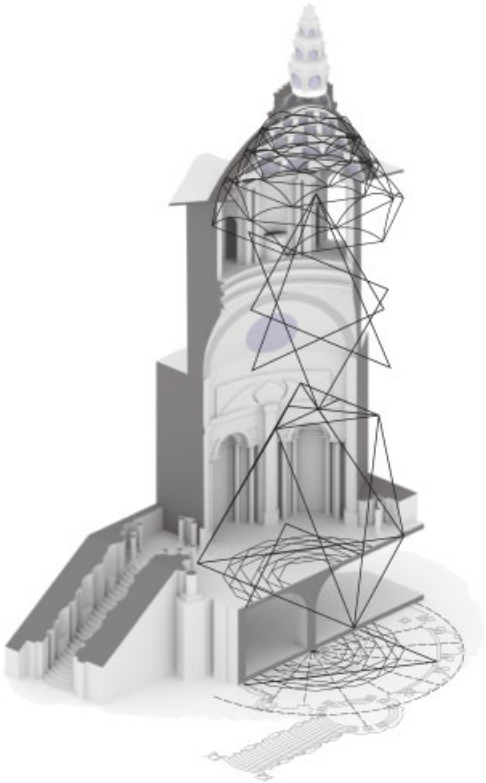
An Instrument for Analysis

The Rensselaer School of Architecture Rome Program studio entitled 'Re-Interpreting the Baroque' (2007) explored scripting as an instrument for analysing how geometry operates in Baroque architecture. Geometry and mathematics were integral to 17th-century science, philosophy, art, architecture and religion. They are what link Baroque architects Francesco Borromini and Guarino Guarini to other great thinkers of the period including Descartes, Galileo, Kepler, Desargues and Newton.[3] Plasticity and dynamism are explicit signatures of Baroque architecture; less obvious are the disciplined mathematical principles that generate these effects.

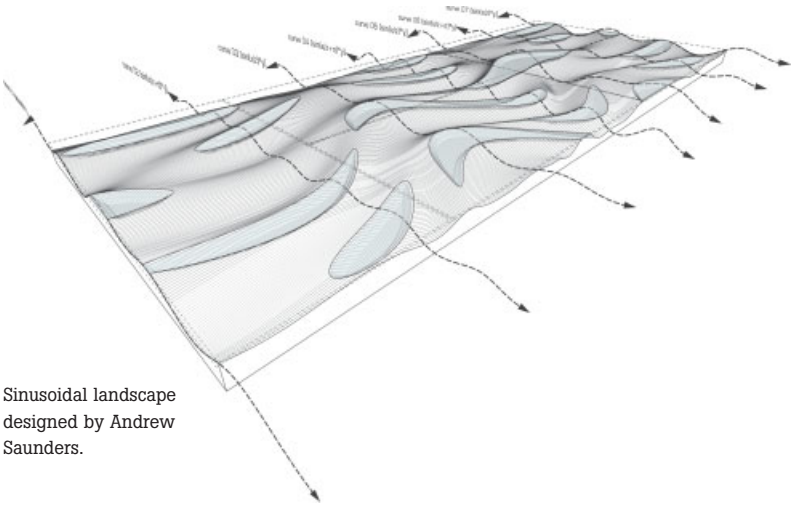
Trigonometry Through the Arc and the Chord

Borromini is often portrayed with traditional drawing tools of the 17th century: the compass to draw an arc, and the ruler to draw a straight line or chord. In order to construct a square, architects of his time would first compose a governing circle and segment it with chords to constitute the four sides.[4] Geometry derived from this process is related by its association with a governing circle. As a result, triangles, circles or any equal-sided polygons can be understood as parametric variations of each other. To script these relationships, trigonometric functions are used to plot geometry by polar coordinates.[5] Trigonometry originated from chords (Ptolemy's Table of Chords was the most famous trigonometric table), and calculations used for these chord lengths are equivalent to the modern sine function.[6] Through the exploitation of these ingrained trigonometric parameters, Baroque architects produced astonishing effects, performance and continuity.

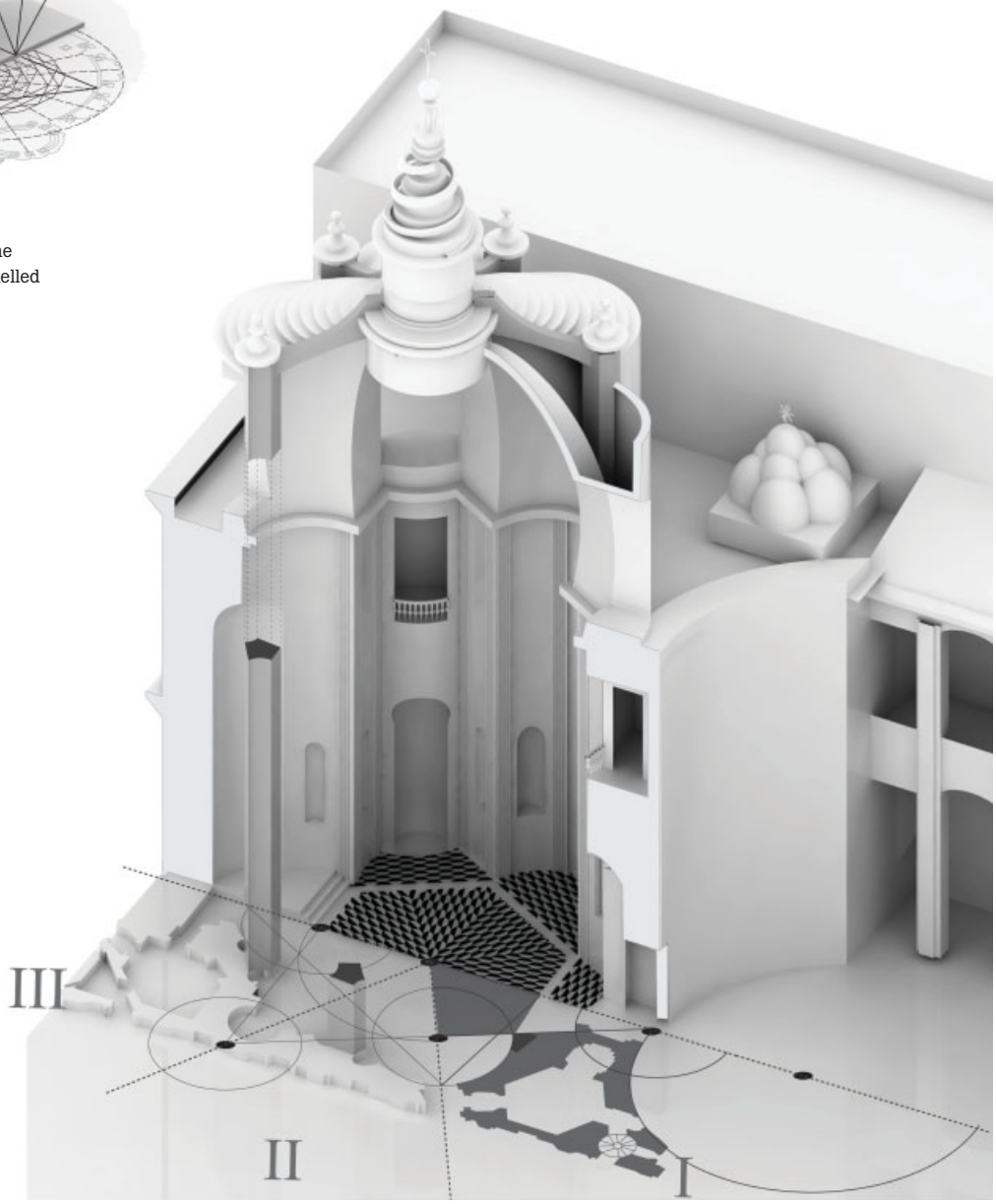
In his Sant'Ivo alla Sapienza church in Rome (1642–60), Borromini capitalises on the verticality by transitioning parametrically from the most basic of polygons (two overlapping triangles) at the base of the chapel to the infinite-sided polygon – the perfect circle crowning the cupola. One can trace the movement downwards from the chastity of



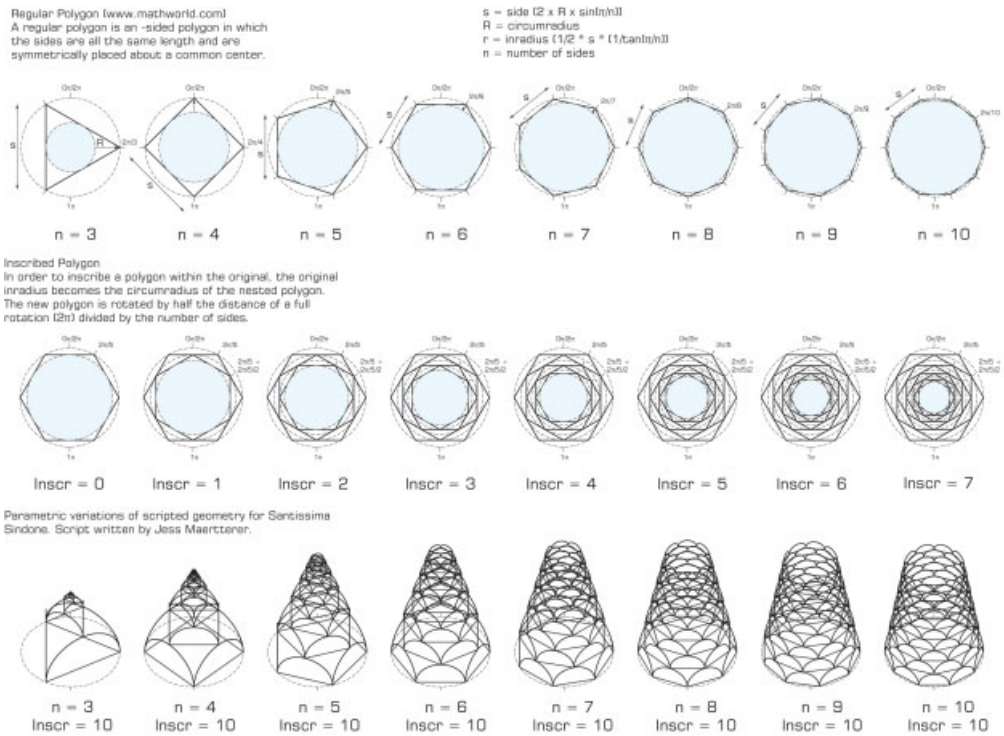
Sectional model and geometric analysis of the Santissima Sindone by Guarino Guarini, modelled by Rensselaer student Brian Spangler.



Sinusoidal landscape designed by Andrew Saunders.



Sectional model and geometric analysis of the Sant' Ivo by Francesco Borromini, modelled by Rensselaer students David Holbrook and Rachele Louis.



Polar-coordinate regular polygon geometry diagrams by Andrew Saunders and Jess Maertterer.

forms in the heavenly zone to the increasing complexity of the earthly zone.[7] This continuous morphology from crude to smooth in turn initiates a novel structural performance. Because it cannot be reduced to a static element, the cupola of Sant' Ivo avoids technical classification as a dome and is its own unique structure.[8]

In the Santissima Sindone chapel in Turin, Guarini uses a similar strategy to progress from a triangular base geometry, and culminates in a kaleidoscope of hexagons. The staggering hexagons on the interior create an effect of perceptual psychology, fostering an illusion of extreme depth through telescoping vertical space.[9] The porosity of the nested geometry results in a relatively lightweight structural solution of an openwork dome and allows for maximum light to penetrate the chasm below. A parametric model reveals that Guarini integrates both structural performance and spatial effect through equation-based scalar and rotational operations.

Re-Interpreting the Baroque

The geometry of Baroque architecture gains a renewed relevance when understood parametrically. By merging the capabilities of programming within the digital modelling environment, scripting, unlike traditional two-dimensional or static projected analyses, reveals the flexible and generative aspects of the equation-based geometry of the Baroque. More importantly, it exposes how these geometric principles were intuitively deployed in order to integrate a wide range of effects and performance. Δ+

The analysis of Baroque geometry was the starting point for the 2007 Rensselaer School of Architecture Rome Program that took as its premise 'Re-Interpreting the Baroque'. The studio went on to problematise the original parametric principles of the 17th century with contemporary design parameters of performance and effect in the design of a Counter Reformation Art and Architecture Museum located in the historic centre of Rome. Research from the 'Re-Interpreting the Baroque' studio was exhibited at the Italian Cultural Institute in New York City from 1 to 9 October 2008.

Andrew Saunders is an assistant professor of architecture at Rensselaer Polytechnic Institute in New York. He received his Masters in Architecture from the Harvard Graduate School of Design. He has significant professional experience as a lead project designer for Eisenman Architects, Leeser Architecture and Preston Scott Cohen, Inc, and has taught and guest-lectured at a variety of institutions including Cooper Union and the Cranbrook Academy of Art. He is currently working on a book on the use of parametric modelling as an analysis tool for 17th-century Italian Baroque architecture (see www.rpi.edu/~saunda2/ICIRPI/).

Notes

1. George L Hersey, *Architecture and Geometry in the Age of the Baroque*, University of Chicago Press, (Chicago, IL), 2001, p 4.
2. David Rutten, *Rhinoscript101*, Robert McNeel & Associates, 2007, p 4. See http://en.wiki.mcneel.com/default.aspx/McNeel/RhinoScript101
3. John Beldon Scott, *Architecture for the Shroud: Relic and Ritual in Turin*, University of Chicago Press (Chicago, IL), 2003, p 157.
4. Antonino Saggio, 'Give me a cord and I will Build … Construction, Ethics, Geometry and Information Technology', in Maria Voyatzaki (ed), *AAVV: (Re)searching and Redefining the Content and Methods of Construction Teaching in the New Digital Era*, Eaae-Enhsa (Athens), 2005, pp 13–34.
5. Jess Maertterer, *Script to Create Nested Regular Polygons*, Rhino 3DE Online Education, 2007. http://www.rhino3.de/educate/
6. Morris Kline, *Mathematical Thought from Ancient to Modern Times*, Oxford University Press (New York), 1972, pp 119–20.
7. Rudolf Wittkower, *Art and Architecture in Italy 1600 to 1750*, Penguin Books (Baltimore, MD), 1958, p 138.
8. Federico Bellini, *Le cupole di Borromini. La 'scientia' costruttiva in età barocca*, Documenti di Architettura (Milan), 2004.
9. HA Meek, *Guarino Guarini and His Architecture*, Yale University Press (New Haven, CT), 1988, p 75.