The Art of Contemporary Tracery

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At the beginning of the 21st century, following the death of the 'single surface' project in digital design, a sudden interest in tectonic discretization and componentry emerged. To some degree this development can be attributed to the first generation of digital designers beginning to tire of virtual continuity in the form of endless blank surfaces, moving toward fine-grained surface articulation driven by material limits and available production methods. Since then, a huge amount of work has been undertaken in this area, with issues ranging from buildability and cost-effectiveness, to the aesthetic implications of CNC tooling, to the use of parametrics to generate variable panelization across surfaces. Parametric discretization, in particular, has taken the discipline by storm, with its seductive implications of being an art form conveniently couched in an economic model- a perfect match of beauty and optimization. The problem is, parametric work tends to be immediately identifiable and therefore consumable. It is identifiable through its indexicality to the algorithms that drive it as much as to the industrial methods of production that underwrite it.

More compelling, perhaps, is the competing sensibility of a new generation of architects focused on surface features which exceed such limitations towards the transformative and the mysterious. This sensibility avoids the aesthetic and conceptual limitations of linear parametric gradients, recognizing that surface discretization as it relates to the expression of material limits is expedient but ultimately passé. A perfect example is the recent advent of 'meta-seaming', or the articulation of seams as ornament, driven by affect, rather than as a one-dimensional index of the beginnings and ends of pieces of material. Meta-seaming puts form and material into a more complex relation; once a joint or seam is released from indexicality, it is free to obfuscate or enhance formal, ornamental, or even infrastructural features within surfaces. Meta-seaming logic can begin to break down the lock-step of seams and sub-structure into articulations in surfaces which can begin to do unexpected kinds of work in unexpected patterns. Meta-seams, like tribal tattoos, can shift between emphasizing underlying bone structure or musculature and expressing completely independent painterly effects.1

The meta-seam is a subset of what might be called the art of contemporary tracery. Tracery refers to the moment when a surface transforms into line, expressed as a negative seam, a slight protrusion, or deep relief, but also when lines pull off of surfaces entirely to become spatial armatures. It also invokes the issue of the trace, or vestige, which is when a pathway is just barely discernable from a smooth field, in a state of either appearing or disappearing, tensing or relaxing. The architecturalized trace is however not a map or diagram, nor is it symbolic; it is an exquisite form of becoming, of surfaces oscillating between dimensions. The sensibility of tracery is deeply embedded in the discipline, appearing in the transformation of the three-dimensional Classical column into the two-and-a-half dimensional pilaster, or as Gothic bundled columns spreading out into vault relief and window tracery, or as organic Art Nouveau surface relief flattening out into graphics in one area only to tense back up dimensionally in another.

Contemporary tracery can be lacy, branchy, cellular, or hybrid-- a repertoire recently expanded through developments in generative computation. But more importantly, it must fade in and fade out of flatness and avoid indexicality. This is what distinguishes tracery from the structural expressionist ribs and lamella systems of Nervi as well as from Mies van der Rohe's decorative yet standardized mullions. Tracery doesn't languish under the need to express singular performative diagrams. Nevertheless, while it operates at the level of form and affect, this does not exclude it taking on other kinds of instrumentality. In fact, the cross-categorality of line and surface, depth and flatness, is most productive when it imbues aesthetic formations with other types of performance. The pleat, or becoming line of a surface, creates a bridge between technological and ornamental territories. The double-pleat, in addition to creating beam-like stiffness in surfaces, provides hollow poché spaces within which air, fluid, and light can flow. Adding performative dimensions to tracery is not an alibi, however. It is a way of increasing effects of ambiguity and delight by activating multiple ontological frameworks. Tracery is therefore at odds with Venturi and Scott Brown's concept of the "decorated shed", where ornament operates independently from all other architectural and tectonic concerns.

Composite Materials, Hybrid Systems, and Goblin Hands

The re-emergence of tracery within architecture is no doubt supported by developments in composite materials and hybrid systems. These include fiber-resin composites, impregnated membranes, glass fiber reinforced concrete, and other such super-plastic materials. Composite materials not only allow for smooth formal transitions between surface and line, but increase in capacity through such blending. Fiber-composite monocoque construction in automotive, naval, and aerospace applications is entirely dependent on patterns of pleats, warps, and bas-relief in surfaces for structural performance, thus forcing a feedback loop of visual and structural concerns. Fiber-composites are driven by intensive materiality in the sense that they are themselves organized by micro-tracery of fibers laid out according to force pathways as well as local build-ups of matrix and fiber. In terms of assembly, traditional hardware and substructure gets thrown out the window in favor of seamless connections using structural adhesive and hidden lap joints. This means, ironically, that construction seams, made visible or invisible, are more likely to run against the grain of tracery patterns to maintain structural continuity.

Hybrid systems such as 'beam-branes' and 'beam-shells' are also tied to the language of contemporary tracery. These two systems hybridize shell or membrane surfaces with variable veining, allowing for wider application in asymmetrical or unbalanced conditions. Patchy, veiny patterns embedded in the surface can resist anomalous bending forces occurring in irregular membrane and shell morphologies. According to force analyses as well as aesthetic criteria, these patches can vary in depth or even pull-off and reconnect with other patches forming strange transitions between brambled vector-active systems and smooth surface-active systems. Another species of beam-brane is the 'boom-brane', recently developed by my office. Boom-branes allow for the construction of huge bubble structures via networks of air-pressurized, double-pleated tracery. This type of tracery, which can also be stiffened in-situ using pre-preg technology, has the amazing characteristic of not spanning, per se, between supports. It inhabits the interior of the surface, rigidizing its peaks, valleys, or transitional moments, then fading back into flatness before reaching its perimeter. This engenders a radically different pattern and density of articulation in transparent surfaces compared to that forced by the heavy glazing and mullion systems of the last century. The leap is as game-

changing as that between plate glass and iron frame construction in the mid-19th century and annealed glass curtain walls in the early 20th century.

Fuelling the desire for these kinds of technological leaps are new design techniques that allow for unprecedented control of geometry and formal transitions. Indeed, without the simultaneous evolution of digital design tools, offering advanced ways of modeling the in-between of line and surface, the art of tracery might have remained a lost craft. Subdivision surface modeling in particular has made it possible for architects to manipulate surface in ways not possible even five years ago. Invented by the entertainment industry in response to the problem of efficiently modeling goblin hands, subdivision surfaces are driven by the mathematics of non-uniform meshes, where areas of extreme articulation and areas of repose can inhabit a single surface patch. You certainly can't model fingers, veins, and wrinkles with NURBS lofting- the U and V logic will always end up producing things with indexical directionality, and local articulations will always fade off too uniformly.

Still, neither technique nor technology can explain the seductiveness of tracery. Tracery resonates along a disciplinary thread stretching back hundreds of years. This thread is characterized by a loose, fluctuating relationship between building technology, formal features, and painterly composition, synthesized in a wild array of experiments.

The Excess of Vault Ribs and Pilasters

Over the last two centuries, there has been a lively and revealing discussion as to the relation between what is ornamental and what carries loads in Gothic cathedrals. The debate began in earnest with Viollet-le-Duc's assertion in the mid 19th century that vault ribs were not only structurally active but that the surface of the vault was merely infill and structurally passive. This view was attacked in the 1934 by Pol Abraham, who was convinced that the opposite was the case: that vaults were shell-active and that vault ribs were ornamental. It was a zero-sum duel of rationalist thinking. Not until the early 1970's was the debate at least provisionally settled by Jacques Heyman, who did finite element analysis on digital models of existing cathedrals. He found that shell and ribs exhibit differential, composite behavior, and it became suddenly clear that the terms of the debate had been flawed all along.2 The flaw was the belief that vault-ribs could be categorized at all, and more importantly, that the art of illusion was not as important as the truth of engineering. It is actually quite charming and ironic that it took an engineer to usher the discussion back to architecture.

The 'function' of the classical pilaster has similarly been the subject of much study and debate, although not in such techno-rationalist terms. The first pilasters were of course actual columns- called engaged columns- embedded in non-structural infill walls. The Roman temple Maison Carrée (Nîmes,16 B.C.) has no pilasters per se, although the visual effect is that columns-in-space begin to merge with the surface of the infill wall towards the rear of the building. Later Roman architecture began to dissolve engaged columns into bearing walls, and the pilaster was born as architectural excess. Despite Wittkower's description of the pilaster as a "flattened column which has lost its three dimensional and tactile value"3, it seems unproductive to frame the discussion in terms of lack, even when thinking of Alberti, who pushed the pilaster so close to the surface of the wall that it almost ceased to exist. The pilaster, seen instead through Deleuze, is a becoming-column of a wall, a virtual spatiality emanating from flatness. This virtual phase-changing becomes all the more complex when the verticality of the pilaster and its link to gravity begins to dissolve in the Late Baroque period; in this case, pilasters become more and more broken down and overgrown through figuration

and color effects alien to the classical orders. The mega-tracery of the pilaster is transformed into an atmospheric field of micro-traceries.

What the histories of the vault rib and the pilaster reveal is an evolutionary tendency toward exquisite excess rather than minima, despite their structurally instrumental beginnings. In the vault rib versus the vault surface, the excess is in the structural redundancy of the two systems combined through a unifying surface-to-line ornamental sensibility. In the pilaster, it is the cultural tendency to consume structural solutions and embed them in a painterly realm that is excessive. In both cases, it is the migration of behaviors between features, and the tendency of features to therefore become excess, that is key to their architectural affect. Mysteriously, the same phenomenon is everywhere to be found in nature, where such migrations generate endless weirdness and complexity.

Co-option and Biological Excess

Despite incessant arguments to the contrary- that species and ecologies are pure expressions of purpose- the reality of biological formations is far more messy. While it is true that species and ecosystems do work, they often do it in a non-optimal way. Features are built up over time through leaps of random mutation as much as refinement, creating inherent redundancies and excesses. This is what happens when you never begin with a tabula rasa, as nature never does. The hammerhead shark, for example, does exceptionally well as a species considering the massive disadvantages of the hammer-mutation, related to vision and hunting, and only minor advantages, related to increased surface area for electro-receptors. The hammer is not, contrary to popular belief, a navigational diving-plane driven by optimization. And this is not an exceptional case. Indeed excess pervades every level of the biosphere and is a primary driver of the biodiversity so intrigues us.

The phenomenon of co-option reveals how the de-linking of features and behaviors can produce astounding effects as well as do unexpected work. Co-option refers to the fact that behaviors tend to migrate between features over time: a classic example is that although bird feathers originally evolved for insulation, they were co-opted for flight. An even richer example is found in the keel-billed toucan of the Amazon rainforest. The male toucan has a gigantic colorful beak which was always assumed to be the singular result of sexual selection pressures. Recently it was discovered however, that although the beak was originally adapted as sexual ornament, it has since been co-opted as a vascular, controllable thermo-regulator for the bird.4 The beak's exquisite formal and color features do not index its ability to collect and exhaust heat, but they are nonetheless critical for the character of the bird.

Muddled together, feature upon feature, mutation upon mutation, species develop complexity, not despite, but because of excess. Contemporary tracery, in the same way, is a productive muddling of line and surface, technology and ornament. Combined with ambiguous materials and unnatural color and lighting effects, the architecture of contemporary tracery engages through its indeterminacy and irreducibility.

1 D. Leatherbarrow, M. Mostafavi. Surface Architecture. MIT Press, Cambridge: 2005.
2 K. D. Alexander, R. Mark and J. F. Abel. The Structural Behavior of Medieval Ribbed Vaulting. Society of Architectural Historians: 1977.
3 Wittkower, Rudolf. Architectural Principles in the Age of Humanism. WW Norton & Co., New York: 1962.
4 G. Tattersall, D. Andrade, A. Abe. Heat Exchange from the Toucan Bill Reveals a Controllable Vascular Thermal Radiator. *Science*, July 24, 2009.