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NATURAL STRUCTURES

NATURAL STRUCTURES - Towards an integrated computational architectural design model.

David Serero

From the production of non-standard mass produced objects to the digital simulation of draperies, Serero Architects and research team explored several strategies integrating digital design technique into conceptual and formal architecture research. We would like to present in this text a series of architectural concepts that emerged in our recent work including "weaving", "iterative process" and "evolving pattern". They lead us to envision the possibility of an alternative architectural design process integrating, in a new way, design and computation. We present here projects that showcase the potential of such a process in the architectural field.

Digital generative processes have changed the idea of **pattern** whether structural, functional, social and ornamental towards a more flexible concept. In living organisms, pattern itself and its aggregation model can evolve and be transformed as the system expands and replicates. **Evolving patterns** may generate variation within systems such as mass-production, emphasizing differentiation rather than repetition. Patterns have been a recurrent notion in our work and were used to redefine spatial notions such as the **definition of limit - visual or territorial, the idea of materiality**, and **the relationship between architectural envelope and tectonics**. Patterns are not only emerging from the mere repetition of a unit. One can identify patterns, when differences occur in the repetition process of any given system. For example, the presence of t**he pattern is evident in the city, because the city has a scale where we can identify seriality, reproduction, repetition or sameness much better**. **Evolving patterns** are based on their ability to respond to a dynamic environment. These patterns constantly mutate towards a better adaptation to the environment.

Historically patterns have been linked to ornamental forms and have evolved towards codification system and support of analysis (pattern recognition). Islamic architecture, often inspired by the logic of the textile, operates **a blurring of the ornamental and structural patterns with a unique intensity**. The Middle East brickworks of the 10th century are fascinating as **they integrate construction technique and ornamental forms**. T**he most striking formal kinship between Islamic ornamentation and textile lies in the logic of the interlace**. Like the thread, which weaves over and under each other and form a fabric, the lines of Islamic ornamentation whether vegetal, organic or geometric **make use of an over-under dynamic to guarantee the cohesion of the ornamental surface**. The interlace has been a strong figure of this architecture, and beyond the ornamental motif has been used as an organizational and spatial concept of palaces.

One of the first fabrication devices, which introduced the idea of variation in the fabrication process, was **the weaving machine**. At the beginning of the XIXth century, Joseph Marie Jacquard invented an automatic weaving machine, which woven patterns could be controlled by perforated cards during the fabrication process. **This new technique of fabrication integrated the notion of pattern variation within the fabrication process.**

Anthropological studies meets the theory of the German architect *Godfried Semper*, showing the way ancient cultures developed **very sophisticated techniques of weaving while they did not have developed writing knowledge**. Semper defined the knot and the textile as a key original element of architecture like the soft woven mat of roof instead of the stone tectonic of the Greek temples. "Weaving" is not a formal or visual concept but rather an operative technique allowing fabrication of complex geometries. **Because of its very binary nature it is conducive to be directed converted into digital fabrication methods.**

The mathematician *Steven Wolfram* applied several types of very simple Cellular Automata like models to generate patterns, which complexity and beauty approach the one of the natural world. B**ased on very simple and reduced number of rules, this research proves that computer generated patterns, after a high number of iterations, would approach organic form**. For Wolfram, **the difference between systematic and organic is maybe only a number of iterations.** For example the generative process of snowflakes can be simulated by the iteration of a systematic mathematical rule, which produce visual patterns by . This technique could be used for other models like fluid movement, or biological processes like pigmentation. **A set of very simple rules creates complex and even chaotic organizations, which internal logic is not visually perceivable**.

These different analyses have triggered our interest in a **new understanding of patterns, not as a mere tiling of the surface but rather as a strategy to articulate the different temporal and spatial dimension of architecture.** We aim to develop structures, which **have a universal or prototypical quality that can be unfolded in different environments specifically. Architecture is therefore a response to multiple patterns from social to contextual patterns, from structural to ornamental patterns.**

Our architecture projects are not systematic design processes; but they converge toward the possibility of using a computational based design model. The development of this model would allow **a higher degree of variation and differentiation in architecture.** This new design model should use variation; repetition and proliferation, without reducing architecture to a generative process or a mathematical variation of ideal types. **Without the component of differentiation, digital design processes are reductionist, closed and incapable of discovering new innovative paths of development.**
How could one create systems, which think as they perform, and can evaluate their relevance at each step of the design process?
Can digital technologies enable us to produce architectural environments as prototypes, responding specifically to local conditions?

In this respect, one can outline 3 principles for an architectural computational design model:
1 - The computational design model is **a self-generative device:** the rules of its expansion are automatically iterated from an initial set of conditions.
2 - **At any time of this iteration process, the model is opened to the input of new parameters**. This introduces a cybernetic relationship between the designer and the computation model. In other words, it combines a generative process, where the designer interacts with the system and reshapes the codes to better adjust it to each condition. The concept of iteration allows at any step of the design process to get a large number of variations and consequences of this decision.

3 - **The generation logic has to be based on a concrete organization of matte**r (matter in a broad sense). Matter not only as materiality but also at the other vectors of architecture: circulations, light, and functions.

The following projects from our current research illustrate ideas and design strategies and converge towards an integrated computational design model.

METARING - Mathematics of the soul

Metaring, a collection of ring commissioned by a German jeweler, allowed us to develop a great consistency and continuity between digital design and robotic fabrication techniques.

The rings, designed using "nurbs" based geometry, follow a set of very simple geometric rules of transformation based on the relative position of 3 circles in space and the sectional transformation of the ring profile. The Metaring collection is generated using a mathematical algorithm that digitally inflects the shape of a three dimensional torus. **The result is an unpredictable and endless sequence of transformations, a geometric modulation of metal knots in space.** Each instant of this sequence produces an object, which can be fabricated as a unique item by the use of a stereolithographic process where layer-by-layer, a laser beam sweeps the profile of the ring and solidifies a gel. This design is not conceived as an object shaped in space but rather as **a reactive structure informed by time-space related parameters.** There are no more prototypes to test the product behavior, but a **metatype, belonging to the system, which cannot be represented as a concrete instance**. **Each singular object actualizes the potential of the process and carries the traces of the precedent instants.**

The increasing availability of rapid prototyping technology transforms the traditional production system into an interactive chain. As a business model, we imagine that the global communication network, would allow a better integration of consumer behavior and design trends by a quasi real time transformation of the Metaring model.

ATHENA - Drapery of ancient greek structure for ephemeral structure design

Our winning entry for the International Competition for Athens Olympic Games landmark tower design took, as a point of origin, the study of draperies of ancient Greek sculptures and in particular the representation of the Goddess Athena and the relationship between body and cloth. If her dress seems to contain and mold her body, in many representations one could say that it is, on the contrary, the body that is structured by the fabric as a kind of a crumpled body. The movement of the woven fabric denies its autonomy. The clothing is no more what is wrapped around but rather what gives form to the body through its own transformations. In opposition to doubling or molding a limit, Athena's dress contradicts the permanence of its circumscription. The complex movement of the fabric structures the ephemeral state of the body.

The continuous transformation of the drapery is operative in our project neither as a metaphor nor as a model to be reinterpreted, but as an effective force in the design process. It can be perceived as a process itself since the essence of the drapery is only to

fix momentarily an occurrence. **In this sense it is both formless and contains a multiplicity of forms.**

The landmark towers are shaped with 3 surfaces, which twist together around the steel frame.. The fabrication process for this surface is a combination of pre-engineered steel frame with free-formed shape by a computer numerically controlled wire foam cutter. In each of the 30 towers to be erected, the foam patterns will have different relationship with the steel frame. In the logic of the body/fabric relationship, the foam surface dresses the frame in different way in each of the towers.

ART ARENA - Art film Museum organized by time

Commissioned by a British Art collector, this museum presents an important collection of films about art, ranging from Classical to Contemporary art forms. The project addresses two main challenges : The first one is to combine 45 projection rooms playing simultaneously in an open space, where visitors would freely move from one room to the other without lighting or audio perturbances. Programmatically, the typology of the multiplex movie-theater blends with the typology of the museum. The second is to develop circulation patterns that must be integrated with the movies schedule, which includes movie duration ranging from a few minutes to two hours. Therefore the museum spaces are organized by time-based parameters.

The layout of the museum is designed in relation to time zones controlled by the schedule of film projections. This allows **to generate flexible visit patterns of the museum and to reach a synchronization of architectural sequence with the experience of time-based artworks**. In plan, 2 to 6 theaters are combined together creating clusters. There are adjusted and rotated to allow the alignment of the structure above and to facilitate the circulation from one cluster to another. In the interior spaces, the profile of the screen is an inverted profile of the seating area creating a continuous movement between them. **New audio set technology and video projection systems have been utilized to free the museum spaces from the conventional acoustical limitation of projection room and to remove the spatial enclosure of the traditional film theater**. By using wireless headsets triggered by proximity sensors the visitor can only hears the sound of the movie he is watching without any interference. The projection spaces can therefore blend one into another along the continuous wall and ceiling surface.

The roof, at the street level is at the same time a portal and a public ground extending the museum activities to the city with open-air theaters for special events and night projections. The existing ground of the site will be carved out to accommodate the volume of the theaters.

GLASS MILLE-FEUILLE - A media Library in Carnoux, France

The French Ministry of Culture invited SERERO Architects to propose ideas for a new type of library called "Mediatheque of proximity", to accommodate a collection of books, CDroms and DVDs for a series of isolated cities of French territory.

Instead of celebrating the possible forthcoming disappearance of the book, our project **blends in a same space traditional ways of storing books on shelf with the glass block technology of digital media storing**. **Digital information such à texts, films and musics are stored in glass shelves through subsurface laser engraving.** The walls of the building are conceived both as the storage space for books and digital media, **in a stacking of glass and stone blocks**, which defines an uncertain boundary between interior spaces and the landscape outside. The glass shelves for the digital media support and the stone shelves for the books are stacked along the walls, creating a pattern that is defined by the content of the library.

The 1500 linear meters of storage of books and information support have been compressed inside of the medialibrary and, by a process of folding and splitting, generate the reading, working, listening and reception spaces. This strip defines zones of interaction containing books, CDroms, DVDs and electronic devices to interact with them and offers a great flexibility of the interior spaces. **The stacking of stone and glass blocks of the load-bearing wall extends to the inside of the space to become shelves and support and integrates the tectonic dimension to the ornamental.** The transparency of the walls-support of the library constantly varies depending on the type and amount of information that it contains and **frame as well as blurs the limit of the interior spaces with the landscape.**

GHOST TRACK - Blendind digital modelling technique with traditional manual weaving

Our installation for the VIII Venice Biennial focused on designing an envelope, which creates its own environment as much as it is adaptable to local context. We worked on the weaving technique, which attracted us because of its complex fabrication process and as it is difficult to be codified. Nevertheless it represents one the oldest ways to create objects or space with surfaces and **its technique blends structural with ornamental patterns.**

Beyond computer numerically command fabrication, our attempt in this project was to **integrate digital modeling with artisanal weaving technique**. It is easier to create a digital model of verbal knowledge (like teaching a machine to play chess, for example) than to **model a "savoir-faire" or making, a technique of manual elaboration that implies irregularity, hesitation, trial and error, internal logics of compensation, in an attempt to keep the surface as a whole together**.
The technique of braiding evokes this kind of complexity where the hands interact with the form in each of the knots. It points to the power and product of a *trans-formative intelligence,* which is a mental and material process shared by any kind of technique.

The art of braiding, knotting, twisting and curling motifs, the oscillation of the thread around the fabric generate an **incessant inversed and reversed figure** as they are dreams of spaces without seams, w**here the weave looses in its density of the surface the linearity of its contour**. Like a carpet covered with ornamental patterns, the woven surface uses a simple movement, which repetition and recurrence proceed by gradual complication in time and in space. **The woven surface tends towards the loss of its figure, an internal pulsation of the surface, which is both graphic and structural, and blurs the legibility of its surface.**

As we know, the principle of the textile essence of architecture, as stated by Semper in **"Prinzip der Bekleidung"**, **addresses the shell and its texture as primordial, preceding the structure.** Architecture begins with and in ornament, or rather, in the woven mat; not with its capacity to provide shelter or put up an enclosure, but with its actual fibrous quality. The interior is not defined by a continuous enclosure of walls but by the folds, twists, and turns in an often-discontinuous ornamental surface. The ornamental destiny of the twisted surface begins the process of superposition of form and structure. **Strictly speaking, it is only the ornament that is structural.** What matters, in the woven surface, is **the coincidence of graphic and structural,** the textile pattern that determines its own internal tension and its physical behavior. From this differential process of the constitution of the surface we can, we believe, draw out structural and formal issues that go well beyond the form/structure debate.

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