Computational Design, Progression, and Future Generation

Explorations, Challenges, + Possible Future Solutions

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Abstract: Computational design processes have evolved over the last 20 years with the speculation that unification between disciplines within the realm of architecture is necessary. Throughout that unsolved difficulty, much advancement has been made with regard to generative modeling, building optimization, energy analysis, and materials development. To unite the fields for further optimization strategies in the future requires unifying factors that may lie in the exploration of morphogenetic design.

Computational design has come a long way. From inklings of wonderment of whether or not morphogenetic design can link discourses and cause cross- referencing data analysis, to knowing that it can, has, and now with the open source sharing of Grasshopper, will do so, excites one further to understand and explore its possibilities. People are curious of one another, and their surrounding environment. We all share the desire to search and explore, to understand, to help, and to make. It is through this process of sharing, searching, exploring, understanding and making, that we find letting go, the answers to creation.

As we have achieved the accomplishment of optimizing material and pattern organizations in order to enhance performance and increase efficiency, we learn that we are capable of much, but that leaving generative design up to self-organized chance really is where exists magic in the creation. Dangers may lie therein, but we are hopeful that if mimicking the Creator as closely as possible, perhaps we will be rewarded something wonderful that can do well for our brothers and sisters, and our world. We can utilize several tributaries of thought with regard to computational design to understand how

different evolving branches acted in the past, present and will possibly help to contribute in the future.

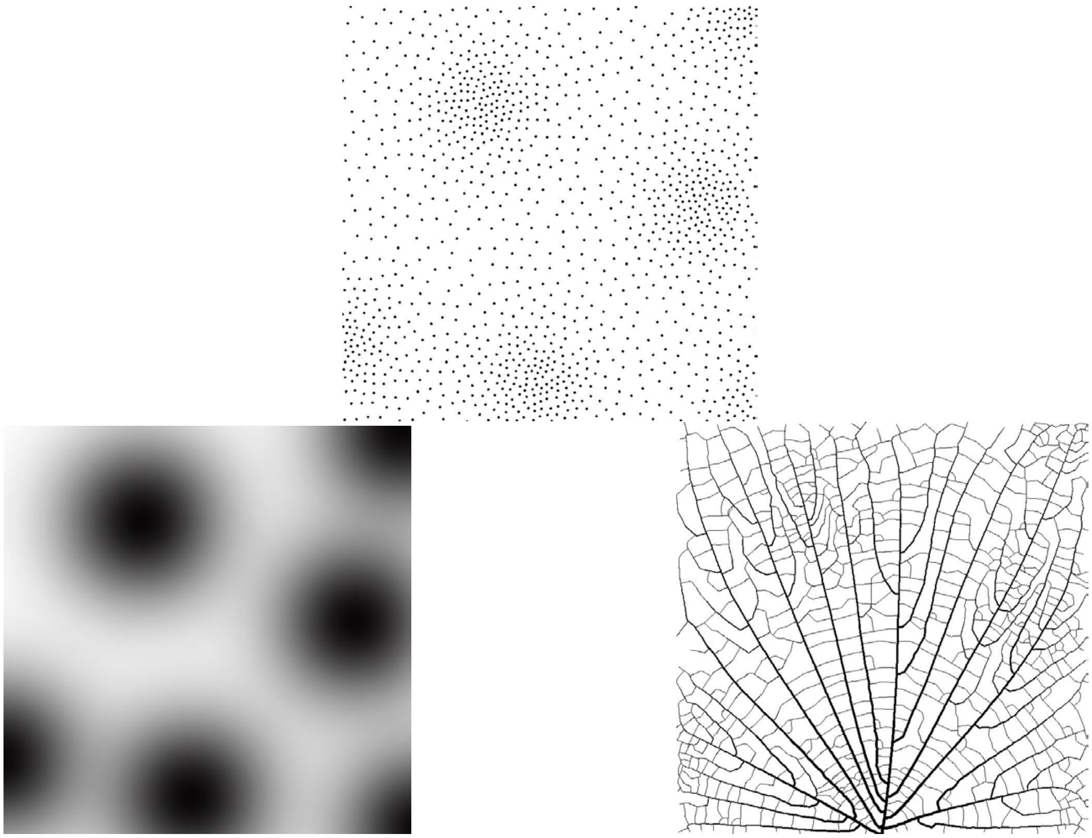


Fig. 0 Leaf Venetion algorithm with different densities. (Gokman, A Morphogenetic Approach for Performative Building Envelope Systems Using Leaf Venetian Patterns)

As Alvar Aalto put it : “the large amount of demands and sub problems (from architecture) form an obstacle that is difficult…after I have developed a feel for the program and its innumerable demands have been engraved in my subconscious I begin to draw a manner rather like that of abstract art.“ We are struggling like babies taking small meandering steps to take this massive amount of data we are given through the evaluation of computational design and generative modeling, make sense of it all, and optimize it for the best possible solutions to form, structure, and energy concerns. We have found out its efficiency and effectiveness regarding its possibilities.

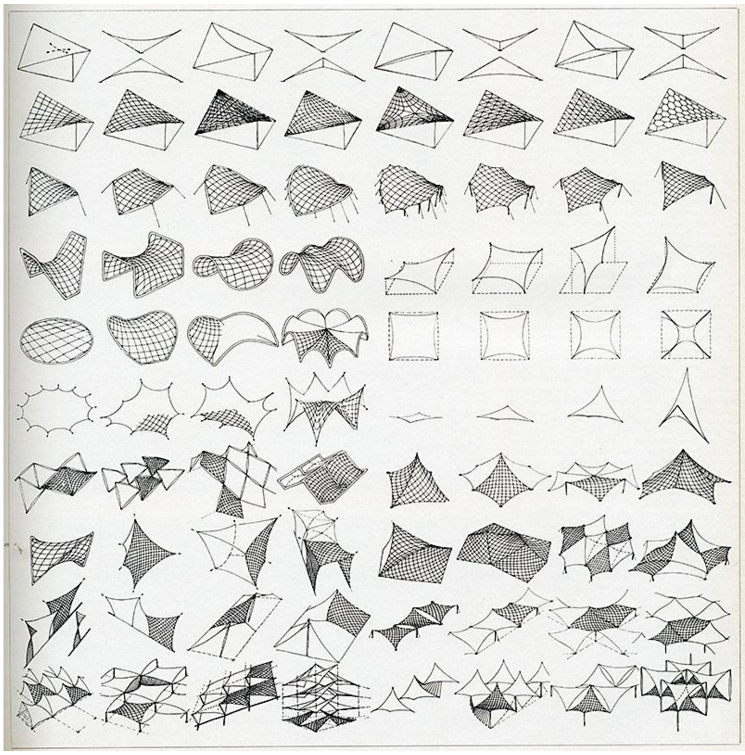


Fig. 1 (Otto, Frei, 1966)

Currently, computational design and generative modeling is being used to analyze everything from building envelope, form, and core, to material design and comparisons to those structures found in nature. For one, we are trying to analyze and develop optimal massing structures. We find problems lie therein later with communication between parties to ensure that this method is optimal. (Marcello, Eastman, 2011) Simultaneously we know that benefits lie in development of optimizing use of materials. As NASA explores use of morphogenetic design principles in their study of how computational design and algorithmic principles can help to develop design and manufacturing of tow-steered composite shells using fiber placement (Wu, Tatting, Swift, Smith, Thornburgh, American Institute of Aeronautics and Aerospace, 2009).

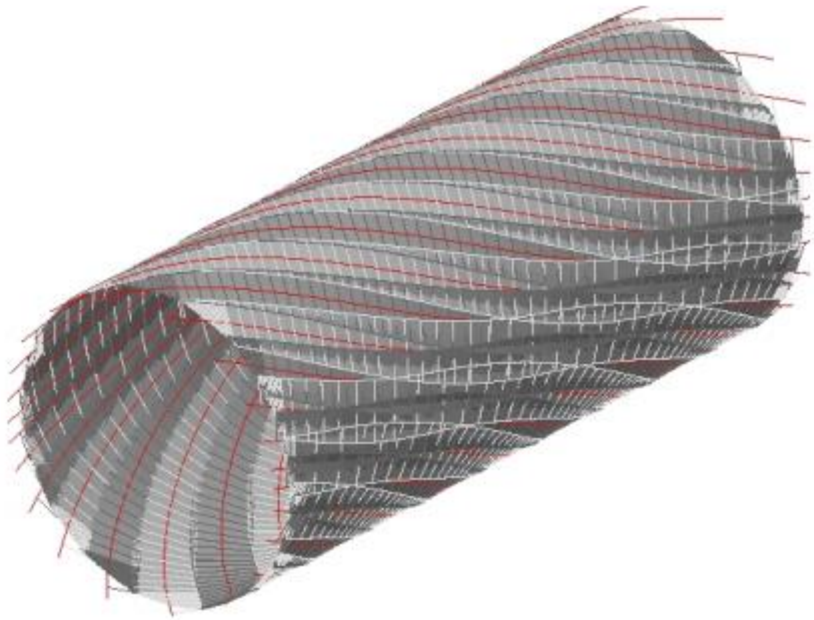


Figure 4. Courses for shell with overlaps.

Fig.2 Fiber courses for fuselage shell showing varying fiber placement. (Wu, Tatting, Swift, Smith, Thornburgh, American Institute of Aeronautics and Aerospace, 2009.)

In 2011, Daniel Richards of Manchester Metropolitan University noted when speaking on evolving performance within component-based structures that "to date, design processes that facilitate the integration of 'form generation' and 'spatial analysis' remain under-developed" – and we can now question four years later if this is still as true when we see the many contributing bodies of people and knowledge with the open source database of exchange that programs like Grasshopper offer (i.e.: Kangaroo, Firefly, etc.) We know that the repeated pattern of difficulties that shows up lie in our communication and network of exchange of information bridging over the various disciplines falling in the field of architecture (the age old scene of exchange between architect, engineer, etc.).

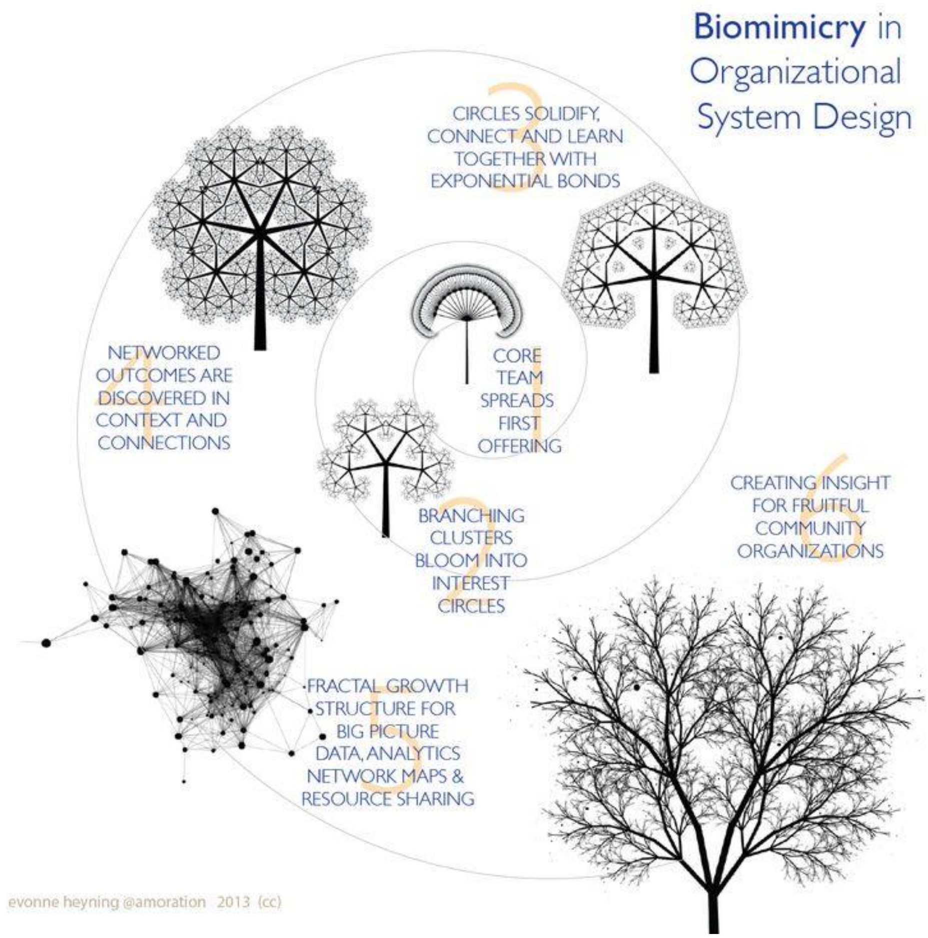


Fig.3 (Evonne Heyning, 2013)

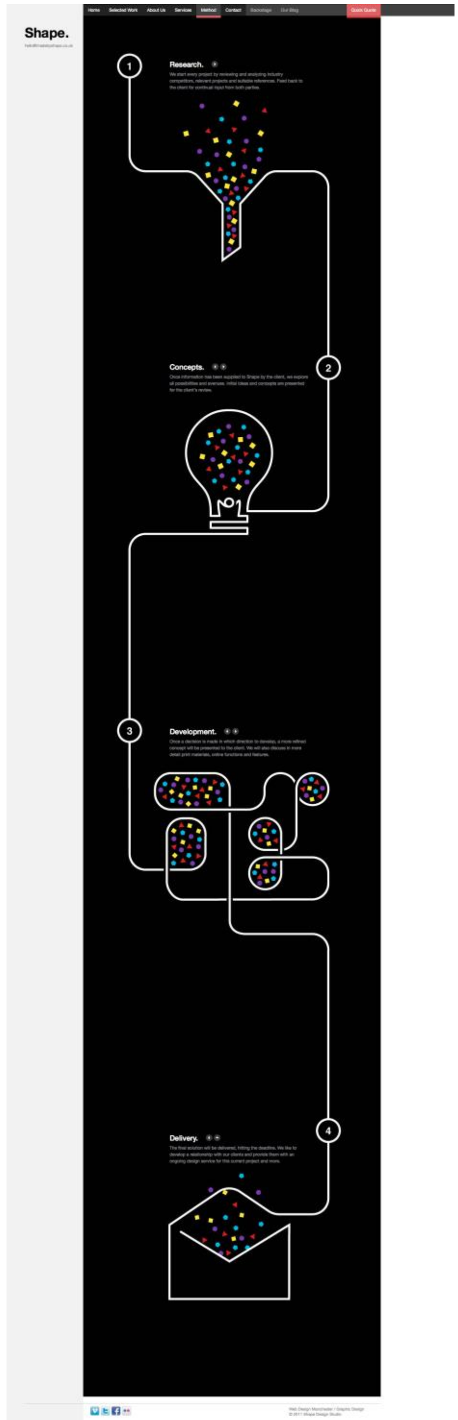
With regard to biological considerations, we know the potential of this exploration is almost limitless, but this somewhat ontological exploration may be the key to the synergistic cross exchange of language and sharing of information to solve this problem. Meaning, a common goal that is the human exploration of truth and necessity for biological solutions (via an inherent need for survival solutions) may generate new models to offer receivers for input to link the various disciplines together, thus simplifying the complexity of ideas. But first, we have to start somewhere, and that possible solution may lay in the

“letting go” that result from the outputs of morphogenetic design. It’s within the results found from morphogenetic design that the “ontological” becomes explored.

Whereas the ontological means to study the nature of being, becoming, existence, or reality, mimicking nature, via biological data inputs, analysis via parametric modeling, and resultants via morphogenetic design will signify all of those categories, with the mystery, excitement, and perhaps even non-argumentative results of the “becoming” the natural element to unify our fields of study towards a common goal.

We see that a natural inclination to argue for a “top down” approach in about building core development exists in the discipline of parametric design. “Design activities vary from high-degree of freedom in early design stages to highly constrained solution spaces in late ones, which entail large amount of design expertise. A top-down approach based on nested assemblies and custom functions is proposed to embed such a design expertise in reusable parametric objects.” (Marcello, Eastman, 2011) Naturally, this is understandable, as we saw Aalto mentions the need to start large with many inputs of

information, and reel these factors in to come to a concise formula for solutions within



building design.

Fig. 4 "Top Down" Approach(http://bestaboutpages.com/2011/12/12/made-by-shape/)

Marcello and Eastman argue that the "specific case of architecture entails a specific amount of knowledge in some design decisions which makes translations into parametric environments more difficult." The authors further argue that expertise within the field of architecture is strongly based on "rules of thumb" from trials and error from previous experience, (Marcello, Eastman, 2011) and those parametric objects can be developed to nest what has already been learned in order to create the parameters to generate more concise solutions. Rather than relying on human expertise alone, we are entering this data into the computer, and storing it for future output and solutions. The use of this is to store what we know is empirical knowledge, and therefore to formalize it. In analysis of how to do this with an MCM (massing core model) and a SCM (service core model) Marcello and Eastman explain that while BIM allows for solutions regarding cost and automatic floor plan schedules for design solutions, a problem lies in finding a solution with regard to real – time updating of this information when designs are changed.

Earlier in time we see "As Clarke (1991) points out, the conflict between power and ease of use is further exaggerated by the divergence of the conceptual outlook of the design-orientated program users and the technically orientated program developers. And to add to the confusion, the various engineering professions use subtly different terminology. "(Hensen, Eindoven) Again we see, a pattern of difficulty of exchange between communicating parties who build the buildings, and the computer as the "middle man". We see an opportunity for morphogenetic design to step in and take the reins with regard to "no argument" with resulting empirical and evolved evidence for design.

Morphogenetic design is defined as being "concerned with the breeding (or replication, mutation, selection and survival) of forms and structures according to a fitness evaluation

function and the emergence of more complex systems out of the produced aggregations." (Daru, Schnijder, 1996) In Daru & Shnijder's "Morphogenetic Designing in Architecture - resolving controversies in and between design, research and development" we find out that the authors were intriguingly accurate when predicting some key nuances with regard to generative modeling within the sphere of computational design.

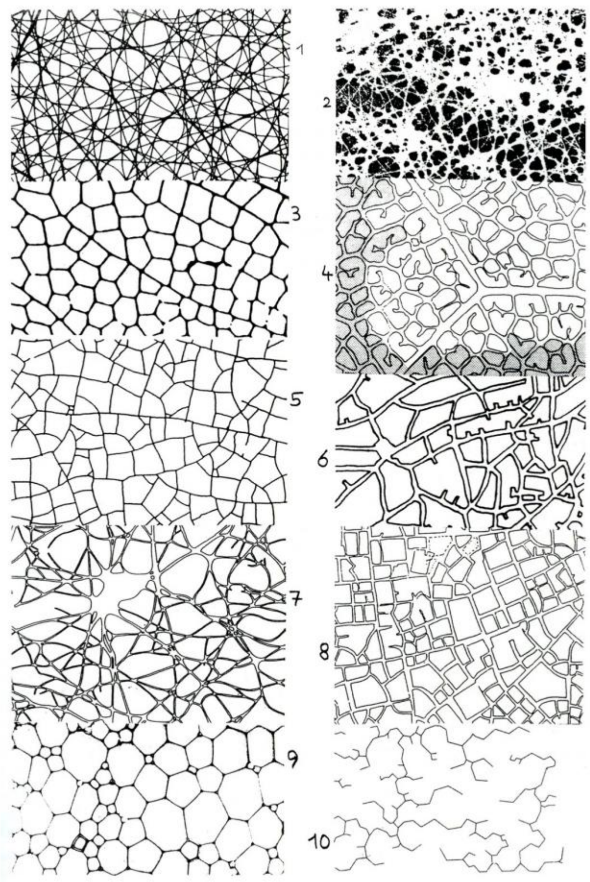


Fig. 5 (Otto, Frei, date unknown)

"The development of morphogenetic design opens new possibilities to **bridge the gap between the different traditions."** The traditions Daru & Schnijder refer to here are the hermeneutical and empirical traditions of study within design and science. The authors point out that the "form generating acts" can provide better design studies that prototypes alone can,

meaning that patterns and sequences generated from within the sphere of "emergent design" can offer much needed information that will interest all fields, thus causing greater cross-exchange and sharing of inputs which one can argue is derived from an inherently instinctual need for the ontological pursuit, and biological necessity.

How to make the computer, as a design partner, more "human" to ensure the safety in this pursuit is an obstacle that we may never overcome. Whereas we can see how necessary this is becoming as "to try to set-up a system that would enhance the design process by suggesting possibilities, has been preferred to an approach that emphasizes optimization and problem solving." (Carranza, Self-design and ontogenetic evolution). Carranza importantly brings up that "societal development" can be considered a morphogenetic process.

When looking back to 1996 again with Daru & Schnijder's discussion, noteworthy is the suggestion that "for the majority of architects, working within the artistic and hermeneutical tradition, the morphogenetic approach to designing will feel strangely familiar. The morphogenetic software programs developed so far …suggest a new way to explore and enjoy." It is in this exploration and artistic approach that we find the natural inclination of intuition – following our design, natures design, we see the possibility of our intrinsic and intuitive minds formulating flowing ideas through fingers onto the keyboard, to commands and gut instinctual shapes and forms, informed through already acquired empirical evidence and data – to be released into the secondary tool of the computer, to, within a series of defined parameters generate an evolving model, random and beautiful as nature is. Our challenges going forward lie

in further understanding the Creation and all of its properties. A caveat to that will be our ability to evolve our building materials to suit these needs. Because design research "about architectural designing could use the automatic registration facilities of the morphogenetic programs involved to automate empirical observations or quantitative analysis", Daru and Schnijder argue that this will therefore unite the schools of thought i.e.: the artists and the hermeneutists and the technicians and the empiricists, especially the latter because of the empirical data put into the parameters. Where this gets tricky, lies in the unification of the schools of thought when we release the design to chance, organic evolution, or happenstance to see "how the plant grows". Chaos exists in nature, and therefore, we must be wary that the advances of morphogenetic design come with it, the chaos and the chance. Where we really have an ability to hone in on our optimal ability to optimize, may be in the exploration of textiles and materials. As NASA uses parametric modeling to advance its fuselage structures utilizing different angles of fiber in varying manners for the structure of the overall form, we are able to see just how beneficial parametric modeling can be. It results in less material wastage, less touch labor time, and greater performance. (Wu, Tatting, Swift, Smith, Thornburgh, 2009) Applied to a building in this manner, it is safe to say all of the same things can be achieved.

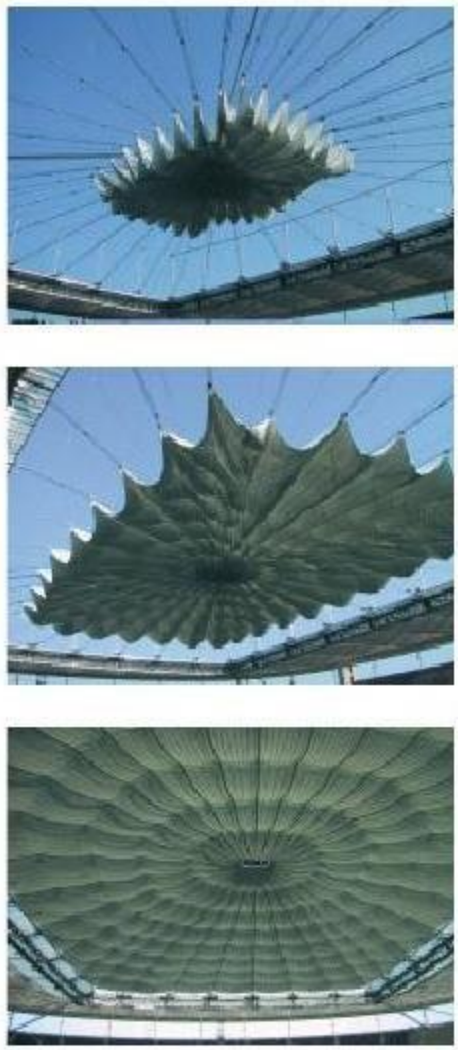


Fig.6 (Gerken, Mark & Partner Architects, 2005)

Views of Skyspan retractable PVC/PES-coated PVC fabric roof of the Commerzbank Arena, Frankfurt, designed by Gerkan Mark & Partner Architects, 2005.

Reviewing back to Daru & Schnidjer, "the hermeneutical researcher might ask global questions and get holistic answers with ethical and moral connotations" whereas "the empirical researcher on the other hand might ask more specific questions and get both analytical and

generalizable answers out of his simulated experiments." It is here that we can see the unification may occur. What will unify us all is the logic – biology – cycle. Human activity is in a cycle of polluting. Can computational design analyze those cycles? Also, we might pose the question of the relationships between human vs. building vs. plant. A building needs air and a human needs air, and a plant needs air. However a plant and a human don't need the same things. So how do we find the equilibrium between the existing sciences? Perhaps this generates our next discussion, and next list of parameters. But first, we need to bring together the disciplines of science, biology, and architecture and unify them in the virtual world of computational design. There we may be able to achieve the nexus to develop this balance.

Fig.7 "Silk Leaf" (Melchiorri, Julian, 2014)

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