

Ordering the Aesthetic (A+) in Architecture: Advancing a Theory of Modular Computation

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Abstract

Aesthetic content is perhaps one of the least understood, and discussed, concepts in architecture. Our purpose here is to demonstrate the efficacy of a computing environment created for the purpose of instantiating aesthetic content as a context for ideation in the architectural design process. A four-part approach is taken: We first abstract, from historical sources, a definition of “aesthetic sensitivity” founded in the evolutionary structure of psychological adaptations of the human mind. This definition asserts an essential human need for positive (A+) aesthetic environmental content. Next, similarly, from historical resources, we form a compendium of aesthetic concepts, attributes kinetically associated with aesthetic sensitivity, that can be reasoned with to describe formal properties of real world objects. We limit our object field to an architectural context. Thirdly, the analyses which derive aesthetic concepts are formalized as generative processes. Lastly, these processes are converted into algorithms, to interpret and subsequently instantiate aesthetic concepts as formal geometrical productions. For this purpose, we demonstrate a software tool that generates modular constructs in 3-space, which reflect the aesthetic influence of its algorithms (in contrast to the aesthetics of the formally generated object per se).

Introduction

As the building professions are so constituted today technical knowledge and its application has come to dominate design inquiry in the built environment. Architectural design, and architectural practice in particular, given its multiple responsibilities of functional needs, organizational efficiencies, and construction technology, is quite accomplished in the vocabulary and articulation of empirical issues. By comparison, sensitivity for aesthetic dimension and purpose in architecture has lost ground in inverse relation to the rise of the sciences and technology. While undeniably some aesthetic influence exist in various contexts in many contemporary architectural works, hard evidence demonstrating a sustained systemic commitment to aesthetics’ essential place in architecture is lacking. There seems to be no uniform and comprehensive level of competency, similar to that of technology, in the understanding, explanation, or instantiation of the necessary aesthetic features of architecture.

This paper speaks to these conditions by arguing that aesthetic sensitivity is common to all humans, secondly that aesthetic experiences are an essential phenomenon of human psychology, thirdly, that there exists certain aesthetic precepts seated in the human mind associated with descriptions of formal objects, and lastly by demonstrating the efficacy of a computing environment useful as an idea machine to generate formal constructs based on positive aesthetic attributes.

A History of “Aesthetic”

Aesthetic as a concept is historically rich and varied. Here we search for a working definition of “Aesthetic” in the domains of philosophy, anthropology, evolutionary biology and psychology, and experimental aesthetics. Our search focuses on aesthetic sensitivity as fundamental to the human psyche, and aesthetic sensitivity’s relation to real world objects (and perhaps, objects of the imagination.)

Prior to Plato’s time, the beauties and pleasures of human existence were fundamentally those of the corporeal world - pleasures experienced without any meaningful understanding of their foundation in human aesthetic sensitivity. Plato’s philosophical theorizing was the first thoroughly documented inquiry into beauty, and pleasure, considered as cognitive ideal more than a worldly phenomenon.¹ Plato’s shift to ideas of the mind essentially recognized Beauty as one of the realities of human conscientiousness, and that understanding Beauty required philosophical analysis

Following Plato, philosophers from Descartes to Hume to Collingwood have continued to render aesthetics’ meaning in the domains of mind and human existence. Kant notably was the first to convincingly argue for aesthetic sensitivity as an “a priori” human mental faculty, and that particular aesthetic judgments should be common for all.² Kant’s arguments ultimately served as a foundation for beliefs in other disciplines that aesthetic perceptions of many kinds were universal among all humans.

In concert with Kant, Baumgarten’s *Aesthetica*, published in 1750, elevated aesthetics to a formal philosophical discipline, which then evolved through the writings of modern day philosophers as diversified theories, for example, of art, and as bases of enculturation.³ It was arguably such diversification that in modern times broke the essential connection between aesthetic sensitivity and the human psyche. Even so, within the extended history of philosophical examination of aesthetics, there is substantial evidence for a belief in aesthetic sensitivity as a given human quality.

We can look for further substantiation of this belief in modern day Anthropology. Beginning with the work of E. B. Tylor in the late 19th century, and Franz Boas in the early 20th, we find, for example, evidence of a “homogeneous nature” common to all humans across races and cultures.⁴ Later anthropological studies by Herskovits, Kluckhohn, and Brown, among others, established an influential inventory of human “innate universals”, human psychological constructs again in evidence across cultures and races. Their inventories included for example, kinship systems, aggression, romance, gestures, grammar, emotions, psychological defense mechanisms, recognition of individuals by their facial features, and notably, aesthetic sensitivity.⁵ Brown also introduced the concept of “manifest universals” as a response to localized variations observed in the innate forms.

The pursuit of innateness logically led to questions of causality. Hallowell introduced what became known as “behavioral evolution”, an isomorph of Darwin’s Natural Selection.⁶ Behavioral evolution eventually led to research in evolutionary psychology which verified the occurrence of psychological adaptations in parallel with the biological adaptations of epigenetic evolution. Ongoing research now indicates that human aesthetic sensitivity, and judgments in responding to aesthetic sensitivities, is de facto based in evolutionary psychological adaptations to environmental influences. In general, the conclusion we draw is that what we consider as positive (A+) aesthetic experiences are those events that our adaptations have led us to sense as useful for enhancing the probability of extending life, while the negative (A-), those experiences that are life threatening.

Preference for life enhancing experiences in our environment abound. For example, certain biomes (configurations of trees, surface conditions, vegetation) are preferable over others. Beauty in the human body reflects enhanced physical preparedness for both reproduction and longevity. Moreover, even newborn babies of just a few months are able to detect beauty in facial features. Studies of these kinds form the body of Experimental Aesthetics, or more contemporarily, psychobiological aesthetics. Experimental aesthetics began in the late 1800s with the Wundt curve (a metric of arousal vs. hedonistic value as aesthetic stimulus.)⁷ The discipline's investigations essentially focus on measuring aesthetic response preferences in subjects presented with formal, or "collative" sensory stimulus patterns. Within the body of research, stimulus patterns are quite varied, from the biome patterns mentioned earlier, to patterns in poetry and music, formal configurations typical of Gestalt investigations, and more generalized configurations of objects in visual settings. Most importantly, psychobiological studies have demonstrated both a consistency in classes of aesthetic judgments, and profound cross-cultural preferences for commonality in aesthetic judgments.

While the discussions referred to here are by no means exhaustive of aesthetic oriented research in the various fields of inquiry mentioned, they are offered as sufficient background for the purpose of further analysis and a source for reasoning about a definition of "Aesthetic". Of interest firstly is establishing the precept that the aesthetic dimension in human psychology is in broad terms universally extant. Secondly, that the aesthetic dimension, even though its expression varies among humans, is, most importantly, connected to phenomenon in the real world by means of identifiable causal relationships. And thirdly, through further investigation, supported by the present research, a sufficient body of casual relationships can be identified and formalized for the purpose of enhancing the experience, the aesthetic sensing, of architecture.

Summary – A Working Definition of "Aesthetic"

Any use of the concept "aesthetic" going forward must rest on a well-structured definition. Absent such a definition, the traditional battle of the philosophies (theories) would reign as an impediment to the use of aesthetics as a functional means of interacting with the environment.

"Aesthetic" for use here is a universal, innate sensitivity (faculty) imbedded in human psychology, a bimodal emotional judgment of pleasure or displeasure, focused on the immediate sensual response to the form of objects or ideas without purposeful reference to concepts associated with their existence - purely a sensual response - "a return to that fundamental and most concrete level of human experience which the Greeks had called *aisthesis*: 'sense experience'."⁸ Note that the definition does not serve as a "theory of architecture", or as a theory of styles. But rather it is a description of an essential human dimension that must be attended to, positively, as a necessary enhancement to quality of life.

Aesthetics as Design Criteria

Both object and subject are required in the corporeal world for aesthetics to make sense as a useful proposition in reasoning about aesthetic purpose. We take "sensory stimulus patterns" to be objects in the real world, objects capable of projecting essential A+ aesthetic qualities judged by human aesthetic sensitivity as enhancing the quality of existence. We ask then, what are these qualities of objects? What do their salient features look like, and what are their functional relationships to aesthetic sensing? And, most importantly, are such qualities useful for architectural design and projecting aesthetic dimension into the built environment?

Formal Relations and Aesthetic Attributes

Information about an object's aesthetic qualities is imbedded in its compositional makeup, (which assumes the object is composed of one or more formal descriptions in Cartesian 3-space), and in particular combinations of relations between descriptions, or alternatively, components. It is thus necessary to know something about the set of compositional elements and the relationships most closely representative of positive (A+) aesthetic character.

Firstly, relationships among a composition's elements (typical of architectural constructs) imply the existence of an Order – Disorder continuum. The A+ aesthetic weighs on the side of order. “what distinguishes beautiful things from other things is a high degree of some kind of order.”⁹ Order is for aesthetic sensitivity the quality about objects that increases comprehension and understanding in the world of knowledge required for survival. In early Pleistocene times the world may have appeared far less complex, however survival, and successful existence, relied, much as it does today, on constructing formal descriptions of real world phenomenon. The more organized and coherent descriptions yielded not only more useful understandings, but also quicker comprehension of the task at hand. Such formalization process, as they were, obtained from dynamic, state changing environments. Understanding the formal characteristics of states and state changes amounted to predicting outcomes such that future states could be anticipated and successfully adjusted for in ways that enhanced survival.

While Ordering is essential to the pleasure of understanding, maximum order, a complete state of homogeneity among objects (maximum entropy), is chaos. It is arguable whether such chaos is disorder, however it surely projects a negative aesthetic (A-) since there is insufficient information to discern the character of individual component objects. A positive aesthetic order affords information about the state of affairs that's useful in the real world. Homogeneity offers no such information other than proof of existence. What we conclude then is that in the ordering of relationships among objects, some chaos is necessary as a filter through which information passes about the underlying state of order.

A sense of ordering also implies coherence, although coherence does not conversely require a strict sense of ordering. Coherence is taken in the Gestalt sense of objects in relationship exhibiting the quality of belonging together, i.e. there exists an internal structure in the object's relationship to which they all belong.¹⁰ Furthermore, the structure's character is comprehensible and adds to the positive aesthetic projected by the composite object. Note that highly chaotic structures, or compositions, may still show a positive degree of coherence within the commonalities of their constituent parts.

Complexity, a fourth essential quality, has been endemic to aesthetics from the time of Aristotle. Complexity is a direct metric for informational content. Complex constructs obtain their beauty and A+ qualities from firstly, a high level of information, and secondly from the ordering (and possibly coherence) that structures complexity in a form that can be sensed as both accessible and comprehensible. Positive aesthetic response follows from the sense that the complexity of information has been understood, and moreover that its usefulness attaches to an increasingly complex environment, one that offers enhanced ability to understand and function in the real world. Complexity is varied. For example, in architecture, or generally, the built environment, complexity may accrue to redundancy of similar forms, or perhaps even a variety of disparate forms. Providing that complexity is well ordered, and remains below some critical threshold, the kind and degree of complexity will solicit

a positive aesthetic response. We can say then that increasing complexity in an ordered system increases the potential for positive aesthetic character in the architectural construct.

While *order*, *chaos*, *coherence*, and *complexity* are the most affective determinants of aesthetic character, other attributes contribute in important ways as well.^{10, 11} For example, symmetry and balance provide a sense of fixedness, or stasis, that matches a human need for stability in the environment. Stable environments provide a background over which small variations are more easily understood. Symmetries typify an ideal state of balance, and in some sense a perfect order, but reduce information because of the difficulty in differentiating components of the symmetry. Balance achieves an equal stability, but with greater information content in its varying elements. Balance is subjective. We understand balance only because we experience balance so pervasively in the real world.

Clarity, a third lower order aesthetic attribute, implies discerning elements in a construct from one another. Clarity derives from characteristics like contrast, brightness and smoothness (often associated with newness), and finely delineated features rather than from, for example, an ordering function. A fourth attribute, novelty, also imbues a positive aesthetic character in constructs that in some way pass a threshold of difference in their formal composition from similar objects in the environment.

Unity, a fifth concept, frequently serves as a surrogate for coherence. However here it is subsumed by coherence specifically as a means of varying coherence to achieve a stimulating level pattern recognition, or “supersigning.” Constructs that maintain aesthetically positive coherence yet provide sufficient ambiguity to allow a sense of discovery, particularly in abstracting patterns that have informational content, will enhance their positive aesthetic.

Lastly, third order aesthetic attributes, for example, rhythmicity, oppositions, and implied linkages (relationships) offer numerous opportunities for manipulating a construct’s aesthetic content. They are reminiscent of ongoing environmental events and conditions fundamental to human existence and so are sensed and appreciated in an object’s aesthetic content.

Aesthetics in the Computing Environment

Computing space is often considered a medium for design activities similar to analog media space. Architects as designers move freely between their own imagination space and media space, conducting an internalized bi-directional dialog that informs and expands the idea, concept, and solution space surrounding the design problem. While analog design media has been essential, computing media has over the past decades shown not only a robust capacity for presenting ideas, but also for generating new ideas in its inherent capacity for reactive content. Computing space represents a space for initial ideation that fractures the ideal of an isomorph in the sense that formal descriptions of ideas presented in computing space may exist without a comparable form in imagination space. Such fracturing constitutes a reversal of the typical analog design environment by making advantageous use of computing concepts originating within the design media itself. Formal constructs built in computing space by means of algorithmic tools presents both a paradigmatic shift from imagination space as the primary idea space to computing space as idea space, supported by a conceptual suggestion of unbounded ideation.

It should be noted that a general understanding of aesthetic content, and aesthetic attribute, is of prime interest not because it might serve of as a foundation for deterministic aesthetic rules, but for sustaining a more modest approach aimed at improving the probability of generating and evaluating

formal constructs within the realm of a positive (A+) aesthetic. Essentially, a computing environment is sought that will be useful to architects and designers for the purpose of intentionally instantiating architectural constructs with formal qualities reminiscent of the positive aesthetic responses necessary for enhancing human existence. Towards this goal, the desired outcome will appear as a quasi-organizational environment susceptible to heuristic search processes that will produce aesthetic outcomes (objects) satisfying a sense that aesthetic purpose has been achieved.

The Software

Fs, a software application created to define the computing domain for this project, is one of a class of form generators. Shape grammars and system-based programs are also form generators, however fs differs by being method rather than rule based.¹³ Fs' methods (aggregation methods) represent parameterized algorithms imbedded in the fs basic framework for use in arbitrary combinations to yield formal constructs. In the abstract, each method may be considered a sketching tool, thus a set of sketching tools similar to the conceptual design tools typical of analog environments. For this reason, the "s" stands for "sketcher" (the "f" for "form".) The software runs in the AutoCAD 3-space environment as an application implemented in ObjectARX. AutoCAD's text box function serves as the user interface.

Basic fs framework forms a bounded 3-space grid ordering system, thus allowing constructs to develop with varying degrees of order. In Fig. 1, the light gray base defines x and y limits, the aggregation's top modules approximate the z limit. The framework's bounding limits also serve as a first order coherence filter. Form generation tools (aggregation methods) of which there are three, adjacency, axial, and stacking, each parameterized at several levels, build formal constructs by iterative addition of a modular form. Fig. 1 illustrates an adjacency construct composed of prisms, each one attached to its predecessor at an edge. Corners and faces are also selectable for attachment in this method. Eighteen modular forms are presently available to the aggregation tools. Included are basic forms, i.e. spheres, cones, prisms, etc., the regular solids, and arbitrary forms. For the AutoCAD user, the basic system will accept any modular form in AutoCAD format.

User variables control the basic framework's dimensional characteristics (x, y, z limits), the modular form's scale and size in the framework, and first module placement. As constructs aggregate a tychistic sub-algorithm provides a degree of chaos, and complexity, for most of the parameterized functions associated with each method. Fig. 1 illustrates the typical variability in module placement.

Adjacency constructs tend to remain coherent within the basic framework, even though their linkages are weak. Fig. 2's form, in the axial aggregation method, improves linkages, and ordering, but lacks complexity. As shown, the modular forms typically adhere to a grid type modulation such that modules attach to their predecessor/successor to form continuous constructs. Figs. 3 and 4 are additional examples of both adjacency and axial aggregations of different modular forms.

Figs. 5-8 illustrate various stacking method aggregations. Stacking responds to numerous dimensional and configuration variables, making it the most complex of the three aggregation methods. Ordering, complexity, chaos, rhythmicity, and linkage attributes respond to the method's manipulations to create some of the more facile and aesthetically powerful constructs. Where the adjacency and axial methods aggregate modules, stacking constructs compositions evocative of architectural character. Staking parameters include staking axis spacing in the grid, axis height, modular spacing on the stack, and eccentricity about the stack axis.

Presently, the fs user interface is quite basic within AutoCAD, a graphical drawing environment pervasive in the architectural community. Many native AutoCAD features are interactive with fs, for example, all of the object manipulation and selection functions attached to the mouse (pointing device), and the command function allowing arbitrary context switching between AutoCAD and fs while maintaining a parametric history. Fs' text window interface explains each function and accepts its variables as serial input. Fs driven interactivity also includes both arbitrary pointer intervention at select specific locations for module placement in the grid, and module replacement in aggregated constructs.

Fs' use is straightforward. It is invoked by an AutoCAD command, sk, at the command line, followed by text window input. Module aggregation begins after all parameters are satisfied and continues until a specified module instance count, or until arbitrarily terminated. With an aggregation, or construct complete, the designer has in hand a 3-space model to manipulate either within fs, or alternatively, within native AutoCAD. The model may be viewed from various perspectives, and elements deleted or moved in response to the designer's reactions to the images and ideas invoked by the model. If the model proves fruitless, it's discarded in favor of another generated by changing one or more of fs' variables. In this way a designer may quickly create and explore an endless stream of fs models. Typically, most are worth considering, many of which serve up a rich palette of images and ideas. And as a designer gains knowledge and experience with fs, the interplay between its many functions becomes more facile and productive.

Lastly, fs implements two additional functionalities: symmetries and compositing. Both increase compositional ordering, complexity, and perhaps chaos, within a coherent structure. Symmetry implementation is basic: mirror, cyclic, and translation, where cycles and translation counts are variable. All allow interactive selection of symmetry axes and orientations. Figs. 9-12 illustrate the compositional effects of symmetries. Compositing combines two or more aggregations (or constructs) created individually by retaining previous aggregation(s) within a new aggregation's drawing space. Compositing can be quite complex, as the illustrations show in Figs. 13-18. Even in their simplicity, symmetries and compositing are most lucrative in their capacity for increasing complexity while enforcing order and coherence.

Summary

We posit a context for the concept of "Aesthetic" founded in human evolutionary adaptations to environmental influences. Positive linkages exist between formal constructs in the environment and acquiring information to enhance survival and quality of life. Historically, such linkages once found were pleasurable and formed the foundation of positive aesthetic sensing (and judgment.) Our ancestor's ability to develop positive linkages depended greatly on acquiring information from the environment that was both meaningful and stimulating. In conformance with human psychology, certain formal environmental characteristics proved to be essential for useful and efficient information transfer. We summarize these characteristics as attributes of formal objects, and as the conceptual basis for fs' functional design. Lastly, Fs is not intended as a "computable design machine", but instead as an "ideation machine" driven by aesthetic precepts for use by designers in exploring open-ended formal design problems with a focus on aesthetic content an purpose.

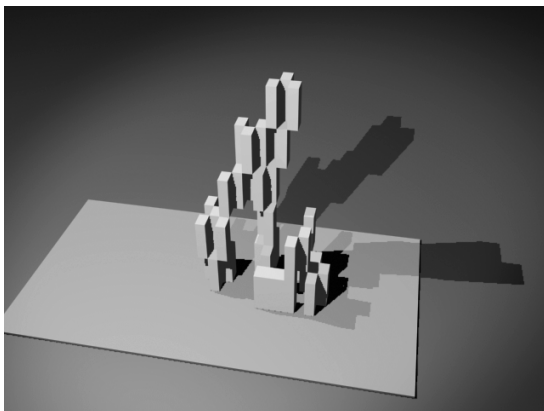


Figure 1

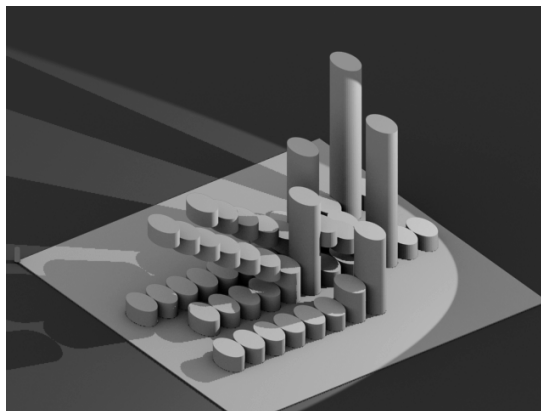


Figure 2

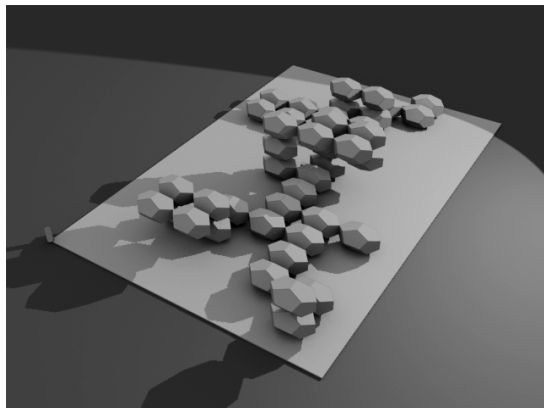


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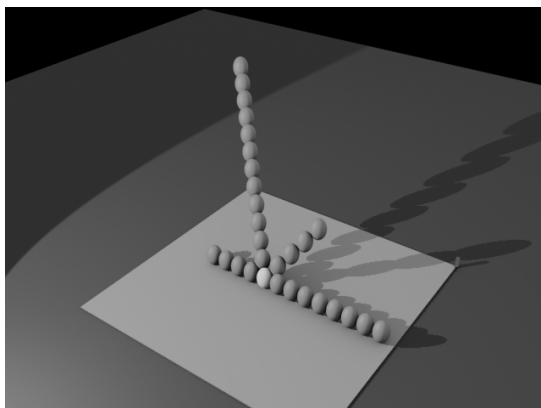


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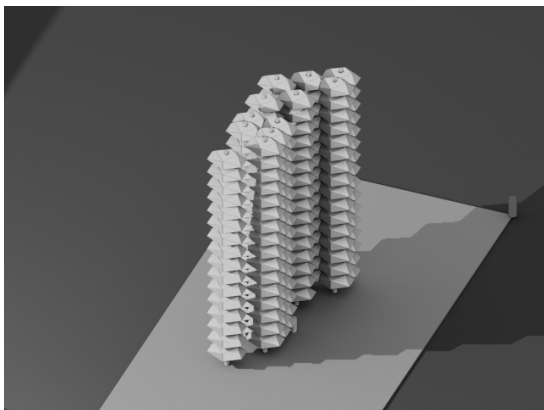


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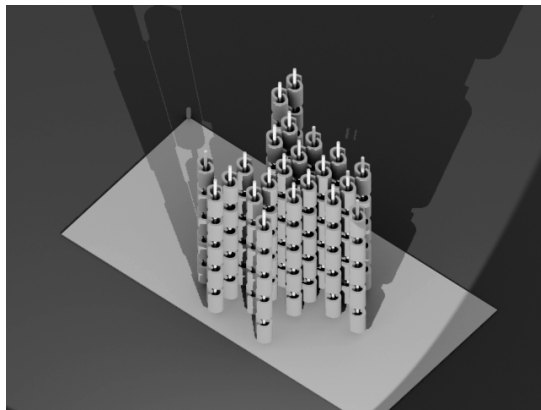


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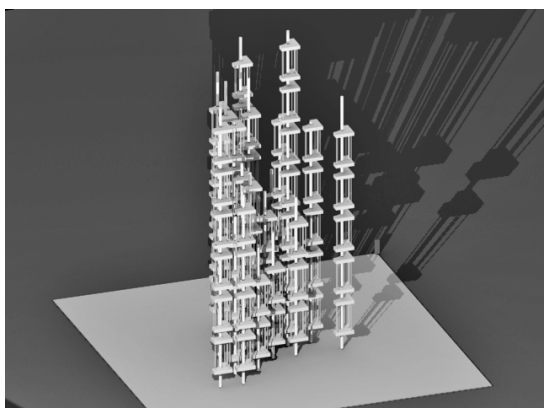


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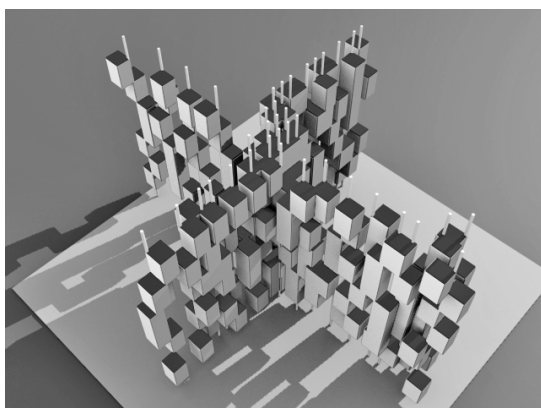


Figure 8

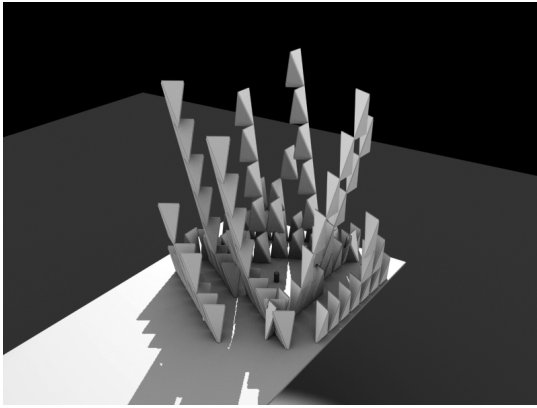


Figure 9

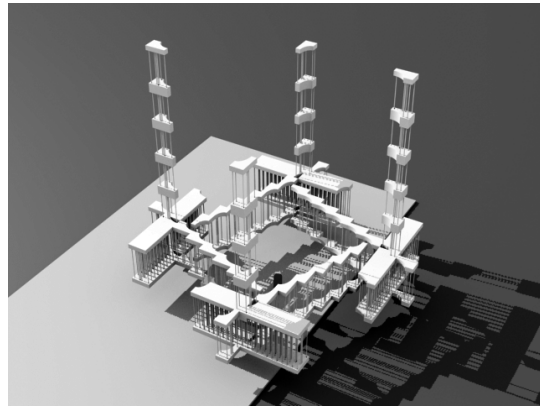


Figure 10



Figure 11

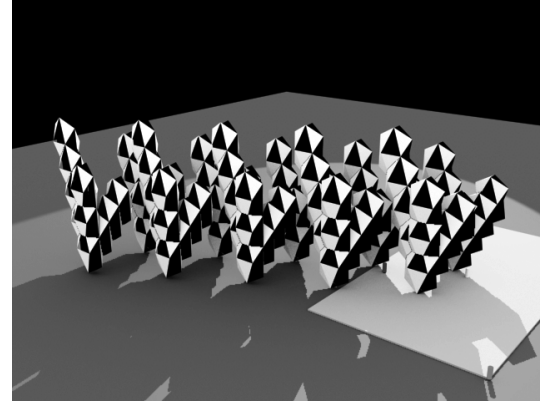


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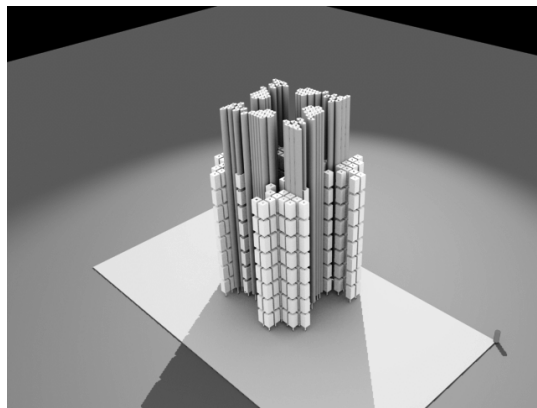


Figure 13

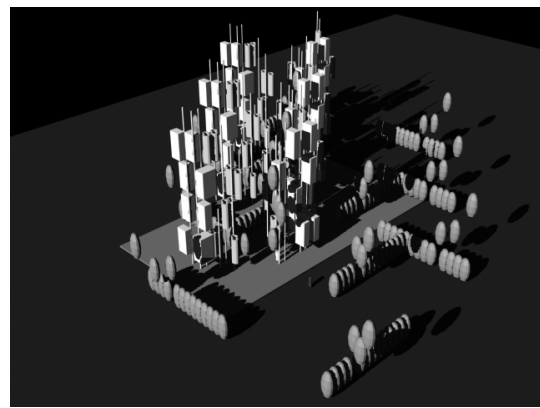


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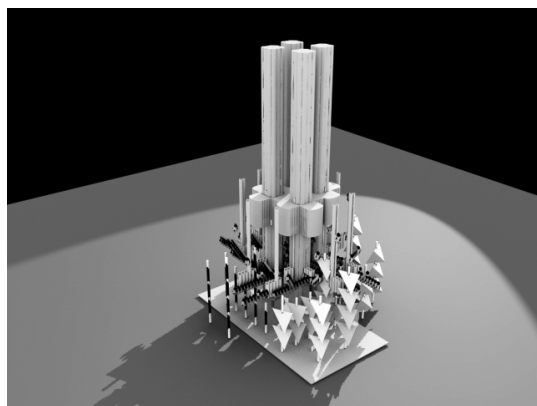


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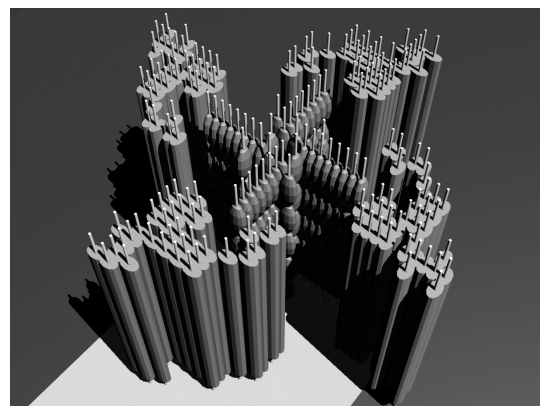


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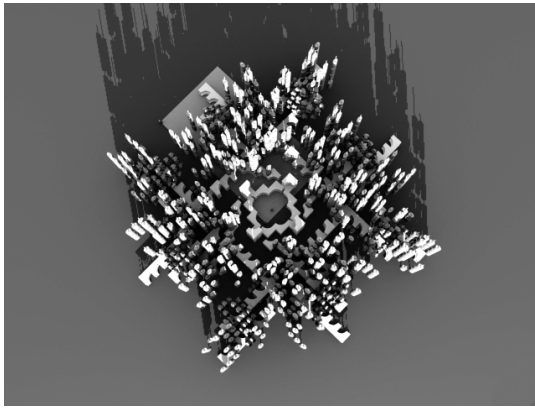


Figure 17

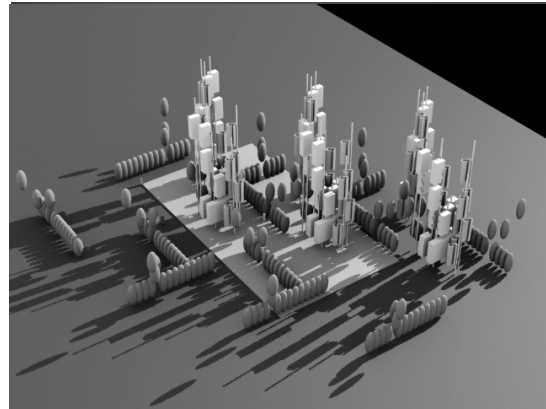


Figure 18

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