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Research

Integrated Function Systems and Organic Architecture from Wright to Mondrian

Abstract.. The development of an architectural form where the individual parts reflect the integrated whole has been a design goal from ancient architecture to the current explorations into self-organizational structures. Organic architecture, with this part-to-whole association as an element of its foundation, has been explored from its incidental use in vernacular structures to its conscious endorsement by Frank Lloyd Wright. Traditionally Piet Mondrian has not been associated with organic architecture but a closer examination of the artistic and philosophical underpinnings of his work reveals a conceptual connection with organic architecture.

The development of an architectural form where the individual parts reflect the integrated whole has been a design goal from ancient architecture to the current explorations into self-organizational structures. From medieval castles such as the Castel de Monte, Gothic cathedrals such Reims to Hindu temples [Sala 2000] historically it appears that our minds are oriented to appreciate buildings constructed with this quality [Salingaros 2001]. Organic architecture, with this part-to-whole association as an element of its foundation, has been explored from its incidental use in vernacular structures to its conscious endorsement by Frank Lloyd Wright. Traditionally Piet Mondrian has not been associated with organic architecture but a closer examination of the artistic and philosophical underpinnings of his work reveals a conceptual connection with organic architecture. This relationship is explored through the application of some of nature's fundamental structural principles to his artistic style.

The appreciation of beauty is one of the most basic human capacities. Architectural beauty is developed by the awareness of a balance of order in diversity of the unified whole and its constituent parts or the "ensemble effect of beauty"[Langhein 2001]. The quest to understand beauty in architectural design leads us to examine the intrinsic idea of nature [Bovill 1996].

Gestalt psychology focuses on visual perception to emphasize the dynamic interplay of parts and whole. Gestalt is usually translated as form or organized structure and is rooted in German thought of the self-actualizing wholeness of organic forms [Hubert]. It holds that we have certain tendencies to perceive visual data in organized or configurational terms [Detrie 2002] and to "constellate" or to see as "belonging together" elements that look alike, are proximate to each other, are similarly spaced, or are arranged in such a way that they appear to continue each other. The appearance of parts is determined by and understood relative to the systematic whole [Behrens; Crowe 1999]. A Gestalt quality is not concerned with the combination of the various elements per se but in the entity that is created based on their unity but is still discernible from them [Lyons].

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Gestalt theorists believe in an aesthetic dimension of inherent order in nature [Lyons]. Nature has a highly complex and ordered system which we connect to through our involuntary and subconscious perceptual system as well as our conscious understanding. As we are a part of nature's province it is logical that we are structured to appreciate nature's underpinnings [Detrie 2002]. Our constructed world is an alternative environment and it is inherent that there is a coherent connection, subconscious or conscious, between it and the natural world. In the striving for a harmony between the two worlds it is compelling to search for the source of nature's structure.

Jean Piaget, the noted cognitive developmental psychologist, advanced a theory of structure based on three properties: wholeness, transformation and self regulation. Wholeness, the "defining mark of structures", developed from elements that were subordinated to laws and it is in terms of these laws that the structural whole is defined. Transformations are laws that govern the structure's composition and are based on the overall properties of the whole. Self regulation is the concept that the transformations tend to develop elements that belong to the structure and preserve its laws [Kranbuehl 2000]. All of these properties bear the hallmarks of Integrated Function System (IFS) fractals.

In the 1950s Beniot Mandlebrot formalized the study of fractals, which had been ongoing since the nineteenth century, culminating in his book *The Fractal Geometry of Nature* [1977]. Due to the amount of calculations involved, this study was stunted until the advent of computers. Mandelbrot's goal was to describe nature with geometry and numbers in order to illuminate its underlying structure. There are a number of different types of fractals, including escape time fractals, which are the source of many fractal images. Fractals based on IFS have been shown to possess nature's structural traits. Fractals have been cited as being representative of real plant structures, among other natural structures, whose distinctive feature is self-similarity based on a recursive procedure called algorithms for creating these forms. The self-similarity trait manifests itself in the analysis of the fractal on different scaling levels. An IFS fractal is produced by taking a starting object, such as a box, as a seed shape or initiator. Copies of the seed shape are manipulated by certain permitted affine transformations, such as rotation, translation, shearing, and scaling. The summation of these transformed copies becomes the new seed shape, which is again transformed by the exact same set of transformations that was used to create it. Each set of transformations is called an iteration. As the amount of iterations increase the initial seed shape becomes less evident and the rules used to create the subsequent seed shapes become more significant. The transformation rules, which are made up of the various affine transformations, are the essence of the fractal form. The fractal rules are expressed in the following format, which can be viewed with a text editor (Table 1).

a	b	c	d	e	f	g	h	i	j	k	l	p
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1.

In this example there would be a set of four transformed copies. The letters a, b, c, d, e, f, g, h and i are values which describe the rotation, shearing and scaling transformations on the object in three dimensional space; j, k, and l are the vectors which describe three-

dimensional translation. P is a probability factor and the summation of that column will equal 1. The critical determinant elements in an IFS fractal structure are the affine transformations or rules represented by these values.

A classic IFS fractal is a tree. In fig. 1, the seed shape is shown on the left as a slightly deformed column. To the right of it is the graphic representation of the transformation rules which constitute the first iteration. The rules are three-fold: 1) take the seed shape, reduce it, rotate it slightly to the right, and translate it approximately halfway up the seed shape; 2) take the seed shape, reduce it, rotate it slightly to the left, and translate it approximately three quarters up the seed shape; 3) take the seed shape, reduce it, rotate it slightly to the right, and translate it close to the top of the seed shape. The figure at the right represents the fractal after three iterations.

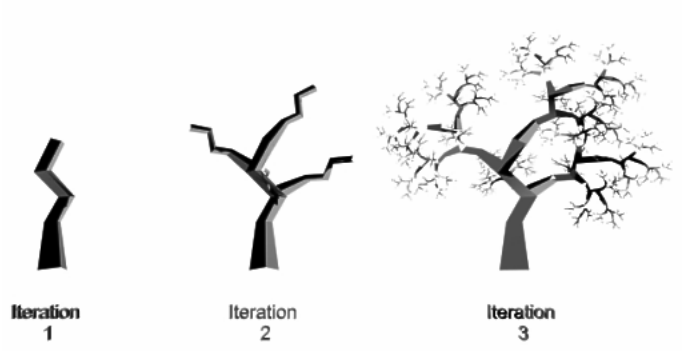


Fig. 1

The component parts of an IFS fractal after the first iteration look like a scaled-down copy of the whole and demonstrates the self-similar character of fractals in general. As demonstrated in fig. 1 and the table above, IFS fractals contain the "DNA" structure of natural objects and form the connection between mathematical elements and nature. Compositions based on IFS fractals can be the source of organic architecture whose inspiration is the underlying structure of a fractal [Lorenz 2003].

Frank Lloyd Wright believed in the importance of the study of nature as the basis for establishing an emerging American architecture. In a speech to the Royal Institute of British Architects he declared, "Modern architecture is a natural architecture—the architecture of nature, for Nature" [Wright 1939, 10]. Wright's mentor, Louis Sullivan, studied botanist Asa Gray and utilized the "manipulation of the organic" in the development of motifs [Gans and Kuz 2003]. Wright used nature as the basis of his geometrical abstraction and wanted to extract the geometry he found in nature [Eaton 1998]. He held that "nature means the essential significant life of the thing" and believed the term organic meant the relationship "in which the part is to the whole as the whole is to the part and which all devoted to a purpose consistently…some connection with this inner thing called the law of nature" [Meehan 1987]. These relationships are the essence of IFS forms and the basis of natural structures.

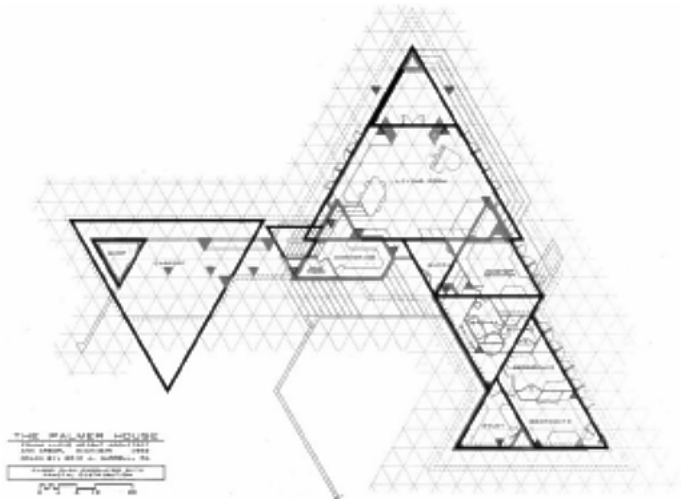


Fig. 2

One project of Wright's that has been cited for its fractal qualities is the Palmer House [Eaton 1998] (fig. 2). The citation of this building points out the misconception that a repetition of a form, the triangle in this case, constitutes a fractal quality. It is not the repetition of the form or motif but the manner in which it is repeated or its structure and nesting characteristics which are important. In fig. 3 I have developed a fractal form which is similar to the Palmer House plan. In the first iteration, the seed shape is shown in darker gray and the three transformations are shown in lighter gray. In the second and third iterations the original seed shape is dropped out and the iterations are color coded in three shades of gray.

Fig. 3

Fig. 4. Photograph by Thomas A. Heinz, AIA

Fig. 5

Frank Lloyd Wright only had two high-rises built: the Johnson Wax building in Racine Wisconsin and the Price Tower in Bartlesville, Oklahoma (fig. 4). In fig. 5 I have developed an IFS fractal model, utilizing 3D Max Maxscript, which approximates the Price Tower. The seed shape is an extruded square which represents the shaft of the Price Tower. The transformation rules consist of scaling, rotations and skewing of the seed shape and can be categorized into the base, shaft and top portions of the building. The bottom portion consists of four seed shapes scaled down to small vertical slabs with four additional copies of the seed shape scaled down to bars. These scaled-down seed shapes are then rotated for a pinwheel effect in plan. An additional scaled-down seed shape representing the lobby is skewed and translated to the corner. The middle portion consists of three sets of groupings stacked vertically. Each grouping consists of a spandrel level, a vision glass level and two sets of horizontal mullions. Each of these was a vertically scaled-down version of the seed shape. At the spandrel and vision glass levels four reduced copies of the seed shape are skewed and rotated as per the pinwheel structure shown in plan and another reduced copy of the seed shape straddles one corner of the seed shape. The crown portion, similar to the base area, has four seed shapes scaled down to thin slabs, rotated to produce a pinwheel shape similar to the base. There is a scaled-down seed shape that remains in the center and another reduced copy of the seed shape translated over to where it straddles one corner of the seed shape similar to the shaft portion of the structure. Lastly there are two copies of the seed shape which are skewed and rotated as one arm of the pinwheel. They are arranged above each other to continue the vertical arrangement from the middle section.

Wright's buildings have been reviewed and appreciated by critics for exhibiting "fractal" qualities at different scales. As one approaches one of his structures there is a progression or

unfolding of additional elements or details which reflect variations of buildings characteristics [Lorenz 2003]. Although this experience is not a direct correspondence to the self-similarity characteristic of IFS based fractals, it is analogous; this is especially interesting considering that the concept of fractals did not become wide-spread until years after Wright's death.

Norman Crowe compared Wright and Le Corbusier, contemporaries of Mondrian, and the relationship of their architecture to nature [Crowe 1999]. A comparison of their respective masterpieces, Fallingwater and Villa Savoye, highlights the differences in their approach. While Villa Savoye represents a "celestial vision" developed out of Greco-Roman classicism, Fallingwater brings the visitor back to earth with a structure based on an emerging American architecture enmeshed in its natural setting. Cynthia Schneider has compared Fallingwater with another example of celestial architecture, the Guggenheim Museum in New York [Schneider 1999]. The Guggenheim interacts with its environment in a way similar to the Villa Savoye but, like Fallingwater, it is considered an example of organic architecture. Thorsten Schnier and John Gero have used principles of genetic engineering on examples of Wright's stained glass and Mondrian's artwork [Schnier and Gero 1998]. They performed the genetic operations of mutation and cross-over of their respective genes to create hybrid art forms. These genes are analogous to the IFS codes that map the transformations of organic fractal architecture.

Wright and Mondrian believed that Truth could be achieved by reducing nature to her most fundamental forms. They viewed their art as part of the dynamic whole of the cosmos expressing inner harmonies and the basic truths of the universe. These views are characteristic of the reduction of nature's forms to IFS codes and the fractal relation of the part to the whole.

Mondrian was a disciple of Theosophy and believed religion and art were on parallel paths: the aim of both was to transcend matter and understand the universal. "Religion always sought to harmonize man with nature, that is, with untransformed nature" [Mondrian 1993]. Mondrian revealed his relationship with nature in his essay "Natural Reality and Abstract Reality," in which his characters agree that beauty and inspiration are to be found in nature. The Mondrian character, the Abstract-Real Painter, believes they need in a sense to look through nature for its transcendental knowledge. He wanted to pierce the chaotic complexity of natural appearances, to glimpse past this veil to see the ultimate harmony and "cosmic rhythm" of the universe. The aim of his art was to capture the underlying structure of nature. Given the enduring popularity of his work "perhaps Mondrian succeeded in glimpsing through nature's veil with unmatched clarity" [Taylor 2004]. The relationship of Mondrian's art to the underlying transcendental structure of nature makes it an appealing candidate for applications of IFS.

Although Mondrian's art is associated only with two-dimensional representation, he frequently wrote about architecture and Neo-Plasticism. In his article "Toward the True Vision of Reality" Mondrian noted "While Neo-Plasticism now has its own intrinsic value, as painting and sculpture, it may be considered as a preparation for future architecture" [Mondrian 1993]. In "Home-Street-City" he wrote, "The application of Neo-Plastic laws is the path of progress in architecture" [Mondrian 1993] and in "Is Painting Inferior to Architecture?" he stated, "The new aesthetic for architecture is that of new painting….Through the unity of the new aesthetic, architecture and painting can together form one art and can dissolve each other" [Mondrian 1993]. He experimented with

architectural aspects of his work in some stage designs as well as the design of his own studio. He was part of the De Stijl movement, which significantly affected architectural design with some notable buildings.

Mondrian based his art on the presence of scaffolds and the spatial interplay between their pictorial parts, which is analogous to the manifestation of IFS rules or codes and the resulting interplay of the parts to the whole. It seems fitting to explore this relationship by overlaying IFS with Mondrian's work. In fig. 6, we take the slab seed shape and apply transformation rules to produce a first iteration of a building facade that is inspired by Mondrian's *Composition No.1, Composition with Yellow*. The upper right element and the bottom three elements, in addition to being scaled down, are rotated 90° to the right. The middle element on the left side is scaled down and rotated 180°. The upper left element is simply scaled down. In the second and third iterations (figs. 7 and 8), they increasingly exhibit the rhythm Mondrian discussed in his writings and approach the vitality of his Boogie-Woogie paintings. In figs. 9 and 10 this facade is incorporated with another Mondrian-influenced IFS facade into an architectural structure.

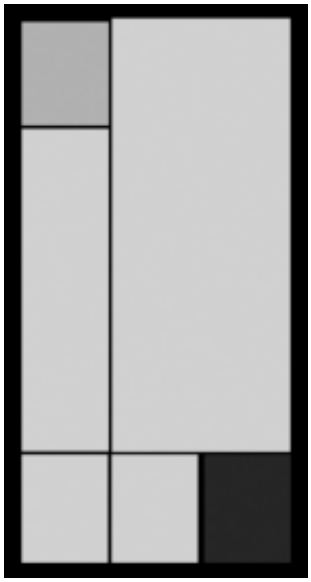


Fig. 6

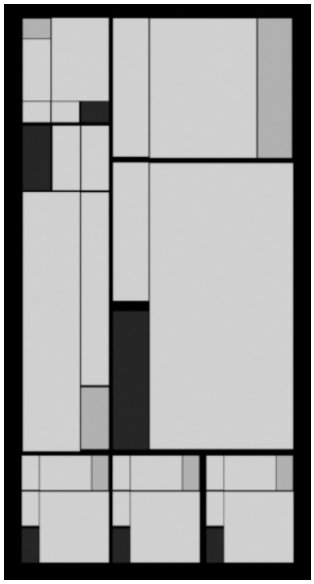


Fig. 7

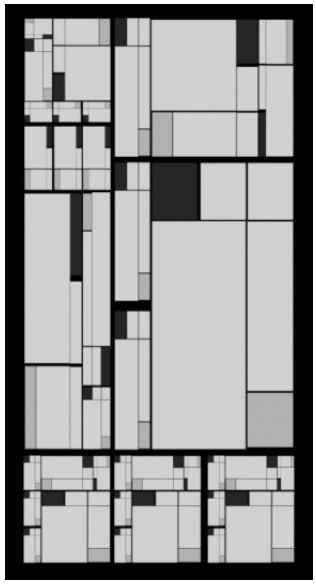
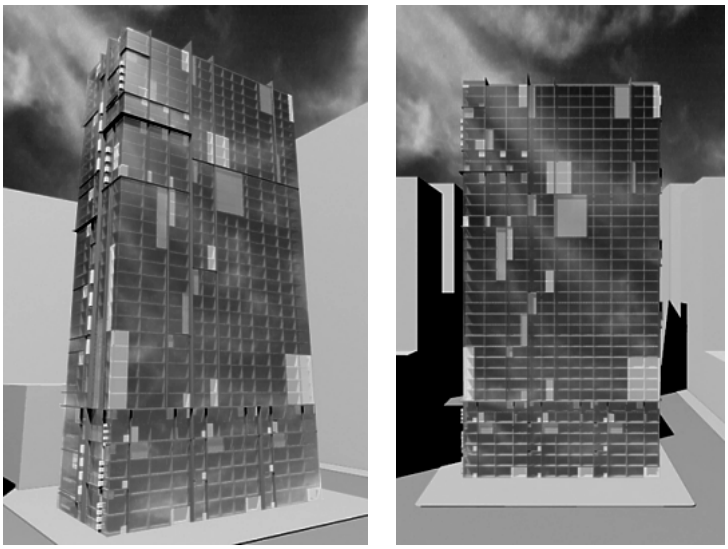


Fig. 8



Figs. 9, 10

I have been struck with the natural association of IFS and architecture to generate structures that engender a natural affinity in the observer. In applying IFS to Frank Lloyd Wright, the principal architect associated with organic architecture, and the artist Piet Mondrian, who represents the other end of the spectrum, I hope I have demonstrated the range of possible architectural applications of IFS. I have continued exploring this concept at http://www.fractalarchitect.com and encourage the reader to continue the experiment.

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About the author

James Harris has a degree in architecture from Catholic University, an MBA from Fordham University and is currently a licensed architect in New York City. As a Senior Vice President for the Related Companies, he has been involved in large scale New York developments, building over four million square feet of commercial and residential structures in Manhattan.