10

Parquet Deformations: A Subtle, Intricate Art Form

July, 1983

WHATS the difference between music and visual art? If I were asked this, I would have no hesitation in replying. To me, the major difference is clearly temporality. Works of music intrinsically involve time; works of art do not. More precisely, pieces of music consist of sounds intended to be played and heard in a specific order and at a specific speed. Music is thus fundamentally one-dimensional; it is tied to the rhythms of our existence. Works of visual art, by contrast, are generally two-dimensional or three-dimensional. Paintings and sculptures seldom have any intrinsic "scanning order" built into them that the eye must follow. Mobiles and other pieces of kinetic art may change over time, but often without any specific initial state or final state or intermediate stages. You are free to come and go as you please.

There are exceptions to this generalization, of course. European art has its grand friezes and historic cycloramas, and Oriental art has intricate pastoral scrolls of up to hundreds of feet in length. These types of visual art impose a temporal order and speed on the scanning eye. There is a starting point and a final point. Usually, as in stories, these points represent states of relative calm-especially the end. In between them, various types of tension are built up and resolved in an idiosyncratic but pleasing visual rhythm. The calmer end states are usually orderly and visually simple, while the tenser intermediate states are usually more chaotic and visually confusing. If you replace "visual" by "aural", virtually the same could be said of music.

I have been fascinated for many years by the idea of trying to capture the essence of the musical experience in visual form. I have my own ideas as to how this can be done; in fact, I spent. several years working out a form of visual music. It is perhaps the most original and creative thing I have ever done. However, by no means do I feel that there is a unique or best way to carry out this task of "translation", and indeed I have often wondered how others might attempt to do it. I have seen a few such attempts, but most of them, unfortunately, did not grab me. One striking counterexample is the set of "parquet deformations" meta-composed by William Huff, a professor of architectural design at the State University of New York at Buffalo.

I say "meta-composed" for a very good reason. Huff himself has never executed a single parquet deformation. He has elicited hundreds of them, however, from his students, and in so doing has brought this form of art to a high degree of refinement. Huff might be likened to the conductor of a fine orchestra, who of course makes no sound whatsoever during a performance. And yet we tend to give the conductor most of the credit for the quality of the sound. We can only guess how much preparation and coaching went into this performance. And what about the selection of the pieces and tempos and styles-not to mention the many-year process of culling the performers themselves?

So it is with William Huff. For 23 years, his students at Carnegie-Mellon and SUNY at Buffalo have been prodded into flights of artistic inspiration, and it is thanks to Huff's vision of what constitutes quality that some very beautiful results have emerged. Not only has he elicited outstanding work from students, he has also carefully selected what he feels to be the best pieces and these he is preserving in archives. For these reasons, I shall at times refer to Huff's "creations", but it is always in this more indirect sense of "meta-creations" that I shall mean it.

Not to take credit from the students who executed the individual pieces, there is a larger sense of the term "credit" that goes exclusively to Huff, the person who has shaped this whole art form himself. Let me use an analogy. Gazelles are marvelous beasts, yet it is not they themselves but the selective pressures of evolution that are responsible for their species' unique and wondrous qualities. Huff's judgments and comments have here played the role of those impersonal evolutionary selective pressures, and out of them has been molded a living and dynamic tradition, a "species" of art exemplified and extended by each new instance.

* * *

All that remains to be said by way of introduction is the meaning of the term parquet deformation. It is nearly self-explanatory, actually: traditionally, a parquet is a regular mosaic made out of inlaid wood, on the floor of an elegant room; and a deformation-well, it's somewhere in between a distortion and a transformation. Huff's parquets are more abstract: they are regular tessellations (or tilings) of the plane, ideally drawn with zero-thickness line segments and curves. The deformations are not arbitrary but must satisfy two basic requirements:

(1) There shall be change only in one dimension, so that one can see a temporal progression in which one tessellation gradually becomes another;

(2) At each stage, the pattern must constitute a regular tessellation of the plane (i.e., there must be a unit cell that could combine with itself so as to cover an infinite plane exactly).

(Actually, the second requirement is not usually adhered to strictly. It would be more accurate to say that the unit cell at any stage of a parquet deformation can be easily modified so as to allow it to tile the plane perfectly.)

From this very simple idea emerge some stunningly beautiful creations. Huff explains that he was originally inspired, back in 1960, by the woodcut "Day and Night" of M. C. Escher. In that work, forms of birds tiling the plane are gradually distorted (as the eye scans downwards) until they become diamond-shaped, looking like the checkerboard pattern of cultivated fields seen from the air. Escher is now famous for his tessellations, both pure and distorted, as well as for other hauntingly strange visual games he played with art and reality.

Whereas Escher's tessellations almost always involve animals, Huff decided to limit his scope to purely geometric forms. In a way, this is like a decision by a composer to use austere musical patterns and to totally eschew anything that might conjure up a "program" (that is, some sort of image or story behind the sounds). An effect of this decision is that the beauty and visual interest must come entirely from the complexity and the subtlety of the interplay of abstract forms. There is nothing to "charm" the eye, as with pictures of animals. There is only the uninterpreted, unembellished perceptual experience.

Because of the linearity of this form of art, Huff has likened it to visual music. He writes:

> Though I am spectacularly ignorant of music, tone deaf, and hated those piano lessons (yet can be enthralled by Bach, Vivaldi, or Debussy), I have the students 'read' their designs as I suppose a musician might scan a work: the themes, the events, the intervals, the number of steps from one event to another, the rhythms, the repetitions (which can be destructive, if not totally controlled, as well as reinforcing). These are principally temporal, not spatial, compositions (though all predominantly temporal compositions have, of necessity, an element of the spatial and vice versa-e.g., the single-frame picture is the basic element of the moving picture).

* * *

What are the basic elements of a parquet deformation? First of all, there is the class of allowed parquets. On this, Huff writes the following:

We play a different (or rather, tighter) gate than does Escher. We work with only A tiles (i.e., congruent tiles of the same handedness). We do not use, as he does, A and A' tiles (i.e., congruent tiles of both handednesses). Finally, we don't use A and B tiles (i.e., two different interlocking tiles), since two such tiles can always be seen as subdivisions of a single larger tile.

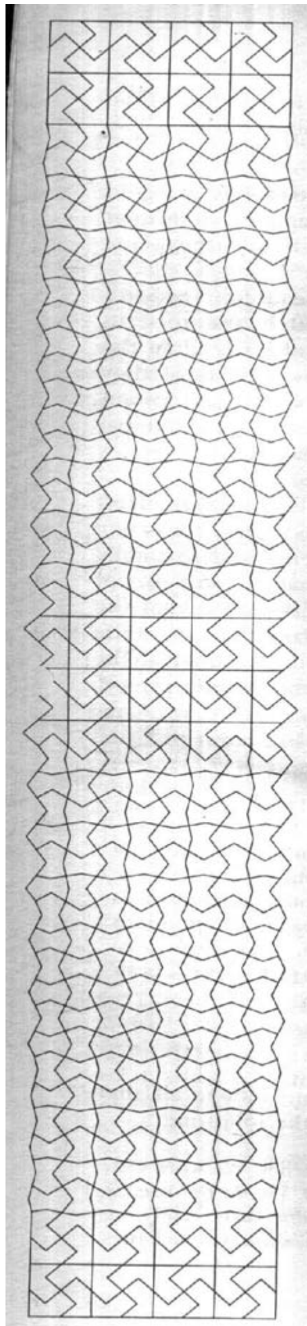


FIGURE: 10-1 *Fylfor Flipflop by Fred Watts. Created in the studio of William Huff (1963).*

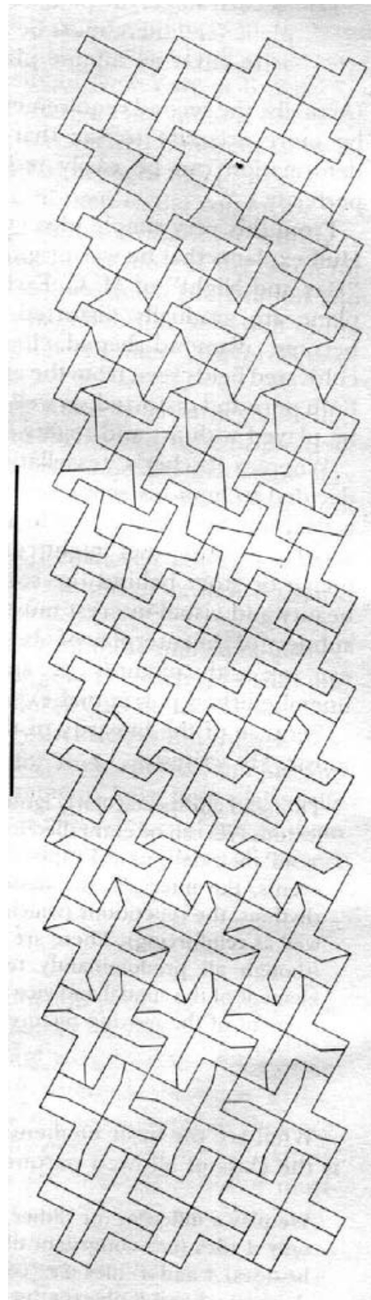


FIGURE: 10-2 *Crossover by Richard Long. Created in the studio of William Huff (1963).*

The other basic element is the repertoire of standard deforming devices. Typical devices include:

- lengthening or shortening a line;
- rotating a line;
- introducing a "hinge" somewhere inside a line segment so that it can "flex";
- introducing a "bump" or "pimple" or "tooth" (a small intrusion or extrusion having a simple shape) in the middle of a line or at a vertex;
- shifting, rotating, expanding, or contracting a group of lines that form a natural subunit;

and variations on these themes. To understand these descriptions, you must realize that a reference to "a line" or "a vertex" is actually a reference to a line or vertex inside a unit cell, and therefore, when one such line or vertex is altered, all the corresponding lines or vertices that play the same role in the copies of that cell undergo the same change. Since some of those copies may be at 90 degrees (or other angles) with respect to the master cell, one locally innocent-looking change may induce changes at corresponding spots, resulting in unexpected interactions whose visual consequences may be quite exciting.

*   *   *

Without further ado, let us proceed to examine some specific pieces. Look at the one called "Fylfot Flipflop" (Figure 10-1). It is an early one, executed in 1963 by Fred Watts at Carnegie-Mellon. If you simply let your eye skim across the topmost line, you will get the distinct sensation of scanning a tiny mountain range. At either edge, you begin with a perfectly flat plain, and then you move into gently rolling hills, which become taller and steeper, eventually turning into jagged peaks; then past the centerpoint, these start to soften into lower foothills, which gradually tail off into the plain again. This much is obvious even upon a casual glance. Subtler to see is the line just below, whose zigging and zagging is 180 degrees out of phase with the top line. Thus notice that in the very center, that line is completely at rest: a perfectly horizontal stretch flanked on either side by increasingly toothy regions. Below it there are seven more horizontal lines. Thus if one completely filtered out the vertical lines, one would see nine horizontal lines stacked above one another, the odd-numbered ones jagged in the center, the even-numbered ones smooth in the center.

Now what about the vertical lines? Both the lefthand and righthand borderlines are perfectly straight vertical lines. However, their immediate neighbors are as jagged as possible, consisting of repeated 90-degree bends, back and forth. Then the next vertical line nearer the center is practically straight up and down again. Then there is a wavy one again, and so on. As you move across the picture, you see that the jagged ones gradually get less jagged and the straight ones get increasingly jagged, so that in the middle the roles are completely reversed. Then the process continues, so that by the time you've reached the other side, the lines are back to normal again. If you could filter out the horizontal lines, you would see a simple pattern of quite jaggy lines alternating with less jaggy lines.

When these two extremely simple independent patterns-the horizontal and the vertical-are superimposed, what emerges is an unexpectedly rich perceptual feast. At the far left and right, the eye picks out fylfots-that is, swastikas-of either handedness contained inside perfect squares. In the center, the eye immediately sees that the central fylfots are all gone, replaced by perfect crosses inside pinwheels.

And then a queer perceptual reversal takes place. If you just shift your focus of attention diagonally by half a pinwheel, you will notice that there is a fylfot right there before your eyes! In fact, suddenly they appear all over the central section where before you'd been seeing only crosses inside pinwheels! And conversely, of course, now when you look at either end, you'll see pinwheels everywhere with crosses inside them. No fylfots! It is an astonishingly simple design, yet this effect catches nearly everyone really off guard.

This is a simple example of the ubiquitous visual phenomenon called regrouping, in which the boundary line of the unit cell shifts so that structures jump out at the eye that before were completely submerged and invisible -while conversely, of course, structures that a moment ago were totally obvious have now become invisible, having been split into separate conceptual pieces by the act of regrouping, or shift of perceptual boundaries. It is both a perceptual and conceptual phenomenon, a delight to that subtle mixture of eye and mind that is most sensitive to pattern.

For another example of regrouping, take a look at "Crossover" (Figure 10-2), also executed at Carnegie-Mellon in 1963 by Richard Lane. Something really amazing happens in the middle, but I won't tell you what. Just find it yourself by careful looking.

By the way, there are still features left to be explained in "Fylfot Flipflop". At first it appears to be mirror-symmetric. For instance, all the fvlfots at the left end are spinning counterclockwise, while all the ones at the right end are spinning clockwise. So far, so symmetric. But in the middle, all the fylfots go counterclockwise. This surely violates the symmetry. Furthermore, the one-quarter-way and three-quarter-way stages of this deformation, which ought to be mirror images of each other, bear no resemblance at all to each other. Can you figure out the logic behind this subtle asymmetry between the left and right sides?

This piece also illustrates one more way in which parquet deformations resemble music. A unit cell-or rather, a vertical cross-section consisting of a stack of unit cells-is analogous to a measure •in music. The regular pulse of a piece of music is given by the repetition of unit cells across the page.

And the flow of a melodic line across measure boundaries is modeled by the flow of a visual line-such as the mountain range lines-across many unit cells.

* * *

Bach's music is always called up in discussions of the relationship of mathematical patterns to music, and this occasion is no exception. I am reminded especially of some of his texturally more uniform pieces, such as certain preludes from the Well-Tempered Clavier, in which in each measure there is a certain pattern executed once or twice, possibly more times. From measure to measure this pattern undergoes a slow metamorphosis, meandering over the course of many measures from one region of harmonic space to far distant regions and then slowly returning via some circuitous route. For specific examples, you might listen to (or look at the scores of): Book I, numbers 1, 2; Book II, numbers 3, 15. Many of the other preludes have this feature in places, though not for their entirety.

Bach seldom deliberately set out to play with the perceptual systems of his listeners. Artists of his century, although they occasionally played perceptual games, were considerably less sophisticated about, and less fascinated with, issues that we now deem part of perceptual psychology. Such phenomena as regrouping would undoubtedly have intrigued Bach, and I for one sometimes wish that he had known of and been able to try out certain effects-but then I remind myself that whatever time Bach might have spent playing with new-fangled ideas would have had to be subtracted from his time to produce the masterpieces that we know and love, so why tamper with something that precious?

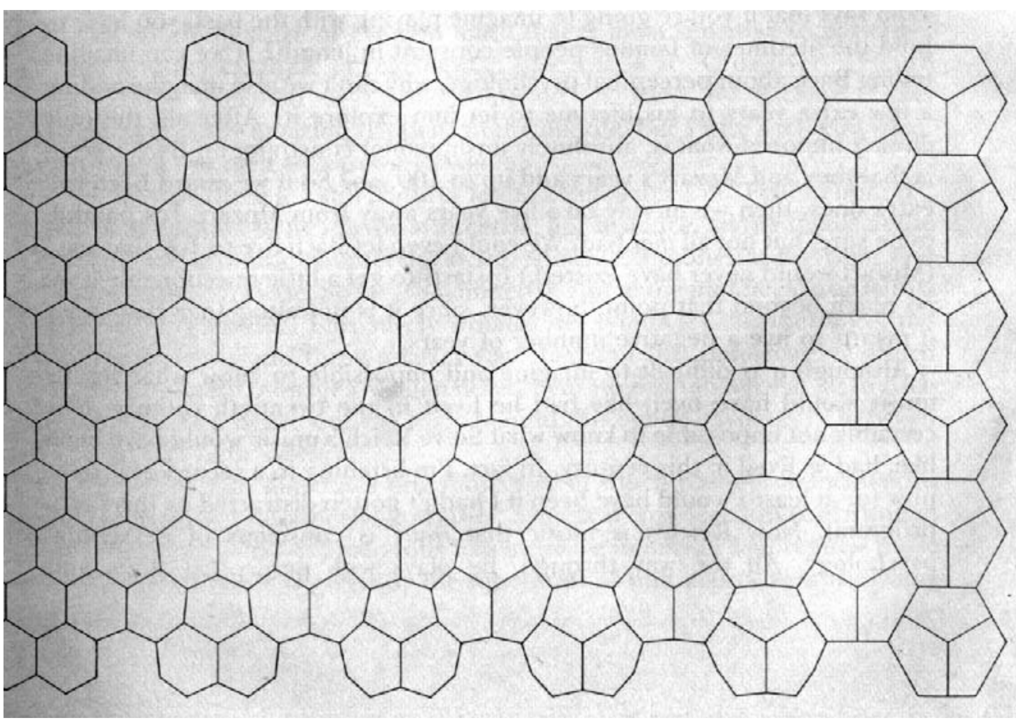
On the other hand, I don't find that argument 100 percent compelling. Who says that if you're going to imagine playing with the past, you have to hold the lifetimes of famous people constant in length? If we can imagine telling Bach about perceptual psychology, why can't we also imagine adding a few extra years to his lifetime to let him explore it? After all, the only divinely imposed (that is, absolutely unslippable) constraint on Bach's years is that they and Mozart's years add up to 100, no? So if we award Bach five extra ones, then we merely take five years away from Mozart. It's painful, to be sure, but not all that bad. We could even let Bach live to 100 that way! (Mozart would never have existed.) It starts to get a little questionable if we go much beyond that point, however, since it is not altogether clear what it means to live a negative number of years.

Although it is difficult to imagine and impossible to know what Bach's music would have been like had he lived in the twentieth century, it is certainly not impossible to know what Steve Reich's music would have been like, had he lived in this century. In fact, I'm listening to a record of it right now (or at least I would have been if I hadn't gotten distracted by this radio program). Now Reich's is music that really is conscious of perceptual psychology. All the way through, he plays with perceptual shifts and ambiguities, pivoting from one rhythm to another, from one harmonic origin to another, constantly keeping the listener on edge and tingling with nervous energy. Imagine a piece like Ravel's "Bolero", only with a much finer grain size, so that instead of roughly a one-minute unit cell, it has a three-second unit cell. Its changes are tiny enough that sometimes you barely can tell it is changing at all, while other times the changes jump out at you. What Reich piece am I listening to (or rather, would I be listening to if I weren't still listening to this radio program)? Well, it hardly matters, since most of them satisfy this characterization, but for the sake of specificity you might try "Music for a Large Ensemble", "Octet", "Violin Phase", "Vermont Counterpoint", or his recent choral work "Tehillim".

*   *   *

Let us now return to parquet deformations. "Dizzy Bee" (Figure 10-3), executed by Richard Mesnik at Carnegie-Mellon in 1964, involves --perceptual tricks of another sort. The left side looks like a perfect honeycomb or-somewhat less poetically-a perfect bathroom floor. However, as we move rightward, its perfection seems cast in doubt as the rigidity of the lattice gives way to rounder-seeming shapes. Then we notice that three of them have combined to form one larger shape: a super hexagon made up of three rather squashed pentagons. The curious thing is that if we now sweep our eyes right to left, back to the beginning, we can no longer

FIGURE 10-3. *Dizzy Bee, by Richard Mesnik. Created in the studio of William Huff (1964).*



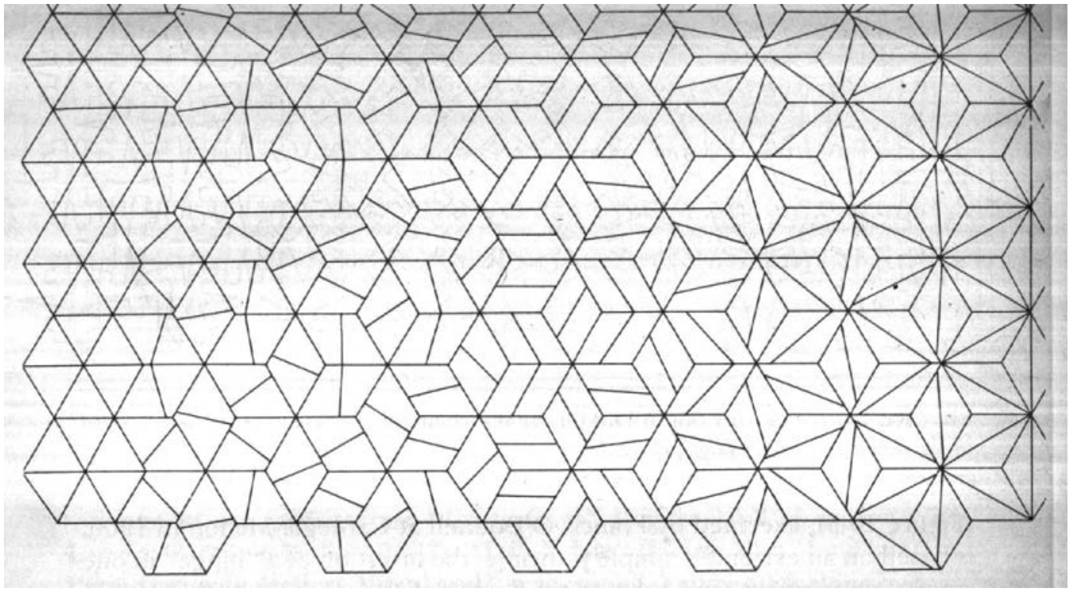


FIGURE 10-4. *Consternation, by Scott Grady. Created in the studio of William Huff (1977).*

see the left side in quite the way we saw it before. The small hexagons now are constantly grouping themselves into threes, although the grouping changes quickly. We experience "flickering clusters" in our minds, in which groups form for an instant and then disband, their components immediately regrouping in new combinations, and so on. The poetic term "flickering clusters" comes from a famous theory of how water molecules behave, the bonding in that case coming from hydrogen bonds rather than mental ones. (See the P.S. to Chapter 26.)

Even more dizzying, perhaps, than "Dizzy Bee" is "Consternation" (Figure 10-4), executed by Scott Grady of SUNY at Buffalo in 1977. This is another parquet deformation in which hexagons. ,and cubes vie for perceptual supremacy. This one is so complex and agitated in appearance that I scarcely dare to attempt an analysis. In its intermediate regions, I find the same extremely exciting kind of visual pseudo-chaos as in Escher's best deformations.

Perhaps irrelevantly, but I suspect not, the names of many of these studies remind me of pieces by Zez Confrey, a composer most famous during the twenties for his novelty piano solos such as "Dizzy Fingers", "Kitten on the Keys", and-my favorite- "Flutter by, Butterfly". Confrey specialized in pushing rag music to its limits without losing musical charm, and some of the results seem to me to have a saucy, dazzling appeal not unlike the jazzy appearance of this parquet deformation, and others.

The next parquet deformation, "Oddity out of Old Oriental Ornament"

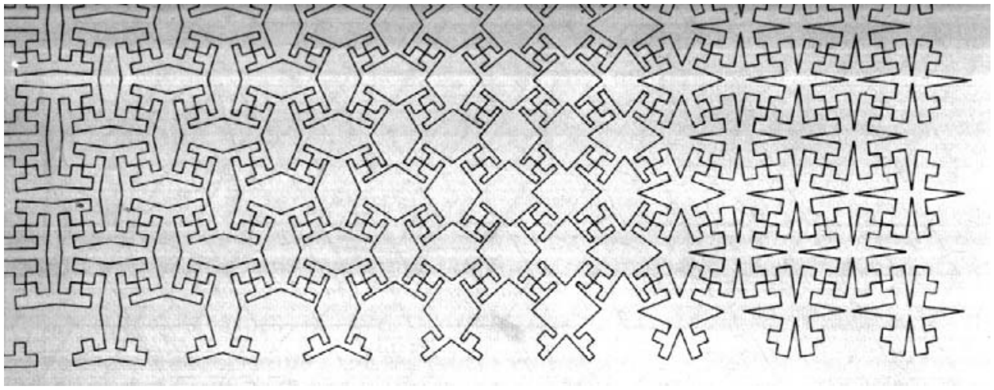


FIGURE 10-5. *Oddity out of Old Oriental Ornament, by Francis O'Donnell. Created in the studio of William Huff (1966).*

(Figure 10-5), executed by Francis O'Donnell at Carnegie-Mellon in 1966, is based on an extremely simple principle: the insertion of a "hinge" in one single line segment, and subsequent flexing of the segment at that hinge! The reason for the stunningly rich results is that the unit cell that creates the tessellation occurs both vertically and horizontally, so that flexing it one way induces a crosswise flexing as well, and the two flexings combine to yield this curious and unexpected pattern.

Another one that shows the amazing results of an extremely simple but carefully chosen tranformation principle is "Y Knot" (Figure 10-6),

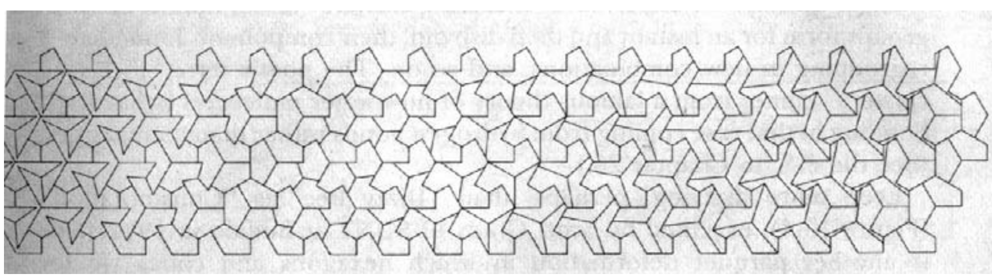


FIGURE 10-6. *Y Knot, hi Leland Chen. Created in the studio of William Huff (1977).*

executed by Leland Chen at SUNY at Buffalo in 1977. If you look at it with full attention, you will see that its unit cell is in the shape of a three-bladed propeller, and that unit cell never changes whatsoever in shape. All that does change is the 'Y' lodged tightly inside that unit cell. And the only way that 'Y' changes is by rotating clockwise very slowly! Admittedly, in the final stages of rotation, this forces some previously constant line segments to extend themselves a little bit, but this does not change the outline of the unit cell whatsoever. What well-chosen simplicity can do!

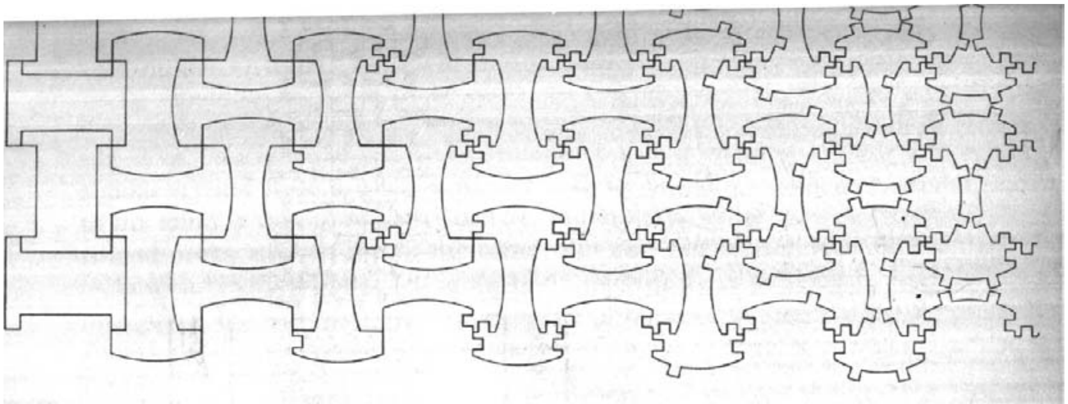
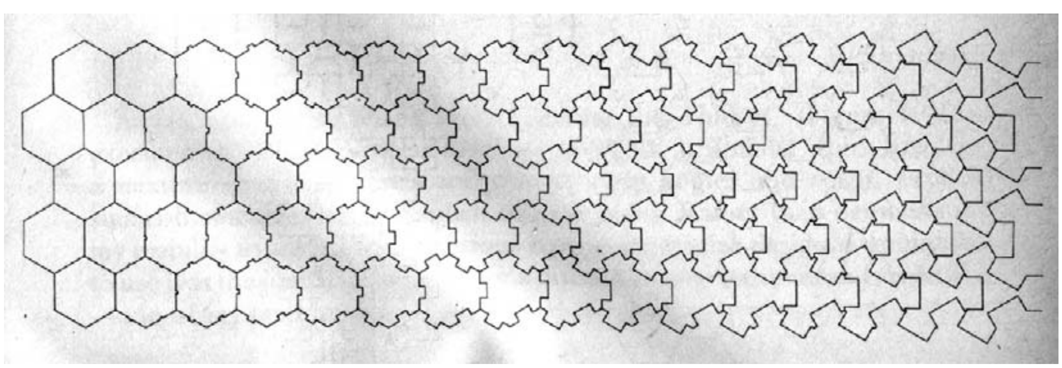


FIGURE 10-7. *Crazy Cogs, by Arne Larson. Created in the studio of William Huff (1963).*

Three of my favorites are "Crazy Cogs" (Figure 10-7, done by Arne Larson, Carnegie-Mellon, 1963), "Trifoliolate" (Figure 10-8, done by Glen Paris, Carnegie-Mellon, 1966), and "Arabesque" (Figure 10-9, done by Joel Napach, SUNY at Buffalo, 1979). They all share the feature of getting more and more intricate as you move rightward. Most of the earlier ones we've seen don't have this extreme quality of irreversibility-that is, the ratcheted quality that signals that an evolutionary process is taking place. I can't help wondering if the designers didn't feel that they'd painted themselves into a corner, especially in the case of "Arabesque". Is there any way you can back out of that super-tangle except by retrograde motion-that is, retracing your steps? I suspect there is, but I wouldn't care to try to discover it.

To contrast with this, consider "Razor Blades", an extended study in relative calmness (Figure 10-10). It was done at Carnegie-Mellon in 1966, but unfortunately it is unsigned. Like the first one we discussed, this one can be broken up into very long waving horizontal lines and vertical structures crossing them. It's a little easier to see them if you start at the right side. For instance, you can see that just below the top, there is a long snaky line

FIGURE 10-8. *Trifoliolate, by Glen Paris. Created n(//), hub,-I_ William Huff (1966).*



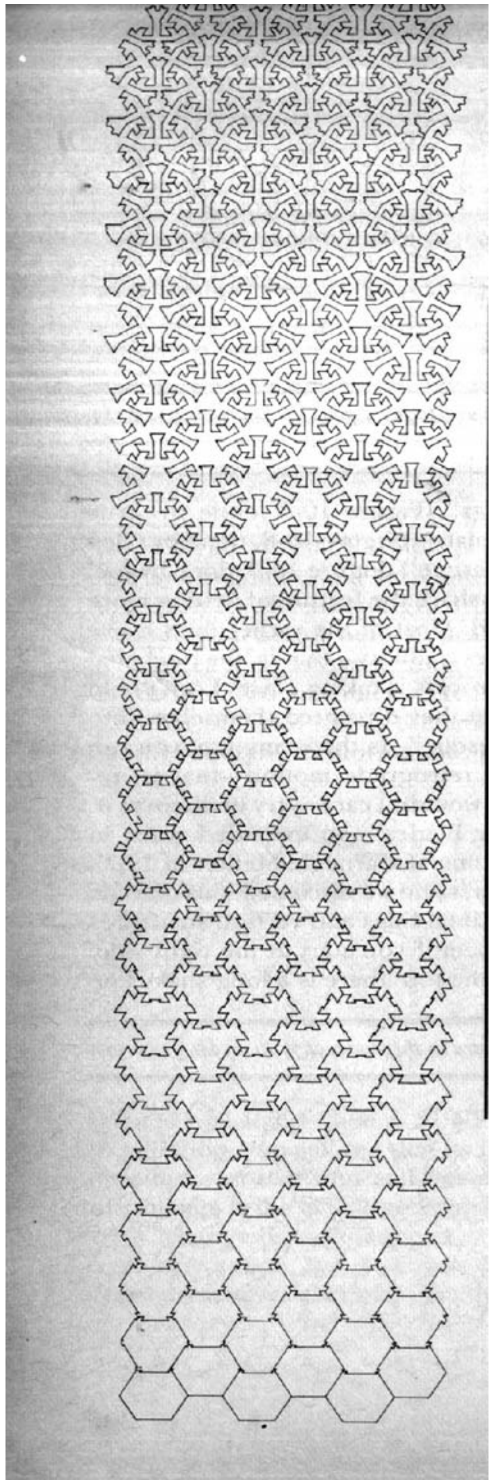


FIGURE 10-9: *Arabesque by Joel Napach Created in the studio of William Huff (1979).*

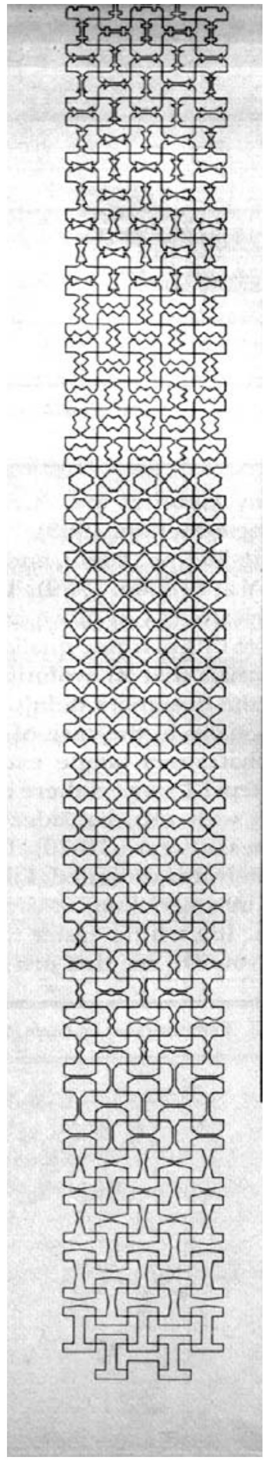


FIGURE 10-10: Razaor Blades (unsigned) Created in the studio of William Huff (1966).

with numerous little "nicks" in it, undulating its way leftwards and in so doing shedding some of those nicks, so that at the very left edge it has degenerated into a perfect "square wave", as such a periodic wave form is called in Fourier analysis. Complementing this horizontal structure is a similar vertical structure that is harder to describe. The thought that comes to my mind is that of two very ornate, rather rectangular hourglasses with ringed necks, one on top of the other. But you can see for yourself.

As with "Fylfot Flipflop" (Figure 10-1), each of these patterns by itself is intriguing, but of course the real excitement comes from the daring act of superimposing them. Incidentally, I know of no piece of visual art that better captures the feeling of beauty and intricacy of a Steve Reich piece, created by slow "adiabatic" changes floating on top of the chaos and dynamism of the lower-level frenzy. Looking back, I see I began by describing this parquet deformation as "calm". Well, what do you know? Maybe I would be a good candidate for inclusion in The New Yorker's occasional notes titled "Our Forgetful Authors".

More seriously, there is a reason for this inconsistency. One's emotional response to a given work of art, whether visual or musical, is not static and unchanging. There is no way to know how you will respond, the next time you hear or see one of your favorite pieces. It may leave you unmoved, or it may thrill you to the bones. It depends on your mood, what has recently happened, what chances to strike you, and many other subtle intangibles. One's reaction can even change in the course of a few minutes. So I won't apologize for this seeming lapse.

Let us now look at "Cucaracha" (Figure 10-11), executed in 1977 by Jorge Gutierrez at SUNY at Buffalo. It moves from the utmost geometricity-a lattice of perfect diamonds-through a sequence of gradually more arbitrary modifications until it reaches some kind of near-freedom, a dance of strange, angular, quasi-organic forms. This fascinates me. Is entropy increasing or decreasing in this rightward flow toward freedom?

A gracefully spiky deformation is the one wittily titled "Beecombing Blossoms" (Figure 10-12), executed this year by Laird Pylkas at SUNY at Buffalo. Huff told me that Pylkas struggled for weeks with this one, and at the end, when she had satisfactorily resolved her difficulties, she mused, "Why is it that the obvious ideas always take so long to discover?"

* * *

As our last study, let us take "Clearing the Thicket" (Figure 10-13), executed in 1979 by Vincent Marlowe at SUNY at Buffalo, which involves a mixture of straight lines and curves, right angles and cusps, explicit squarish swastikoids and implicit circular holes. Rather than demonstrate my inability to analyze the ferocious complexity of this design, I would like to use it as the jumping-off point for a discussion of computers and creativity - one of my favorite hobbyhorses.

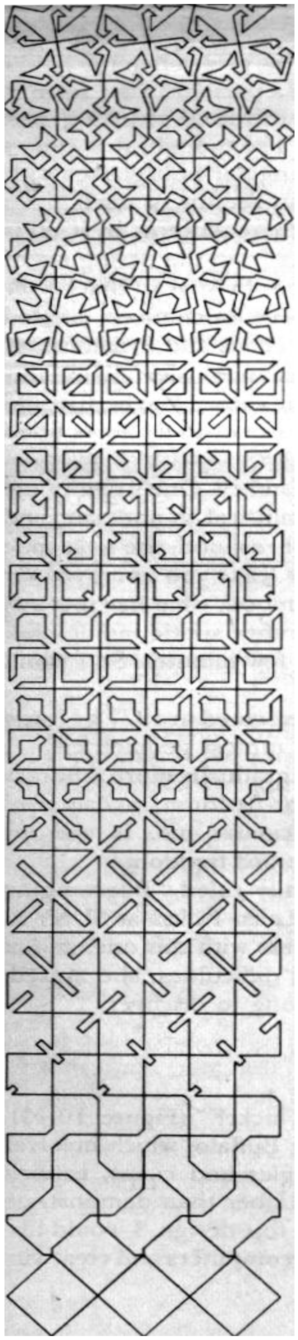


FIGURE 10-11: cucuracha by Jorge Gutierrez Created in the studio of William Huff (1977).

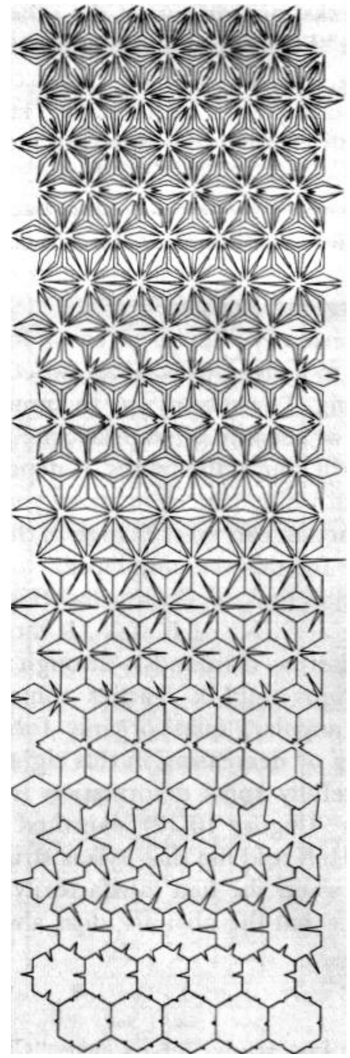


FIGURE 10-12: Becoming Blossoms, by Laird Pylhas. Created in the studio of Wiolliam Huff (1983).

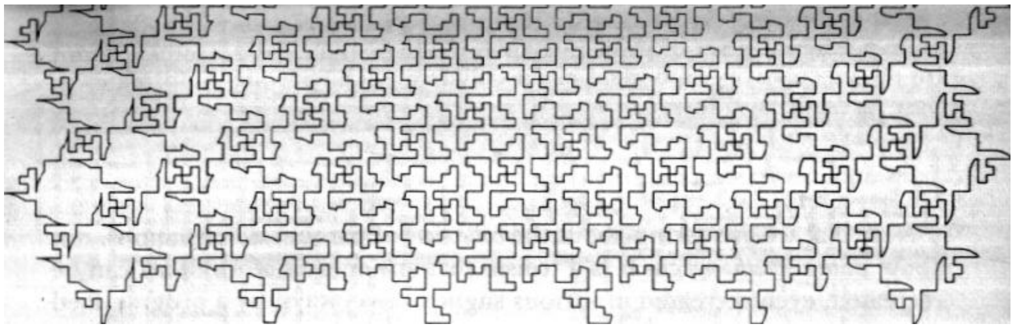


FIGURE 10-13. *Clearing the Thicket, by Vincent Marlowe. Created in the studio of William Huff (1979).*

Some totally new things are going on in this parquet deformation-things that have not appeared in any previous one. Notice the hollow circles on the left side that shrink as you move rightward; notice also that on the right side there are hollow "anticircles" (concave shapes made from four circular arcs turned inside out) that shrink as you move leftward. Now, according to Huff, such an idea had never appeared in any previously created deformations. This means that something unusual happened here-something genuinely creative, something unexpected, unpredictable, surprising, intriguing-and not least, inspiring to future creators.

So the question naturally arises: Would a computer have been able to invent this parquet deformation? Well, put this way it is a naive and ill-posed question, but we can try to make some sense of it. The first thing to point out is that, of course, the phrase "a computer" refers to nothing more than an inert hunk of metal and semiconductors. To go along with this bare computer, this hardware, we need some software and some energy. The former is a specific pattern inserted into the matter binding it with constraints yet imbuing it with goals; the latter is what breathes "life" into it, making it act according to those goals and constraints.

The next point is that the software is what really controls what the machine does; the hardware simply obeys the software's dictates, step by step. And yet, the software could exist in a number of different "instantiations"-that is, realizations in different computer languages. What really counts about the software is not its literal aspect, but a more abstract, general, overall "architecture", which is best described in a nonformal language, such as English. We might say that the plan, the sketch, the central idea of a program is what we are talking about here-not its final realization in some specific formal language or dialect. That is something we can leave to apprentices to carry out, after we have presented them with our informal sketch.

So the question actually becomes less mundane-sounding, more theoretical and philosophical: Is there an architecture to creativity? Is there a plan, a scheme, a set of principles that, if elucidated clearly, could account for all the creativity embodied in the collection of all parquet deformations, past, present, and future?

* * *

Note that we are asking about the collection of parquet deformations, not about some specific work. It is a truism that any specific work of art can be recreated, even recreated in various slightly novel ways, by a programmed computer.

For example, the Dutch artist Piet Mondrian evolved a highly idiosyncratic, somewhat cryptic style of painting over a period of many years.. You can see, if you trace his development over the course of time, exactly where he came from and where he was headed. But if you focus in on just a single Mondrian work, you cannot sense this stylistic momentum -this quality of dynamic, evolving style that any great artist has. Looking at just one work in isolation is like taking a snapshot of something in motion: you capture its instantaneous position but not its momentum. Of course, the snapshot might be blurred, in which case you get a sense of the momentum but lose information about the position. But when you are looking at just a single work of art, there is no mental blurring of its style with that of recent works or soon-to-come works; you have exact position information ("What is the style now ?"), but no momentum information ("Where was it and where is it going?").

Some years ago, the mathematician and computer artist A. Michael Noll took a single Mondrian painting-an abstract, geometric study with seemingly random elements-and from it extracted some statistics concerning the patterns. Given these statistics, he then programmed a computer to generate numerous "pseudo-Mondrian paintings" having the same or different values of these randomness-governing parameters. (See Figure 10-14.) Then he showed the results to naive viewers. The reactions were interesting, in that more people preferred one of the pseudo-Mondrians to the genuine Mondrian!

This is quite amusing, even provocative, but it also is a warning. It proves that a computer can certainly be programmed, after the fact, to imitate-and well-mathematically capturable stylistic aspects of a given work. But it also warns us: Beware of cheap imitations!

Consider the case of parquet deformations. There is no doubt that a computer could be programmed to do any specific parquet deformation-or minor variations on it-without too much trouble. There just aren't that many parameters to any given one. But the essence of any artistic act resides not in selecting particular values for certain parameters, but far deeper: it's in the balancing of a myriad intangible and mostly unconscious mental forces, a judgmental act that results in many conceptual choices that eventually add up to a tangible, perceptible, measurable work of art.

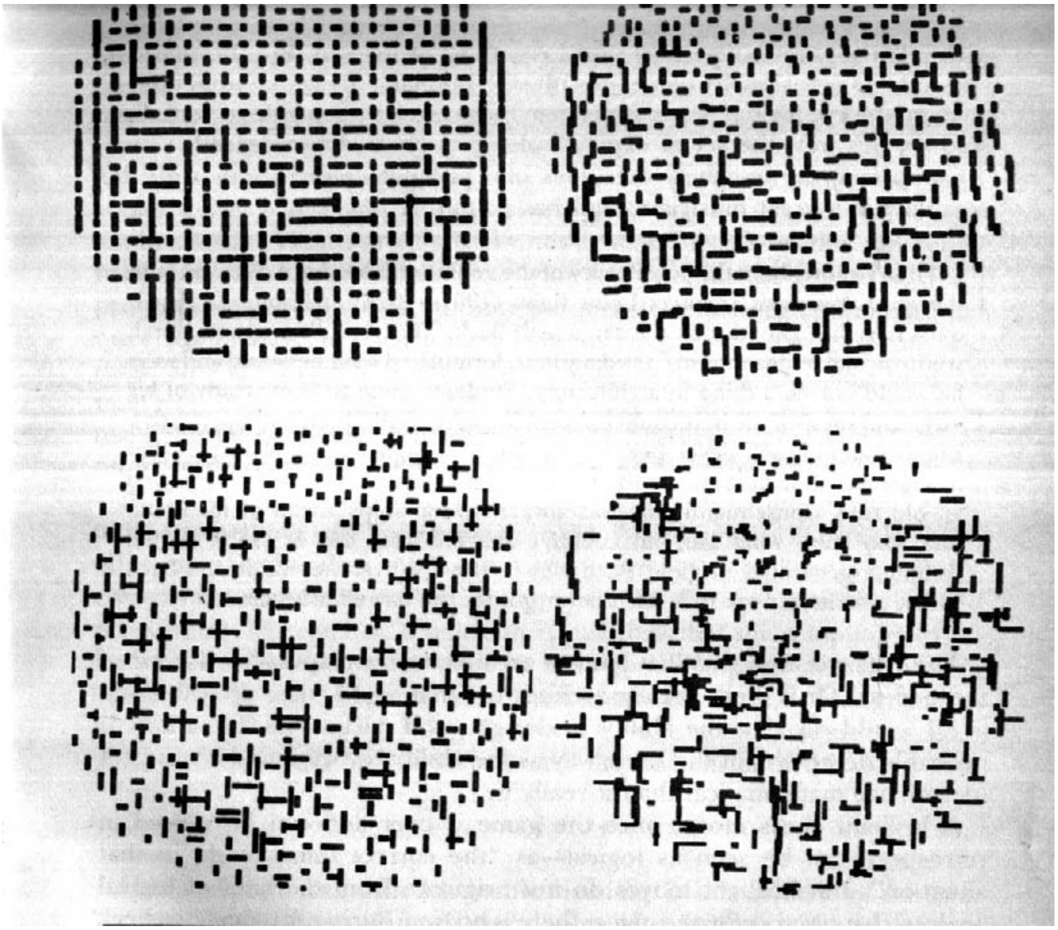


FIGURE 10-14. *One genuine Mondrian plus three computer imitations. Can you spot the Mondrian? If you rotate the figure so that east becomes south, it will be the one in the northwest corner. The Mondrian, done in 1917, is titled Composition with Lines; the three others, done in 1965, comprise a work called Computer Composition with Lines, and were created by a computer at Bell Telephone Laboratories at the behest of computer tamer A. Michael Noll. The subjectively "best "picture was found through surveys; it is the one diagonally opposite thegenuine Mondrian!*

Once the finished work exists, scholars looking at it may seize upon certain qualities of it that lend themselves easily to being parametrized. Anyone can do statistics on a work of art once it is there for the scrutiny, but the ease of doing so can obscure the fact that no one could have said, a priori, what kinds of mathematical observables would turn out to be relevant to the capturing of stylistic aspects of the as-yet-unseen work of art.

Huff's own view on this question of mechanizing the art of parquet deformations closely parallels mine. He-believes that some basic principles could be formulated at the present time enabling a computer to come up with relatively stereotyped yet novel creations of its own. But, he stresses, his students occasionally come up with rule-breaking ideas that noneth°less enchant the eye for deeper reasons than he has so far been able to verbalize. And so, this way, the set of explicit rules gets gradually increased.

Comparing the creativity that goes into parquet deformations with the creativity of a great musician, Huff has written:

> I don't know about the consistency of the genius of Bach, but I did work with the great American architect Louis Kahn (1901- 1974) and suppose that it must have been somewhat the same with Bach. That is, Kahn, out of moral, spiritual, and philosophical considerations, formulated ways he would and ways he would not do a thing in architecture. Students came to know many of his ways, and some of the best could imitate him rather well (though not perfectly). But as Kahn himself developed, he constantly brought in new principles that brought new transformations to his work; and he even occasionally discarded an old rule. Consequently, he was always several steps ahead of his imitators who knew what was but couldn't imagine what will be. So it is that computer-generated `original' Bach is an interesting exercise. But it isn't Bach -that unwritten work that Bach never got to, the day after he died.

The real question is: What kind of architecture is responsible for all of these ideas? Or is there any one architecture that could come up with them all? I would say that the ability to design good parquet deformations is probably deceptive, in the same way as the ability to play good chess is: it looks more mathematical than it really is.

A brilliant chess move, once the game is' over and can be viewed in retrospect, can be seen as logical-as "the correct thing to do in that situation". But brilliant moves do not originate from the kind of logical analysis that occurs after the game; there is no time during the game to check out all the logical consequences of a move. Good chess moves spring from the organization of a good chess mind: a set of perceptions arranged in such a way that certain kinds of ideas leap to mind when certain subtle patterns or cues are present. This way that perceptions have of triggering old and buried memories underlies skill in any type of human activity, not only chess. It's just that in chess the skill is particularly deceptive, because after the fact, it can all be justified by a logical analysis, a fact that seems to hint that the original idea came from logic.

Writing lovely melodies is another one of those deceptive arts. To the mathematically inclined, notes seem like numbers and melodies like number patterns. Therefore all the beauty of a melody seems as if it ought to be describable in some simple mathematical way. But so far, no formula has produced even a single good melody. Of course, you can look back at any melody and write a formula that will produce it and variations on it. But that is retrospective, not prospective. Lovely chess moves and lovely melodies (and lovely theorems in mathematics, etc.) have this in common: every one has idiosyncratic nuances that seem logical a posteriori but that are not easy to anticipate a priori. To the mathematical mind, chess-playing skill and melody-writing skill and theorem-discovering skill seem obviously formalizable, but the truth turns out to be more tantalizingly complex than that. Too many subtle balances are involved.

So it is with parquet deformations, I reckon. Each one taken alone is in some sense mathematical. However, taken as a class, they are not mathematical. This is what's tricky about them. Don't let the apparently mathematical nature of an individual one fool you, for the architecture of a program that could create all these parquet deformations and more good ones would have to incorporate computerized versions of concepts and judgments-and those are much more elusive and complex things than are numbers. In a way, parquet deformations are an ideal case with which to make this point about the subtlety of art, for the very reason that each one on its own appears so simple and rule-bound.

At this point, many critics of computers and artificial intelligence, eager to find something that "computers can't do" (and never will be able to do) often jump too far: they jump to the conclusion that art and, more generally, creativity, are fundamentally uncomputerizable. This is hardly the implied conclusion! The implied conclusion is just this: that for computers to act human, we will have to wait until we have good computer models of such human things as perception, memory, mental categories, learning, and so on. We are a long way from that. But there is no reason to assume that those goals are in principle unattainable, even if they remain far off for a long time.

* * *

I have been playing with the double meaning, in this column, of the term "architecture": it means both the design of a habitat and the abstract essence of a grand structure of any sort. The former has to do with hardware and the latter with software. In a certain sense, William Huff is a professor of both brands of architecture. Obviously his professional training is in the design of "hardware": genuine habitats for humans, and he is in a school where that is what they do. But he is also in the business of forming, in the minds of his students, a softer type of architecture: the mental architecture that underlies the skill to create beauty. Fortunately for him, he can take for granted the whole complexity of a human brain as his starting point upon which to build this architecture. But even so, there is a great art to instilling a sensitivity for beauty and novelty.

When I first met William Huff and saw how abstract and seemingly impractical were the marvelous works produced in his design studio ranging from parquet deformations to strange ways of slicing a cube to gestalt studies using thousands of dots to eye-boggling color patterns-I at first wondered why this man was a professor of architecture. But after conversing with him and his colleagues, my horizons were extended about the nature of their discipline.

The architect Louis Kahn had great respect for the work of William Huff, and it is with his words that I would like to conclude:

> What Huff teaches is not merely what he has learned from someone else, but what.is drawn from his natural gifts and belief in their truth and value. In my belief what he teaches is the introduction to discipline underlying shapes and rhythms, which touches the arts of sight, the arts of sound, and the arts of structure. It teaches students of drawing to search for the abstract and not the representational. This is so good as a reminder of order for the instructors/architectural sketchers (like me), and so good especially for the student sketchers without background. It is the introduction to exactitudes of the kind that instill the religion of the ordered path.

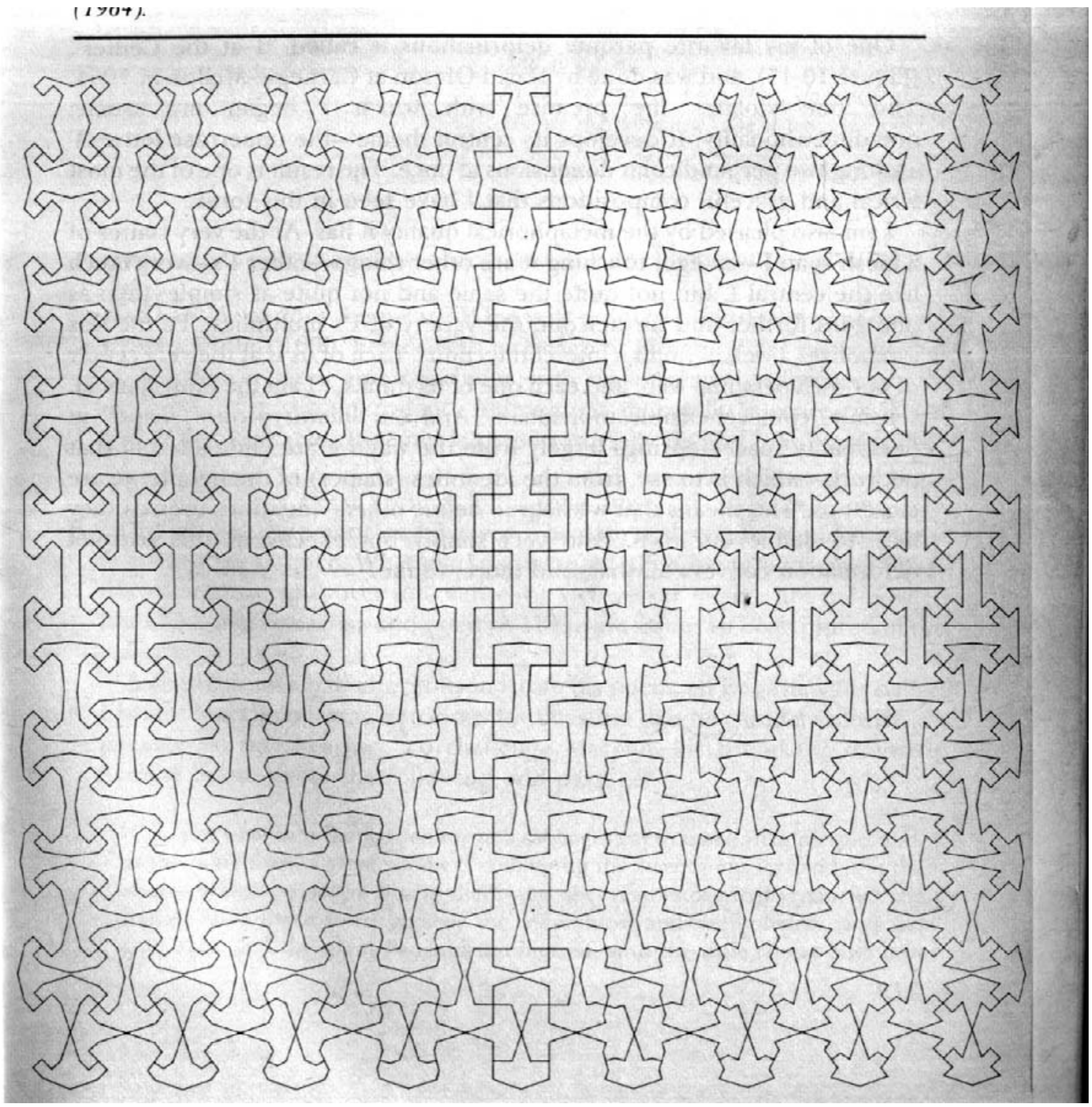
Post Scriptum.

"The religion of the ordered path"-a lovely phrase. I did not know at the time this column was written that it would be my last full column (the one reporting on the results of the Luring Lottery, here Chapter 31, was only a half-column). Both William Huff and I were pleased with my bowing out this way, and I was especially pleased with the phrase with which I bowed out. Though ambiguous, it captures much of the spirit that I attempted to get across in all my columns: dedicated questing after patterned beauty, and particularly after the reasons that certain particular patterns are beautiful.

In this column, I repeatedly claimed that it is relatively easy to make a computer program that creates attractive art within a formula, but not at all easy to make a computer program that constantly comes up with novelty. Some people familiar with the computer art produced in the last couple of decades might pick a fight with me over this. They might point to complex patterns produced by simple algorithms, and then add that there are certain simple algorithms which, when you change merely a few parameters, come up with astonishingly different patterns that no human would be likely to recognize as being each other's near kin. An example is a very simple program I know, which fills a screen with rapidly changing sixfoldsymmetric dot-patterns that look like magnified snowflakes; in just a few seconds, any given pattern will dissolve and be replaced by an unbelievably different sixfold-symmetric pattern. I have stood transfixed at a screen watching these patterns unfold one after another, unable to anticipate in the slightest what will happen next-and yet knowing that the program itself is only a few lines long! I have seen small changes in mathematical formulas produce enormous visual changes in what those formulas represent, graphically.

The trouble is, these parameter-based changes-knob-twiddlings, as they are called in Chapters 12 and 13-are of a different nature than the kinds of novel ideas people' come up with when they vary a given idea. For a machine to make simple variants of a given design, it must possess an algorithm for making that design which has explicit parameters; those parameters are then modifiable, as with the pseudo-Mondrian paintings. But the way people make variations is quite different. They look at some creation by an artist (or computer), and then they abstract from it some quality that they observe in the creation itself (not in some algorithm behind it). This newly abstracted quality may never have been thought of explicitly by the artist (or programmer or computer), yet it is there for the seeing by an acute observer. This perceptual act gets you more than half the way to genuine creativity; the remainder involves treating this new quality as if it

FIGURE 10-15. 1 *at the Center, by David Oleson. Created in the studio of William Huff*



were an explicit knob: "twiddling" it as if it were a parameter that had all along been in the program that made the creation.

That way, the perceptual process is intimately linked up with the generative process: a loop is closed in which perceptions spark new potentials and experimentation with new potentials opens up the way for new perceptions. The element lacking in current computer art is the interaction of perception with generation. Computers do not watch what they do; they simply do it. (See Chapter 23 for more on the idea of self-watching computers.) When programs are able to look at what they've done and perceive it in ways that they never anticipated, then you'll start to get close to the kinds of insight-giving disciplined exercises that Louis Kahn was speaking of when he wrote of the "religion of the ordered path".

* * *

One of my favorite parquet deformations is called "I at the Center" (Figure 10-15), and was done by David Oleson at Carnegie-Mellon in 1964. This one violates the premise with which I began my article: one-dimensionality. It develops its central theme-the uppercase letter `I' -along two perpendicular dimensions at once. The result is one of the most lyrical and graceful compositions that I have seen in this form.

I am also pleased by the metaphorical quality it has. At the very center of a mesh is an I-an ego; touching it are other things-other I's-very much like the central I, but not quite the same and not quite as simple; then as one goes further and further out, the variety of I's multiplies. To me this symbolizes a web of human interconnections. Each of us is at the very center of our own personal web, and each one of us thinks, "I am the most normal, sensible, comprehensible individual." And our identity-our "shape" in personality space-springs largely from the way we are embedded in that network-which is to say, from the identities (shapes) of the people we are closest to. This means that we help to define others' identities even as they help to define our own. And very simply but effectively, this parquet deformation conveys all that, and more, to me.