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ARCHITECTURE AND ALGORITHMS IN THE COMPOSITION OF *ANALOGIES*

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Abstract

This paper presents an interdisciplinary approach to the composition of a piece for orchestra entitled *Analogies*. Composition involved the creation of musical analogies to structural characteristics found in architecture. More specifically, four movements were composed based on various structural facets of the Eiffel Tower. The paper discusses compositional issues that arose during the inception of the project and then reveals how the architectural analogies were created in each of the four movements. There are also brief remarks regarding an algorithmic composition program that was used throughout the composition process.

1 Architecture and Music: an active inquiry

In the Summer of 1998, I had the pleasure of working with Iannis Xenakis' graphic synthesis system, UPIC, at the Xenakis studios (CCMIX) in Paris. Since studio time was limited, I often spent my non-studio time pursuing one of my favorite pastimes—namely, exploring architecture. As I thus moved back and forth between graphic synthesis and my encounters with architecture, I began to wonder about the potential of importing architectural drawings into the UPIC system.

It was immediately apparent to me that the results of such a process could easily produce masses of sound which would exhibit none of the characteristic details of the architecture that I loved. The use of UPIC would clearly require some refinement; but my return to the USA precluded my pursuing it and left me with a lingering, more abstract question: how might a piece of music take on the characteristics of a work of architecture? Or to put it another way: how might a work of architecture function as a model for a musical composition?

1.1 Answers eschewed

There were two potential responses to this question that I rejected early in my quest for answers. First, I decided to avoid using the graphic model as an 'inspiration'—i.e. as a subjective source of musical moods, such as occurs, for example, in Mussorgsky's *Pictures at an Exhibition*. Although an emotional response to a work of architecture might form the basis of a successful composition, such a composition would exhibit characteristics of the respondent and not of the architecture which provoked the response.

Second, I eschewed any attempt to use acoustic space to replicate 3-dimensional aspects of the architecture. Because space is the one dimension shared by music and architecture, its use would lead all too easily to attempts at mere replication and thus to an abdication of the challenges inherent in changing media—in a word, to an abdication of composition.

1.2 The road taken

What I did want was to identify the unique structural characteristics of an exemplary building and to create similar characteristics in the structures of music. In other words, I wanted to transfer a clearly identifiable set of relationships from one system to another, which is to say that I wanted to use the process of analogy. In the world of painting, this is perhaps akin to what Paul Klee accomplished in his numerous paintings based on music.

1.3 Testing the proposed answer

To explore the issue concretely, I chose three buildings to use as models for musical compositions. Since numerous examples of French architecture were fresh in my mind, I chose three buildings located in France: the Pompidou Center, the Lyon Airport Railway Station (Fig. 1), and the Eiffel Tower.

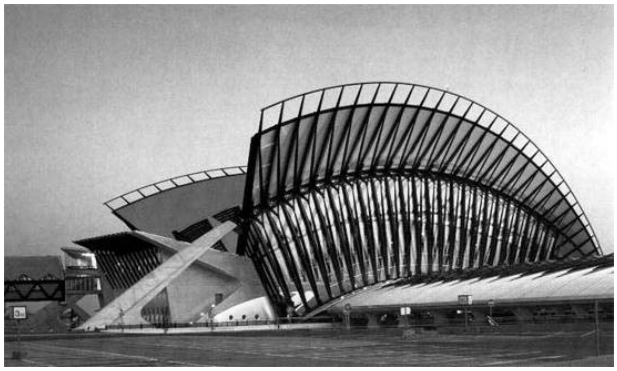

Fig. 1. The Lyon Airport Railway Station, designed by Santiago Calatrava.

I began the process by returning to France and simply experiencing each of these buildings—walking inside and outside of them, photographing them, and taking notes about particularly striking features and impressions. I also spent time learning about them—reading their histories, viewing architectural drawings, and studying other works by the architects.

1.4 Preliminary results: a slew of questions

After gathering this data, I returned home and made a list of the unique or striking characteristics of each building. I pondered how each of these characteristics might be realized in the medium of music and found that the process had led me to compositional propositions that would have never otherwise arisen. For example, if the Pompidou Center can be described as an inside-out building, what would it then mean for a piece of music to be inside-out? And this led to further questions regarding the nature of music itself: is there some sense in which music has an inside? Or suppose we rephrase the basic idea of the Pompidou Center as being 'the revelation of

architectural elements that are traditionally concealed.' Can we then turn to music and assume that it is possible to conceal things from a listener?

1.5 Limitations of analogy

It thus became rapidly clear that some characteristics might not transfer easily, or at all, from the one medium to the other. It also became clear that, though an architectural model may have many characteristics ripe for musical analogy, it might not be possible—or, if possible, desirable—to fold all these characteristics into a single piece of music. For example, I had drawn up a list of nearly thirty characteristics of the Eiffel Tower that I found compositionally potent. Even if I could somehow find a musical parameter available to manifest each of these, the chances that the musical result would sound coherent seemed slim at best.

But was it yet possible to recreate the *uniqueness* of the model in another medium? In other words, is there some more limited group of characteristics possessed in combination only by *it*, the model, that could be recreated in another medium? And might it even be possible for some intelligent listener attending to these characteristics to infer the identity of the model by hearing the analogous characteristics in the new medium? To say, for example, 'This piece is to music what the Pompidou Center is to architecture!'

While I have not definitively concluded that such a goal is unreachable, I did in fact feel sufficiently stymied to shift from the perspective of essential re-creation to that of architecture as 'compositional fodder.' In other words, I now saw the architecture not as a unique essence to be matched in another medium but as a set of characteristics from which I could begin to compose, using them to establish a musical framework or to begin compositional experiments.

Using this revised modus operandi, I decided to focus on the Eiffel Tower and subsequently chose a subset of its aforementioned list of characteristics to use in the composition of four movements for orchestra, collectively entitled *Analogies.*

1.6 A separate issue

When I began to write the music for *Analogies*, I encountered a separate compositional issue—namely, my own tendency to focus too much on intuitive approaches to compositional minutiae and too little on intellectual approaches to the statistical tendencies of my music. I therefore decided to use stochastic procedures and computer algorithms to help solve this problem. By using random selection within carefully constructed constraints, I was able to create desired musical characteristics without spending undue amounts of time on selection of details.

After some initial attempts at writing my own code to accomplish these goals, I perused available algorithmic composition programs and chose Paul Berg's AC Toolbox [1], which includes a wide variety of algorithmic functions, the ability to export MIDI files (useful for notation), a number of graphic tools, and a great deal of flexibility in the implementation of all these.

Composing *Analogies*

2 Why the Eiffel Tower?

It was with some reservation that I decided to draw upon the structure of a building often viewed as a kitschy tourist trap. It was difficult, however, to ignore the excitement that I experienced the

first time that I walked beneath, and up into, the Eiffel Tower. When I returned a year later to further explore the three buildings, my enthusiasm for the Tower was refreshed and amplified.

2.1 Chaos

My strongest initial impression of the Tower arose from the extreme contrast between, on the one hand, seeing the simplicity and elegance of its form from a distance, and on the other, seeing the complexity and seeming chaos of its support structures from 'inside' the Tower when ascending its staircase (Fig. 2). A second component of this impression was the rapidity with which the perspective changed during the ascent: a new group of elements would suddenly appear to form a new field of chaos.

Fig. 2. Detail of the Eiffel Tower

I chose these two characteristics—chaos and rapid change—as the bases for the first movement of the piece. I did not intend, however, to use chaos in the vernacular sense of the word, which implies complete disorder. I intended, rather, to use it in the mathematician's sense, in which one sees a tension between order and apparent disorder—in which we find a system having predictable overall output but whose output at any given moment cannot be precisely predicted. This view of chaos-as-tension is more consistent with my experience of the Tower, wherein my confidence in the logic of its support system was contradicted by a visual jumble. I realized this tension in the music by way of a mathematical model of chaos known as the Hénon map (Fig. 3) [2] .

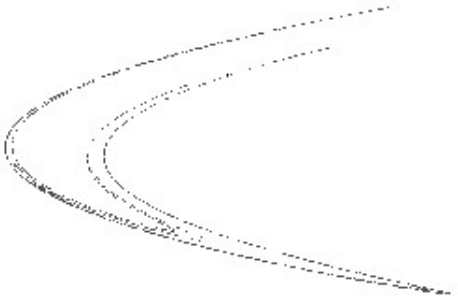

Fig. 3. A graph of the Hénon equation. Results fall into predictable regions, but the exact location of any given iteration cannot be precisely predicted.

Using AC Toolbox, I applied the x axis of the map to time and the y axis to pitch and thereby produced a quasi-ostinato figure (Fig. 4)—constant in its overall contour and pitch content, but irregular in its precise order of pitches. In the rhythmic domain, I reinforced this tension by working with a small set of rhythmic values (six eights, three quarter and a quarter rest) whilst permuting their order randomly (again, via AC Toolbox).

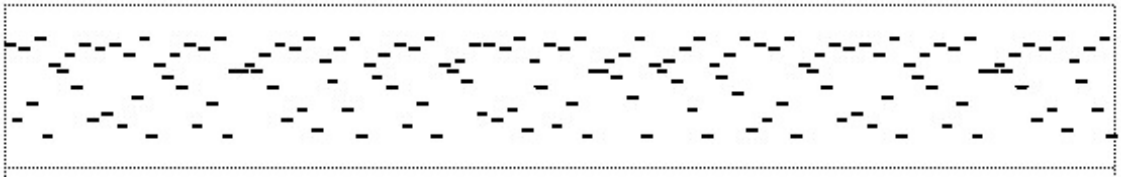

Fig. 4. A sequence of notes generated by the Hénon function in AC Toolbox. The x axis is time and the y axis pitch.

As I mentioned above, the second element used as a compositional basis in this movement was that of rapid change. This takes place in the formal dimension through frequent interruptions in the flow of events.

2.2 Convergence

Perhaps the strongest impression of the Tower in the public conscious is that created by the extreme sweep of its four piers from a wide base to a narrow peak—a characteristic that I have abstracted as 'convergence.' In the second movement, this trait finds analogies in the realms of both rhythm and pitch. As the movement begins, nine wind instruments play rhythms that are similar but completely non-synchronous. As time passes, the probability that an instrument shares its rhythm with another increases until the probability reaches 100%, so that all nine winds are playing exactly the same rhythm synchronously, thereby achieving a collective state of convergence. In a later section of the movement, the complement of this state, divergence, is realized by moving from 100% probability of synchronous rhythm to 0%.

To apply the principle of convergence to pitch, I used the graphic capabilities of AC Toolbox. I began by saturating the five-octave pitch range of the opening section (Fig. 5). I then drew a 'mask' resembling a stylized version of the Tower (turned on its side) and used this mask to filter out notes from the original, saturated section, resulting in pitch content which begins in a narrow, converged state and then expands at an exponential rate to the full, five-octave range (Fig. 6).

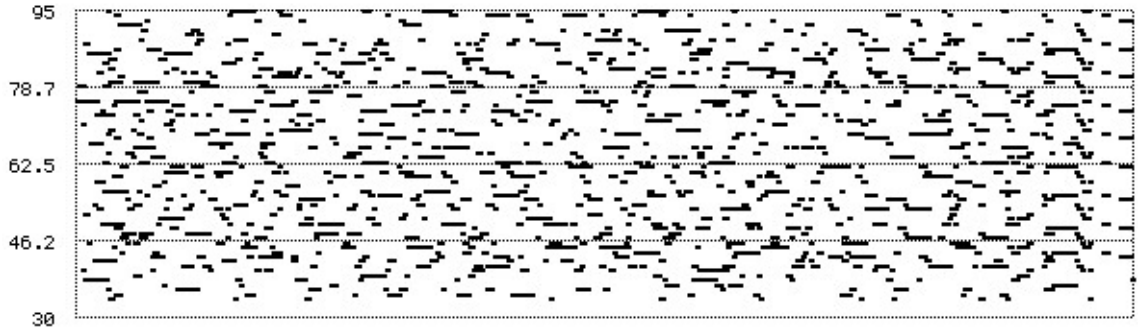

Fig. 5. Nine wind instruments, covering a five octave range, rhythmically converging at the far right. The numbers at lleft are MIDI note numbers.

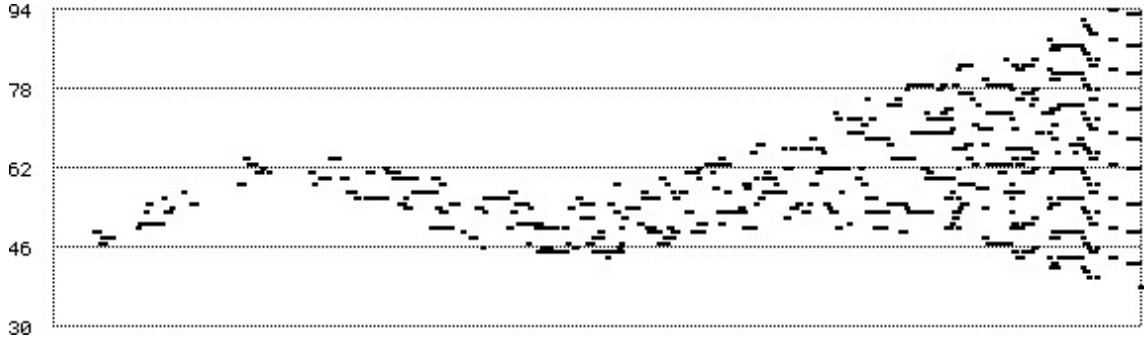

Fig. 6. The sequence from Fig. 5 has been graphically filtered in AC Toolbox.

2.2.1 Positive and Negative Space

Another aspect of the Tower's silhouette is its creation of positive and negative space. In its lower half, it has two large openings which frame well defined empty spaces. This concept of positive and negative space was realized in the music by using the above-mentioned mask to filter pitches in two ways: using both the outside of the shape and its inside. In the final section of the movement, the 'positive' filter is applied to the winds while the 'negative' filter is simultaneously applied to the strings, resulting in a pitch range that is constantly saturated but also constantly changing in timbre (Fig. 8).

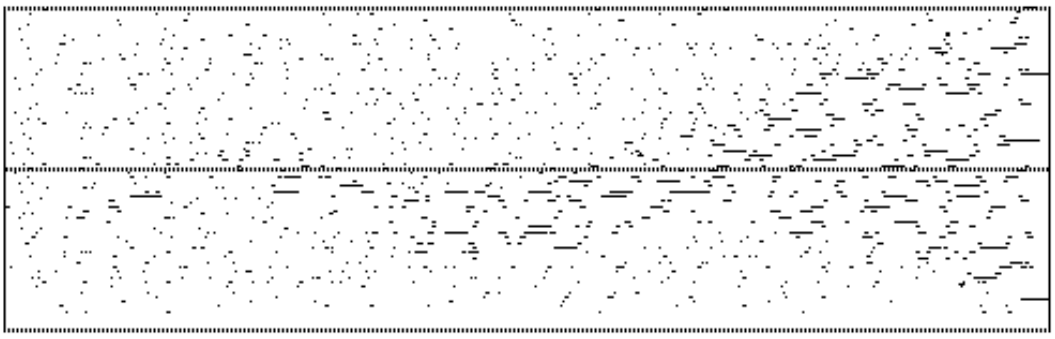

Fig. 8. The 'positive' filter applied to the winds (dark, long dots) with the 'negative' filter simultaneously applied to the strings (light, short dots).

2.3 A new use for an old material

Among the most important architectural developments in the late 19th century was the transition from the use of iron as ornament to its use as principal support. Given its unprecedented height, the Tower played a salient role in this development. (Several prominent French engineers predicted that it would collapse under its own weight.) On the other hand, Eiffel did not abandon the old use while employing the new—he simply grafted iron filigree onto the structural iron of the Tower.

The analog of iron in the third movement is the trill. In its opening section, trills serve a traditional function of decorating sustained notes within a three-part contrapuntal texture. The second section, however, 'telescopes' one of these single contrapuntal phrases into extended masses of

sound, moving gradually from masses of eighth notes to a sustained section of massed trills, so that the trill has become the principal structural material.

As with movements one and two, constrained randomness, probability, and masks were used to control elements of pitch, rhythm, and contour.

2.4 Oscillation

As has now been shown, in each of the first three movements, one or two characteristics of the Tower were used to make a few key compositional decisions. By contrast, in the fourth movement two such characteristics were used to make decisions for almost *all* parameters.

One of these two is that of modularity, for the Tower actually comprises twenty-seven structural panels, one on top of the other. This modular character finds its musical analogue in the strongly sectional form of the movement—i.e. in the absence of transitions between sections. (The number of sections, however, is not twenty-seven but sixteen, corresponding to the Tower's sixteen pylons. The significance of the number sixteen is carried out at a micro level, as well: within each section, each instrument present plays a total of sixteen notes.)

A more ubiquitous characteristic in the movement is that of oscillation, for if imagined as a plot on a graph, the Tower presents a single, exponential rise to a point and a subsequent complementary fall. In the domain of pitch, the principle of oscillation provides a simple rule: any rising interval must be followed by a falling one and vice versa. On a macro level, pitch oscillation also takes place, first, as an alternation of tessituras, and second, as a series of rising and falling contours.

Another form of oscillation in the music takes place in movement between static and dynamic states. In the realm of rhythm, a static state is one having only one rhythmic value (i.e. a pulse), while a dynamic state is one having multiple rhythmic values. In the realm of pitch, a static state occurs when oscillation takes place between only two pitches, whereas a dynamic state occurs when the oscillation touches on a variety of pitches. When these two pitch states are combined with the two rhythmic states, four melodic states become possible (Fig. 9).

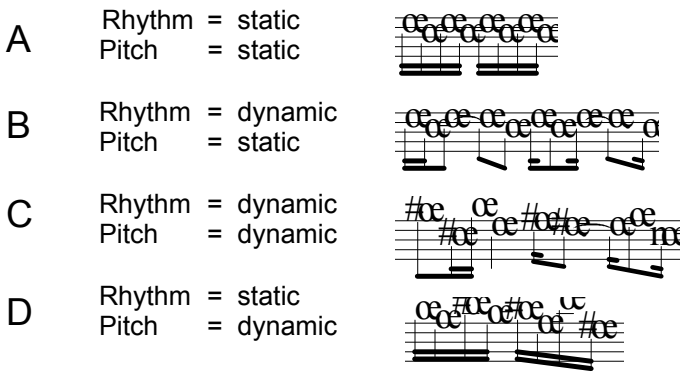

Fig 9. Four melodic states with regard to static and dynamic properties.

Furthermore, each of these melodic states can be thought of as a member of a set which comprises their possible polyphonic combinations. There are fifteen such combinations possible, each of which is used in one of the movement's sixteen sections (see Table 1, column 2).

Section #	Melodic states used	# of orchestral families	Scale transpositions
1	A	1	1
2	B	2	1
3	C	3	1
4	CD	4	Multiple
5	BD	1	Multiple
6	AC	1	Multiple
7	ACD	2	1
8	AD	2	1
9	AB	3	1
10	BCD	3	Multiple
11	BC	4	Multiple
12	ABD	4	Multiple
13	ABC	1	1
14	ABCD	2	1
15	D	3	Multiple
16	ABCD	4	Multiple

Table 1. Three manifestations of 'oscillation' in three different parameters.

There are a number of other parameters which employ the concept of oscillation. In the realm of orchestration, for example, a kind of sawtooth oscillation is used, beginning with one orchestral family per section, then adding another until the peak of four is reached, at which point the number returns to the minimum of one (see Table 1, column 3). In the realm of harmony, a square wave is the model: three sections having a single transposition of an octatonic scale are followed by three sections using multiple transpositions, and so forth (see Table 1, column 4).

3 Conclusions

I began my investigation of the compositional potential of architecture thinking that I could capture the structural essence of a building in a piece of music—thinking, that is, that I could compose a musical version of *it.* Though I still maintain this as a proposition worthy of pursuit, I have nevertheless found it to be compositionally elusive and have instead come to see architecture as a resource for structural relationships that may have fruitful musical applications.

Given this revised perspective, composition becomes not a quest to discover the elusive *it,* but rather, a craft in which one experiments with the transfer of relationships from one medium to another. A given characteristic in the model will not simply *imply* the musical parameter to which it should be applied—these are choices that must be made by the composer, and they will often

be arbitrary. Nor are there rules regarding the *extent* to which analogies are used. They can be used in a comprehensive, top-down fashion, or they can be used in a limited, trial-and-error fashion.

Whatever the method chosen, there is a high probability that the resulting composition would not have been written without the use of the model. For example, the principle of convergence can no doubt be found in numerous other man-made or natural objects, but it was not until I pondered the structure of the Eiffel Tower that I thought to use it as the central process of a musical composition.

Architecture is, I believe, a largely untapped resource of compositional ideas that could be successfully mined by anyone who cares to explore it. On the other hand, the use of an exemplary, coherent model brings with it no guarantee of an exemplary, coherent piece of analogous music. As always, that will come about only as the result of the blood and sweat of the composer.

4 References

[1] Berg, Paul. AC Toolbox is freeware that can be downloaded at www.koncon.nl/ACToolbox.

[2] Bidlack, Rick. 'Chaotic Systems as Simple (but Complex) Compositional Algorithms,' *Computer Music Journal*, Vol. 16, No. 3, Fall 1992.