Algorithmic explorations of juxtaposition and simultaneity in computer-aided composition.

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ABSTRACT: Methods of applying a space grammar structuring process are explored by considering techniques used in the generation of three specific compositions: *CHRONOMETRIC WEBS* for gamelan anklung, *GENETIC GLOSSARIES* for 16 voices, and *ARBORHYTHMIC PRELUDES* for piano solo. In each case a fixed seeding cycle of control values is repeatedly accessed to determine how a recursive sequence of splitting operations is applied over a time and texture (or voice) space; vertically as a rhythm-generating gesture, or horizontally as a voice-generating gesture introducing polyphonic activity. The nested, self-similar structures produced are related to the fractal phenomena known as 'curdling clusters'.

KEYWORDS: algorithmic composition, cellular automata, fractals, space grammars

Although significant work has been done exploring algorithms for the generation of melodic, rhythmic and harmonic patterns, techniques concerned with details of structural organisation such as texture, voice relationships and ensemble are less developed. In a paper concerned with various aspects of stochastic composition, Jones (1981) proposed the use of a *space grammar* as a useful means of approaching some of these compositional elements. Although limitations in handling vertical pitch relationships have been identified in this approach (Chemillier & Timis, 1988), the potential for handling sophisticated relationships between simultaneous musical voices and in the generation of complex rhythmic and textural structures is significant. Drawing upon developments described in Jones (1989), this paper describes techniques used in the generation of three compositions: *CHRONOMETRIC WEBS* for gamelan anklung, *GENETIC GLOSSARIES* for 16 voices, and *ARBORHYTHMIC PRELUDES* for piano solo, which illustrate something of the compositional potential that exists.

In each case the entire score is generated by the repeated application of a fixed seeding cycle of control values which determine how a recursive sequence of splitting operations is applied over a time and texture (or voice) space. The only decisions made by the program are whether splitting operations should continue, or stop so that the currently defined area of 'space' is occupied by a rest or a sound (i.e. note, impact or vocal effect) determined by the next value in the seeding cycle. If splitting continues, the split may be made vertically dividing the time axis as a rhythm-generating gesture, or horizontally to divide the texture space as a voice-generating gesture introducing polyphonic activity.

The initial seed values are chosen at random, but from these the entire structure of the resulting composition is totally determined. A set of seed values contains sufficiant genetic information to determine unique characteristics for each composition in terms of rhythmic patterns, density of sound, amount of repetition, interrelation of simultaneous voices and, in the case of the vocal piece, choice of syllables used for the text. The process parallels the use of cellular automata as a space-filling device for building complex models from a simple source, and is also closely related to what Mandelbrot (1982) terms 'curdling clusters', a two-dimensional version of the Cantor Set, in his description of certain species of fractals.

The recursive nature of the generative process tends to produce nested, self-similar structures where, for example, rhythmic and voice-grouping patterns reappear and combine with themselves in augmentation and diminution.

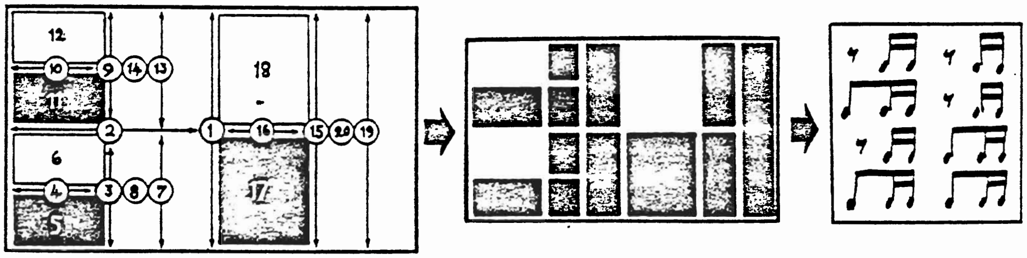

Figure 1: Mapping a cyclic division of the plane into musical rhythmic space

Using the designation V for a vertical split, H for a horizontal split, N for a note or sound, and R for a rest or empty space, then Figure 1 shows the result of repeatedly applying the sequence of operations V-H-V-H-N-R. For the purposes of this example, terminating conditions limit splitting to a maximum of 4 voices vertically and 8 rhythmic units horizontally. Operations 1 to 6 are straightforward applications of the seeding cycle, always working out from the origin at the bottom left-hand corner. After operations 7 and 8, the limits are reached in that region and the sequence jumps to the next available space for operation 9; and so on. Again, for this particular example, where the limiting condition is reached the remaining indivisible 'spaces' are occupied by notes or sounds, though alternative rules could be applied. Examination of the resulting pattern shows top and bottom pairs of voices sounding the same pattern in parallel for the first half, with voices 1-3 and 2-4 doubling up; whilst for the second half the same motif is expanded and re-scored with, this time, 1-2 and 3-4 doubling up.

This simple example gives just a hint of the multiple and intricate polyphonies of voice combinations which can emerge when the splitting process is continued to deeper levels. Figure 2 is an example of a more complex planar pattern generated in a similar way. A wide variety of contrasting patterns may be generated by applying this simple process, which requires just a few lines of program code, with different seeding cycles. Drawing upon obvious biological parallels, the DNA-like seed responsible for each unique score could be termed a *chronosome*.

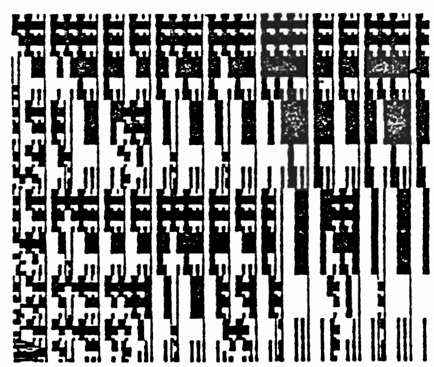

Figure 2: Extended cyclic division of the plane

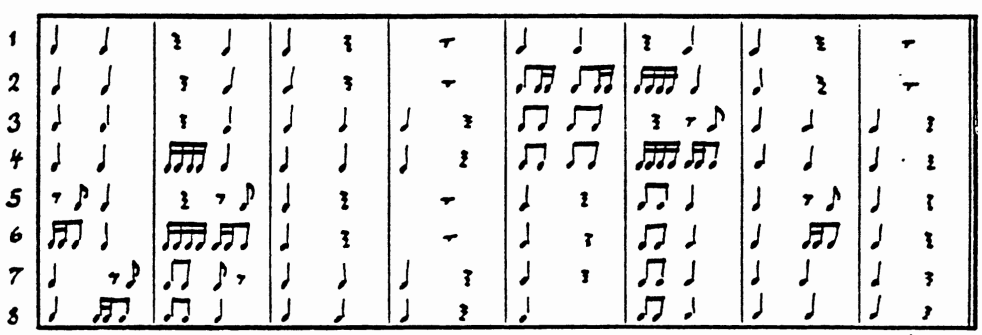

Figure 3: Extract from *Chronometric Webs* for gamelan angklung

1	e	.	snee	peu	peu	—	.	.	.	snee	snee	peu	e	.	snee	peu
2	e	.	snee	peu	snee	—	.	.	.	snee	snee	peu	e	.	snee	peu
3	.	.	snee	peu	.	.	.	.	.	.	snee	peu	e	.	snee	peu
4	e	—	snee	peu	e	—	—	—	.	.	snee	peu	e	.	snee	peu
5	peu	—	.	.	e	.	snee	peu	e	.	snee	peu	e	.	snee	peu
6	snee	—	.	.	e	.	snee	peu	e	.	snee	peu	e	.	snee	peu
7	.	.	.	.	.	.	snee	peu	.	.	snee	peu	e	.	snee	peu
8	e	—	—	—	e	—	snee	peu	e	—	snee	peu	e	.	snee	peu
9	.	.	.	.	e	.	snee	peu	.	.	snee	peu	e	.	snee	peu
10	.	.	.	.	e	.	snee	peu	.	.	snee	peu	e	.	snee	peu
11	.	.	.	.	.	.	snee	peu	.	.	snee	peu	e	.	snee	peu
12	e	—	—	—	e	—	snee	peu	e	—	snee	peu	e	.	snee	peu
13	peu	—	—	—	.	.	.	.	peu	—	.	.	e	.	snee	peu
14	snee	—	—	—	.	.	.	.	snee	—	.	.	e	.	snee	peu
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	snee	peu
16	e	—	—	—	—	—	—	—	e	—	—	—	e	—	snee	peu

Figure 4: Extract from *Genetic Glossaries* for 16 voices

Figures 3 and 4 are extracts from the scores of *Chronometric Webs* for gamelan angklung, and *Genetic Glossaries* for 16 voices, both of which contain clearly balanced examples of multiple antiphonies. In *Genetic Glossaries* notes are replaced by sung syllables whose absolute sound is not particularly significant but which represent alternative terminations of the splitting process. Dots in the score represent rests and dashes indicate that a sound should be sustained. Typical of many embedded symmetries present in this extract is the cell in the top left corner where a sustained "e" on voice 4 followed by a final "*snee peu*" from all voices is a diminution of the structure of the whole extract which it represents in microcosm.

Figure 5: Extract from *Arborythmic Preludes* for piano

In Figure 5, an extract from *Arborythmic Preludes*, terminals are represented by pitches chosen on the same cyclic basis as the syllables in the previous example. Here, a diatonic tonal space has been used with a fractal model of key changes superimposed to determine accidentals, which favours movement between closely related keys in adjacent bars. Again, there are examples of many-levelled motivic relationships which produce a suprisingly 'composed' result.

References

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