PATHS TO A POINT IN A MUSICAL LANDSCAPE

by

Joel Chadabe

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INTRODUCTION

This paper is an explanation of a way I have been working for several years now. I call it "interactive composing." It is a two-stage composing process of first creating with a computer a musical automaton which has its own "personality," and then, in performance, interacting with that automaton, improvisationally and intuitively controlling the course and shape of the music it produces.

Interactive composing, like every new idea, is a point within a metaphorical landscape of related thoughts and feelings, both musical and nonmusical, historical and contemporary. In this paper, I will describe the idea and follow several paths through that landscape.

SOLO AS AN EXAMPLE OF INTERACTIVE COMPOSING

I composed Solo in 1978. It was composed and is performed with a computer/digital-synthesizer system designed and built by New England Digital Corporation. I carry the system to concerts in a suitcase.

Solo is based on a melody which is modeled upon what I imagined as a free jazz solo clarinet improvisation. I composed the melody by devising rules according to which the computer composes the melody by itself, as an independent melody-generating "machine." The computer also composes "chords," groups of notes at varying intervals above and below each melody note which give the melody varying width and contour.
I perform with two proximity-sensitive antennas, actually modified theremins. The antennas inform the computer as to the position of my hands. As I move my right hand in relation to the right antenna, I control speed by increasing or decreasing the duration of each note. As I move my left hand in relation to the left antenna, I control timbre by passing my hand through "zones" in which different "instruments" are playing. The sounds of the "instruments" were at first composed by simulating the sounds of certain acoustic instruments - xylophone, clarinet and flute - but after I began working with those sounds, I could not resist an urge to creativity and the computer sounds came to be less and less like the acoustic models which at first gave rise to them. Referring to them still by the names of their models, however, when my left hand is farthest from the left antenna, only the xylophone is playing. As I move my hand towards the antenna, I cause the other instruments to play in addition to the xylophone, in the following order: first one clarinet, then two clarinets, then two flutes, then two clarinets and two flutes together.

The melody is nonrepetitive and virtually endless and - because I cannot foresee what notes the computer will produce by following the rules -- continually surprising. In performance I interact with the melody, responding to what I feel it will do next and trying to control it, to keep it varying, graceful, and lyrical. I try to feel the flow of the music and move with it. My gestures resemble conducting. A performance of Solo is something like conducting an improvising orchestra.

The "orchestra" is "improvising" in the sense that the computer system has an identity of its own and makes original, unforeseen contributions to the situation, so that influence for action runs in both directions -- I am reacting to the computer as well as causing the computer to react. Since our actions and reactions are mutually dependent, our relationship is truly interactive. And it is because the music takes form as a result of these interactions that I call this approach "interactive composing."

CONTROL, FEEDBACK AND REAL TIME

Interactive composing requires the performer to react quickly, one might say improvisationally. But it is different from typical instrumental improvisation in that an improviser plays notes in reaction to another improviser, without controlling the progress of the whole. Here, the performer is controlling the machine which plays the notes. The performer is participant and yet sees the system from an overview and controls its progress.
Control is possible only with feedback, which Norbert Wiener described as essential to "control and communication in machines and in living organisms." Wiener's model for a goal-oriented information processing system shows an (i) information entry, (ii) a place where it is processed, or used, (iii) an output, or resulting action, and (iv) a feedback loop returning some of the output back into the input so that the real output can be compared with the intended output and the system's behavior regulated accordingly. Regulatory feedback in living organisms is part of a continuous circular process whereby information enters the nervous system through the senses, moves to the muscles to direct an action, and, as a perception of the effectiveness of the action, reenters the nervous system through the senses. I reach to pick up a glass of water, for example. I am able to regulate the motion of my hand towards the glass only because I can always see the extent to which I have not yet picked up the glass.

My ability to perform *Solo* depends upon my immediate perception of the effects of my actions, and, therefore, information must flow through the system with enough speed to take in a control gesture, use it to affect the music in some way, and play the musical result while the gesture is being made. It is the flow through the system, the speed with which the performer hears the results of a performance gesture, that enables the performer to function in a controlling capacity. Interactive composing requires a real time system, a system which can process information and produce a result fast enough to allow for regulatory feedback.

**FLEXIBILITY AND COMPLEXITY**

The connection between a particular control gesture and a particular musical result is decided by the composer in an earlier, design stage of composition. Interactive composing means twice composing, where first the composer defines the way the composition will function and, second, performs in interaction with what was initially designed. In comparison with composing for traditional instruments, the first stage, the design stage, offers great flexibility. A piano, for example, always sounds like a piano and is always performed with a keyboard which controls pitch and loudness. But a computer/synthesizer system can make any of a wide diversity of sounds, it can be performed with any device that can convert a human gesture into electrical variation, and the performer can control any aspect of the music (speed, rhythm, articulation, and timbre, for example, in addition to pitch, loudness, and other variables associated with traditional instruments). In other words, the composer is defining every aspect of the composition: the sound, the music, and the way the music is performed.
The composer also defines the device used in the performance. The proximity-sensitive antennas articulate the idea of Solo as "conducting" an "instrumental" ensemble because the gesture of moving one's hands in the air resembles a conductor's gestures. The antennas also affect the musical result of the performance in that the motions used in performing with them encourage a performer to stay in motion, rather than find a position and hold it. In general, the nature of a particular device, which is to say the gesture that it requires, is an important factor in performance. Playing keyboards or footpeals, waving one's hands in front of a television camera, dancing in a costume with mercury switches sewed into it, or playing a drum, are all possible performance gestures, and every gesture suggests a different type of musical sensibility which will lead a performer to think and feel in a different way about the music and about the specific aspect of the music that the performer is controlling.

The definition of the composition is a matter of constructing a system of variables and controls, i.e. effects and causes. A variable is part of a system which can vary. A control is something that changes a variable. Variables may themselves be interconnected and function as controls for other variables. Performance controls enter the system from without, but other controls are generated from within, and controls may affect other controls. The number of control-variable (cause-effect) relationships in a system is a measure of its complexity, and it is, needless to say, a measure of the composer's art that the appropriate control be applied to the appropriate variable, and that the appropriate controls be performed.

What are the important variables in Solo, for example? There are eight voices, each a separate "instrument"—four vibraphones, two clarinets, two flutes. Each voice is defined by two variables for timbre, one variable for the loudness pattern of each note, and one variable for overall loudness. The sounds of Solo are defined by a total of more than forty variables, some of which need new controls every few centiseconds. In addition to the variables of the sounds themselves, there are musical variables which determine the melody, the notes of the chords, the duration of each note, and which instruments are playing.

The performer controls the duration of each note and which instruments are playing, but the controls for all of the other variables in Solo are generated internally. The generator of the controls is a random number generator, which is, in actuality, a procedure which generates a "pseudorandom," i.e. mechanical and repeatable but from an observer's point of view unpredictable, sequence of numbers. One starts with a row of numbers, either "0"s or "1"s, in which the leastmost and rightmost number are combined according to the following rules: 1+1=0, 0+0=0, 1+0=1, 0+1=1. That operation produces a new leftmost number in
the following row. The other numbers in the following row result from shifting the previous row one position to the right, with the previous rightmost number "dropping off" and vanishing. The combining, shifting, and dropping off operations are repeated for each successive row, as illustrated with the binary numbers in the following example: (The decimal equivalents of the binary numbers are shown to the right.)

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Other arithmetic operations are performed to put the random number between low and high limits specified by the composer: (1) the low limit is subtracted from the high limit to find the difference between them; (2) the difference is compared with the random number and the larger number is divided by the smaller number; and (3) the remainder is taken from the quotient and added to the lower limit. Also, it should be noticed that if, as in the example above, the rows contain four figures, the numbers will begin to recycle at every sixteenth row. The way to determine the number of numbers in a cycle is to take the number "2" to the power of the number of figures in a row and subtract one. In the case of a row of four it is fifteen, but if the row contained sixteen figures, the cycle would contain 65,535 different numbers.

The notes of the melody are determined by a random walk on an imaginary keyboard, where the decision to go up or down and by what musical interval is made by the random number generator. In Solo, the rules which determine the melody are: (1) Choose a starting note within the range of notes which will be used in the music; (2) Choose a number between 3 and 21 that will determine the number of notes in a phrase; (3) Decide whether to go up or down; (4) Choose a number between 1 and 7.
which will determine how many times to go up or down; (5) Choose a number between 1 and 5 which will determine the musical interval by which to move, and remake that decision for each note until the number from step 4 is reached; (6) Repeat steps 3, 4 and 5 until the number from step 2 is reached; (7) Start again at step 2; (8) If the melody goes beyond the range of the “keyboard," start again at step 1. The notes above and below the melody note, which are played by the various instruments, are determined by random intervals from each melody note.

These steps generate a nonlinear melody, i.e. a melody where the successive notes are determined by underlying factors rather than by a sequential connection between the notes themselves. It is perhaps paradoxical that such a melody is usually heard as an understandable, even lyrical, flow, rather than as something complicated or "random," but such nonlinear procedures do not necessarily produce disjointed or senseless melodies.

The impulse to nonlinearity, even when satisfied by random numbers, is not an impulse to randomness. The intention is to automate decision-making so that a succession of events will seem surprising yet coherent. The use of random numbers, and throwing dice, and a wide variety of other methods accomplish the same end.

SOME RELATED APPROACHES

Lejaren Hiller was one of the first composers to experiment with automatic procedures in composing. For his Illiac Suite, in 1957, Hiller used a random procedure whereby many random numbers were generated and then judged, and accepted or rejected, according to specific criteria. The numbers were used to represent pitches, among other musical attributes, and the criteria for their acceptance included the following rules: no tritones; the melody had to start and end on middle C; the range of the melody from its lowest to highest note could not exceed one octave. Once a note was accepted, it was placed in a note list which was eventually printed out and transcribed by hand into musical notation to be played with traditional instruments.

John Cage stressed the surprise and the discovery that results from randomness. As he said in his well known interview with Roger Reynolds, "What actually happened was that when things happened that were not in line with my views as to what would be pleasing, I discovered that they altered my awareness. That is to say, I saw that things which I didn't think would be pleasing were in fact pleasing, and so my views gradually changed from particular ideas as to what would be pleasing, toward no
Cage's and Miller's HPSCHD is an example of a composition unfolding as the result of a multitude of automatic procedures and chance interactions. HPSCHD, composed between 1967 and 1969, is of unspecified duration and contains no sectional differentiation. There is no beginning, no end. It is an ongoing complexity of unpredictable simultaneities, usually performed throughout an evening, four hours, say, with the public free to wander in and out. There is music for up to seven harpsichordists based partly on computer realizations of Mozart's dice game; there are computer-generated sounds which divide the octave into different tunings, played back from up to 51 tapes and heard from loudspeakers around the room; and there are over 5000 slides and several films of space imagery and abstract designs projected throughout the space. A performance is exhilarating, joyful, circular, a completely encompassing environment. Unlike earlier pieces by Cage where there are given structures for which performers choose materials, in HPSCHD, the materials — scores for the harpsichordists, audio tapes, slides, films — are given without any indication of structure. The performance simply goes together in an anarchy of intense activity and cooperation, with no single person, not a director and not the composer, shaping the sequence of events.

The automation in David Behrman's Cello with Melody-Driven Electronics results from the way his system works. It senses the pitches a cellist is playing and in response to preselected pitches generates a preselected accompaniment chord. There are many examples of this use of an electronic system to respond to environmental or performance stimuli, among them Lis Phillips' Windswept, where sounds are made to vary in proportion to local wind conditions.

Interactive composing adds interaction to automated decision-making, and there are two examples that I know of outside of my own work. Giuseppe Engbert, in Paris, performs in response to a random process by means of which his computer selects sounds. And there is an earlier example, The SaltMar Construction, an extremely complex composing and performing system, built by Salvatore Martirano in 1969 with the help of some friends and engineers. It consists of a console which contains a control panel with over 200 touch-sensitive switches and twenty-four loudspeakers arranged throughout a performance space. The system automatically generates sounds with different timbres, pitches, and loudnesses, and routes the sounds through the arrangement of loudspeakers. Martirano's performance is a manipulation of the process in interaction with what it produces, controlling speed, pattern, octave, spatial distribution, and cycling, among other things.
THE DISTINCTION OF THE IDEA

Interactive composing is distinct from earlier ways of composing in that a composition is defined as much by the way it functions as by its sounds. The performance is, in other words, the substance of the composition. (One thinks of Yeats' words: "How can we know the dancer from the dance?")

The idea of a functioning composition is relatively unfamiliar and at this date perhaps still somewhat uncomfortable. The tradition of art and music that comes to us from the past, which is very much a part of our musical awareness, has composers producing pieces that become external from themselves, and fixed, as objects are fixed, perfect in their detail. The composer is assured that the composition will be exactly as intended, regardless of the quality of a particular performance. It is when the unpredictable nature of performance affects the context and quality of the work itself rather than merely its execution, that there is, as Lukas Foss puts it, "danger."

It is only recently that such an idea could have any credence whatsoever. The idea of "intelligence" in something inanimate, such as an intelligent musical instrument or computer system, had its basis in the observation, which was also the basis for Wiener's work, that a process may be discussed apart from any specific material in which it exists. Goal orientation, for example, may be studied apart from anything specific that is oriented towards a goal, and that study may be used to understand similarities in functioning between humans and animals. Homeostasis, an example of automatic self-regulatory feedback systems in living organisms, is the process by which warm-blooded animals maintain a stable body temperature despite fluctuations in the external air: when the external temperature shifts colder or warmer, heat is generated or shed by the organism by shivering, sweating, and by other physiological processes, to maintain the organism at its goal temperature. A thermostat-controlled heating system functions similarly in that it senses environmental temperature via a thermostat, compares it with a goal temperature, and turns the furnace on or off to keep the system oriented towards its goal. Through an understanding of similarities in functioning, conceptual bridges can be built between living and nonliving systems which make it possible for composers to think of computers as capable of doing something so intelligent as to perform a melody interactively with a performer.

The idea of a functioning composition also brings into focus the conflict between linearity and nonlinearity which exists in the minds of many composers.
A process is an unfolding of events in time, as, for example, in a musical performance. In a linear process, one sound follows another because of a sequential relationship between the two sounds. A composer composes sound after sound, choosing each successive sound because of the way it follows the preceding sound. Or, as in many of Steve Reich's compositions, the music moves gradually from one situation to another. Because the composer controls the sounds themselves, a linear process may be planned and shaped by the composer so that it reflects the balance, the symmetry, and the completeness that is possible only when the whole is known before the parts are made. In a nonlinear process, on the other hand, each sound is determined by underlying causes rather than by sequential relationships between the sounds themselves. Instead of composing sound following sound, a composer determines a succession of sounds by creating a procedure which determines the succession of sounds, for example assigning numbers to sounds and determining their order by throwing dice. In throwing an eight, say, and then a five, the five is not there because the eight was there before; the five is there because of a multitude of elusive underlying causes -- such as the way the dice are held as they are thrown, the strength with which they are thrown, the balance of each die, the relative weight of each die as the dice hit each other, and so on. Because the composer is not composing the sounds directly, nonlinear processes are inherently unpredictable.

The crux of the matter is in a composer's feelings for complexity. If there is any basis at all for my implication that interactive composing is a chronological development from other methods of composing, it is in my feeling that composers as people perceive changes in the nonmusical world as well as in the musical world, and that we have grown through the first half of the 20th century from understandings of simplicity to understandings of complexity, from the perception of clear cause-effect relationships between successive events to the perception that effects often have many causes -- in fact sometimes so many, so elusive, and so intertwined, that finding clear relationships between effects and their causes, and between successive events, is impossible. In dice, in Solo, in other things in life like administration and romance, a multitude of variables can create a series of events which is nonlinear, complex, and seemingly whimsical. For some composers, the beauty of completeness and balance is missing. But for others, a nonlinear process, where one sound proceeds to the next for no apparent reason and where the end is unforeseen, seems magical and lyrical. And interaction with that process is musically and personally satisfying.
CONCLUDING REMARKS

I think that the idea of interactive composing is a paradigmatic idea for music, especially applicable to real time computer systems. It is an idea which has much consistency with current interests in artificial intelligence approaches to music, performance devices, and learning and memory processes. Its possibilities are open enough to contain an immense variety of personal approaches, styles, and particular circumstances. It is a powerful enough idea to provide a coherent framework for further research and experimentation in its various component aspects.

The landscape surrounding interactive composing contains the ideas of many composers and others whose work has demonstrated some resonance with its basic premises. From that point of view this paper could be considered a formulation of what has been and is in the air. Perhaps it comes just enough ahead of its hour that it might clarify certain issues for other composers whose work is anyway heading in this direction, and I hope that these words have been of some interest at least to those composers.

(Albany, August 4, 1981; revised January 5, 1982)