Computer Music and the Importance of Fractals, Chaos, and Complexity Theory

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Dr. Mladen Milicevic, The University of South Carolina - Media Arts, Columbia SC 29208, USA MMladen@SC.edu

Abstract: *The main concern addressed in this paper relates to the postmodern vs. hypermodern use of knowledge based on scientific findings as applied to philosophy and the aesthetics of computer music.*

1. Possibilities of Complexity

In the last decade there has been increasing interest in emerging sciences related to complexity, Chaos theory, fractals, neural nets, and the Gaia hypothesis. According to the modern view, the universe is developing regularly along a line that the physicist and mathematician can plot and understand. The prevailing efforts in science have tried to explain all phenomena as variants of an essentially ordered structure. However, in the last twenty years, a reverse hypothesis has grown which supposes that most of the universe is non-linear and, perhaps, beyond understanding. Cosmocentric complexity grows into deterministic chaos, a chaos that shows some emergent innovation--balancing on the delicate edge between order and chaos. Per Bak, a physicist from Brookhaven National Laboratory in New York, illustrates this with a pile of sand on a tabletop. Imagine a growing sand pile, with grains of sand being continuously dropped from above. The pile grows higher and higher until it cannot grow any more reaching the critical height. The complexity of interlocking grains of sand has reached "self-organizing-criticality" [Waldrop 1992] and it is ready to do something. So when the next falling grain hits the pile, nothing or--anything--may happen. It can result in a tiny shift of just few grains or in a catastrophic collapse of the whole pile--there is no way of predicting this non-linear result. This example displays a behavior very similar to the critical mass of plutonium, in which the chain reaction is just barely on the verge of nuclear explosion. Such behavior is very common in nature, points out Bak, and we can see the ubiquity of large impulses being rare and small ones being common. Crisis management becomes a norm for nature, pushing itself to the brink between control and chaos.

There is an easy misunderstanding of emergent behavior which lies in the assumption that whatever is produced on the verge of chaos is good or creative. It is simply new, and evolution over time may show only if it is anthropocentrically positive or negative. Even when the product of emergent behavior fits into the ecological system, this does not mean that it is elegant or aesthetically pleasing; it simply means that it works within the larger context. It does not even mean that it is the best solution--it simply represents the first one that came along, hit critical mass and went into action.

Another characteristic of nonlinear systems is that they are self-organizing. Myriads of dumb and mindless entities interconnect into tangles similar to hives of bees or masses of neurons in a brain. Out of this dumbness and quite by accident the neural network of the brain emerged, and humankind became smart for no predetermined reason at all. What is interesting is that these self-organizing systems have no focal points--they are mostly decentralized. For example, there is no central authority in the human brain, one that is in charge of all others, "a place where it all comes together" [Dennett 1991], only unrestrained redundancy and colossal parallelism. Accelerating up organic time via computer simulations of complexity theory; neural nets, and self-organizing evolutionary systems have been tried. However, most of the models were, understandably, realized using serial computer processing to simulate parallel behavior, as in the beehive.

Parallel processing is still in its early days and what we are trying to do here is to put the technological cart in front of a conceptual horse. Humans think in serial narratives, thus the first computers were programmed on an idea that copies that logic. The human brain obviously works through parallel activity but yields a consciousness which operates in a serial way--a linear story. Hence, we may never be able to write a software that takes parallel computer processing to its fullest capacity. Today's artificial intelligence projects are as feasible as pragmatic physical designs of four-dimensional objects, in spite of Nicholas Negroponte's daring prediction that "machines will be intelligent" [Negroponte 1995]. Humans are certainly the best at designing small, elegant, and manageable systems that they can understand and use creatively; complexity in nature is for the present moment beyond human reach and next to impossible to use pragmatically.

Now what relevance do these new scientific findings have to computer music? Applying computer models of complexity theory to musical structure, then pushing the compositional system out of equilibrium to the very edge between order and chaos is rich only in possibilities. Believing that "creativity is balanced at this knife edge between predictability and randomness" [Jencks 1995] is wrong. All that results is something new and beyond quality control. If, as earlier posited, complexity is dumb and mindless as universal law, then human-edited musical structure based on such a complexity, cannot be otherwise. It is an illusion to believe that music constructed this way works beyond cultural boundaries on the level of transcendental communication. It should always be kept in mind that complexity of sound structure's emergent behavior is amoral and has no intrinsic value. It may result in something new and innovative but also be a blatant bore to the musical audience.

This problem can be viewed through Einstein's absolute mis-statement that the "universe is a friendly place" (for whom ???). This premise is feasible only in relation to the thinking that humans have more rights on this planet than, say, the AIDS virus. But do they? How about an asteroid which, as a result of some emergent behavior of cosmic proportions, wipes out all life on the Earth tomorrow--can we believe that the universe would really care about it? Imagine the question from the universe's point of view: does it make any difference for the universe if Mars or the Earth disappear? As far as we know at this historical moment, the universe would just mind its own business and keep on expanding into the next emergent innovation. For innovation to be considered creative, we need a viable context, an ecosystem to whose well being this innovation will contribute. Thus, rather than struggling to incorporate these new scientific findings into the structure of our electronic music, it would be better to concentrate on the environment that can understand our "masterpieces." Music needs to operate within human's reach not within any chancy hyper-complexity.

So, what is the environment in which our music exists, and how do we conclude whether its contribution is positive or negative--this is the question with which composers ought to be concerned. Switching contexts, how do we figure out what is good and what is bad food. We look for response and, based on that response, we draw conclusions. Eating greasy cheeseburgers often, would certainly raise my cholesterol level and, in the long run, I may end up having a heart attack. Conversely, if I release my music into the public arena of my environment and get no positive response or audience interest, I probably would fall into the category of esoteric innovator rather than pertinent creator. Let me try to clarify the difference between creation and innovation using a biological analogy.

2. Creativity vs. Innovation

The human body is an amazing living system intricately designed to survive in its environment. One day a new virus penetrates the body and threatens the stability of the entire system; alarms go off and differentiated lymphocytes (one type of white blood cells) approach the virus in order to figure out their makeup. Browsing at the speed of light through the enormous data base of previously produced anti-bodies, these lymphocytes find out that they have never before encountered this particular viral strain. Then, quickly, the undifferentiated

lymphocytes rush to read the genetic code of the unknown virus. Using that information lymphocytes mature and become differentiated, changing their identities so that their genetic code matches the code of the unknown virus. Now, ready for the fierce battle, these new lymphocytes start to multiply as fast as they can. Each new lymphocyte produces a deadly anti-body protein which kills the virus, saving the social order of the organism. Concluding the transaction, the lymphocytes memorize this viral genetic code and store it in their data base, in case of eventual need in the future. The ecological day--and long term organismic gratification--has been won!

On another day, one of the body's delicate parts, a single living cell turns out to be a self-expressive innovator, although no one knows exactly why, and changes its social function--decides not to die at all. Therefore, instead of vanishing at the end of its lifetime, it starts to multiply, producing more and more innovative siblings. This geometrically progressing, separatistic growth has no concern for the societal coexistence of its constructive elements. It functions egocentrically and with self indulgence, destroying everything in its path. Cutting and ravaging the other surrounding cells and tissues this anti-social cancer grows until it reaches a point where it can expand no more. At this instance, the delicate social organization of the original system--the human body--is so disturbed that it cannot function as a whole any longer; it has to collapse and die, killing itself and the cancer. The ecological day has been lost!

You may wonder how all this relates to computer music. Let me explain. Computer music, tightly linked to technology and its development, became one of the biggest proponents of modernism and the musical avant-garde. The question rose: Was this music innovative or creative? There are several ways of answering. But let me use my biological analogy once more. In both cases mentioned earlier, the changes made within the cells rendered specific responses from the organism. It was not the change or the single action taken by the changed cells that made it into a good or bad choice; it was the complexity of responses and transactional ecology generated by the components of the holistic system. Quality does not exist in the cell nor in any singular component of a living system; it is rooted in the transactions among them within their existential context. Similarly, computer music artifacts cannot be analyzed apart from responses made by the environment in which they are presented. If there is to be an evaluation, it has to come from the quality of the transaction which includes not only the musical configuration but its cultural response as well.

3. The Scope of Action

Let me assume that the most common function of music is its attempt to communicate--to present a body of aural information which may eventually be understood and embraced by society. How does that work? Have you ever wondered why a funeral march from the Chinese culture does not sound to western ears like anything even remotely mournful? That happens because the funeral music is sound organized into culturally understood patterns unique to the Chinese. Musical sounds per se are certainly meaningless, because music cannot express anything extra-musical, unless the association to which it refers already exists in the minds of the listeners. There is no way to convey any meaning if there is no common redundant ground of socially shared experiences and responses. I would venture to say that almost all of us agree that music when placed in a public arena is primarily about communication between a composer and the audience. The question thus becomes: should my intention "have larger orientation: the universe as a whole" [Jencks 1995] addressing a community of intergalactic proportions where the complexity of emergent structures is commonly understandable, or should I present my music to a community of interested inhabitants on planet Earth?

How big, after all, does community have to be in order to be manageable for successful interaction. This can be answered by another question: what size is the audience that understands your "language" of communication? Nicholas Negroponte predicts that "we will socialize in digital neighborhoods in which physical space will be irrelevant and time will play a different role" [Negroponte 1995]. But what he misses is that the primary focus of socializing on the Net is not only transcendence of space and time, but, most importantly the transcendence of the body. To paraphrase Marshall McLuhan "technology is the extension of human powers" and what we see today is that "technological prostheses had begun to 'liberate' us from the limitations of the human body" [Slouka 1995]. Cyberspace is being tilted as a hyperreal simulacrum designed to be a pure, clean, and spotless--providing us an escape from the real world (already demoted by the Net's digerati to the acronym RL) as being "boundless in its difficulties" [Borgmann 1992]. This is the reason why "the biggest difference between horses and cars," as Keith Hensen points out, "is that cars don't need attention every day and horses do" [Kelly 1994]. In other words silicon-based machines are supposed to work infallibly, while carbon based ones fail almost every day. One could well ask at this point why are humans so unhappy about the shortcomings of life and the body and such big suckers for pseudo-perfection?

4. Perfection Chase

Human obsession with perfection has a long and sullen history. From the early beginnings of scientific treatment of music by the ancient Greeks, who derived Greater and Lesser Perfect Systems of musical intervals, long-desired aural perfection has never been achieved. It is not by chance that musicians, being far more interested in formal theory of musical structure, seldom talk about the meaning of musical content From a different angle, the history of western music can be perceived as a series of failed attempts in achieving absolute formal perfection as a bridge to transcendental purity and personal redemption.

It would be silly to blame Plato, who lived 400 BC., for believing that various types of musical scales produced an automatic subconscious process which, in turn and with great precision, were capable of modifying a listener's behavior. But two millennia later, were Boulez, Babbitt, Xenakis, LaMonte Young, and Cage, to name a few paradigmatic ones, essentially any different in a philosophical sense? All of them held to the modernist music idea, that objective musical perfection can transcendentally affect the listener. Yet they are so similar to Plato in their musical undertaking. These modern composers either attempted to create "the perfect structure" using various methods of extreme complexification such as total serialism, pitch set manipulations, mathematical permutations, etc., or they searched for purity by stripping the structure to the basic elements of sound such as perfect fifth "to be held for long time." John Cage, as always, makes a unique case in his endeavors for perfection through indeterminancy and chance--which he believed operate unpredictably and transcendentally as does nature. It is easy to see how modernist composers struggled to improve their formal structures, getting closer and closer to ultimate purity, but it is not easy to see why.

Achieving ultimate purity was always very important to humans. By cleansing the world around them, purging it from evil and dirtiness, humans hoped to qualify themselves for eternal life. Human effort reflects this urge toward perfection, the striving for immortality. Body was the first thing on this superhighway to purity, which had to be abandoned. Next came the real world with its imperfections. Ernest Becker makes this argument vividly clear pointing out that humans "are truly sorry creatures because they have made death conscious" [Becker 1975] and, therefore, they have "to transcend the limitations of the human condition and achieve victory over impotence and finitude" [Becker 1975]. People like to surpass their physical fate in the perishable world of flesh and blood, devising a "nonsensible project" that would assure immortality in a spiritual rather than physical way. Through this transference humans try to overcome what Freud defined as "fear of self-knowledge," realizing that what they are is nothing but frightened creatures conscious of their limitations. I am not quite sure that the above mentioned composers were seeing their artistic activities from this perspective; because if they did, they would have realized the implausibility of their efforts.

No wonder that these various perfection strategies, applied to the field of music never generated any important human response. These composers treated music as a stand-alone object of absolute value. They seemed to ask, why base quality of music on cultural response, which represent no absolute categories but rather are subjective properties of the dirty world filled with non-perfection, death, and impermanence. The conviction that music, which has structural quality and is close to some imaginary perfection, affects the listener

transcendentally--is not that far from Plato's ancient belief. The living proof that the whole idea of purity in music was an embarrassing failure lies in its tremendous lack of communication with any audience.

Surely these composers must have cared whether the audience listened. Milton Babbitt's 1958 article "Who Cares if You Listen?" clearly exemplifies the core of the problem. Babbitt was lamenting how the "general public is largely unaware and uninterested in" contemporary music. Let's suppose that this paper is written in Klingon instead of English you would thus be expected to make an effort to understand it. But, would you do it? Of course not! Thus, as a writer, I can blame your ignorance for miscommunication in getting my message across. This logic makes no sense at all. On what grounds may one suppose that the public is going to be *largely* interested in anything or anybody who is not, in return, interested in the public interest. It should have been understandable to Babbitt why the public is much more appreciative of a car mechanic at a muffler repair shop than of a mechanical engineer with Ph.D. at NASA. The former is not more important than the latter, but because in the everyday world where ordinary people live and dwell, it is much easier to experience the benefits of having a muffler replaced than the benefits of the ingenious construction and design of the launching pad for the space shuttle. Perhaps, we need more composers who get a bit more musical "grease" on their compositional hands.

5. Hypermodern Conditions

What I'm trying to stress here is that as long as there are composers--or, for that matter any artists--who exclusively concentrate on transcendental subjects and do not address the human condition in the real world--communication with their audience is going to be very difficult. What makes this problem even more complicated is the present condition of our culture, exponentially driven by desire for progress via technology, which is producing historically unprecedented complexity and contradiction among its structural elements. Building denser and denser data highways, hypermodern people are confronted with a glut of information which forces them to make one of two choices. A) They can metabiologically cause excessive stress to themselves by attempting to digest all incoming data--a suicidal quest. The amount of information in a single issue of *The New York Times* contains more data than a person who lived 400 years ago had to process in an entire lifetime. B) Or, in order to escape this general information overload, people can resort to a tunnel vision that concentrates on an unbelievably narrow window of highly specialized interests. Such individuals are learning more and more about less and less, leaving out of the equation any semblance of a holistic understanding of how their specialty fits into the rest of existence. They soon discover that they are not living their life; their specialty is living them, and the result is an iconoclastic insanity. Neither of these choices offers an attractive life strategy, but, out of sheer informational desperation, more and more people are opting for the second alternative. Of course, these hypermodern specialists have lost touch with the common base of humanity in pursuit of their own unconnected obsessions. T. S. Eliot, in commenting on Dante's *Inferno*, describes Hell as some place where nothing connects with nothing. Sound familiar?

Does the above mirror what we are doing in our computer music world? It really does if we choose to have a hypermodern lifestyle that aborts all possibility of dwelling sanely within the limitations of the body. Look at the Internet--or even computer music conferences--where we are exchanging primarily technical information. Or examine the electronic music education, which focuses mainly on teaching computer software. Are we losing touch with our common base--music as a service oriented art? It is perfectly all right to exchange among ourselves the technical information about the makeup of our music, but, in the end, to paraphrase Gertrude Stern---a sound is a sound is a sound. No audience would particularly care to find out all the peculiarities of our highly specialized software, nor would that information bear any significance in their interpretation of our music. Perhaps we should stop making music exclusively for ourselves and look at the world outside our own narrow niche, in order to understand where we came from, and where and how we want to go. If we want our music to culturally survive we may look at into biology again, and it is not going to be "difficult to see that a species would not survive without a `built-in' sense of responsibility both for self and for others of the species" [Salk 1972]. What is the prospect of achieving this important task?

6. Postmodern Conditions

What we need are composers willing to give up chasing perfection in the narrow realm of highly specialized perfection and, instead, address the problem of communicating with real and imperfect human beings--and finding the most efficient way to do so. We need a new approach. The first step toward this new approach should be focusing on small neighborhoods, on communities that try understand us even as we strive to understand them, communities of common people that we care about and with which we want to share some common emotions and experiences. We should educate ourselves globally, learning all the peculiarities of the universe that we possibly can, but our efforts for musical communication ought to be directed locally. As Kevin Kelly says: "Where there is an ecosystem, there are local experts. An outsider can muddle through an unfamiliar wilderness at some level, but to thrive or to survive a crisis, he'll require local expertise" [Kelly 1994]. In these small neighborhoods, we may be able to concentrate on what Lyotard calls "small narratives," or things that are valuable and useful to local populations. If we lose our local context, which is the only context within which we can physically dwell, we may immerse ourselves into an utterly amoral universe. We should beware of the "global village" concept which is evolving away from the locally-defined, individual nature, toward a collective hive-mind of the mass self. In such an environment, there is no concern for individuals or the music that they produce; communication becomes a non-controllable, unpredictable, non-understandable, and self-organizing amoral complexity.

We must understand that the "Information Age" should represent "quality, not the quantity of information" [Jencks 1995] and in that light, we ought to use our globally-acquired knowledge of complexity theory. As we look at the musical world of modernity, we can see that it has been moving, for the most part, according to complexity theory. Composers composed an avalanche of musical pieces that relate more to each other than to the common human condition. One innovation followed another to infinitude, just like mindless and purposeless emergent products. We can decisively conclude that complexity may be a law that governs the universe, but at the same time a law which humans must defy. The reason is best described in Becker's words: "the tragedy of evolution is that it created a limited animal with unlimited horizons," [Becker 1975] making us already an exception to the rule. The humans have a mind and the wisdom which "implies making judgments in advance rather than retrospectively" [Salk 1973]. Evolution does not have a mind. Thus, we may as well stay on this divergent evolutionary path and start caring and communicating with each other rather than succumbing to the powers of mindless complexity that innovated us.

There may be a promise in postmodernism and in the possibility of culture arriving at the hyperconscious state, in which creative wisdom begins to replace innovative complexity. Holistic, environmentally-concerned creation must take precedence over separatistic, self-expression; both/and continuums must become a priority over either/or polarities. "Post-modernism means the end of a single world view and, by extension, `a war on totality' a resistance to single explanations, a respect for the difference and a celebration of the regional, local, and particular" [Jencks 1992]. Is the task which emerges utopian and impossible to achieve? Recently, a TV commercial advertised computers made by DIGITAL whose slogan stated: "Man has an increasing appetite for more and more." They are right, if one assumes that humans follow only their instinct for instant gratification. Postmodern hyperconsciousness, which demands a disciplined slow-down, is as difficult to attain as it is to convince the public of the importance of appetite control and staying on a healthy diet. So, what do we--composers of computer music--have to do? Slow down and make sure that the amount of time we spend on figuring out new software is accompanied by an equal amount of time spent studying philosophy and aesthetics, not only in the field of music but equally in the other arts and sciences. This slow-down does not necessarily mean a quantitative change but rather a qualitative one. On the contrary, the

amount of work we may be required to perform can actually increase; what would change is the focus of our efforts. We should not be attempting to bite off a single piece of innovative information that cannot be chewed and carefully digested. More time ought to be spent studying and attempting to understand the transaction between computer music and its social environment. We have to educate ourselves broadly about the various aspects of our own and other cultures, if we want to convey and share common experiences. Without this mutual understanding no communication is possible. Only connect... the rest is silence.

7. Postmodern Strategies

So, what are the strategies for breaking this silence in communication we created among ourselves and our audiences? The primal concept of "bricolage" [Levi-Strauss 1970] is one of the strategies which postmodern culture may use for action. Bricolage is an assortment, of finite number of thoroughly understood, but limited means, for solving a large number of diverse problems. A common illustration of this concept might be the handyman who comes to your house to repair something, and innovatively and comprehensively uses the same bricolage of tools regardless the difficulty. No matter how technologically sophisticated society may be, its subjects still operate within the bricolages assembled through personal knowledge and intelligence. Most important for postmodernists is to realize the scope of one's bricolage in proportion to the scope of the musical problem before them. Global proportions versus local neighborhoods.

In order to successfully communicate with an audience, we have to rely on the redundancies already proven to work within the small neighborhoods. One of the most important general characteristics of postmodern musical configurations is the new use of old music. The musical information already known and previously digested by the public is presented again in new constellations. Postmodernists regard the unassimilated past as much a partner in musical creation as the yet-to-be-explored future. Therefore, postmodernism has no absolute canon related to proportion and beauty; it regards all historical styles and strategies as equally viable options in solving contextual aesthetic problems. By eclectically selecting, not only from the past but from the diverse non-western worlds of music as well; by collapsing the differences among high, middle, and low cultures--postmodernism, always with its neighborhood in mind, produces fresh and interesting musical constellations. This collage of divergent cultural levels may often carry more than one possible interpretive meaning; these meanings are double coded and are configurations fraught with potential for parody, pastishe, and irony. When combined, all these characteristics invariably produce products that are disjunct and discontinuous--which is not to say that they are similar to a disjunctness and discontinuity often associated with musical innovations of the avant-garde. If there is a single negative point about the avant-garde in music, then it is the use of discontinuity and disjunctness without any historical or compositional reflexivity. This music has been obsessed with one unconnected novelty after another, never going back and re-evaluating what has gone before in relation to what is going on now. Being aware of this perceptual problem, postmodernists repeatedly use reflexivity as one of the most important features in their work and their compositions. This reflective concern also requires the postmodern computer music composer to study extensively the ideational redundancies embedded in the culture. More importantly, the composer has to find ways of clearly explaining to the intended audience the intentions of the musical compositions and the necessity of engaging the designated public in musical disjunctness with an active, reflective perception. No reflexivity in the contemporary composer's cultural matrix, or no reflexive intentions and intellect in the contemporary listener--no connection, and no music!

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