Conceiving Music Today: Manifold Compositions, DISSCO and Beyond

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Abstract: - Manifold compositions consist of all actual and potential variants of a work that contains elements of indeterminacy and is generated by a computer reading the same data for each variant. The relationship between manifolds and classes of composition is discussed and a tool (DISSCO) unifying composition and sound synthesis is presented. Deterministic and random processes facilitate by DISSCO are shown to correspond to an implicit worldview and the role of the computer is defined as that of a collaborator complementing the skills of the human composer. It is also shown how musical compositions can be described as complex dynamic systems and two related projects are proposed: a sound "fountain", an ever changing stream of sounds, and a "brewing" piece continuously re-arranging its parts in search of an elusive optimal solution.

Key-Words: - music composition, sound synthesis, stochastic distributions, sieves.

1 Background

The two and half decades that followed the end of the Second World War in 1945 were marked by a period of innovation and consequential ideas unprecedented in music history. In the absence of a common language and in need of finding, in Anton Webern's words, a "substitute for tonality", major composers of that time proposed radically new ways of creating music and thinking about it: unifying the work through the use of similar proportions applied to all its parameters; using chance as the primary constructive device; employing mathematical tools to realize intricate textures, forms and melodic lines. Seminal publications such as the article "... wie die Zeit vergeht …" by Karlheinz Stockhausen [7], "Penser la musique aujourd'hui" by Pierre Boulez[2], the many writings of John Cage, and the book "Formalized Music" by Iannis Xenakis [10] document personal systems but also offer general, abstract definitions of the most fundamental elements of sound and composition.

Born in the same effervescent period, electro-acoustic music has facilitated and enhanced the search for new ideas, expanded enormously the realm of possible sounds and textures, and helped better understand and exploit acoustic phenomena. It should be also pointed out that even during the more recent period of post-modernist retrenchment (characterized by sociologist Daniel Bell as "living in interstitial time"), technology as applied to music has produced actual advances and has stimulated creative endeavors.

Following is the description of a system using both mathematical tools and computer technology, a system that tries to overcome the present stagnation and points to future developments.

2 Manifold Compositions.

The term, first introduced in 1989 [8], defines all actual and potential variants of a musical work generated by a computer that a) runs a comprehensive program containing elements of indeterminacy and b) reads essentially the same data for each variant. Since each member of the Manifold has a unique character and since an arbitrary number of them can be produced, a variant should not be presented in public more than once.

Members of the manifold (variants of the composition) share the same pitch and rhythmic materials, same textures, and same general formal characteristics but different seeds for the random number generator trigger variations in the output. These variations can range from a slight re-arrangement of the notes in the score or of computer-generated sounds in time, to radical alterations of textures and even of the formal architecture of the piece. Similar to faces in a crowd, the members of the manifold are different while partaking in common features.

There are parallels between the manifold concept and that of an equivalence "class of compositions", a proposition exploited by composers in the 1960s. Discussing such aleatory works, Umberto Eco writes: "They are to be seen as actualization of a series of consequences whose premises are firmly rooted in the original data provided by the author" [3]. In both cases, all conceivable variants are equally valid results of an abstract blueprint and a related process. Although there have been a number of previous attempts at computer-generating variants of the same work - the *ST* pieces of Iannis Xenakis, Lejaren Hiller's *Algorithms*, or Gottfried Michael Keonig's *Ubung für Klavier* - none of them have attempted to mass-produce such variants and they use somewhat different sets of data from run to run.

In the case of manifold compositions, a particular relationship is established between the composer and the computer due to their complementary abilities: while humans are more capable of devising rules and structures, computers are superior at providing speed and random elements. In this context, the computer and the composer establish a true collaboration [9].

Finally, manifold production depends on the availability of comprehensive software that does not require or allow the intervention of the user once it starts running. Such a "black box" set of instructions for the computer is necessary for preserving the integrity of the process. Modifying the output or intervening during the computations would amount to the alteration of the data or of the logic embedded in the software. This model assumes extensive pre-compositional work and promotes an experimental and speculative attitude. Post-production interventions become not only incongruent but also unnecessary especially in the case of a seamless approach to composition and sound synthesis such as that of DISSCO.

3 DISSCO.

A Digital Instrument for Sound Synthesis and Composition, DISSCO [6] represents a unified and comprehensive approach to sound synthesis and composition - unified in the sense that its components share a common formal approach and use similar tools, comprehensive in the sense that they deliver a final product (a musical "event") that does not require further processing. DISSCO is a "black box" that reads in data provided by the user and outputs a finished object.

DISSCO consists of two parts: LASS, a Library for Additive Sound Synthesis, and CMOD, a Composition Module both written in C++. Both components are grounded in the idea that identical or similar operations are required at different time scales when constructing a musical work. The entire piece is conceived as a collection of objects (events) and each object is in turn a collection of lesser objects in a Russian dolls type of arrangement: the piece contains sections, a section includes aggregates of sounds, these are made out of sounds and a sound is a collection of partials. The durations of these event types tend to decrease in an orderly way and even inside a sound, one can distinguish a number of time scales: the duration of a sound itself around 10^0 seconds, "modifiers" such as vibrato (FM) and tremolo (AM) around 10^{-1} second, and the frequency around $10^{-2} – 10^{-3}$ seconds [5]. Choices are made at each of these levels and DISSCO provides a number of possible ways for making such selections.

3.1 Utilities.

As shown before, randomness is an essential part of manifold production. First introduced by Iannis Xenakis in *Pithoprakta* (1955-1956) and detailed in his book [10], ***stochastic distributions*** have become by now a rather common composition tool which provides the "controlled randomness" desired by some musicians. DISSCO has a utility, *Stochos*, that reads in two functions of time (or envelopes as musicians like to call them) defining the dynamic changes of the minimum and maximum values of a range; a third envelope controls the distribution of values within this range at any given moment. A second *Stochos* option stacks up a number of probability envelopes whose values add up to 1 at any point and selects an item corresponding to one of the areas thus identified with the help of a random number.

Such envelopes are defined by specifying x and y points and the type of segment between y points which can be linear, exponential or spline. Usually, they are normalized and segments are labeled as fixed or as flexible if the distances on the x axis can be stretched or compressed in order to accommodate events/sounds of various length. Predefined envelopes are either stored in a library or they can be created on the spot if a certain amount of randomness is desired in the selection of x or y points - in that case *Stochos* may be called to perform the task. A third option is to evaluate an existing probability distribution function. Traditionally, musicians have preferred to deal with predefined envelopes containing few segments because they tried to avoid involved computations mistakenly believing that complicated shapes have no or little bearing on perception.

A deterministic way of selecting values out of a continuum is provided by ***sieves***. First introduced by Iannis Xenakis [10] and hinted at by Lejaren Hiller [4], sieves are logical filters, part of Set Theory, based on equivalence relations modulo *m*. Combining equivalence classes through Boolean operations ($\cup$, $\cap$, etc.) could produce traditional structures such as the octatonic scale (also a Messiaen mode with limited transpositions) from the simple superposition of two stacks of minor thirds:

$$3_0 \cup 3_1$$

or the major scale through a more involved sequence:

$$(\bar{3}_0 \cap 4_1) \cup (\bar{3}_2 \cap 4_2) \cup (3_0 \cap 4_3) \cup (\bar{3}_1 \cap 4_0) .$$

Sieves may be used as selection tools at other parameters, rhythm being a prime candidate. In a more elaborate example, a rhythmic sieve whose modulo numbers and indices are in a symmetrical relationship

$$3_0 \cap (4_1 \cup 4_3) = \{3, 9, 15, 21...\}$$

will generate a palindrome, a non-retrogradable rhythm repeating after 12 units (3 and 9 are equally distanced from 0 and $12 \equiv 0$). Combining deterministic and probabilistic features, weights can be assigned to equivalence classes, a situation leading to even more sophisticated constructs in which more or less importance is given to select individual elements. Weighted sieves can even lead to the approximation of orchestration rules when combined with conditional probability restrictions.

Another feature, ***patterns***, offers a similar blend of determinism and probability. A sequence of predetermined (pitch) intervals is provided by the user; it may be used as such or it may be distorted in a number of ways: by randomly modifying selected intervals, by scrambling their order, etc. At the same time, an origin of the pattern is selected and a range defined. Values within that range corresponding to each equivalence class become available and are assigned a weight. Depending on how strict the selecting procedure is, the result could be either a well defined melody, a pitch class collection typical for tone-row music, a “reservoir of pitches” as in Boulez's domains or anything in between. The same observation made in the case of sieves applies here as well: patterns may be used in connection to any parameter, not only for controlling pitch.

3.2 Event factories.

The C++ class Event produces objects/events of various sizes from piece down to individual sounds. All events have a minimum of three attributes: start time, duration and type. A “parent” event can be described as a “window” or *gestalt* and generates its “children” events in a uniform and consistent way, using the same method for all of them. Three such methods are presently available: Continuum, Sweep, and Discrete. Continuum distributes start times and durations randomly sprinkling them within the parent's duration according to a specified density and children's probabilities of occurrence. Sweep arranges them in sequential order making sure that start times are equal to or greater than the end of the previously assigned child event.

Discrete is the most elaborate method and involves a three-dimensional matrix containing probabilities for each possible combination of start time, duration and type. Such probabilities result from multiplying the weights of a general sieve which determines when events can take place with envelopes the show when each individual type of event has a better chance of occurring and with a probability vector weighing the importance of each type. If the density of the parent is high, DISSCO might not succeed at creating the full number of children in one try and new attempts are allowed until either the operation is successful or the user lowers the density.

4. Other possibilities.

DISSCO is a work in progress and new features are added as needed. Some of them have been already tested in different contexts or are scheduled for implementation in the near future.

Together with stochastic distributions, ***Markov chains*** have become a relatively common tool used in contemporary music to generate sequences of sounds or of higher level events. By designing carefully the transformation matrix, the composer can manipulate the variety embedded in the musical discourse - and thus the information it delivers - and control how fast the process will reach a stationary state (if at all). In another practical application, Markov chains may be instrumental in solving the nagging problem of how to generate only durations that can be transcribed in traditional Western notation. A large matrix that encompasses two or more beats and includes all possible subdivisions of the beat could avoid impossible situations such as having an eight note of a quintuplet at the beginning of the beat followed by a sixteenth. However, the matrix will allow the same combination if the eight note quintuplet is placed at the end of a beat and tied to the first sixteenth of the next.

Related to Markov chains, ***random walks*** have been used extensively by Xenakis in creating the ***arborescences*** present in the works of his middle and late periods and as part of the Dynamic Stochastic Synthesis (GENDY) which engenders directly the air pressure wave.

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A more substantial means at the disposal of a present day musician is ***Group Theory***. Introduced by Milton Babbitt in his discussion of tone-row music [1] and applied by Xenakis both as a form-generating device and as a means to control "metabolae" or modulations between sieves (in *Akrata*, *Nomos Alpha* and *Nomos Gamma)* [10], Group Theory should be recognized along with the concept of ***vector space*** as crucial in understanding the fundamental structures of music beyond styles, history or geography.

In *Formalized Music* Xenakis also offers an alternative to aleatory compositions which asks the performers to contribute to the final version of a piece by choosing (improvising) among options offered to them either in matters of detail or with regard to formal aspects of the work. Although only three of his pieces (*Duel*, *Strategie* and *Linaia Agon*) make use of the ***Game Theory***, this approach remains – in our opinion – a potentially powerful ingredient in creating manifolds that involve a dialog between performers and, more generally, between sound sources.

5. World view.

All musical works evince a world view either explicitly or implicitly through their language and formal design. In the best instances, when the composer is aware of this, the choice of a particular system and materials goes beyond a mere aesthetic decision. Although DISSCO could conceivably be used as a neutral tool, it contains strong biases and the manifolds created with it display and enhance these biases.

The world thus created tries to "imitate nature in its mode of operation" - to use John Cage's words. It is a world in which probability plays a major role especially at the level of surface details, but a world that is also anchored in deep structures many of them characterized by symmetries. The play between determinism and indeterminacy, universal laws and chance, or among destiny and free will can also be seen as the interaction between Being (Algebra: sets, groups, etc.) and Becoming (Probability: randomness, distributions, entropy/information, etc.). Using musical terms, one can talk about static or "outside time" structures - scales, meter, textures – and the dynamic, "in-time" realization of a piece (see *Formalized Music* [10]).

On another level, the manifolds point toward the ephemerality of the individual and toward the role of the composer as a *demiourgos* setting in motion a process that acquires a life of its own, independent of its creator. In turn this accomplishes the social-oriented goal of refusing to allow a work of art to become a commodity: each manifold variant ceases to exist at the end of its performance, it can not be sold or kept in a drawer waiting for its market value will increase.

6 … and Beyond.

Two related future projects expand on the scope of manifold compositions.

The first, a sound "fountain", is indebted to an idea Romanian composer Aurel Stroe once shared: a piece that would be performed over a long period of time without interruption, similar to water streams coming out of an artesian fountain. The music should be created continuously, ever changing in its appearance, never the same but restrained by stable constraints. The computing power available today could make it a reality and DISSCO could provide the means for creating a complex and sophisticated work of art unlike the muzak one hears in airports. From time to time live performers could join in predetermined moments of higher density. Decisions made by them could change the initial probabilities and affect the behavior of the computer-collaborator. Instead of discrete variants of a manifold, an evolving composition would develop and transform itself, even in the absence of an audience, over days, weeks and months, like a living organism.

The second project involves a manifold in endless transformation, or a "brewing piece". Presently, in order to generate a manifold variant, choices are made successively until the density (total number of sounds) and the time constraints are satisfied, each selection being final. However, another possibility is for individual choices to influence no only future ones but also to have a retroactive effect on already existing sounds modifying their parameters or even erasing them. This will result in a piece that is continuously metamorphosing, exhibiting only transitory aspects and permanently "brewing". Samples of the process could be taken at arbitrary times and performed; this way versions of the work will come to life only when someone is "looking" - snapshots of particular manifestations of the manifold.

Both projects consider musical compositions a complex dynamic systems whose parts are interrelated and compensate for each other. While the "fountain" channels such influences in one direction following the arrow of time like jets of water, the "brewing" piece can be imagined as an extensive electric power network in which a failure of one component or an increase in demand in another part trigger adjustments in the entire network. In both cases there is no optimum solution while the system is searching for an elusive stable state.

No decisions have been made yet on exactly how to implement these ideas but the design should establish a "buddy system" probably in the form of weighted graph structures linking mostly same level (but not only same level) events. Such events could be considered as objects moving in the multidimensional vector space of sound parameters, random walks or similar probabilistic ways could be used to explore various paths between objects/vertexes while ways in which the creation of new objects and their destruction is controlled are to be defined.

Translating all this into computer code and solving related problems of memory management is not a trivial task since even a modest musical composition contains a few thousand sounds. The effort, however, becomes its own reward: investigating new ways of conceiving music today.

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