Music, Technique and Technology : A mutual challenge

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Art, science, music, engineering, physics, sound, signals, artificial intelligence, cognitive psychology, information processing : words loaded with meaning, today. A few come from far away and bear with them the sign of a long history : the history of a whole culture. Others are younger, their meaning more widely standardized. Never, before this century, had all these words been living together in a common, interdisciplinary environment. Such an environment is now a reality in the world of computer music.

But what is science ? and what is music ? I will not try to hint at an answer : too many people have already done it. I will nonetheless start with a functional definition and state that the purpose of art is to communicate. The contents and structure of such communication are extremely varied and will not be discussed here. I prefer concentrating on the form it may take.

One of the differences between artistic communication and other forms of communication is that it is not essential to our survival as a species. We do not need art to survive, yet we have had it for a long time. There is, strictly speaking, no progress in art, no struggle for survival. Some ancient sculptures look very much like some Picassos : is it mere coincidence ? What indeed matters is that some ideas exist and that they be expressed with a certain support.

Here are the three ingredients to communicate : ideas, or, more naivly, something personal to say ; technique, or the way in which one expresses himself, and a support, that is some material, tools, codes, symbols, technologies and, eventually, a physical quantity impinging upon our senses, with which ideas can be manifested. In the case of music, such a quantity is sound.

If an artist is, above all, a master of communication, whether he likes it or not, artistic expression can be analyzed in terms of a particular communication network that links a creative source to a potential user, whose role is to receive, decode and interpret the contents of such communication.

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The analysis of the Musical Communication Network (MCN) which is still being used by the large majority of avantgarde composers will therefore constitute the first part of this text. Codified by the occidental culture a few centuries ago, it is the most widely adopted for that kind of music. What is happening and what has happened when listening to a piece of music, say an orchestra piece ?

The origin of the creative act is the composer. He may spend months or years to conceive and accomplish a piece ; a written score is usually the product of his activity.

We will consider a score as the principal means of communication at this stage of the MCN. It contains different qualitative instructions for a performer expressed through a set of symbolic codes. Provided that everything has been used correctly, the result one will eventually hear will match the composer's initial intentions.

One step further, we find the complex task of decoding a score which involves both a translation of the symbolic instructions into control movements appropriate to a given instrument, and the integration of missing information according to previously acquired experience. This is a crucial aspect of what is called interpretation. In the case of ~~the~~ an orchestra piece, for instance, the task is fulfilled by highly specialized musicians : a conductor, who supervises the overall result by shaping such musical dimensions as tempo, dynamics and balance, and the instrumentalists, who are actually in charge of the performance details.

To summarize, the input of this level is both a score and some cues from a conductor and from other performers. The output are motor movements over some physical body, the instrument.

The next component along the MCN is represented by the instrument which reacts to the performer's action in a complex and still poorly understood way and produces sound, or, more precisely, pressure waves.

An instrument is not a neutral tool ; rather it embodies the way a specific culture related to music at a certain period of its history and is often the result of centuries of refinement by generations of instrument manufacturers. I shall look at an instrument from two different perspectives. Their understanding is essential to appreciate the revolutionary impact of computer music on the traditional musical experience.

When dealing with the sound of an instrument one may think of the movements that originate from a performer and it into motion : they are the cause of sound. Unless we are already familiar with it, it is not easy to identify an instrument correctly by simply hearing it. However, it will be much less hard to recognize the way the sound is generated (for instance, by beating, plucking, or scraping the instrument) and what kind of material is involved (wood, metal, skin, etc...). This is highly significant information for our perceptual system. It is the world of instrumental music.

On the other hand, if we look only at the external characteristics of the sound produced by an instrument, that is at the effect, or the way sound looks like, rather than at the cause, we will consider sound as a signal carrying energy through a medium. Such a signal contains information about the time and frequency domains of sound and may be stored in various forms.

These two ways of describing sound are so specialized that it is not yet possible to pass from one to the other smoothly.

How would a Japanese explain, for instance, to a european friend of his who has never seen and heard them what the difference between a samishen and a shakuachi is if he is not allowed to mention the way sound is produced, the size and material of instrument and other causal phenomena ? I am afraid the task will be impossible. On the other hand, how will one be able to describe the difference between a "usual" clarinet sound and a "multiphonic", without referring to the inner frequential contents of sound, that is to one of its characteristics as a signal ? As we shall see, the world of signals is, for the time being, the main world of computer music.

The final component of the MCN is the receiver, who is made, roughly speaking, of an auditory system and of the brain cortex. The former is responsible for perception by converting acoustic signals into neural impulses, the latter is charged of the interpretation of such impulses. It is only at this stage that sound becomes music.

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...even without delving into its social, cultural or aesthetical aspects, a

~~Any~~ musical activity is ~~therefore~~ so varied and complex that it is pointless to talk about computer music without specifying with which part of the MCN we are dealing with.

Since the main demands in terms of power and speed of computation progress have approximately been satisfied, computer music has reached a degree of maturity of expression as an art that no other arts using sophisticated technologies have yet been able to match. At present, each component of the MCN can be simulated - or even be substituted, more or less succesfully - by a computer, provided that the composer be familiar enough with the right kind of knowledge that has to be acquired so as to communicate with a machine satisfactorily.

One of the earliest applications of computer technology was to use a machine as an assistant to the composer, which would help him sketch out a piece by generating large quantities of raw compositional material and placing it at the composer's disposal. In more ambitious applications a computer program directly produced some parts of a piece, if not a whole piece, automatically. In this case, the role of the human composer was to specify just the global behavior of a musical structure by means of some rules and let the machine work out the details of each solution. The product of such computation can be applied either to instrumental music or to computer-generated sounds. One of the first examples of automatic composition, Lejaren Hiller's Illiac Suite (19--) is an ordinary string quartet whose score was entirely generated by a computer. However, in order to communicate with a machine successfully, a composer must be willing to formalize his own musical processes, and this is often a source of trouble and frustration with very intuitive musicians. At present, progress in computer-aided composition will depend on research in artificial intelligence, knowledge representation and automatic learning of intuitive reasoning.

At the beginning of the 1980s, Barry Vercoe of the Massachusets Institute of Technology opened a completely new research area : he succeded in making a machine approximately behave like a performer. Using some fast special-purpose hardware and an efficient software environment, he gave it the ability to interact with a real performer playing on stage. Like a sensitive partner, it would put up with a performer's errors - wrong or skipped notes, incorrect rhythms, and the like - or with his tempo changes - accelerando, rallentando, rubato - and could even progressively learn his stylistic choices after several rehearsals.

It is certainly too ambitious to pretend that a machine is now also an interpreter. Nonetheless, following and reacting to a live performer is already displaying some of the features of human interpreters.

It has been in the domain of sound generation, however, that the use of computers was most influential on great many composers, including myself. For the first time in our musical history, the technology at our disposal allowed us to look inside a sound and to discover its hidden microscopic structure in great detail. New words and new concepts had to be found to describe such an entirely new structure that we had then started to contemplate and analyze. Since they could not come from our tradition - there was no tradition at all to account for them -, these words and concepts had to be borrowed from another domain : signal processing. A totally new subject suddenly appeared on the musical scene : a scientific subject. Musicians had never thought of sound as a signal, until then. And words like amplitude, spectral envelope, attack, linear prediction, fourier transform, sampling rate and the like became part of their common language, at the same level as pitch, dynamics, rhythm, harmony.

As soon as it was clear that a new type of knowledge had to be acquired so as to understand and control these phenomena, the composer's traditional background was severely shaken. Because such knowledge could not come from the old-fashioned academic programs of music departments, new educational systems were claimed for. This claim has not yet been fully satisfied. By learning the means to build new synthetic materials, the composer extended the power of his imagination to the microscopic world of sound. New materials called for new forms and a new concepts to tackle them. In a surge of activities, new ideas to deal with music had to be developed and even some aspects of our historical tradition were analyzed with a different and fresh perspective.

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One of the most important achievements of that time was the unification of timbre and harmony (explain briefly). Time was seen as a "fused" state of sond, "harmony" as a defused state. This unification had dramatic consequences on musical thinking : never before that time had we the oportunity to make a continuous transition between timbre and harmony. So, the analysis of sounds using powerful SP techniques revealed many features with complex time-varying structures of a special richness. These structures were also used to generate the harmonic material of orchestral pieces. In this exemple by Gérard Grisey, a french composer in his forties, you will hear only traditional instruments playing slow chords, but theirs structure is derived from the structure of a single low trombone sound. The result is something intermediate between a real chord an a real timbre.

You see, you cannot play this music on the piano since it uses a microtonal tuning. Can you hear the difference between these very strange sounding chords the following similar exemple which was composed by Schonberg more that 60 years earlier ?

At that time, a great deal of knowledge was still missing and Schoenberg could not even think of making chords sound closer to timbres. You can play this music on piano: it is all made of 5 well-tempered pitches, it uses the same musical scale as Bach (comment and active listening), the nuances between harmony and timbre become much more refined. In this exemple, french composer, Jean-Claude Risset, one of the pioneers of computer music, starts from some trills of real instruments to explore a dream world of synthetic sounds culminating in a powerful crescendo. Again, may I try to focus your attention on these synthetic sounds ? What are they ? Chords, hybrid structures timbres, bell-like sounds, gong-like souns, or what else ? Every single listener among you has to find his own answer, has to listen more carefully and be an active participant to the experience.

I already mentioned thar computer allow a composer to generate new materials, and that these new materials yield another way to organize music. So, the use of a machine has promoteol new ideas which could then be applied back to instrumental music for instance. One of these materials was the concept of "layer", which are long sustained sounds that require only a global control of their structure. Layers were very easy to produce even at the beginning of computer music. Here is an application of the concept of layer to orchestral music... (it's a piece by G. Ligeti).

... and here is an application of the same concept to computer synthesized sounds. It is by an american composer, John Chowning (apologies for quality !!).

Finally, a few composers felt expecially attracted to the interactions between traditional instruments and new sound materials. They felt like doing it not because it was something in the air at that time, but because their imagination could not be expressed completely by using cither one of the techniques.

In this exemple by italian composer, Lugi Nono, two real instruments, a Bass Clarinet and a Bas Flute are playing in a so unusal manner, that they are hardly recognizable even by professional ears. Their unfamiliar souns are processed on stage by a various machines which further increase their distortion. The result has an indeniably special color (piano extended into space, piano expanded into timbres by computer).

In this last exemple taken from a piece of mine for piano and computer-synthesized sounds there is no will to hide or mask the identity of the traditional instrument. The piano indeed does always sound like a piano. But the way it is played, its phrases, gestures and resonances are so carefully controlled that they interact with the computer sounds so as to generate an embiguous world were both the instruments, piano and computer, keep their identity and at the same time fuse together. This may seem hard to explain with words but it will be easier to listen to.

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These and many other examples witness a fertile period of active production, centered around the late 70s and early 80s. In spite of the hardship of the working conditions, our optimistic enthusiasm gave us the strength and the determinacy of pioneers. Not only is that period characterized by a strong, interdisciplinary approach, but composers and scientists were also working physically on the same place and interacted with each other in such institutions as IRCAM in Paris or Stanford University. The research, experience and intuitions of the former turned into a challenging test field for the latter. Conversely, new models that were developed by scientists inspired many composers.

But if the use of the same techfilogy favored and catalized the exchange of ideas between musicians and scientists, it was because these ideas already existed and were then mature that a new conceptual framework was eventually established.

During the few years which separate that period from the current days, the technological progress was so striking that the reality became much more complex and radically different. I shall try to group most of these changes in four points.

The first one is mainly psychological. We found out that the more we knew about the structure of sound, indeed the less we knew. Sound is so complex that the more refined were our analysis instruments, the larger was the amount of information they were producing and that we had to learn and digest. A few composers, who had already spent years of intense technical studies, felt the danger of endless research and no composition, and therefore gave up research and continued to generate the same sounds, if not the same pieces, over and over again.

The second point is that it became obvious that the technology which was being used had not been invented for - and therefore was not so well suited to - making music. Researchers started to grope for better interfaces that would facilitate the musician's expression without hindering, however, his power of imagination.

This exigenge turned out to be extremely hard to satisfy.

Third, it was clear that the machine was not at all the only electrical technology implicated in computer music. Other components were also equally important. and still have to be improved.

For instance, the quality of the system used to project sounds in a concert hall is still not good enough, both in terms of the quality of its main element, the loudspeaker, and of the precision of control over it. The inadequacy of the current projection systems with respect to the composer's artistic expectations is even more evident in the case of mixed pieces, combining real instrumental sounds with amplified sounds. There is a kind of artificial juxtaposition between two different sound worlds. One has the impression of a mismatch, of some false coexistence which resists fusion and risks undermining the musical value of the outcome. A lot more fundamental research and technological development still need to be done so as to improve this crucial component of computer music.

Finally, the most dramatic change over the last few years has been the mass diffusion of cheap personal computers and synthesizers to a large community of people . The social important of this phenomenon is indeniable. A great many people had access to and could practice CM.

But there was a dangerous side-effect. Because these machines had to be cheap and appealing at the same time, they were made in such a way that they looked very powerful while they were indeed very limited. (In order to please and satisfied immediately the user they were filled with gadgets). That made everything too easily accessible. The commercial interfaces favor the most reactionary approches to music. Hence, in this domain, larger acess to informaton also meant lower quality, fewer risks, and risking is one of the artis's roles, isn't it ?

In the recent past, it often took 2 ou 3 years of hard work befor one felt he could master teh technology well enough to express himself and write a piece. Nowadays the majority of the users of commercial synthesizers often teke no lenger than 2 or 3 minutes to turn the machine on and pretend that tgheyt are already CM composers and do not need any further studies. And, they tent-d to use what had already been prepared for them, and no longer think over what they really sant. Their pieces all lookk alike, they are all standardized. Standards kill art !

Since everything is immediately accessible at no or little cost, the power of concentration becomes lesser, and thinking less ambitious. I think this is only the musical side of a larger social problem among the youth in highlly developed post-modern societies. (refer to discussion - notime to elaborate).

This phenomenon is emphasized by the current speed of the technological progress when we compare it to the needs of reflection of our compositional thinking. Every musician has to work a whole life to learn to become a master in this domain. A composer working with computers has to dedicate a lot of time to learn how to use a particular synthesizer, for instance, and when hge feels he is ready the machine is often obsolete and he has to start again frustrated to learn how to use a new machine to express the same old ideas.Some clever scientist should find a way to make it possible for artists to keep both speeds.

So, in the recent past the technological dulp spurred the dulp of new musical ideas. We now realized that the interface with a certain machine is not only a technical term, but represents the way we relate, communicat and think of it. In other terms, it represents our experience and our culture. Will our artistic culture, and not only marketing and profit reasons, be ever able to influence the technological dulp and be incorporated with it ?