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作曲家、演奏家、コンピュータ・システム間の リアルタイム・インタラクション

コート・リッピ
ニューヨーク州立大学バッファロー校
lippe@buffalo.edu

概要

コンピュータはますます社会のどこにでもある存在となりつつある。そのようななか、「インタラクティブ」という言葉が広く使われるようになってきたが、誤解されて使われている。本稿では、インタラクティブ音楽とインタラクティブ音楽システムの定義、インタラクティブ音楽での演奏の問題、またインタラクションを引き起こす演奏者／マシンの関係に関して、私がこの分野をどのように、そしてどうして追求しているか解説を試みるなか、述べることにする。さらに、私の作品のなかでのコンピュータの機能と、私が演奏者／マシン間のインタラクションを探究する方法についても記すことにする。

Real-Time Interaction Among Composers, Performers, and Computer Systems

Cort Lippe
The Hiller Computer Music Studios
Department of Music, University at Buffalo
Buffalo, New York, USA 14260
lippe@buffalo.edu

Abstract

As the computer becomes more and more ubiquitous in society, the term " interactive" has become a widely used, but misunderstood term. In this paper, I discuss definitions of interactive music and interactive music systems, performance issues in interactive music, and performer/machine relationships that engender interaction in an attempt to explain how and why I pursue this discipline. Furthermore, I describe the function of computers in my compositions, and the manner in which I explore performer/machine interaction.

Personal Background

Prior to 1980, I was equally active as both an instrumental and electronic music composer. I was originally drawn to the computer because of a strong interest in designing new sounds, something at which computers are quite good, and exploring algorithmic compositional structures, simulation being another particular strength of computers. While new sounds and compositional algorithms can be readily explored in a non-real-time environment, and the tape and instrument paradigm has existed since the beginnings of electronic music, my first experiences with electronic music were with analog synthesizers, and my earliest experiences with computers in the 1970s were predominately with real-time systems. In addition, during the second half of the 1970s, I worked with an improvisational music/dance ensemble exploring live-electronics combined with acoustic instruments. For the past 20 years, I have pursued creative and research interests in interactive computer music involving live instrumentalists and computers in performance situations. The opportunity to combine instruments and computers became increasing practical as real-time digital signal processors became more available in the

1980s. As the level of refinement of real-time control became proportionally greater, it became evident that composed music for instruments and interactive computer systems was a viable medium of expression. And while it is true that interactive computer music is a relatively new area in the electronic music field, developments in the power of desktop computers and the sophistication of real-time software have been responsible for enormous growth of the genre in the last ten years.

The challenge of interactive computer music has been to articulate sonic design and compositional structures in some sort of interactive relationship with live performers. While some composers use computers to model or imitate musical instruments, and others are interested in modeling human performance, I am not interested in replacing either instruments or performers. Musicians, with their years of experience playing on instruments which have often developed over centuries, offer rich musical and cultural potential, and are perhaps the ultimate driving force for me as a composer working with computer technology.

Interactive Music

Robert Rowe, in the seminal book *Interactive Music Systems* [Rowe, 1993], states: " Interactive music systems are those whose behavior changes in response to musical input" . A dictionary definition of the word interactive states: " capable of acting on or influencing each other" . This would imply that a feedback loop of some sort exists between performer and machine. Indeed, the Australian composer Barry Moon suggests: " levels of interaction can be gauged by the potential for change in the behaviors of computer and performer in their response to each other" . [Moon, 1997]. George Lewis, a pioneer in the field of interactive computer music, has stated that much of what passes for interactive music today is in reality just simple event " triggering" , which does not involve interaction except on the most primitive level. He also states that since (Euro-centric) composers often strive for control over musical structure and sound, this leads many composers to confuse triggering with real interaction. He describes an interactive system as " one in which the structures present as inputs are processed in quite a complex, multi-directional fashion. Often the output behavior is not immediately traceable to any particular input event." [Rowe et al, 1992-93]. David Rokeby, the Toronto-based interactive artist, states that interaction transcends control, and in a successful interactive environment, direct correspondences between actions and results are not perceivable. In other words, if performers feel they are in control of (or are capable of controlling) an environment, then they cannot be truly interacting, since control is not interaction. [Rokeby, 1997]. Clearly, on a continuum from triggering to Rokeby's non-control there is a great deal of latitude to loosely label a wide range of artistic approaches and human/machine relationships as "interactive".

Fortunately, a composer can assign a variety of roles to a computer in an interactive music environment. The computer can be given the role of instrument, performer, conductor, and/or composer. These roles can exist simultaneously and/or change continually, and it is not necessary to conceive of this continuum horizontally. On a vertical axis everything from simple triggering to Rokeby-like interaction can have the potential to exist simultaneously. If performer and machine are to be equal in an interactive environment, one could argue that the performer should also be offered a similar variety of roles. A performer is already a performer, and already plays an instrument; therefore, a composer can assign the role of conductor and composer to a performer. The conductor role comes quite naturally to a performer in an interactive environment, and is commonly exploited. The composer role is more problematic: composers exploring algorithmic processes are often willing to allow aspects of a composition to be decided via a computer program, as this is inherent in the very nature of certain approaches to algorithmic composition. But some composers question the idea of allowing a performer to take on the role of composer, and usually this involves giving the performer some degree of freedom to improvise. While I am not attempting to equate performer improvisation with algorithmic procedures, there are certainly interesting connections between the two which are outside the scope of this paper. But if we look closely at the various explanations of interactive music, most of them imply or clearly involve some shifting of the composer's " responsibilities" towards the computer system, towards the performer, or both. Interaction is a very complex subject, and we are probably only at the beginnings of a discussion of human/machine relationships, which I suspect will continue to develop over many years.

Musical Interactivity

While this discussion about interaction is fascinating on aesthetic, philosophical, and humanistic levels, at the practical level of music-making the quantity or quality of human/machine interactivity that takes place is much less important to me than the quality of musical interactivity. Musical interactivity is something that happens when people play music together. Rich musical interactivity exists in music that has no computer or electronic part, and can even be found in instrument/tape pieces (albeit only the musician is actively interacting), so the level of interactivity of a computer system is really a secondary consideration from a musical point of view. While I stated that I am not interested in modeling performers or instruments, I am interested in using the computer to model the relationship that exists between musicians during a performance. This relationship involves a subtle kind of listening while playing in a constantly changing dialogue among players, often centering on expressive timing and/or expressive use of dynamics and articulation. We often refer to this aspect of music as "phrasing", an elusive, yet highly important part of performance. While concepts of musical interpretation exist in solo performance, and one can discuss a solo performer's "interaction" with a score, the musical interactivity that exists when two or more musicians play together is a more appropriate model for describing interaction between musicians and computers in real-time.

Musical Expression in Performance

At its core, European music notation has developed as a Cartesian coordinate system in which precise and measurable information about just two parameters, frequency and time, are specified. In a typical performance we assume that frequency will be respected, usually rather precisely, while we assume that time will be respected in a less precise manner. But, within certain boundaries, variants in both frequency and time are expected and considered part of an expressive performance. Vibrato, portamento, rubato, accelerando, ritardando, etc., are all common markings used by composers and are part of the interpretive toolbox which a performer is expected to exploit in transforming frequency and time. Some composers prefer not take responsibility for notating subtle variations in frequency and time beyond the notated pitches and rhythms, so that expressive decisions are left to the performers' discretion. Other composers, who perhaps prefer to rely less on cultural conventions, specify variations of pitch and time in greater detail. Beyond frequency and time notation there exists an enormous variety of imprecise notation that can be found in any glossary of musical terms: staccato, legato, mezzo-forte, crescendo, sul ponticello, etc. Since these notations are not as easily measurable as pitch and time, they are considered more in the domain of performers. More importantly, a performance is judged, not by whether the pitches and rhythms are correct (this is a given), but by how well the performer expressively alters pitches to a small degree, and rhythm to a larger extent, while interpreting expressive markings pertaining to parameters of loudness, timbre, articulation, etc., with a rather large degree of freedom. The interpretation of these parameters is subjective and relative. The loudness scale (the difference between mezzo-forte and mezzo-piano); the interpolation between various loudness specifications (linear or exponential crescendo or decrescendo); the way in which pitches connect from one to another (portamento), the articulation of notes (staccato, legato, etc.), and timbral nuances (sul tasto, sul ponticello, etc.) are all very subjective parameters. More importantly, the way time can be contracted and expanded (rallentando, accelerando, rubato, etc.), and the way groups of notes can be organized into phrases, making use of all of the abovementioned subjective parameters, are highly valued aspects of a performer's interpretation of a piece. If we consider a musical score, the performer, and instrument as components of a "complex system", the musical interpretation of a set of instructions executed by a performer in real-time is both arbitrary and self-governing. The written score is ordered in time, but the way the score is performed in its details is beyond the composer's control. A given interpretation of a notated score is the piece of music. In the hands of a skilled performer, each performance of a piece is subtly different. The score is simply a road map, a set of instructions used to produce the music. And, although I began this paragraph with the qualification "European", if the word "score" is replaced with "set of rules, conventions, and/or customs", almost any musical performance can be discussed qualitatively by listeners familiar with the traditions of a particular musical culture.

Detection

Using a microphone and an analog-to-digital converter as input data, computers can track parameters of instruments, such as frequency, amplitude, and spectrum. This information can be combined to derive further details including silence, articulation, tempi, and timbre. Further programming allows a computer to make distinctions about more " musical" parameters. Pitch detection is principle in determining vibrato, portamento, and glissando. Amplitude detection predominates determinations such as staccato, legato, mezzo-forte, crescendo, rubato, accelerando, and ritardando. Spectral measurements determine sul ponticello, sul tasto, pizzicato, sordino, multi-phonics, and changes in instrumentation. Sensors can also be employed to track physical motion, which can aid in the determination of phrasing information. The ability to recognize what a musician is doing during a performance can be very useful. A composer is not limited to simple determinations about pitch and time during a performance, but also can collect data about musical interpretation of a score. This information can be used for a variety of purposes: to trigger specific electronic events, to continuously control or affect computer sound output by directly affecting digital synthesis algorithms, to affect the behavior of compositional algorithms, etc. Performers find themselves in situations where their performance has a variety of influences on the electronic output. More importantly, subtle aspects of their musical interpretation affect the computer part. There is a greater chance that a musician's performance can be influenced by the electronic output if the musician senses the effect of his/her playing on the computer part, thereby creating a feedback loop between performer and machine. The ability to recognize what a musician is doing, on as many levels as possible, gives a composer more ways to enrich an interactive environment. Thoughtful high-level event detection and subtle performance nuances can be used to directly affect the electronic output of a computer, much in the same way that performers affect each other in the chamber music paradigm of concert music.

Compositional Approach

My compositions for instruments and computer have an underlying structure that cannot be altered. Most pieces do not include improvisation. Electronic and instrumental events are ordered and their unfolding is teleological. The computer " score" has events that are analogous to the pitch/rhythm parameters of traditional musical notation, in that these events are essentially the same for each performance. But, overlaid on this skeletal computer score, a great diversity of potential for variety exists, so that while the computer part is pre-composed conceptually, the performer shapes the final version during a concert. The computer score functions in much the same way as the musician's score. (I apologize to those who might hope for something more original conceptually. I would propose that 99.99% of what is done with computers is purely a simulation of a tool or activity that already exists, and that the other 0.01% probably represents real breakthroughs in human thinking.) Since the performer's musical interpretation of the written score directly affects the electronic score, and since the performer's interpretation is different each performance, the electronic part is different each performance. The performer is "empowered" by being given the possibility to control and interact with the computer to produce the final computer output, and while I maintain my European concept of "ownership" as composer, the performer creates the final musical artifact.

Increasing the degree of interactivity (or autonomy) might be seen as a way of reducing my control as composer. A completely closed interactive feedback loop negates the concept of control of a system since control is not interaction. In this sense, my music has certain limitations. At times, the performer controls (triggers events) more than interacts. As the composer, if I were to give both the performer and the machine more autonomy, a self-governing interactive environment could be created. But, my intention is not to create an interactive environment, nor to create a meta-musical environment, but to compose a piece of music in which the performer is offered the possibility of interacting with a computer system much as he/she interacts with other musicians. The feedback loop between performer and machine is based on the software environment that I build and on the abilities of the performer to react to what he/she hears coming from the electronic part. This interaction gives the performer both greater responsibility and more control over the environment. I would hope that, via the music, this more " intimate" relationship between performer and machine can be heard and sensed by listeners.

As mentioned above, the computer can be given various roles, horizontally or vertically, of instrument, musician, conductor, and composer; and the performer can be given the roles of conductor and composer. In addition, the performer/computer relationship can move on a continuum (also horizontally or vertically) between the poles of an extended solo instrument to a multi-voiced or multi-part chamber ensemble. That is to say, musically, the computer part can be, at times, inseparable from the instrumental part, serving rather to " amplify" the instrument in many dimensions and directions; while at the other extreme of the continuum, the computer part can have its own independent musical material. In addition, within this relationship, another continuum exists: the sounds in the electronic part can be derived directly from the composed instrumental part, so that, certain aspects of the musical and sound material of the instrumental and electronic parts are one and the same, while at the other end of this continuum, the electronic part can be derived from other sources, which could include synthesis or sound material other than the instrument's sound material.

Human/Machine Relationships

Humans have a rather complicated and intertwined conception of what is human-like and what is machine-like. We spend a great deal of time trying to discipline ourselves to perform like machines: our ideal of technical perfection and efficiency is something akin to our idea of a perfectly working machine, and yet, we also have another entirely negative viewpoint towards anything human that is too machine-like. Our relationship with machines becomes more and more complex as our contact with machines increases in daily life. While I feel it is important to explain technical issues to performers in order to increase their understanding of the various kinds of interaction possible in a performance, I, nevertheless attempt to offer them a certain degree of transparency in their relationship with the computer, so that they may be free to perform on stage as they would with other performers, concentrating on musical issues. My aim is not to put performers in a technological context, but to place technology in an artistic context.

Conclusion and Future Work

A dynamic relationship among performers, musical material, and computers can enrich the musical level of a performance for composers, performers, and listeners alike. Compositions can be fine-tuned to the individual performing characteristics of different musicians; performers and computers can interact expressively, and musicians can readily sense the consequences of their performance and musical interpretation.

As a composer, it is difficult to predict what direction my future work will take. In addition to my work as a composer, I am active in creating interactive pieces with performers that are collaborative improvisations in which I " perform" the computer part. But the software environment for these improvisations is similar to the environment I use for my composed pieces. Of course, while numerous research directions, such as, interactive improvisation environments, interactive computer performer agents, electromechanical control, robotics and AI, gesture tracking via sensors and cameras, real-time graphics and video, etc., all inform my work, there is still much to be done in the research areas in which I am presently active. Specifically, the topics of analysis, processing, resynthesis, and spatialization in the spectral domain [Lippe, 1999] continue to be areas of great potential.

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