Real-time Interaction between Musicians and Computer: Live Performance Utilizations of the 4X Musical Workstation

P.-F. Baietta, J.-B. Barrière
O. Koschkin, R. Rowe

IRCAM 31, rue St. Martin 75004 Paris France
Tel: (11) 47 72 13 32 ext. 46 13
web site address: serious@ircam.fr/PJEP.RG

Abstract
This paper presents applications of one of the most important new directions taken at IRCAM by a constant growing number of performers and composers: real-time interaction between musicians and computers. Three live performance pieces are described, musically and technically, by their composers and software developers.

1. INTRODUCTION
This direction is perceived by composers as a real musical necessity: use of tapes or automatic execution of pre-written computer music precludes the flexibility of instantaneous improvisation, and use of direct interaction instruments that synthesize or passive transformation boxes prohibits the use of intelligent computer processing.

A couple of recent technological developments allow us today to go further in this direction: real-time signal processors, MIDI interfaced devices like dynamic keyboards, pitch-sensors, expanders, etc.; to program micro-computers, and recent developments in multiprocessing and artificial intelligence software.

Rather than giving a simple exposition about this subject, we prefer to present a set of different applications developed at IRCAM to be used in musical compositions.

All these applications have a general structure composed of the following elements:

- input sensor(s) or register the status of the musician(s) and/or the sound of the instrument(s),
- computer hardware on which will be implemented the logical decision algorithms, or rules of the interaction,
- fast signal processing hardware on which to implement analysis, transformation or synthesis,
- output device(s) to diffuse the sound(s).

The basic interest of the 4X musical workstation is that flows of information can be easily organized and processed in this structure between any of its elements, using powerful interactive software tools.

These applications are:

1.1. Dynamic Filtering
Piece: "Epigones" composer: J.B. Barrière software development: P.F. Baietta
Among other elements, this application uses complex filters whose parameters are given by models taken from analysis of real instrument sounds excited by internal sources (sound or white noise impulses) and controlled by playing a midi keyboard.

1.2. Real-time sound micro-splitting
piece: "Table of Mirrors" composer and software development: R. Rowe
This application uses sounds taken in real-time from a basic clarinet and transforms them by several techniques, including a division into 64 segments of 1/16th of a second each which are then re-ordered.

1.3. Interactive improvisation based on sensor recognition
Piece: "Growing Elements: You are in it!" composer:obby Faw software development: O. Koschkin
This application uses a program that allows to extract an optimal tempo and a recognize a melodic motif in a flow of MIDI events coming from a grand piano equipped with a MIDI interface. Using this information, the system will propose a synthesizer of previously sampled percussion instrument sounds. A feedback loop occurs then between the musician and the system, that allows him to learn how to use it.

1.4. Score following computer controlled synthesis
composer: T. Lescio software development: M. Puckette
This application uses the flux4X interface developed by L. Beauregard and M. Surkyn, among other instruments. Each instrument is controlling digital parameters of transformations over itself and the other instruments (amplitude, frequency, shifts, delays, retriggering, sound content...). In certain cases, the instrument will be followed by the B. Vioresso and M. Puckette's step-follower that operates a pattern matching process between the detected playing of the live instrument and a reference score.

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In this piece, we also implemented on the 4X, a bank of harmonizers, to process both amplified instruments and their filtering. As improvement has been added to the harmonizers, allowing them to be put in place at a closer moment. If their frequencies are well chosen, for example distant from each other by a little constant quantity (water over here) very impressive phase effects are produced, very similar to the phase effect developed by J.C. Risset (cf. "A synthesizer monologue" on a 25 years of sound treatment of music), Proc. 111 ICTA, Paris 1983, and also W.M. ferrarin, "The first UNESCO poster", ICMC 86, Gen. 86, June 1986?) with live and unison, in duration.

3. "TALLS OF MIRRORS": Studies for a man-machine duet

Composer: R. Rowe

There are many agencies in the interaction between man and machines. I am interested in how they operate as machines. To this end, I am working on a machine environment which can be considered a duet (for bass clarinet and 4X), in which each partner should be able to function intelligently with the other. Because, I want to concentrate on the interaction between a human and a machine as they make music, I do not have use of any real-time inputs to make the machine rather than the sound of the clarinets alone. There is no operator for the computer because I feel that this would make the environment too easy and add to eliminate the need for the music and the machine to depend on each other.

I consider that machines and human beings are able to do different things well, for example, a person is better at interpreting, in context, a wide range of outside stimuli, while a computer is unparalleled at performing repetitive operations quickly and accurately. My goal is to minimalise to the minimum of each one. I do not want any kind of musical Turing test: so on one will recognise the 4X for an invisible human performer. Rather I am interested in exploring the unique skills of men and machines: their areas of complementariness and difference, and how combine music.

The use of a computer as a musical instrument is quite different from the use of other musical instruments: a computer is not a vibrating body with controlled movement (like a piano or clarinet). A computer can also be programed, that is, can store and use information, knowledge, the kind of knowledge which is expressed and used depends on what role the computer is meant to play in the minds of the music. This creates the scop of musical composition, necessarily, and necessary to analyse then when a computer is used to create compositional algorithms in real-time. A musical performer is then no longer only a matter of interpretation of an existing score: the music is a product of compositional processes executed at the moment they are heard.

In Hall of Mirrors, there is a progression from pre-composed bass clarinet music with computer interaction in which the computer responds to the performer's improvisation according to compositional algorithms calculated by the machine. The machine is then left to its own devices, playing itself. When the machine creates the music which the performer works with the machine to shape the music, the mirror each face each other.
Each player of the 4K is directed to a different part of the treatment/reaction porponent of the machine. The player simply records and plays back sounds taken from the histrionical roles of the four major areas of the action, and then uses the computer to play back his interpretation of these roles. The four players turn the 372 cards to a position and any method of reading the sound can be used to play it back. The 'original' sound was then, backspotted, slowed down, sped up, etc. on the other plotters, other two sound segments are included, but this time cut up on every 64 of a 372 of a second. Thus segment on then reassembled. A mixing player is used to mix three voices from the others and send the music to four outputs.

The last player follows the amplitude of the base line, to supply the machine with information it needs to read back to the human.

There are two possible modes of instruction: either for machine music or the human or the human music to the machine. When the machine is to react, it is a time "window" to which it must wait for a change in amplitude, a specific pitch, or both. When it finds what it is looking for, it senses a predefined function. If the end of the window arrives and it has not seen what it wanted, it plays its function anyway. The activation sense of an expected event is used to suppress or delay the machine's idea of time while the player actually is in the environment. A different approach to score following from that of entering each note with the human will play music of its own attention on the machine's part coordinate the two patterns.

Moreover, a flexible approach to machine music is required by the reception of situations in which the human's behavior is not known in advance.

Half of Mimesis is a musical composition and a process. Each execution of the piece is unique. A version in which the 4K is used in one of the parts, is performed only a kind of impression of an object in motion. The live version of half of Mimesis was performed at IRCAM on 20 May, 1986. The live version will be performed at the ICIMC '86 in Tokyo.

4. CHOICE REMINDERS: YOU MAY USE IT!

Improvised accompaniment for piano and 4K

Composer and musicus: Bobby Few
Software development: G. Korschel

The principle of improvised music is to run under a previously available rule. Couples allow for or demand musically more inspiration. The 4K is the central tool of this musical. It is in the history of black music that improvisation has been implicitly first formalized, then quantified and given other implicit rules that will be formulated again, and so on...

We want here to allow the performing musicians to formulate their own rules by use of the 4K. In order to enhance his improvisation, the performer is given to the improvisation of the 4K. Musical improvisation is a set of algorithms which performs the following functions:

- 1. during the exam, restriction of information (processing of chords, long rests,)
- 2. quantization of rhythmical values, on the current suggested time
- 3. random number of tempo (accidentally randomly)
- 4. selection of the most coherent pulsation with accents (MIDI intensity levels)
- 5. analysis of the current music's mode
- 6. recording of the playing of the musician, in terms of rhythmical values and degrees in the current melodic mode
- 7. synthesis of accompanying instruments, under the rules of their own playing modes, or using the micro-sequences generated by function 6, under the current pulsation and melodic mode suggested by functions 4 and 5.

This program has been implemented using the key real-time control language of the 4K system, developed by R. Rovey and G. Korschel.

Two versions are developed in parallel, which differ in the complexity of each: the simplest is designed to be played on small individual system interfaced with 4K (Mac forever for the instrument). The most powerful one is the 4K instrument for larger computers, and is able to produce the previous version (plastic) inside the improvisation.

Using this improvisation, the musician will prepare a series of previously sampled instrument samples (daily base, trumpet, bass, trombone, traditional african, joint, piano, and human voice).

The rhythmical phrases of these improvising instruments will be chosen in two different modes: values defined by pitch only corresponding to their real function in a certain kind of music, or recorded from the musician's performance with the micro-sequences. The choice of one of the two modes, and rules of the first mode, are one of the sequencing and the selection of the instrument can be programmed or controlled in real time using the 4K/4000 control panel.

Feedback loop mechanisms, between the process and the musician, that allows him to learn how to use it, and to overlap different rhythmical layers that he can change while he plays. In this way, we hope that the experience of improvisation will be expanded by the use of a new instrument, in which the definition of certain rules makes the experience to the listener.

This instrument will be used in a new performance improvisation of Bobby Few, one of the novel features and creative process in contemporary improvisation.

He will play a set of percussion instruments, from the piano, in a continuously evolving spectrumb, including the electronic signalization and transportation of rules in musical improvisation.

4.5 CONCLUSION

Thus three pieces gives a first idea of what can be real-time interaction between musician and composer using the 4K system. New pieces will be materialize by Jean-Pierre Rampal and Tom Magny, using the live-4K interface and MAC4 from ICIC, published by Software Development for the 4K final release, ICIC '86, a real-time projects schedule allowing more following.

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