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FROM INTERACTIVE LIVE ELECTRONIC MUSIC TO NEW MEDIA ART

Jin Hyun Kim

Prologue

Recent diverse artistic projects using interactive technologies are indeed complex, but many of them together form a new direction, which relocates and dissolves traditional boundaries between different categories of art. This article is particularly concerned with a shift related to the concept of music. In the culture preserving the heritage of Western art music, music often refers to works of art consisting of well-formed sound structures which are free of any purpose, i.e. autonomous, and can be understood by distant attentional listening. This understanding of music as an autonomous work of art was supported by autonomous aesthetics grounded in romanticism on the one hand, and by the philosophy of history oriented towards the idea of progress of Western history towards the point of modern times on the other.[1]

Even though metanarrations acting as a legitimation of Western art music began losing their validity at least due to the postmodern discourses on delegitimation and plurality,[2] it is remarkable that discourses on legitimation of one category of music definitely decay in the digital era. It may be observed that there is an unexpected shift from a traditional concept of music, due to the essentially changed format of production and reception of "art" and of formation of artistic experience in New Media Art, even in the cases where sonic materials are primarily used and therefore auditory perception is strongly engaged.

"Interactivity" as a key concept calling into question a traditional understanding of music in the Western music tradition

"Interactivity" is a concept which came into focus in Western music tradition through a dadaistic trend, in which John Cage is a key character.[3] This concept is closely related to questioning the traditional concept of music as an autonomous work of art which is considered as intentionally produced by a 'genius' on the one hand and as receptively perceived by the audience on the other. Cage aims at 'indeterminacy' of the relationship between composition and realisation using a graphical, meaning-free notational system with which musical parameters are not determined as absolute variables, but in a relative relation to each other. He carried out the performances of happenings and fluxus arts with Merce Cunningham, Robert Rauschenberg, and

1 Kim 2004, Chapter 3-4

2 Lyotard 1979; Kim 2004, Chapter 6

3 I refer to "Western music tradition", since the concept of interactivity should be discussed from a different point of view when taking into account other musical cultures.

David Tudor, among others, at the Black Mountain College in North Carolina (U.S.A.) at the beginning of the 1950s, reformulating the concept of art and the relationship between artist, work of art, audience/public and environment: In these performances, creativity is not manifested in a durable work of art, but brings forth action. "Interactivity" becomes a core concept which makes a musical work emerge from the interplay between the composer, the performer, and the audience, from which an unpredictable effect arises during each processual performance. In this way, the artist becomes part of her or his work of art.[4]

Cage opens a new conception of music. Music becomes an aesthetic experience of the unpredictable, the source of which can be found elsewhere than in the intention of a musician being considered as the subject of music. Musical performance is not conceived of as a stage on which an intentional subject expresses her- or himself, but as an occasional situation in which sounds come into the focus of attention. Such desubjectivisation gives rise to the demise of the progress idea of musical structure underlying Western art music, which is oriented towards the modern philosophy of history, and furthermore to the abolition of the category of the 'closed' work of art into an open *aesthetic process*.

Cage's musical compositions include diverse experiments with musical materials, instruments, and performance constellations. However, it is remarkable that he is one of the pioneers in new directions of music composed electronically.[5] In the 1930s and 1940s he used a film phonograph and electronic musical instruments (e.g. "Novachord", a polyphonic synthesiser manufactured by Hammond, and "Theremin", an antennae-based musical instrument played with free hand gestures) for *The Future of Music: Credo* (1937) and oscillators, turntables, and generators for his composition series *Imaginary Landscape No. 1–4* (1939-1951). The use of sound materials created by electronic means and the exploration of different electrotechnical methods of sound collection, generation, and control are closely related to his search for a new concept of music.

In the 1950s and 1960s, after he introduced the principle of "indeterminacy", a live character was assigned to his compositions for sounds created electronically, taking the process of electronic sound generation out of the studio. A musical event of electronic sounds which is formed as composition results from a series of actions which can vary in each performance. A predetermined compositional idea is only concerned with the whole structure including duration, possible actions, sound materials prepared, and if

4 Harris 1987

5 Since the term "Electronic Music" is generally assigned to the musical genre in which a sine wave generator has been used for sound generation in Cologne since the 1950s, I avoid applying this term to early compositions of Cage.

necessary a kind of dramaturgy. The completion of this composition relies rather on (partially unpredictable) performative actions. *Variations V* (1965), which Cage realised with Merce Cunningham as an interactive composition for dancers, can be taken as an example. The performance stage for dancers – equipped with antennae measuring the electromagnetic capacities produced by the various distances from the dancers to each antenna, and with photo-electrical cells measuring light conditions on the stage changed by the dancing movements – serves as a stage for actions which lead to musical interaction between pre-recorded sound materials on tape recorders and short wave radios resulting in a sound mix. With the vertical movements of their bodily parts, the dancers were capable of influencing the sound intensity; the horizontal direction of dancing movements led to varying proportions of sound distribution on the different amplifiers. In his *Remarks 37* (1965), Cage makes it clear that the composition of *Variations V* consists in the medial configuration, i.e. elements of sound system and control units.[6]

The early stage of interactive live electronic music

The experiments with live electronic music which Cage's new concept of music and musical composition underlies, however, seem to derive from the main trend of live electronic music, taking into account, in particular, the European scene of live electronic music. Even though an integration of live music performance into concerts of Electronic Music is also an essential aspect of the latter, the idea of interactivity which Cage explicitly deals with, questioning the concept of Western art music as autonomous work of art, is hardly found in the early stage of live electronic music rooted in European *Musique Concrète* and Electronic Music.[7] This might consist in the fact that a number of the composers of *Musique Concrète* and Electronic Music tend to extend new musical materials and electrotechnical procedures to create an autonomous musical piece, following the tradition of Western art music.

In most performances of live electronic music, composers tried to experiment with the possibilities of integrating live performing musicians (singers and instrumentalists) into the performances of electronic music, which otherwise are purely based on the reproduction of a pre-composed piece via

6 Cage 1965

7 The French sound engineer and composer Pierre Schaeffer founded *Musique Concrète*, which is created with "concrete" sound objects by an electronic means. Everyday noises, speech sound, or acoustic sounds are recorded using a microphone on magnet tape and processed using montage, filtering, mix, and transposition etc. (Schaeffer 1966). The centre for Electronic Music in Cologne was engaged in techniques of sound generation in a purely electronical way. Sinus tones were generated by an generator, and then either overlapped or mixed with filtered noises and impulses and recorded on a tape (Manning 1985).

loudspeakers. In this way, they aimed at the interplay between traditional (live) music performance and reproduction of electronic musical compositions. Live electronic music can in this context be seen rather as a complementary approach to traditional electronic music performances, giving them a live stage character and enabling the use of an ensemble of instrumental (or vocal) and electronic music. A relocation of the roles of composer, performer, and the audience or the concept of music as a work of art, however, does not seem to be a topic in the European trends of live electronic music.

Interactive live electronic music has been developed in the context of live electronic music as an approach to solving the lack of context-sensitive variations of usual live electronic music consisting of a live performance of instrumental or vocal music accompanied by pre-composed, fixed tape music. Interactive live electronic music tries to render electronic music parts capable of reacting to live performance situations and varying context-sensitively according to each performance situation. For this purpose, a computer-aided analysis of information coming from live performance – utilising interactive software – serves as a basis for an 'interactive' output of electronic sounds. "Interactivity" is here related to the capacity of the computer system to "change [its behaviour] in response to musical input", as the composer and researcher of computer music Robert Rowe defines "interactive music systems".[8] This is similar to a technical concept of interactivity used in early information technological research on human-computer interaction (HCI). In those so-called interactive music systems, the tasks of the computer consist in an interpretation of raw data captured during a live performance and in their use for musical composition and for sound generation. In the early stage of live electronic music, the role of interactive music systems was computer-aided automatic accompaniment of a live performance. The composer Joel Chadabe who introduced the term "interactive composing" in 1983 gives an overview of an (early) interactive music system (Fig. 1).

In most performances of early interactive live electronic music, musical information – e.g. pitch, loudness, dynamics etc. – served as the input data of interactive music systems. The so-called score following techniques were developed for this purpose:[9] A musical score for the live performance is put into a computer system in a certain form. The live performance is captured via a microphone or a MIDI interface and analysed by the computer system in real-time. The analysed sound events are compared to the score stored in the computer. If there is a match, the computer accompanies the live performance, generating sound events algorithmically – based on the score storage.

8 Rowe 1993, p. 1; This book entitled "Interactive Music Systems" is the first book dealing with those systems and Interactive Music systematically.

9 Vercoe 1984; Dannenberg 1984

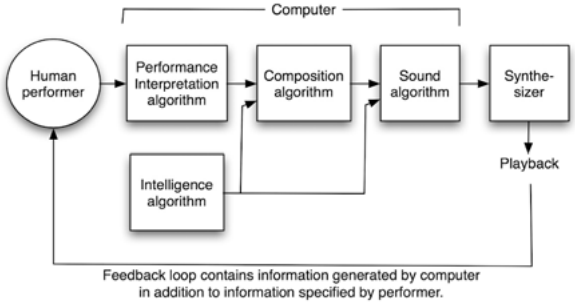

Fig. 1. The general principle of procedure of an interactive music system (Chadabe 1983)

Most score following techniques, however, are based on the principle of a knowledge-based system developed by a traditional approach of artificial intelligence. A musical score, which is put into a computer system, acts as a kind of represented knowledge. A score-following technique, which allows the computer system to monitor input events coming from live performances of an instrumentalist and to compare these with the knowledge – the score – of the computer system so as to process computer-generated sound parts, has a hierarchical structure of interaction processes – from the sensing up to the processing and down to the response stage.[10] A knowledge-based process of interpretation of information coming from the sensing stage takes place in the processing stage, which is separated from the sensing and response stage. In other words, an exchange between internal and external processes does not take place during the processing stage. Output events of machines as a response to input events are determined in this isolated stage and realised by top-down organisation. Hence, knowledge-based interactive music systems are conceived of as decoupled from the environment and therefore as not truly interactive. What is realised in the early form of interactive live electronic music is a more flexible accompaniment of electronic music generated by algorithms to a live instrumental or vocal performance. In most cases, the traditional concept of music as "work of art" still remains.

Bodily-based interaction with sound events

Contrary to score following techniques, which are almost exclusively used for interactive live electronic music originating from the tradition of Western art music, further techniques of motion tracking are applied in broad artis-

10 Rowe 1993

tic contexts. Since the 1980s, in which technological possibilities to capture bodily actions and to use them as input data for the computer system were standardised, many artists have increasingly experimented with a variety of interactive art based on bodily actions of an observer/performer, whether interactive sculpture, installation, or performance.

In interactive live electronic music, motion tracking techniques, which became the focus of attention in the 1980s, have met with large interest since the 1990s, so as to lead to diverse experiments from both artistic and information technological perspectives. Motion tracking techniques are combined with so-called gesture mapping, which means an effective computable mapping from bodily gestural parameters (e.g. position of a body part or intensity of finger pressure) into parameters for sound synthesis (e.g. frequency or amplitude of acoustic wave form). Hence the development of different strategies of gesture mapping has become a hot issue of information technological research on interactive live electronic music. Most of gesture mapping, however, consists of ad-hoc solutions, not based on a general rule. Gesture mapping, however, seems to offer diverse possibilities of designing the interactive relationship between bodily actions and sound events.

Musical interaction which is not based on score-following techniques, but on strategies of gesture mapping, does not only behave as an "ensemble" (live performer and computer accompaniment). Some modes of musical interaction can also be described with further metaphors inspired by traditional music practices such as playing an instrument or conducting. A multiplicity of musical interfaces simulating, extending or re-configuring traditional musical instruments have been used in interactive live performances in which a performer has the role of a player of this new "instrument" and the computer acts as a musical instrument.[11] The definition of a rule of gesture mapping is a main task of composition, which however is often not decoupled from performance. Therefore most composers act at the same time as a performer "playing" her or his musical interface designed especially for her or his compositions, which can be realised and completed during the process of performance.

Fig. 2. Max Mathews with the Radio Baton/Drum in 1992. Photo by Patte Wood (Chadabe 1997, p. 231)

Some interfaces allow the performer to act as a conductor shaping a musical composition expressively. For example, the *Radio Baton/Drum* developed by Max Mathews (Fig. 2) renders the performer

11 Editorial footnote: see for a few examples Jäger/Kim and Goto for an example of his violin interface *SuperPolm* in this book.

capable of controlling musical expressiveness during the performance, moving two batons equipped with different radio emitters over a square surface equipped with receivers. Each baton provides information about its horizontal (x) and vertical (y) position and its height (z). In this way, a three-dimensional movement of each baton can be followed and mapped into parameters for digital sound manipulation.[12]

Such modes of musical interaction inspired by traditional music practices give rise to a rethinking of principles of bodily-based musical interaction, which is basic for each music performance. Especially the coordination of auditory and tactile sensations has become the focus of newer research on the design of musical interfaces based on approaches of physical, haptic, and tangible computing.[13] A number of so-called haptic musical interfaces are capable of offering haptic feedback so that a user/performer can touch, press, or pull a physical material to enter into musical interaction mediated by algorithmic computation. A group of tangible interfaces can be grasped, squeezed, or moved from one place to the other so that a user/performer can use physical actions with the help of physical objects directly situated in a real environment to control and represent digital information.[14] Furthermore, force feedback or vibrotactile feedback have been additionally simulated in some musical interfaces in order to improve musical interaction with new interfaces. Usually a user/performer dealing with haptic or tangible musical interfaces is requested to concentrate on physical actions which are rarely guided by visual representation. Hence she or he can develop the skill of coordination between tactile and auditory feedback the computer system offers, which is similar to the experience underlying the playing of traditional musical instruments. In this way, music can be dynamically composed, "feeling" it at the same time during the bodily-based interactive performance guided by a loop of double feedbacks.

Some strategies of gesture mapping enable a kind of dance-music interaction. The whole bodily movement of a performer can be tracked to trigger and control sound events. Dancing here no longer means an adjustment to pre-composed music, but a process of composing and modifying a musical structure which adjusts to dancing movements. A choreography of dance

12 Boulanger/Mathews 1997

13 Igoe/O'Sullivan 2004, Brewster/Murray-Smith 2001; McGookin/Brewster 2008; for information about current research on tangible computing see *Proceedings of the 1st International Conference on Tangible and Embedded Interaction* 2007, online available: <http://portal.acm.org/toc.cfm?id=1226969&type=proceeding>; *Proceedings of the 2nd International Conference on Tangible and Embedded Interaction* 2008, online available: <http://portal.acm.org/toc.cfm?id=1347390&idx=SERIES11433&type=proceeding&coll=ACM&dl=ACM&part=series&WantType=Proceedings&title=TEI&CFID=17833818&CFTOKEN=87925403> (last access: March 2008).

14 Editorial footnote: see for some examples of tangible musical interfaces Weinberg in this book.

serves here not as an interpretation of musical composition, but rather as a main part of musical composition which can only be realised by dancing performance. A complete composition which can be reproduced independent of each performance does not exist. Experimental computer-aided dance-music interaction is a new field which dissolves traditional categories of dance and music. Besides camera tracking techniques, some wearable interfaces such as the *DIEM digital dance system* by the researchers at the Danish Institute of Electroacoustic Music, the *MIDI dancer* by the artists group *Troika Ranch* and the *SSPeaPer* (Sensor/Speaker Performance Interface) by the composer and researcher Curtis Bahn have been developed especially for the purpose of dance-music interaction.

The principle of dance-music interaction also underlies many interactive sound installations which are not from a stage-oriented performance genre, but originate from the category of fine arts. Interaction often takes place in this context involuntarily, such as by entering into an installation room and triggering a sound generator. Further modes of interaction with sound events, however, can be actively explored. This act of interactive exploration may be compared to dancing. For instance, the *Very Nervous System* developed by the Canadian media artist David Rokeby is used both for dance-music interactions and for interactive sound installations. The *Very Nervous System*, which is based on a camera-tracking technique, is a sonically oriented system, since a virtual environment designed by Rokeby does not provide a visual representation, but consists solely of sound events. Therefore an observer cannot remain passive in order to enter into a computer-generated world, but attains an artistic experience only through an active improvisation. Rokeby intended to develop an improvisation system with which an observer/performer can explore an interactive relationship between her or his dancing actions and the sonifying installation environment.[15] Rokeby's *Very Nervous System* views each movement not as an individual static image, but as a movement flow in the context of linear movement sequence. The temporal aspect comes in via the computation of movement analysis. The movement of the observer/performer is interpreted in a horizontal linear flow, so that a certain movement can be transformed into different sound events according to the whole movement context. The interaction that the *Very Nervous System* provides is not based on the metaphor of dialogue which underlies the most traditional approaches of HCI. According to Rokeby, a dialogue implies a separation of functions of perception and reaction.[16] His system, however, organises per-

15 Rokeby 1990
16 Rokeby 1990

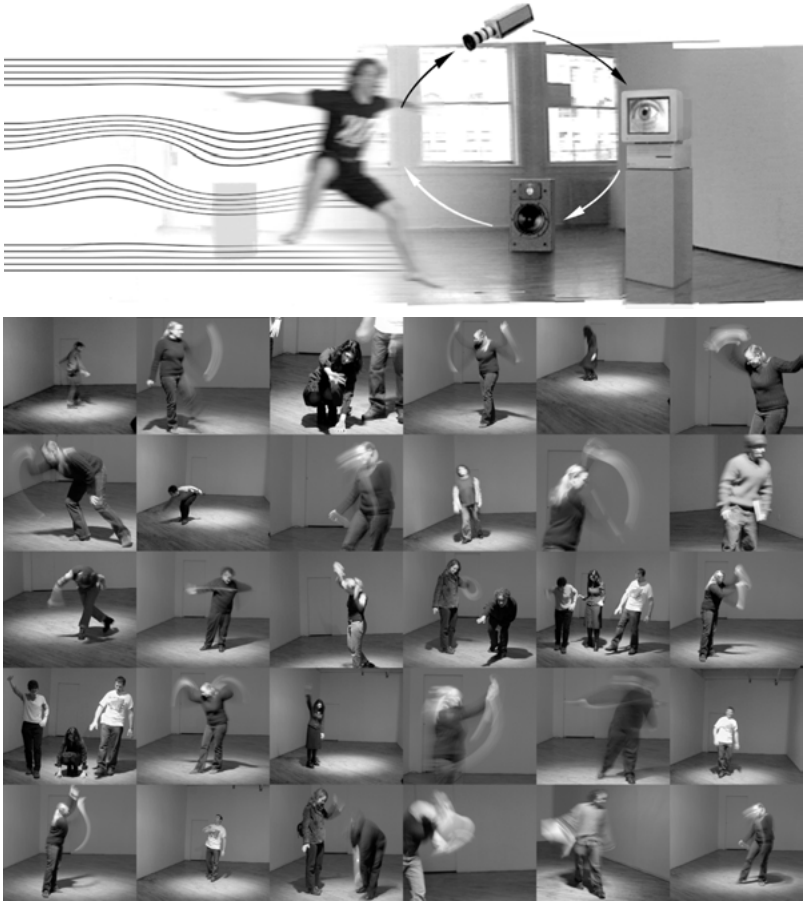

Fig. 3. **Very Nervous System.** ***Courtesy of David Rokeby***

ception and expression at the same time, so that the observer and the computer system form a loop of feedback which is very close and complex.[17]

Interactive emergence

The concept of interactivity has been a topic which in turn needs rethinking due to the recent approaches of information technological research, artificial intelligence, and cognitive science, which place emphasis on new para-

17 Rokeby 1990

digms questioning traditional concepts and their relations (e.g. perception, cognition, action). New technological methods which have been developed in the course of paradigm shift flow into New Media Art, which acts partially as an experimental environment for theoretical questions.

Aritificial Life (A-Life) Art, for instance, is a typical field which was instigated utilising a newer approach of artificial intelligence, *A-Life* procedures.[18] *A-Life* uses the concepts of information processing and computational modeling to understand life in general.[19] *A-Life* research aims at the definition of simple rules from which a complex behaviour emerges[20] – contrary to traditional approaches of artificial intelligence, which give a machine a task to be solved, writing a program accordingly so that the machine can execute this task. Hence *A-Life* procedures focus on simple processes interacting among each other and in this way generating a high-order system behaviour.[21] *A-Life Art* is based on a procedure to generate living behaviour of artificial agents, which is characterised as a bottom-up approach. An *A-Life* approach of computational modeling has recourse to the biological nature of creatures, so that properties such as self-organisation, emergence, reproduction, and adaption are assigned to a machine. *Artificial Life (A-Life) Art* accordingly experiments with different visual, sonic, or physical agents (e.g. robots) which show an emergent behaviour.

In communities of computer music research, a discourse on live algorithms for music (= LAM) has very recently been instigated, which is also the title of a series of conferences taking place since 2004. The main interest is directed towards autonomous interactive algorithms that are characterised by "adaptation and creative contributions of algorithms to the musical dimensions of sound, time and structure."[22] It is concerned with interactive aspects of algorithms inspired by swarm intelligence, evolutionary computation, artificial life and complex dynamics. Live algorithms are intended to avoid "systems pre-loaded with syntax derived from music theory" and "rule-based approaches that relate input to output in a simple way."[23] Some composers and media artists who are engaged in interactive composition and improvisation up to now have experimented with live algorithms approaches in which interactivity is characterised by *emergence*.

The interactive sound installation *Natural Selection* (2005) by Tom Davis and Pedro Rebelo can be taken as an example of LAM projects. Davis and Rebelo use ten mechanical "sound objects", each of which consists of a reso-

18 Bird/Webster 2001; Sommerer 2001; Wilson 2003; Whitelaw 2004

19 Boden 1996, p. 1

20 Boden 1996, pp. 3-4; Braitenberg 1984

21 Boden 1996, p. 4

22 See <www. livealgorithms.org> (last access: March 2008).

23 <www. livealgorithms.org>

nator driven by a motor. Interaction takes place both among these sound objects and between them and the observer. *Natural Selection* is based on an algorithm which is inspired by frogs' behaviour, especially a female frog's choice of her mating partner out of the calling chorus of male frogs.[24] Davis and Rebelo summarise relevant properties of frogs' mating calls from current research results and model them in sonic behaviour of the installation *Natural Selection*: The dominant call frequency is related to the size of the frog, the pulse rate to the temperature of the environment, and call rate and duration to the preference of each individual creature.[25] *Natural Selection* uses a simple model of interactions between male frogs in a chorus, which are symbolised as sound objects, while the observer has a role of the female frog (Fig. 4).

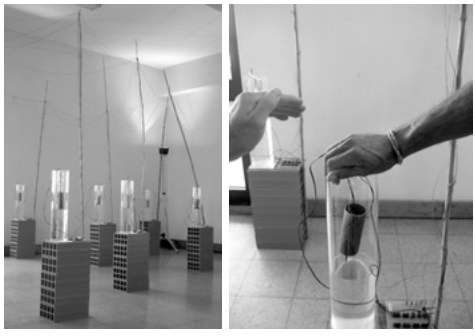

Fig. 4. The installation* Natural Selection *(2005) at the* Música Viva-Festival in Portugal. *Courtesy of Tom Davis

The researchers from the University of Tokyo Jean-Julien Aucouturier, Yuta Ogai, and Takashi Ikegami have very recently experimented with a technique to make a robot dance to music autonomously and synchronously. They avoided a pre-programming of dance patterns. Instead, they built basic dynamics into the robot which render it capable of developing emergent behaviour. The dance movements of the robot were controlled by motor commands generated by using an artificial neural network (ANN), a network of artificial spiking neurons, each controlled by a biologically-inspired model (FitzHugh-Nagumo (FHN)).[26] A sequence of pulses detected from the beats of the music was processed by this ANN, and the output of the FHN network was mapped into the sequence of pulses being used for the robot dance corresponding to the beats of the music. Although this project has not been applied in an artistic context yet, the increasing number of robotic art and musical robotics projects indicates the current directions of using robots as agents of A-Life, contrary to traditional approaches of robotics based on top-down rules.[27]

24 Davis/Rebelo 2005

25 Davis/Rebelo 2005, section 2

26 Aucouturier/Ogai/Ikegami 2007, available online: <http://www.jj-aucouturier.info/papers/ICONIP-2007.pdf>

27 For detailed discussion on musical robotics projects see Seifert/Kim 2007, 2008.

Christoph Lischka's project *par_cho|r* (2001-2004), which exists in different implementations such as *par_cho|r : mono*, *par_cho|r : fugue* (as performances) and *par_cho|r : trans* (as an installation), deals with sound-generating algorithms embodied in the form of a ball robot. In performance projects, a human bass clarinettist interacts live via a 'sound language' with a ball robot which 'listens to' and 'analyses' music played on a contrabassoon and acquires in this way some kind of 'hearing' knowledge.[28] Accordingly this ball robot moves within a certain defined space and plays a contra part. What is observed is an improvisation of two "musicians", which becomes evident in the emergent musical structure.[29] Lischka describes the project as following: The project deals with "artificial ecologies, i.e. artificially generated 'creatures' with their ever particular environments." "An artificial lived-in world of 'ball creature' is created through simulation and reconstruction of this organism by sonic and ultrasonic sensor and actuator technologies. This 'ball creature' develops in each individual and collective characteristic (»swarm«) sonic, visual and choreographic interaction patterns which become in turn an object of artistic experience and performance."[30]

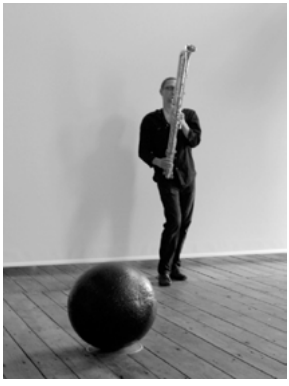

Fig. 5.* par_cho|r : fugue. *Performance at the International Symposium on Music, Art, and Robotics (SMARt) in Bremen (14 June 2006). Courtesy of Christoph Lischka

Such algorithms which allow a machine or/and a unity of human and machine to display emergent behaviour become an essential means of creating works of New Media Art. An experience with evolving sonic behaviour related to her or his behaviour makes an observer act as an actant[31] who, however, does not always possess agency, but is affected at the same time as a patient. A true interaction is based on oscillation between agency and patienthood among the actants participating in this interaction, in a continuous circle of affecting and being affected, in short: reciprocal turn-taking. This concept of interactivity which allows an observer to shape a dynamic process of artistic creation leads to a calling into question of the connotation of "music", which is not limited to a concert hall for Western art music

28 <http://www.zeitmedien.de/AAS.html> (last access: March 2008)

29 Kim 2007

30 <http://www.zeitmedien.de/AAS.html> (translated quoting)

31 The term "actant" is used by Bruno Latour in the context of the *actor-network theory* to refer to entities which carry out an action. This term differs from that of "actor", which refers exclusively to an intentionally acting human subject (Latour 1996).

or opera house culture demanding only one musical behaviour: a passive distant behaviour of music listening. "Interactivity" as a main subject in New Media Art which is of great interest in our digital era makes clear the necessity to delegitimate the hegemony of Western art music and at the same time to rethink the nature of music, which may be conceived of as *interactive* from the outset.

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