Embodiment and Agency: Towards an Aesthetics of Interactive Performativity

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***Abstract* — The aim of this paper is to take first steps in direction of a scientifically oriented aesthetics of New Media Art, taking into account the transformation of musical aesthetics taking place at present induced by new digital methods in artistic sound and music computing. Starting from the observation of relevant current issues in music composition and performances such as gesture control in algorithmic sound synthesis, live coding, musical robotics, and live algorithms for music, certain important concepts concerning a theory of human-machine interaction, which are at present under development in our research project C10 "Artistic Interactivity in Hybrid Networks" as part of the collaborative research center SFB/FK 427 "Media and Cultural Communication", are introduced and related to artistic practices.**

The essential concept of this theory – "interactivity" – is used as a generic term for different kinds of human-machine interactions and is closely related to "agency", "situatedness", and "embodiment". "Agency" stresses a non-asymmetrical relationship between humans and machines. To make clear that some concepts of digital interaction are not conceived of as truly interactive, problems of disembodiment in computer and interactive music and new approaches of embodiment and situatedness in philosophy and cognitive science are discussed. This discussion shows that embodiment serves as a necessary condition for interactivity.

Finally, perspectives towards an aesthetics of interactive performativity are discussed, taking into account interactivity, agency, and embodiment. "Performativity" – as developed in German media theories and aesthetics – is characterized as the capacity of a performative act to generate meaning and "reality". It is proposed as a theoretical approach to an aesthetics of New Media Art.

Keywords – aesthetics, interactivity, agency, embodiment, performativity

I. INTRODUCTION

Algorithmization of sound generation and processing as well as music perception and cognition is one of the greatest effects of digital technologies on music composition and research. In this context it relates to a modeling of musical sounds based on informatization and formalization. In the progress of the early development of computer music, there were some theoretical considerations of the aesthetics of computer music [38][23] based on information theory [53] in which quantified information gains dominance over any other materials.

However, due to the development of computer technologies, interactive systems for music composition and improvisation, signal processing and live performances have been intensively developed in cooperation with information technological research, so that artistic and technological discourses on interactive systems for an artistic-musical use in connection with some communities – e.g. New Interfaces for Musical Expression (NIME), live coding (TOPLAP), Live Algorithms for Music (LAM) and ENACTIVE – have evolved since the end of 1990s. In this way interaction or interactivity seems to have become a core issue of music composition and research using new technologies.

II. RELEVANT CURRENT ISSUES IN MUSIC COMPOSTION AND PERFORMANCES

A. Gesture control in algorithmic sound synthesis

One of the current topics in interactive composition is gesture control in algorithmic sound synthesis, which has come to the foreground since the 1990s due to the increasing number of software for interactive composition and live performances, hardware interfaces for gesture detection, analogue/digital conversion and musical workstations since the 1980s. This approach was primarily developed within interactive music originated from live-electronic music re-integrating performers into algorithmic sound generation and processing in order to use physical gestures as control parameters for algorithmic sound synthesis. But recently, a major interest has been directed towards the integration of the performing body – both the organic and the artificial body – interacting with sound-generating algorithms which may also be embodied – e.g. through an artistic use of robots. In this way, not only an extended form of live performances, but also gesture-based sound sculpture and installation, dance-music interaction and robotic music have emerged. A major issue has been to explore gesture-based musical interaction, for which different approaches have been developed: on the one hand, physical instrument gestures are algorithmically mediated and modeled in order to extend the computer as a musical instrument with gesture interfaces [37][40][50]. On the other, an approach inspired by affective computing [46] aims to recognize physical expressive gestures and accordingly to generate expressive musical features [8][9].

B. Live coding

A further important topic in current interactive composition is what is called in current discourses *live coding* or *programming on the fly* that not only follows an approach of interactive programming – writing and changing a program while the program is executed by the computer – but also a collaborative approach building networks for interactive audio programming in real-time. Hereby, the algorithmic network of programs is integrated into the network of human relations, and vice versa [49]. Interaction taking place in the context of live coding is therefore a distributed and embodied process. Processes distributed over networks by communication protocols such as *Open Sound Control* (OSC) or *User Data Protocol* (UDP) are through embodied participants/programmers in interactive audio programming followed, corrected and intervened. "Embodiment" in this context refers to the aspect of bodily-based coupling of sound perception and programming action. Whereas algorithmic programming off-line that precedes the acts of performance and pre-determine most of musical parameters tends to remain disembodied and to marginalize the environment, interactive audio programming, which started with programs for interactive composition and live performances such as *HMSL*, *M* and *Jam Factory*, *Kyma*, *Max/MSP* and *Cypher* allows the programmer to interact with the ongoing processes in the sound environment. Live coding with networked real-time programming languages such as *SuperCollider*, *ChucK*, *Serpent* and *JSyn* includes interaction of programming processes within a group of participants/programmers.

C. Musical Robotics

Robotic music and musical robotics, which have recently been developed not only in the field gesture control in algorithmic sound synthesis, but also related to issues of autonomous, emergent and complex behavior of embodied agents, are further fields that are coming into the focus of our interest. Two musician-robot interactions that were performed in an international symposium with the title "Music, Art, and Robotics" (2006) are noteworthy. In *Par_choir: fugue* by Christoph Lischka, a ball robot 'listens to' and 'analyzes' music played on a contrabassoon and acquires in this way some kind of "hearing" knowledge. This ball robot moves within a certain defined space and plays a contra part, modulating the gestures of contrabassoon sounds. This leads to an musical improvisation between two 'musicians', which becomes evident in the evolving musical structure and in the music-playing gestures of both as well.

The metaphor of the robot as a musician becomes much more obvious in *Haile* (2004-2006), a robot musician developed by Gil Weinberg and Scott Driscoll [63]. As a percussionist *Haile* carries out a perceptual analysis (detection of note onset, amplitude and pitch) while listening to the playing of human percussionists and accordingly plays a drum by imitating and transforming the playing results of these percussionists. To this end, *Haile* provides the opportunity of improvising with other human percussionists.

D. Live Algorithms for Music

A discourse on live algorithms for music (= LAM), which is also the title of a series of conferences taking place since 2004, is directed towards autonomous interactive algorithms that are characterized by "adaptation and creative contributions of algorithms to the musical dimensions of sound, time and structure" (s. www. livealgorithms.org). It is concerned with interactive aspects of algorithms inspired by swarm intelligence, evolutionary computation, artificial life and complex dynamics. Live algorithms avoid "systems pre-loaded with syntax derived from music theory" and "rule-based approaches that relate input to output in a simple way" (www. livealgorithms.org). Points discussed in this context do not necessarily lead to a new artistic-musical genre, but rather are applied to all possible forms of interactive composition and improvisation mentioned above. Although embodiment has seldom been explicitly discussed in this context, it is observed that most artistic investigations have addressed the embodied interaction of live algorithms, whether with embodied musicians, observers or other agents.

III. INTERACTIVITY AND AGENCY

A. Interactivity in media discourses

In media discourses [60], interaction or interactivity induced by human-computer interaction (HCI) technology and New Media is considered as constitutive for the emergence of a new art form challenging traditional conceptions of aesthetics, although "interaction" is used in different ways and associated with diverse modes of operation in artistic practice, for instance, real-time control in most interactive music systems, immersion in connection with applications of virtual reality [39] and interactive emergence in the context of artificial life art [62].

The adjective 'interactive' as well as the nouns 'interaction' and 'interactivity' encompass semantic spaces that span from a simple metaphor used in computer science for an immediate response of systems to a user's command line input up to the concept of intersubjective communication based on traditional sociological and philosophical theories of action. The nuances of these semantics flow into media discourses about the role which is played by interactivity in art forms using new technologies.

However, it seems to be necessary to distinguish between "interaction" and "interactivity" and to take into account "interactivity" as a theoretical concept that differs from the "dialog" model of traditional computer science or the control-feedback model of cybernetics, which are considered as reactive or responsive rather than as interactive, as well as from the traditional sociological and philosophical analyses of (human) interaction. There seems to be an urgent need to introduce in the social sciences and humanities as well as in computer science a new theory of interaction based on "interactivity" and related concepts such as "agency" and "embodiment". Especially the current development in robotics, artificial life and augmented environments makes it doubtful to ascribe "agency" only to humans. Furthermore, concerning the development in robotics and other branches of computer science there is an urgent sociological and psychological need to clarify and differentiate mental terms such as "subjectivity", "agency", and "intentionality" because in the near future humans will interact with autonomous robots and software agents in everyday life. According to traditional action theories established in sociology and psychology, social processes of interaction are restricted to the communicative actions of speech-capable and action-capable subjects excluding machines and animals. In this way, some kind of "unexplainable" subjectivity in the sense of a conscious autonomous agent supplied with intentionality possessed only by human beings is presupposed. This seems untenable regarding the growing capacities of autonomous robots and software agents to "interact" and "communicate" with people. Hence, new concepts or theories that don't presuppose any asymmetric relation between humans and machines, in which activity is assigned to humans, whereas passivity to machines, are urgently needed to analyze human-machine interactions. To develop such a theory for analyzing human-machine interaction, which is not based on the subject-oriented action theories and does justice to the growing “communicative” capabilities of machines, is at the heart of our research project "Artistic Interactivity in Hybrid Networks".

B. *Agency and interactivity*

For this purpose, our research project C10 "Artistic Interactivity in Hybrid Networks" as part of the collaborative research centre SFB/FK 427 "Media and Cultural Communication" operates with the concept of "agency" that allows human beings, things, technical artifacts, and symbols to be regarded as equal parties participating in an (inter)action [52]. For this concept, three theoretical frameworks are taken into account: Bruno Latour’s actor-network theory oriented towards an anthropology of technique, Alfred Gell’s art theory originating from social anthropology as well as Werner Rammert’s philosophy of technology originating from socionics. Actor network theory deals with a mediated relationship between human and non-human elements [31][32]. Latour introduces the term "actant" instead of "actor" to avoid the exclusive connotation of an acting human subject [31]. Gell’s art theory regards artworks as indices that induce an abductive process [19]. The roles of social actions are split up into agency – activity of action – and patienthood – passivity of action [19]. Rammert’s philosophy of technology stresses components of efficiency respectively effectiveness (*Wirkung bzw. Wirksamkeit*; s. [56]) associated with a semantics of agency in the context of hybrid actions taking place in distributed human-machine networks [47][48].

With regard to the concept of interactivity by use of computer technology, the last position mentioned above serves as a starting point. From the point of view of socionics, a word formed by combination of sociology and computer science, agency permits a changed understanding of technology, which may be shown very well by cooperation of art, science and technology. This new understanding of technology is characterized as follows: the machinery is not conceived of as any universal tool, but a specific instrument for a concrete purpose only realized in a process of "performance" [48]. Therefore, machinery and artworks are produced through testing and using software developed for a particular purpose [48] – for example, interactive systems for real-time music and media performance. Modern technology gains a new quality through its performance as "agency" and through an interactive coupling of distributed actions of human beings, machines and signs in a hybrid constellation [47].

Such an aspect of agency is obviously observed in artistic applications of interactive music systems, multimodal environments, mixed, augmented and virtual reality as well as artificial life. In these systems, human beings – artists and recipients – become – not as in the case of scientific use of simulation technique – a part of the simulation itself. Furthermore, human beings and machines are coupled and merged into a unity organizing and generating an "embodied meaning". As a consequence, an artistic use of such interactive systems brings about their change. Interactivity is based on a taking of effect (*Wirkungsgeschehen*; [56]) that can be understood through the meaning of agency: coming into effect of a physically and socially coupled unity of human beings and machines – "man-machine symbiosis" to quote Licklider – meditated by symbols on the constitution of meaning and reality.

This concept of interactivity stresses the coupling of dimensions separated and polarized in traditional metaphors such as action and perception, representation and control, affecting and being affected. This coupling may be described not only as a symbiotic relation between humans and machines, but also as the process running within an entity being involved in this symbiotic interaction. Both human beings and machines "act" in interaction as agents and at the same time as patients. This patienthood is a potential status of all the "actants" participating in each form of interaction that begins with some kind of disturbance. In this way agency is not considered as opposed to patienthood, but rather as complementary to patienthood. The process of action including passive moments gives rise to interaction. The concept of interaction is not necessarily associated with (pre-given) intentions. Interactivity is therefore viewed as a process in which agency is ascribed to all the entities participating in this interaction.

IV. PROBLEMS OF DISEMBODIMENT INDUCED BY DIGITAL TECHNOLOGIES

Taking into account this concept of interactivity based on agency, disembodied interaction taking place through a closed system, to which a computation process does not allow external input while it is running, may not be conceived of as truly interactive, although it has a minimal exchange with the environment through its input and output separated from the process of computation. Interactivity that is characterized by a process coupling human beings and machines physically and socially is provided by an open system that exchanges information with the environment during an ongoing computational process.

When the computer was used as a musical instrument for the first time in the 1950s [34], the principles of algorithmic sound generation were based on disembodied information that was conceived of as constitutive for sound events and essential for a model of musical sounds. Sound events that are simulated by means of a mathematical construction were algorithmically computed due to abstract information in the form of numbers. The aspects of the body and the environment were marginalized, focusing on the complex process of sound generation and processing by algorithmic computation that was realized by computer programs in the 1950s and 1960s. Programs, if executed on a machine, can be viewed as transforming into (i.e. arguments) into output (i.e. values). In this context programs are descriptions of algorithms that realize computable functions. Mathematical functions are defined extensionally as sets of tuples. In this metamathematical paradigm of computation, the input is completely defined before the start of computation and the output provides a solution to a general problem at hand [61]. The procedure for calculating function values and the arguments of the input domain are specified in advance and cannot be changed during the execution of a program. Therefore, computation of output values from their inputs by such an algorithm is not conceived of as interactive. Such a mechanistic transformation, which is well known as an algorithm in mathematics, has been adopted by computer science. The first idea of the computer as a musical instrument based on its capacity to algorithmically generate sounds therefore leads to a concept of algorithmic – in the sense of disembodied – musical instruments [27].

In early interactive music systems, the principle of a knowledge-based system developed by a traditional approach of artificial intelligence served as a basis for interactive live performances. A musical score, which was put into a computer system, acted as a kind of represented knowledge. The score-following technique, which allows the computer system to monitor input events coming from live performances of an instrumentalist and to compare this with the knowledge – the score – of the computer system so as to process computer-generated sound parts, is a wide-spread technique of interactive music mostly consisting of an instrumentalist and the computer system. Such kinds of interactive music systems based on knowledge-based processing have a hierarchical structure of interaction processes – from the sensing up to the processing and down to the response stage [51]. A knowledge-based process of interpretation of information coming from the sensing stage, taking place in the processing stage, 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 realized by top-down organization. Hence, knowledge-based interactive music systems are also conceived of as decoupled from the environment and therefore disembodied, for embodiment serves as a condition for a coupled interaction with the environment, as will be shown in the next session.

V. EMBODIMENT

In order to elucidate to what extent embodiment is related to interactivity and interaction, the meaning and use of "embodiment" in philosophy and cognitive science will be investigated.

A. Embodiment in philosophy: Merleau-Ponty's phenomenology

A philosophical root of embodiment traces back to the theory of perception of Maurice Merleau-Ponty in the 1940s developed in his major works *La structure du comportement* [36] and *Phénoménologie de la perception* [35]. His focus is directed towards the bodily-mediated aspect of perception: "the relations between consciousness and nature, between interiority and exteriority" [35]. The behaving actor is for Merleau-Ponty not a fully-fledged subject founded on disembodied consciousness. He rejects any notion of a disembodied I that may be 'embodied' in the body acting in space and time. The relation between the behaving actor and the world, which may not be conceived of as 'linear' causation, becomes a main topic of Merleau-Ponty's philosophy.

At the beginning of "sense experience" chapter of *Phenomenology of Perception*, Merleau-Ponty supports the thesis that "perception does not present itself in the first place as an event in the world to which the category of causality, for example, can be applied, but as a re-creation or re-construction of the world at every moment" [35]. Sensations are for him not reducible to "a certain indescribable state or *quale*" [35], but rather a mode of access to the world, a being-to the world, in which form and content meet.

A theory of perception is for Merleau-Ponty at the same time a theory of the body. The subject of perception is according to him not a pure subject without content, but the body [35]. He argues against classical psychology, which treats the body as an object among other objects, and notes that the body is neither a fully external object, which can be observed, nor is it purely internal to consciousness. Rather, the body is comprehended as the body-as-lived (or the lived body), which Merleau-Ponty also calls the phenomenological body or the body-proper (*corps propre*). The relation between the body-as-lived and physical objects cannot be described as a causal relation. Objects are not located "out there" [35], that is, separately from the bodily action, but in relation to the specific field of action. The process of bodily mediated perception is closely coupled with that of action. Perception is a performative act: "the 'perceptual side' and the 'motor side' of behavior are in communication with each other"; "every perceptual habit is still a motor habit" [35]. According to Merleau-Ponty, habits, which refer to repeated actions through skillful copying, provide the stability of perception.

Merleau-Ponty's theory of perception challenges an age-old dualism between subject and object, mind and matter, perception and action, "inner" and "outer". The relation to each other is characterized by "circular causality" [34]. This theory of embodied perception may hence be characterized by action-perception loops and embeddedness in the world mediated by the body.

B. Embodiment in cognitive science

The ideas underlying the theory of embodied perception developed by Merleau-Ponty have recently been taken up in a newer approach in cognitive science after cognitivism and connectionism, which is called "embodied cognition" [12][57], "embodied cognitive science" [44][45], "embodied artificial intelligence" [24] etc. The traditional approaches in cognitive science focused on the system without any further reference to the environment or the coupling of the system with its environment. For example, cognitivism and connectionism as classical approaches in cognitive science study cognitive processes "in" the system. Cognitivism models and explains the (human) mind as a system situated in the "head" based on physical symbol processing. One main technical advantage of this approach is the opportunity to use variable binding and the representation of recursive structures to model cognition and perception. Connectionism uses associative sub-symbolic processing in the style of the brain to model and explain cognitive processes. In connectionism the system under study is the brain or mind/brain. Connectionism provides technical tools well suited to modeling learning, self-organization and classification in cognition. Both approaches focus on the cognitive architecture of the mind/brain and neglect the body and its environment: the philosopher and cognitive scientist Andy Clark refers to these approaches as "isolationism" [13]. Isolationistic cognition separates internal and external processes as well as perception and action from cognition and so may be expressed by the idea of a "sense-think-act cycle" [13] or the "sense-model-plan-act framework" [6].

A new research approach in cognitive science, which has been intensively developed since the 1990s, questions both traditional approaches in cognitive science, cognitivism and connectionism. A core idea of this new paradigm is directed towards the coupling of motor and sensory processes, action and perception as well as inner and outer processes. Francisco J. Varela, who understands cognition as embodied action, places an emphasis on cognitive processes which depend on "the kinds of experience that come from having a body with various sensorimotor capabilities" that are embedded in an environmental context, whether biological or cultural [58]. In other words – speaking with Clark, cognitive processes are considered as emerging from the "continuous reciprocal causation" between mind/brain, body, and environment [12]. According to this embodied approach in cognitive science, not only physical instantiation, but also an agent's situatedness in its environment is of importance to cognition. Hence, a system and parts of its environment are viewed as coupled and forming one new system. The functions and actions attributed to the system are now assigned to the whole system consisting of the system or agent and the parts of its environment. Under this perspective two reciprocal relationships are important: one is the reciprocal relationship between the agent and its environment, the "agent-environment fit". The other is the reciprocal relationship between action and perception: "Perception provides the information for action, and action generates consequences that inform action" [22].

This approach is specified as interactionism by some researchers [1][2]. It challenges the idea of cognition as computation as explained in the framework of Turing machine computability [54]. Theoretically it is assumed that the explanation of "computation" via Turing machines is too restricted to explain computation of interactive systems in a real world. Critics of the Turing machine computability are speaking of the "Turing myth" of computer science [20][21]. From a theoretical perspective, "interactivity" seems to be crucial to the analysis of open computational systems in contrast to closed ones that are modelled by Turing machine computability. Interactionism indicates the opposition to isolationism (i.e. the idea that computation in cognition only takes place in the mind or the brain neglecting the role of the body and its environment). From the point of view of interactionism, one has to clarify the role of computation in cognition in real-world situations where an embodied and embedded entity interacts with its environments and other entities.

C. Embodiment: a necessary condition for interactivity

Physical instantiation – e.g. an observable physical body– serves as a necessary condition for embodiment, but not as a sufficient condition. In other words, "embodiment" means not only possessing a body, but rather the aspect of the bodily entity situated in and coupled with its environment, as discussed in the previous section following Merleau-Ponty's philosophy and approaches of embodied cognition, in particular, interactionism. Therefore, embodiment is characterized by both the coupling of agent with its environment and an action-perception cycle [3] "Embodiment" in this sense places emphasis on the importance of bodily mediated motor-behavior that has an "immediate feedback on their sensations" [6] in a dynamic relation to the world. Accordingly, embodiment that is characterized as a crucial property of agents within the scope of real-world robotics [6][7] and "complete autonomous agents" [44] can be defined with regard to the aspect of structural coupling of the agent with its environment as well as internal dynamics of the agent [15]. Agents having a physical body therefore do not necessarily lead to embodied interaction [27][28], unless the relation between the agent and its environment is mediated by the agent's body situated in and coupled with its environment. As a consequence, Embodiment, which implies bodily-mediated, situated dynamic interactions between the agent and its environment, is considered as a necessary condition for interactivity that is characterized by a process of coupled entities.

VI. TOWARDS AN AESTHETICS OF INTERACTIVE PERFORMATIVITY

Taking into account the importance of "interactivity" and its relation to "embodiment" and "agency" as developed in this article, "performativity" seems to serve as a good starting point for the discussion of a new approach to an aesthetics of interactive music and media performances as well as New Media Art induced by digital technologies.

"Performativity" that can be traced back to John L. Austin's and John R. Searle's speech act theory was developed further in German media theories and aesthetics [17][18][29]. A critique of a representational theory of language meaning underlies speech act theory, which grounds meaning of language not on an immanent structure of language – in particular, sentences –, but on a pragmatic use of language. "Performativity" in the context of speech act theory points to different meanings of a speech act based on extra-language cultural contexts in which this act is embedded. Hence, a speech act is considered as a kind of social action. In this way, speech act theory questions the separation of language and action as well as that of language and facts and directs one's focus towards the efficiency or effectiveness of speech act producing or changing facts of what one speaks, *while* one is speaking [4]. But a further premise of traditional theories of language meaning that a language expression is an intentional expression of a subject still maintains. This idea of speech act theory, which presupposes an intentional subject of speech actions, is questioned in recent theories of performativity.

Current theories of performativity focus rather on the conditions of embodiment of a performative act – whether a speech act or an artistic performance – related to materiality of a performative act situated in a context and mediality constituting reality or meaning rather than transferring intentional meanings of performing subjects. "Performativity" is therefore characterized as the capacity of achieving efficiency which the moment of performance gives rise to. Agency is hence not only assigned to an acting subject as in the case of speech act theory, but may be understood rather in the sense of efficiency. Performativity is therefore not related to the concept of an intending subject that seems to underlie certain goal-oriented actions.

In aesthetics, "performativity" is discussed in connection with the aspect of performance of artistic actions. A performative aesthetics was suggested by Erika Fischer-Lichte, a German literature and theatre theorist [30], to provide new aesthetic concepts adequate to artistic phenomena transgressing the boundaries of art production, artwork and reception. In this framework, art is not reduced to material artifacts. Rather, enacted performance based on materiality and mediality, in which a representational relation to facts external to performance does not play a role, but unrepresentable and presymbolic experience becomes actual, comes into the foreground. Such a concept of performance however is different from that in performance studies in psychologically oriented music research [43][30]. Most of these studies of music performance have treated music production and perception as separate research areas since music processing is regarded as encoding on its productive side and as decoding on its perceptive side, which is based on the transmitter-receiver model of communication theory. Here music performance serves as a channel through which separate processes of active production and passive perception are mediated, in such a way that music performance has the status of a secondary means by which internal music-independent intentions may be externalized [26].

The framework of performativity offers an alternative perspective on music performance, which serves as the ‘stage’ integrating the processes of music production and perception. In performance of a musical action, both music production and perception are guided by action-perception loops. This aspect of the coupling of action and perception, which was specified in section V as one characteristic of embodiment, becomes more obvious in interactive music and media performances, in which an artist becomes a performer who is at the same time a recipient, and vice versa: an observer becomes a performer who functions at the same time as an artist. A performer embodied in interaction is part of the system interacting with the environment guided by turn-taking of activity and passivity and the coupling of action and perception. Hence an 'expressive meaning' of musical behavior is not considered as completely pre-existent before an act of interaction, but as an effect generated in terms of agency. In this way, the idea of artist as intending subject of artistic actions and the concept of closed artwork are dissolved. Rather, aesthetic experience connected to presence taking place in an artistic interaction becomes the focus of a framework towards an aesthetics of interactive performativity. Therefore, a starting point for music research may be not some kind of subject’s, e.g., the musician’s intention that precedes the performance of a musical action, but musical behaviors situated in the world. The focus of research should be directed towards embodied aesthetic experience that emerges during a performance due to the coupling of action and perception.

Having developed some concepts within a theory of interactivity that might be relevant to a scientifically oriented aesthetics for New Media Art, the next step in our research will be the development of experimental and empirical procedures to test and explore the usefulness of these concepts. New Media Art itself provides an excellent test-bed for such empirical research. We will use the Embodied Interaction paradigm of HCI [16] as well as some robots to test and explore aesthetically relevant concepts of our framework.

In interface design, approaches of tangible and social computing may be taken into account for a mutual constitution of action and meaning through embodied interaction or practice embodiment [16]. Tangible computing is characterized as "an attempt to move computation out of the "box on the desk" and into the environment." [16]. Main aspects of tangible computing come into the foreground "[by] capitalizing on the contextual factor like presence, location, and activity it sets out to unify computational experience and physical experience, …" [16]. Tangible musical interfaces, particularly haptic musical interfaces are candidates to explore the process of music production that consists in a perceptually guided coupling of motor and auditory feedback [26][55], supported by the design of force or vibrotactile feedback accompanied by auditory feedback induced by algorithmically generated sound. We expect to provide evidence for the constitution of musical expressiveness through embodied interaction by some case studies planned for 2007 within our ongoing research project in cooperation with the Studio for Electro-Acoustic Music (STEIM) in Amsterdam by modelling haptic feedback of interfaces to allow the performer an action-perception loop while 'playing' gesture interfaces.

Embodiment of algorithmic processes of sound generation or gesture and movement control in robots seems to be more relevant to 'move computation into the environment' in which situatedness – such as presence, location, activity and social factors – plays an important role in embodied interaction. Our research project aims to investigate embodied meaning of musical behaviors emerging in the process of interaction between human beings and robots as well as among robots. Exploratory empirical studies with *Lego Mindstorms* and *Lego Mindstorms NXT* robots have begun and further studies with two WLAN-capable *Khepera-III* prototypes equipped with sound cards "on board" and diverse sensors are under preparation and will start this year. At the same time we are developing a methodology concerning experiments, observation and evaluation of human-machine interaction in New Media Art starting from ethology.

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