Emergent Behavior in the context of Reactive Compositional Environments

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Abstract: This discussion paper identifies a number of fields of practice that consider emergent behavior to be a key element in realising new creative forms. Creators across these fields manifest compositional processes, immersive environments, interface design & tracking systems, human computer interaction, interactive and generative music, collaborative soundscapes and are becoming increasingly engaged by the possibilities of emergent behavior. The potential for new interdisciplinary forms integrating gesture capture, motion tracking, sound synthesis and collaborative forms between people/performers/composers and their environments is a developing field of research that investigates process driven collaboration to inform the design of reactive compositional spaces.

1. Introduction

Process driven collaboration can be described as an embedded strategy that instigates a shared goal to stimulate interaction or participation, either between performers and their instruments, composers and sound or participants and technologically mediated experiences. Increasingly these embedded strategies can be found at the software layer of interactive or compositional systems, for example an Algorithmic approach extending the potential for both the generation of new sound relationships where the dynamics of the environment or performance are directly affected by participants of the system and the system is perceived to be responsive, indeed across a range of fields of practice this 'responsiveness' has been identified and extended, leading to a number of ways of describing emergent behavior. Where once we would have described interaction between users and systems with a clear hierarchy implicit in the language used, we now find these relationships have evolved, in part due to the increased use of embedded strategies to facilitate real time compositional processes in response to interaction. These forms of collaboration between participants and systems in many cases lead to new forms of behavior being realized as an extension of the creative potential of both parties, this language of behavior is playing a key role in the development of new interdisciplinary collaborative processes.

2. Resolution

As practitioners and researchers from differing fields exchange expertise and approaches new possibilities come into focus and a deeper understanding of the language of interdisciplinary work is reached, technologically mediated relationships can be very

effective across a range of resolutions, for example an interaction as simple as moving or clicking a mouse forms the primary act of interaction most people have with computer technology, but clearly the resolution of this act is determined by the sophistication of the interpretation of the act in relation to context and intent, both on the part of the user and in terms of 'expectation' or 'anticipation' of the system or software design – i.e. the resolution of the act is multiplied by the understanding of the range of anticipated or implied behavior, so any system that multiplies the resolution to extend the language of reciprocal engagement with a context or process embedded within the work has the potential to manifest emergent behavior. Court van Mensvoort of the Eindhoven University of Technology has been developing an 'active cursor' method for simulating haptic feedback:

> *"The position of the cursor channel is normally used for input only. We developed a cursor interface in which the system manipulates the cursor position to give feedback to the user. The user still has main control over the cursor movements, but the system is allowed to apply tiny displacements to the cursor position. This system has a lot in common with existing force-feedback systems, except for the fact that in force-feedback systems the location of the cursor is manipulated as a result of the force sent to the haptic display, whereas in our system the cursor location is directly manipulated." [Koert van Mensvoort 2002]*

The key point here from the perspective of interdisciplinary practice is the increase in resolution of information possible from one human computer exchange - a well understood process driven act. As researchers in the field of HCI increase the possible range of reciprocal interaction with feedback processes simulating tactile sensations through visual stimulus, these methods can be added to the possible language of behaviors that can drawn on in the design of interactive environments.

> *"Once interface designers can count on its presence, haptic feedback can become a standard communication channel with the user. Our method was developed for use with standard mouse, but should work on any cursor-controlled interface."[Koert van Mensvoort 2002]*

There is a clear potential here when we begin to describe mouse movement as gestures, as nonverbal language but there are also significant implications on how a system is programmed to react or 'learn' from this, establishing a process of collaboration or dialogue.

In may areas of practice direct manipulation of the media or processes inherent in a system is not a key requirement, the system or piece has been resolved and an increase in resolution of the reciprocal cycle is achieved by a number of means. A low-tech but nevertheless engaging approach can be seen in the recent collaboration between Sam Woolf and Tine Bech whose approach integrates sound sculpture within 'reactive' robots that appear to display a range of autonomous. Simple analogue sensors and control circuits are used to extend the interface of a system to allow intuitive interaction to take place.

> *"Despite its simplicity, Echidna exhibited a large range of interesting sonic behaviors. This behavior reflects not the sophistication of the underlying*

electronics, but the complexity of the environment in which the sculpture is situated." [Woolf & Beck 2002]

Woolf & Beck's paper initially describes the sound sculptures themselves and goes on to 'defend the use of simple reactive robotics in interactive art' but they also make some significant observations not only on the apparent autonomous behavior within the systems but also between viewers who play a significant role in the process.

" we should not forget that humble reactive robotic systems capable of sensing and reflecting the complexity of their environments have the capacity for unpredictable and life like behavior that encourages playful somatic interaction." [Woolf & Beck 2002]

It is an intriguing approach that leads to reflection not only on the emergent behavior manifested by the system but also how the reactive nature of the work instigates this process driven activity within the participants, a clear example of the dialogue or relationship that is formed is given and again it is only a matter of resolution to establish and articulate more complex compositional interactions with such a system.

"...despite the simplicity of its control circuitry, Boundless appears to display complex autonomous behavior. If approached by an observer it will attempt to withdraw, as if trying to flee from a perceived predator. If approached by several people from more than one side, Boundless jitters indecisively, as if unsure of which way to turn. [Woolf & Beck 2002]

It is perfectly reasonable to counter this observation by suggesting that participants ascribe interpretation to perceived actions and react accordingly but if these non-manipulatory modes of interaction are more clearly understood then the potential for sophisticated compositional and collaborative processes within reactive environments becomes a realistic proposition. Just as the designers of screen based interaction are developing subtle but sophisticated visual feedback systems to enhance immersion through representation of tactile, physical properties within a software environment, creators of computer mediated hybrid environments or cybrids are increasingly looking at gesture capture and motion tracking to enhance the systems reactive properties to both participants and environmental parameters alike.

3. Behavioral Semantics

A sophisticated area of research that integrates both an evolutionary approach and compositional gestural interaction can be found in the work of Fels and Manzolli where the semantics of spatial relationships and biological cycles are integrated to provide a new compositional process, interaction is mapped between two participants and their gestural interaction influences the genetic make up of the compositional textures generated. Two approaches are discussed in detail in their paper 'Interactive, Evolutionary Textured Sound Composition' the second method uses direct tracking of two participants within a physical environment and they have successfully mapped performer presence and what could be described as compositionally driven semantic behavioral activities to provide a new form of compositional space.

"In the second technique the two objects are people. The position of the people is tracked using a local positioning system (LPS) developed in-house at the University of British Columbia. The LPS system uses infrared-based active badges and camera modules for tracking the position of moving objects. The idea behind using the interaction of two people to manipulate the genetic algorithm comes from thinking about the semantics of how two people interact with each other and their environment." [Fels & Manzolli 2002]

The emphasis on integrating the way we perceive and respond to spatial relationships in physical space as an extension of compositional process is another effective form of process driven collaboration, participants have a physical context for their interaction and a mental model of how interactions or movements through this environment in relation to the other performer will affect the music mediated by the system,

"...we have developed a system that allows a performer(s) to control an underlying evolutionary process which in turn creates music. We have encoded melodic structure as a genome and have defined a number of genetic operations that can be applied to a population of melodies. We have mapped some of the relationship semantics between two objects to control semantically related operations in the evolutionary cycle."[Fels & Manzolli 2002]

A range of disciplines are now using tracking of participants to add resolution and identify behavioral reactions whilst interacting with these systems and this will inevitably allow us to develop more responsive systems that facilitate forms of collaboration not only mediated by technology but with technological entities be they virtual or integrated into physical systems. In the area of interactive music there are many examples where composers and designers have extrapolated from modes of improvisation and collaborative processes to extend compositional possibilities, a key area of study for those of us engaged with reactive cybrid sound environments is again at the behavioral level where either we need to anticipate forms of behavior for our systems to react to and learn from or we need our systems to facilitate responses or reactions that in turn lead to forms of emergent behavior.

4. Strategies for Participation

When designing interactive sound environments or systems for public spaces or for direct participation, an understanding of the forms of dialogue that are engendered by such systems and those interacting with and through them is a significant factor, again the development of these works is adding to the language of interaction in productive ways. In a paper discussing the interactive music system 'Tonetable' Bowers underlines some of the successful outcomes and implications of this approach, it is clear that the Author's strategy for the work is to engage the public collaboratively and also that the work is influenced by participants activity. The system is table top mounted with four control wheels and participants are invited to manipulate objects within the space which is simultaneously diffused as sound around them, in some ways this work is in the same

interaction genre as Toshio Iwai's 'Resonance of 4' installation which has been successfully exhibited at a number of international locations, where four participants interact with a sequencer like shared grid via mouse interaction, in Bowers work a number of strategies for understanding the way people interact with and collaborate through the system are discussed.

> *"ToneTable manifests a variety of sonic and graphical behaviors which can be progressively revealed through engagement (both individually and collectively) with it. This can give a 'structure of motivation' to its use. That is, we intended to provide an 'in-built' incentive to explore the table and its varied behaviours and image-sound relations. Indeed, in detail, the dynamical behaviours of ToneTable were defined and calibrated with various non-linearities." [Bowers, J. 2001]*

This notion of structure of motivation and incentive to explore allows participants to explore sound image relationships but also invites a range of behaviours or actions from participants, resolution is multiplies not only be the number of interactors manipulating the system via the visual feedback but tacit compositional agreements or shared journeys are embarked upon as participants actively listen to the output.

> *"interruption in object-behaviour is intended to add interest to the graphics as well as being an outcome that is easier to achieve through concerted collaborative activity between participants. Thus, the threshold for the occurrence of orbiting behaviour is set so that it will tend to be exceeded by a local force produced by two or more proximal wavefronts. That is, two or more participants need to align their perturbations of the surface to produce the orbiting effect."[Bowers, J. 2001]*

Bowers also reflects on the range of strategies explored in the development of this approach, this articulation can be considered both in terms of the design of interaction and in terms of collaborative compositional processes but is clearly worth further exploration and definition to inform the design of such systems.

> *"we have tried a number of design strategies for addressing such settings. We have explored notions of 'collaboration through a virtual medium', 'collaborative added value', 'layers of noticeability', 'structures of motivation'. These are all concepts intended to suggest ways for orienting design for variable participation." [Bowers, J. 2001]*

5. Conclusion

The approaches I have discussed all have significant contributions to offer to the area of research I am engaged in; Reactive Compositional Cybrid Environments, I am currently experimenting with a portable system that I have developed. This system comprises original software developed with Max/MSP/Jitter running on a G4 Apple Laptop, the software 'listens' to the chosen environment through audio analysis via MSP while analogue sensors capture live interactions that inform compositional decisions initiated by the software, the compositional process is mediated by the physical or acoustic properties of the space and the presence or interaction of participants, real world data is integrated in the synthesis process of the system. An external Yamaha rack Synthesiser

allows Formant shaping and FM synthesis and is also controlled by the software and reduces CPU overhead. The system uses an Icube for general data collection via midi, an additional midi input is available for other interaction or control surfaces to be integrated while composing or improvising with the system. Gesture capture and positional data is currently facilitated by video input, two Digital Video cameras are used to correlate simple 3 dimensional positional data, for example the orientation of a gesture can be related to a specific spatialised sound output. The software also mediates the compositional output and co-ordinates the eight channel sound diffusion in real time; sounds can be positioned and moved throughout the environment in response to the original compositional framework, which subsequently evolves through live performance and interaction.

A key goal in the development of this approach is to enable and record the emergent behavior that occurs between software, people and live spaces as an integral part of the compositional process. Future areas for further investigation include a more detailed analysis of reactive or responsive compositional spaces, observation of emergent behavior to inform design of interface elements and listener or composer objects and field testing of the system including interfacing with live data from a building management system.

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