Peter Beyls	**Towards Emergent Gestural Interaction** ***Paper and Live Performance***

Topic: (Music, Sound Performance)

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[1] Marin, M. and Peltzer-Karpf, A, Towards a Dynamic Systems Approach to the Development of Language and Music, *Proceedings of the 7th Triennial Conference of European Society for the Cognitive Sciences of Music*, Jyväskylä, Finland, 2009
[2] Mudd, T, Dalton, N. Holland, S and P. Mulholland, Dynamical Systems in Interaction Design for Improvisation, *ACM Proceedings*, Vancouver 2014

Abstract:

This paper develops an approach to live performance through the impact of spontaneous live gestures on complex, non-linear sound producing algorithms. DSP algorithms include chaotic systems and sample-based granular synthesis. A performer provides gestures in 2D and 3D space; gestures are interpreted as control trajectories influencing autonomous behavior in a free running algorithm. The system aims blending explicit gestural control with unpredictable but coherent generative behavior. Consequently, performance is seen as dynamic exploratory engagement with many simultaneous musical processes driven by emergent gestural interaction (EGI).

EGI is a live performance system integrating a number of ideas on musical gesture, interaction and spontaneous play into an open, modular software-defined experimental system. Musical performance is viewed as the acquisition, management and interpretation of user-defined gestures in real-time. A number of principles underpin the present work, including the principle of influence (rather than control), implicit generative behavior, online exploration of the system's affordances and open improvisation.

Musical experiences with EGI explore the relationship between embodied gestures and their multimodal impression; dynamic visualization of gestures appraises the listening process and provides hints as to the perception of implied movement and progression. Therefore, the performer and listener both participate in a dynamic exploratory, improvisational climate where musical meaning crystalizes as islands of understanding of connectivity in multimodal perception. We acknowledge the intensity, quality and depth of the aesthetic experience of music to be informed by a process of anticipation. EGI implicitly investigates oscillatory modes of music production through continuous evaluation of causal associations between gesture and sound. EGI is implemented in SuperCollider.

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Keywords: Emergent behavior, Gestural interaction, Complex dynamical systems, Granular synthesis, Live sampling

Towards Emergent Gestural Interaction

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ABSTRACT

This paper develops an approach to live performance through the impact of spontaneous live gestures on complex, non-linear sound producing algorithms. DSP algorithms include chaotic systems and sample-based granular synthesis. A performer provides gestures in 2D and 3D space; gestures are interpreted as control trajectories influencing autonomous behavior in a free running algorithm. The system aims blending explicit gestural control with unpredictable but coherent generative behavior. Consequently, performance is seen as dynamic exploratory engagement with many simultaneous musical processes driven by emergent gestural control (EGI).

Author Keywords

Emergent gestural control, complex dynamical systems, granular synthesis

ACM Classification Keywords

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing.

INTRODUCTION

EGI is a live performance system integrating a number of ideas on musical gesture, interaction and spontaneous play into an open, modular software defined experimental system. Musical performance is viewed as the acquisition, management and interpretation of user-defined gestures in real-time. A number of principles underpin the present work:

1. Gestures aim the expression of *influence* on the implied sonic behavior of an abstract audio process. The notion of precise and discrete instrumental control is hereby avoided; the orientation is towards the exploration of the effect of continuous gestures.
2. We develop a systemic (rather than instrumental) orientation towards software. A synthesis algorithm is seen as a black box with a number of normalized control inputs. Most units carry 3 inputs, accepting a scalar value (0.0 to 1.0) conceived of as a single point in 3D space. The algorithm defines a private behavioral scope as a complex dynamical system and is free running.
3. Complexity and relationship motivate our design. A continuous evaluation cycle drives performance; the effect of gestural data on audio complexity is assessed – we evaluate the relationship between the visual representation of a gesture and its impact on audio synthesis. Insight develops within the interaction process itself.
4. Gestures are seen as initial basic structures subject to evolution and change. EGI merges ideas of explicit gestural control and implicit generative behavior in an integrated organism.
5. Many sequentially acquired gestures are accommodated in a memory structure. Sampling from an online database provides structural and behavioral integrity to the system.

6. Parallelism is implicit, many simultaneous abstract gestures are linked to many parallel audio producing software components in a network of arbitrary complexity – all components manage private receiving and transmission channels.
7. Scalability is intended musical functionality. Control may extend on the micro-sample level up to musical gestures lasting several seconds.
8. Musical improvisation is at the core of the present system. We explore the affordances implied in the system through a process of real-time incremental optimization. Performance becomes a self-propagating process of anticipation, exploration and discovery. Performance unfolds the systems potential as a sequence of complex, intimately related emergent musical phenomena.
9. EGI is a playground for sound, it suggests a simple, fixed framework – a two-dimensional space – however, allowing for spontaneous movement within these constrains [1].
10. A sound becomes musically communicative and significant if it changes over time. EGI implements arrays of responsive, slowly fluctuating control sources to this effect.

IMPLEMENTATION

EGI contains two basic software components; (1) graphic user interfaces to capture and visualize real-time gestural user input and (2) a collection of Digital Signal processing (DSP) modules of significant diversity.

Gestures capture

Figure 1 shows the standard graphic user interface to capture two-dimensional gestures drawn using a mouse. A 2D trajectory displays as a sequence of colored dots, color maps to the distance between any two consecutive dots. While the dots represent XY values in 2D space, the intervals (changes in distances) may represent a third Z dimension. Beyond a mouse, 3D acceleration sensors are equally accommodated and easily interfaced.

Gestures express numeric influence in 2 or 3 dimensions on a DSP algorithm; four families are implemented so far: (1) generative sound file playback using granular synthesis, (2) audio synthesis using non-linear complex dynamical systems, (3) multi-channel live audio sampling and playback and (4) processing of live audio using complex, composite algorithms.

Gestures are of a fixed, limited capacity: for example, while dragging the mouse, a new coordinate is added and the oldest datum is removed from the list. The XYZ object holds a task stepping through the list of xy-coordinates at a rate between 20 milliseconds to 5 seconds time intervals. The articulation of the gesture maps immediately to the audio generated. Additional methods towards the synthesis of control signals include: (1) *Fly*; the xy-data point is randomly flying and bouncing off the walls in a 2D control space, (2) *Trn*; circular movement around a center point defined by the user's last mouse location, (3) *Rnd*; a single xy-location jumping in 2D space and (4) *Pts*; a small collection of points that slowly move in 2D space while the number of points equally evolves over time. These behavioral modes receive parametric tuning from 3 continuous controllers. As seen in the interface of figure 1, three sliders support the specification of the *rate* (relative speed of change), *range* (for example, the radius of the spinning dot in the *Trn* mode) and *delta* parameters.

A second row of buttons (labeled *Muta* to *Rem*) relates to switching on/off an additional set of independent processes; the delta parameter specifies a probabilistic weight for action to be taken or not. *Muta* mutates the current data vector of the gesture typically involving small displacements. The *Shift* process displaces the gesture as a whole, therefore, a fresh interpretation of its data follows while the shape of the gestures remains guaranteed. *Pick* selects a gesture from memory, an earlier gesture then shows up again potentially creating a significant moment of musical expression. *Add* and *Rem* are complementary functions; gestures may either grow or shrink within limits and according to parametric specification from the delta parameter.

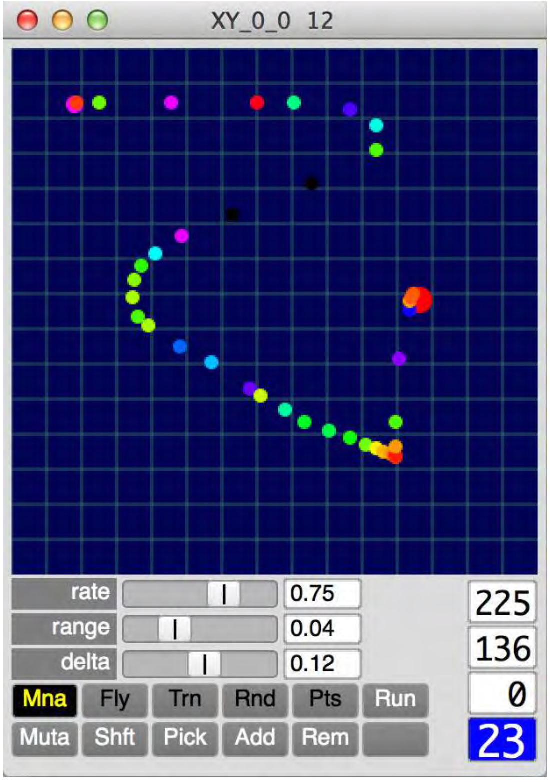

Figure 1. XYZ object.

The blue background number box allows for adjusting the transmission channel of the XYZ control source, the channel is important in the specification of the OSC transmission protocol.

Audio synthesis

Granular synthesis is based on SuperCollider's *GrainBuf* object [10], it accommodates four control signals, (1) a trigger to start a new grain, (2) duration or size of the grain, (3) the playback rate of the sampled sound and (4) the playback position for the grain to start (0 is beginning, 1 is end of file).

The GUI of a four channel live sampling program is seen in figure 2, it supports continuous recording and playback using 5 specific handcrafted generative functions, all of then accepting control information on 3 channels, labeled x, y and z. The latter values map internally as to take effect according to the DSP logic embedded in the five playback functions. XYZ values can be tweaked either using the faders (blue labels) or accept external control signals. In addition, a task (the fader *xyzTask* sets its tempo) may step-wise modify the values independently as to create a smoothly shifting set of control parameters. Other faders specify recording duration (0.5 to 10 seconds), recording- and pre-recording levels (their values relate to how much audio is recorded in a buffer on top of existing audio content). Most DSP playback functions contain combinations of low frequency noise generators (their impact equally conditioned by the XYZ parameters) to articulate dynamic audio playback.

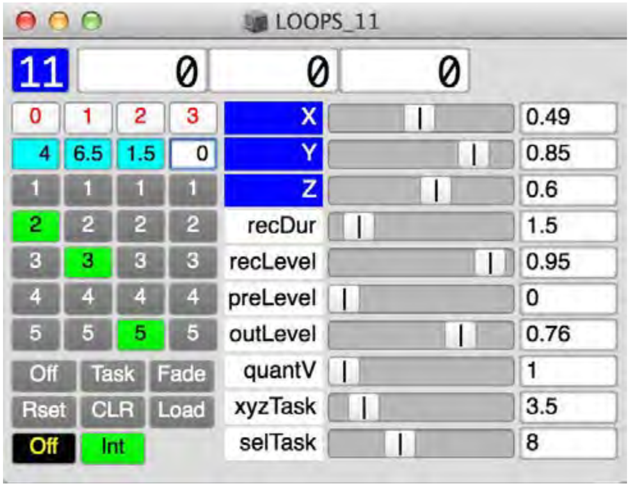

Figure 2: *Loops*, live sampling object

Buttons on the left side in figure 2 are instrumental in switching between recording and playback. The *selTask* slider specifies the tempo of an automation task randomly or sequentially selecting combinations of playback algorithms. Note that one may also load sound files from disk, the musical performance potential of field recordings may then be explored. The semantics and identity of a predefined family of acoustic samples may then blend with the spontaneous nature of live audio sampling.

Complex dynamical systems

Our global design approach views abstract gesture as a trajectory through an n-dimensional control space, while a gesture discloses a particular path through the behavioral scope of a given DSP algorithm. However, the path remains unknown until the moment it is first exposed as audio. User gestures become devices to explore the anticipated complexity of an algorithm since gestural activity is driven by discovery and surprise. This improvisational approach integrates notions of intimate physical embodiment with gesture, non-linearity in the process of discovery and exploration and acknowledges the chaotic interplay and friction of the relationship between gestural complexity and issuing audio complexity [3].

Various complex dynamical systems were implemented in software, for example to model macroscopic language and music development [2], to generate music on the MIDI event level [4] and on the audio sample level [12]. Di Scipio introduced the acoustic properties of a given physical space in the feedback loop towards the creation of sonic ecosystems [5].

Complex systems develop a range of complex behavior; from point attractors, to quasi-periodic to chaotic behavior to strange attractors. Most probably, such systems suggest particular musical potential because they incorporate an uncommon and singular control perspective; a relatively continuous control spectrum that is nonetheless modulated by sharp discontinuities – in addition, the history of the user's input is accumulated in the control structure.

Networks

EGI is implemented as a flexible set of audio processing modules of variable connectivity, modules mutually communicate through the Open Sound Control communication protocol [9]. The number and nature of modules may change during performance, renewing musical functionality on the fly – conceptually, quite similar to musical live coding [13]. Control modules transmit on a specific, private transmission channel, 100 bi-directional channels are allocated in the current implementation. In turn, audio synthesis modules listen only to information arriving at their private reception channel. Future implementations will include sample-level audio applied as control signal in addition to control-rate gestural control data.

DISCUSSION

A particular fascination for dynamical interaction with DSP algorithms is implied in our work. Sample-based instruments typically produce predictable results from triggering a sound file. However, through the continuous parametric articulation of a sound file (rather than instrumental triggering), intimate dynamic performativity and engagement develops between a given gesture and its musical impact. Then, performance oscillates between suggesting gestural patterns in 2D or 3D space, and judging their impact, for instance, on a granular synthesis algorithm.

In the long run, we may observe a gradual change in performance as the inclination evolves from exploration to exploitation, i.e. from spontaneous evaluation of the unpredictable to the deliberate configuration/selection of particular control gestures. Interestingly, qualitative feedback is operational inside the DSP algorithm and, on a much larges scale, in the iterative performance cycle. Incidentally, then, the question arises of how a concert audience might possibly engage in the experience of non-linear musical instruments. What is the relationship between what is seen and what is heard? From performances with the system documented here, the general conclusion is that a motivated non-expert listener wishes to engage visually as well as musically; the listener aims to decipher activity in the graphic user interface, actively trying to create a mental image of the mapping process.

Musical experiences with EGI explore the relationship between embodied gestures and their multimodal impression; dynamic visualization of gestures appraises the listening process and provides hints as to the perception of implied movement and progression. Therefore, the performer and listener both participate in a dynamic exploratory, improvisational climate where musical meaning crystalizes as islands of understanding of connectivity in multimodal perception. We acknowledge the intensity, quality and depth of the aesthetic experience of music to be informed by a process of anticipation [6]. EGI implicitly investigates oscillatory modes of music production through continuous evaluation of causal associations between gesture and sound.

CONCLUSION

We discussed EGI, a modular generative system that blends explicit gestural control and autonomous behavior, a systemic rather than an instrumental approach to spontaneous live performance. Gestures are trajectories activating degrees of freedom in musical algorithms conceived of as complex dynamical systems. Since the sound production process and the control mechanism are unrelated and independent [11] design of mappings between gesture and sound is core in most work in musical interaction with electronic instruments [7]. Composition extends into the creation of sensible relationships between instrumental musical intention and sounding result. However, we suggest the notion of *instrument* to blur toward *process* – a mode of human-machine engagement where musical ideas develop in common effort and through shared initiative. The current implementation of EGI deliberately supports simple mapping schemes though interfacing with distributed, self-organizing control algorithms is straightforward to implement [8]. A particular rewarding musical experience results from the dynamic confrontation of exploration and discovery – that is, from the relationship between a tentative gesture and the complexity of its entailing impact. That relationship is partly unpredictable, so its uncovering into conscious causal understanding underpins a rewarding musical experience.

EGI thus develops a distinct behavioral approach to human machine interaction. It differs from responsive instrumental music control systems since the relationship between gesture and sound remains afloat: from evident causal correlation to uncertain opaque connections.

A global performance challenge remains to further develop hybrid architectures supporting a *control continuum*: (1) from precise and nuanced instrumental action to, (2) blending physical instrumental gesture and generative interpretation and, finally (3) performance with independently coexistent systems interaction using the principle of mutual influence. Ideally, such a structure of scalable complexity and engagement – and its implied potential for performative shifting of focus, intention, process and detail – could also mediate new modes of cultural sensibility and exiting new forms of general musical perception and understanding.

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