Performing Animator Instrument for Live Media

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Abstract

In this paper we discuss the design of Performing Animator, an expressive instrument for live media, we developed in support of our situated interdisciplinary performance practice. The concept of a cinema of braided processes is introduced as a basic structure for media instrument design. This media performance instrument is described in terms of its conceptual, design and performative aspects. The Performing Animator Instrument is analogous to a musical instrument that enables generative animation, film editing and compositing, tailored for improvisational expression of projected visual media elements. Design of the instrument evolved based on eight years of development (2003-2011) initiated by a number of interdisciplinary and cross-cultural performance productions as well as inspirations drawn from our study of Balinese Shadow Play (Wayang Kulit). Our instrument presents the performer with a large set of techniques that enable flexible media manipulation and generation. The paper also addresses issues related to the tensions between narrative structure and perfomative expression, live and recorded media and the structuring of improvised media.

Categories and Subject Descriptors: Computer Graphics: Live Media Perfomance and Animation

1. Introduction

New media performances and improvised animation in recent years have bloomed into a rich live visual practice. Every new generation of moving image platforms comes with a wealth of opportunities for artists to invent new language and form. Today cinematic expression has been freed from the inherent linearity of physical materials. Stored as data on a hard disk that can be accessed in non-linear fashion, cinema no longer needs to be presented as a fixed sequence of shots on a one-dimensional timeline. Rather, it can be presented as a connected assemblage of shots in a multidimensional performance space, traversed in multiple paths and generating varying interpretations of the same source material each time. The cinematic elements, brought forward by association and algorithmic behaviors, exist as a structure adaptable to the real-time conditions of the performance setting. This situation introduces new challenges for the design of a performance system. A practice that combines live performance, recorded media elements and computational algorithms is emerging in new time-based art [War03].

Jim Campbell suggests "if the new element to film was time then ...the new element to interactivity is the present. And it is the program that connects the present to the past" [Cam00]. This potential to express the present moment brings the creation of media out of the production studios and onto the performance stage. This can be achieved using a unique combination of embodied skills expressed with custom-designed performance software allowing artists to animate visual media with sound design and music in the real time of performance.

In this paper we describe the Performing Animator Instrument for live cinematic expression. This instrument allows a performer to assemble a cinematic experience in performance, and diffuse media elements at the right time and in response to events on the stage. We discuss and contextualize ideas that emerge from extending embodied performative gesture and animation into a live computational media performance. In our work we focus on a balance of embodied skills, i.e., drawn and painted animation, musical gesture, dance movement etc., with the ability to dynamically mediate these in a computational media environment. The key question we consider in our work is how to enable the embodied skill of practitioners to be integrated with computational processes available through the use of software designed for interactive animated performance. This objective enables us to produce rich hybrid performances integrating interactive animations and electro-acoustic sound performance. The artistic outcomes that we discuss are interdisciplinary performances across electro-acoustic music, interactive animation and dance. The computational media provide opportunities to explore new production ideas in relationship to animation and real time interaction. Through live interaction and the diffusion of audible and visible images, in an expanded space and across organized time, new expressive hybrid images emerge.

Live animation entails the recording of animated gestures expanded by computational algorithms and re-mixes

of media databases for visual expression and composition within a cross-disciplinary live performance. Our instrument features a variety of methods for generating, sequencing and transforming animation elements. These methods are performed by the animator and displayed on screens, whose performance expressiveness can be augmented and shared by sound and movement analysis modules enabling linkage, visualization and expression of movement and sound performances drawn from other artists working in the same performance context. In addition, the application includes methods for access and montage of a large media database, which enables mixing, processing and compositing various media elements into coherent spatial and temporal media montages.

Figure 1. *Ghost 2007, Sutrisno Hatana (left) Lan Tung (middle); The image shows diffusion of visible images for scenographic composition for seven independent and correlated screens using two projectors and networked computers. Live media performance: Aleksandra Dulic and Kenneth Newby; Music performance: Orchid Ensemble.*

Realizing this flexible approach presents a key compositional problem that requires the transformation of compositional methods of scored and montaged linear media into flexible time based interactive and improvisational strategies. To overcome the challenge of integrating and synchronizing various performance elements, such as instrumental music, dance and live animation, we have developed animation and visualization techniques that can aid the expressiveness of the animator performing with a larger multidisciplinary ensemble. We will describe and reflect on the concepts, tools, structures and processes we use for live animated performances, such as procedures for accessing, selecting, organizing, ordering and composing animated media elements contained in a database of media objects as well as interactive visualization strategies used to aid the overall expressiveness of the animated performance.

2. Background

With traditional recorded media on film or video the flow of time is fixed. This means that sychronization between the cinematic projections and dance, music or any other performance on the stage, must adhere to the linear time structure of the media. Many early films, before the introduction of the recorded soundtrack, were highly performative. The so-called "silent" film was often accom-

panied by a number of performers making music and sound effects and reciting dialogue, synchronized to the linear film structure. With developments in performance, various kinds of theater practitioners began to incorporate moving images into their spectacles — mixing moving-image projections with live performance and music analogous to magic lantern shows. This hybrid of cinema and performance opens an alternative path for the development of cinema. The alternative follows the structure of the work previously explored in magic lantern shows. The Czech theatre director E. F. Burian, in collaboration with Miroslav Kouril, developed the "Theatergraph," a technology for the stage that integrated film and slide projections that could be operated to respond directly to the action on the stage. Theatergraph was first put to use in the production of Wedekind's The Awakening of Spring in 1936 in Prague. Contemporary performing arts continue to be transformed by video projections, becoming part of the scenography of theatre, music, dance and opera. Since the late 90's developments of computational media have enabled many artists to use live dynamic video in their performance productions, with artists such as Robert Lepage, Golan Levin, Jammie Griffiths, Troika Ranch, etc. active in this practice Other strategies for on-stage performer control of video include vision-based motion tracking or motion capture as exemplified in Merce Cunningham's work.

In the 60's Pierre Hebert used multiple film projectors to create improvised film performances live with an improvising music ensemble. He scratched and drew directly on film while juxtaposing multiple film loops of varying lengths all animated live [Dul06]. Today Hebert uses his own performance software developed with Bob Ostertag to perform live animations. Steina Vasulka, in the mid-70's, performed video using her violin to control real-time image processing. Today she continues to refine live performance technique, using a MIDI-enabled violin controller [Win02; You00] In 1989 Don Ritter, in collaboration with George Lewis, made live computer-mediated audiovisual performances. Emerging from the club scene and music video aesthetics of the 70's and 80's live manipulation of video projections has started to invade clubs, making the VJ (video jockey) a natural extension of the DJ in the visual domain. In the late 90's, many electronic artists such as David Rokeby, Golan Levin, Marc Coniglio etc. started building their own performance software tools for interactive performance. The integration of projected light with performance continues to fascinate many artists. With the emergence of new computational media tools media projection languages and expressions continue to develop. We will discuss the conceptual and compositional approached that are critical for the development of our media performance instrument.

2.1 From shadow play to braided media

Many theorists of cinema and animation have examined shadow play in the context of cinema history [MCR95; Ge02]. In cinema studies the focus is often on the mythical narrative that unfolds in time through the interplay of light and shadow on the screen. The historians of animation, on the other hand, focus on a very specific resemblance between the animated objects of shadow theatre and film ani-

mation, stressing often the techniques of actually animating puppets or shadow characters such as in the work of Lotte Reiniger [Rei70]. While these numerous parallels drawn between shadow play and cinema inform our work, here the key concern is the dramatic principle that underlies animated performances of shadow theater. The dramatic structure that enables one to make an inanimate non-moving object come to life by movement, while the performer, or puppeteer, stays outside the audience's focus. The audience focus is centered on the animated events taking place on the screen. The focus is placed on what happens in the improvisational context of the performance. The concept of a cinema of braided processes supports the improvisation and real-time animation driven by the body of the performer.

The composition and presentation of electronic media, using capabilities offered by computation, extends cinema through its ability to braid encoded processes with various media, narrative elements and participant interaction in the real time of the performance. The dramatic model of a cinema of braided processes is developed in order to enable a form of situated media performance that integrates computation as a medium for composition, performance and improvisation [DuNe03]. The Balinese shadow-play (*Wayang Kulit*) performance tradition can be interpreted as a model of braided performance, media and narrative processes, producing possibilities for flexible, interactive and responsive multi-media events and responses to the environment and has provided useful cultural information informing our research practice. We developed the concept of a cinema of braided process as a result our a study of Balinese shadow theater conducted in Bali, Indonesia in 2003 and again in 2005 [Du06], as well as a number of collaborations with Javanese and Balinese puppeteers and performers in 2007 and 2010. The concept of braided processes, informed by our research with Balinese shadow play, is investigated through its relationship to a performing animator instrument that employs improvisation and real-time animation of media driven by the interaction among performers and materials of the work. The cinema of braided processes provides a compositional framework for our media performances.

In Balinese shadow play the structure for a flexible, distributed and shared narrative system is comprised of music, puppetry, singing, poetry, narration, and lighting effects that are braided together over an extended time-frame of three hours under the direction of a single puppeteer. The performance is arranged as a complex and layered temporal and spatial composition constructed in relation to the narrative told. Narrative elements have the flexibility to begin and end at any time but must occur in the right temporal and spatial unit of the overall form. This suggests an interesting alternative to the Artistotelian notion of a narrative arc, continuous action with beginning, middle and end, in which events unfold as causal chains ordered in time [Sch85].

The suggestive power of the *wayang* is that the same story can be told in a flexible fashion not only from performance to performance but within a single performance, in dynamic responses to the context of the performance itself. During a ritual or a play, even in the most traditional genre of Balinese performance, new elements can be dynamically integrated and old ones eliminated. In a kind of braiding of the elements of the narrative structure a continuous reworking and renegotiating of the narrative material is enabled, providing a framework within which novel elements—musical, textual or choreographic— can be introduced in an improvised manner. This open structure also allows direct interaction among the performers and audience. The more experienced the performer, the more he/she can vary the performance, improvise and interact directly with the players and audience. Within the overall performance, too, improvisational elements abound in the way the performers interact with one another, the story, the audience, and the accompanying media threads. This system provides a braided form that has a number of fixed elements yet is fundamentally improvisational. The difference between the Greek and Asian systems affects not only the performance, but also the way the work is created and rehearsed.

Simultaneous and open relationships between time, space, spectator and performer enable participants to savor different aspects of the performance. This aspect of Asian drama is one that attracted Brecht to the technique of independently variable elements, and inspired him to develop his theory and practice of *verfremdung* (estrangement or alienation) [Wil64]. Asian drama actively engages the audience that interacts with these diverse symbolic elements: performative, contextual and narrative. Braided narrative structure includes the procedure of an improvised juxtaposing and it functions as a form of conversation or dialogue with a natural interplay of multiple aspects woven into the overall performance. This interplay of independent elements and responses, is braided together to generate insights, discovery or the sudden awareness within a complex process of interaction. The idea of a cinema of braided processes that forms the basis of our performing animator system mirrors Balinese performance philosophy. The open improvisational structure of the braided process gives a sense of place on both social and metaphysical levels, as a way of putting human activity into the larger environmental context [Her97].

2.2 Cinema of braided processes

The compositional structure of the cinema of braided processes integrates audio-visual media and computation as a creative medium for performance and improvisation. In the cinema of braided processes a braided narrative structure provides a model for the development, composition and organization of media. Enabled by the programmability of the computer, its ability to encode practices, and mediate processes that organize various aspects of the narrative elements, the cinema of braided processes provides a new kind of cinematic experience. A form of braided processes is emerging as the core ordering structure of composition in a computational environment. The threads of this complex braid are composed of visible, audible, typographical images, as well as generative, kinetic and proprioceptive elements responsible for driving real-time processes within the performance. The relationships among the individual media threads are interconnected in different proportions and relations, with all of

the elements simultaneously accessible and potentially correlated.

In the cinema of braided processes the notion of the narrative braid is taken up as a central compositional strategy—weaving and intertwining a variety of threads at several levels of the work. The relationships between the individual elements of a braid are interconnected—"woven"—in different proportions and relations, with all of the elements simultaneously accessible and correlated at
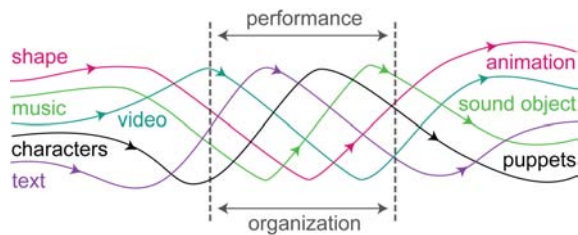

Figure 2. *Cinema of Braided Processes organization diagram*

some point to an underlying deep structure. This complex braid of narrative elements allows different streams of the narrative to be available for mixing in different ways—to be montaged in space and time and accented with responsive processes. The media threads are independent yet correlated and juxtaposed in space and time. This braided organization of media can support a structured system of improvisation organizing a multiplicity of voices and a direct dialog with the materials of the work. The relationship among the braided threads is not simply one of stratification and association but takes into account the need for system agency, taxonomy of generative techniques, and the identification of techniques and procedures for constructing these generative structures.

On a conceptual level the cinema of braided processes provides a model for situating the interactive media events within the particular social, geographical, ethical and spiritual contexts within which the work functions. The conscious braiding of these elements can situate the live media event within specific cultures and local knowledge, crafts and traditions, with a potential to reflect a variety of approaches in new media. The braided processes as a model can enable live media performance to have a critical role, by providing a space for conversations and reflection on contemporary life and technologies that shape the way we live.

3. Instrument Design

The main objective for developing the Performing Animator instrument is to enable the live performance of media. In this section we cover the complex layering of various elements that this instrument allows and consider compositional synergies and relationships of visual animation in relation to other performance elements. We will discuss the instrument design and its development in terms

Figure 3. *Semar's journey 2007, Live animation: Aleksandra Dulic and Kenneth Newby; Shadow puppet performance: by Sutrisno Hartana, Eko Purnomo; Scenography: Andreas Kahre; Music performance: Gamelan Madu Sari.*

of three layers that influence its design: conceptual, compositional, and software layers.

The Performing Animator system provides a variety of inputs; an encoded procedural section which can be functionally divided into three areas of "voicings" of visual material: heterographic, composite and generative; and a display section that supports the diffusion of multiple channels of video display. The system also provides a user interface that puts the performer in an action-reaction loop with the system and enables its use as an instrument for live media performance. In the following sections we describe some of the high-level design considerations of the Performing Animator and describe the three main layers of the encoded procedural section and its relation to the other aspects of the instrument such as user input.

3.1 Software Design

The software modules described in this section are written mainly in the MaxMSP/Jitter programming environment, and include custom made objects for Max written in C. The Max language is particularly suited to the development of experimental media applications due to its "always on" nature, which facilitates experimental design while interacting with a working version of the project. As much as possible use is made of abstractions to emulate an object orientated design that stabilizes and speeds the development process and allows the capabilities of the system to be easily scaled.

3.2 Conceptual Design

Live media performance involves the generation and manipulation of time-based imagery within an improvised or composed spatial and temporal architecture. These images unfold in the contexts of instrumental music performance, live action, movement and dance. Creating works for an integrated performance experience poses some difficult compositional, perceptual and technical problems within the environment of media performance. The perceptual experience of a correlated dynamic animation of diverse visual elements within any given performance cannot be reduced to a simple addition of media image with other performance elements. When these elements are combined they intertwine into a unified experience that presents the viewer/listener with new levels of perceptual complexity [Chi94]. Images, sounds, performance actions and their impressions are therefore considered as an integrated structure, because the perception of each element is actively affected by their relational positioning in space and time.

3.3 Performing Animator Voicing

Performing Animator software enables live manipulation of three unique approaches to composing cinematic experience: Heterographic, Composite, and Generative voicing approaches.

3.3.1 Heterographic Voices

Heterographic organization provides a formal method for ordering structure drawn from musical concepts of an ordered melodic complexity or dynamic steady state [DuNe03]. Heterophony, a musical term drawn from ethnomusicology, describes the difference between traditional European and certain Southeast Asian musical forms [Sut93]. A heterophonic music is organized in terms of how different threads of music relate to one another, and is based on the emergence of an underlying yet unspoken structure that generates the overall composition. The concept of a deep structure guiding the generation of surface
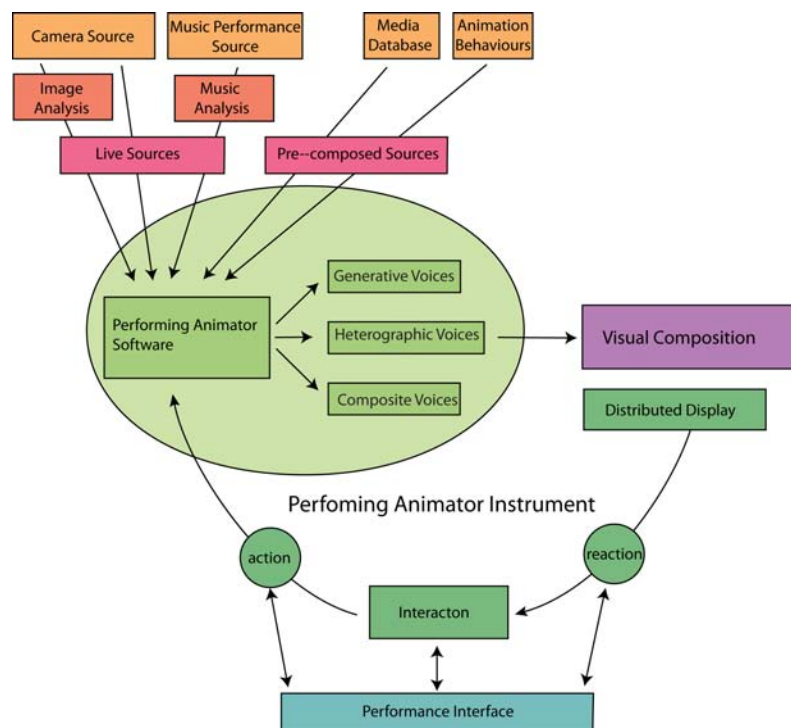

Figure 4. *Performing Animator instrument design*

details is a useful model for the organization of a computer-mediated improvisational system and a key concept in the cinema of braided processes. Heterographic form embraces complexity by using a hidden deep structure to frame simultaneous related, yet independent, performances by its practitioners that form an ecologically balanced whole.

A heterophony of multiple voices offers ways to arrange improvisatory musical co-creation in large orchestral music. The challenge in composing with computing technologies is in balancing the multiplicity of potential media voices that come together to articulate particular instances of the artistic image. Extending the idea of heterophony to include visual and dramatic media a heterographic model is articulated to describe a structured system of improvisation organizing a multiplicity of media voices. Heterographic voices within Performing Animator are composed of a series of short media elements designed as a family of animated gestures that work together to create a more complex animation. Each animated gesture is equivalent to a note or phrase in a musical score. These animated voices are like musical gestures — short and compact — and can be layered together across visual and temporal space and are equivalent to heterophonic voices in music as a set of small relatively independent gestures that are braided together into more complex gestures.

3.3.2 Composite Voices

The composition and presentation of electronic media, using capabilities offered by computation, expands cinema into the real time of performance, bringing normally out-of-real-time techniques of the production studio onto the
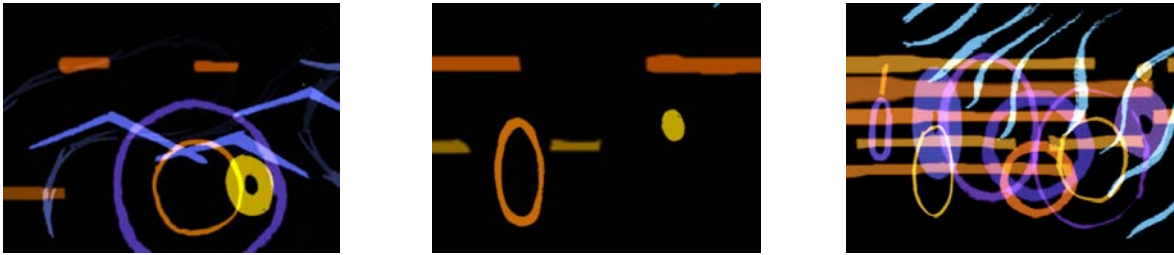
Figure 5. *Symmetry 2007 Aleksandra Dulic and Kenneth Newby; Symmetry is an animated film composed of visual representations of individual sounds that reflect the structure of the music through shape, movement and colour. Each tone has an animated gesture that is comprised of a distinct shape, colour, movement and spatial arrangement. Short animated gestures are triggered and modified by the sound structures exemplifying the correlated and layered relationship between musical note with animated visual gesture. This work presents the combination of Heterographic and Generative voicing.*

stage. The Performing Animator enables layering of media streams and processes that are normally associated with the non-real-time context of film and video post-production: composition, editing, and sequencing are made available to the performer for real time manipulation. All of the post-production compositional decisions that are traditionally made in a non-real time context can be, with our instrument, manipulated and changed in the performance context. Complex compositing arrangements are saved as scene compositions, which can be called any time during the performance. Once the scene is activated it can be further manipulated and modulated in a performance context. The ability to actively recompose and structure the material is critical to the flow of performance. The ability to interfere with the composite image and change it in real time adds to the expressiveness of the overall performance. Performing Animator has three composite layers and any number of overlay layers limited by computer power. Each composite layer has adjustable blending modes supporting spatial montage. Within each composite layer we can specify a movie set for the layer that can be triggered in the context of the performance, therefore ensuring the compositional consistency while allowing for performative expressiveness, and performer directed change.

3.3.3 Generative Voices

Generative voices within Performing Animator have the capacity to produce original material, sequence and animate preexisting media and behaviours, as well as analyze, transform and map the real-time input coming from a performer. The expressiveness of the Performing Animator instrument is enabled by gestural control over visual parameters driven by input from the performers. Here the critical design consideration is in striking a balance between the degrees of improvisational freedom and the specificity of control parameters.

The visual animation modules of Performing Animator, at the low level, operate on the pixel level generating vectors, color characteristics, scale, position, points, lines and planes. The medium level animation modules operate at the object level that encompasses both shape and movement. Mid-level objects generate data such as shape, volume, position, direction, texture application and modification, etc. in three-dimensional space. The animated objects include modules such as textured vector shapes, particles,

groupings of movie objects as well as real time stop-motion animation that is keyed and displayed in an integrated manner in the three-dimensional projection space. The high level modules generate performer-controlled object groupings, time structures and behaviors such as motion vectors and time-based ornament structures.

Figure 6. *Video still from Intersecting Lines 2007 showing the combined use of heterotrophic and generative voicing composed of a database of visually related short animated clips and textured particle system layered in 3D space.*

Performer input at the high level provides compositional structure and event organization, with the capability to organize time-based occurrences at a global level. This high-level control can act as an abstract structure that provides either fixed-in-time or flexible external compositional frameworks driving the synchronic and diachronic relationship of various animation events and acts as the deep structure of the composition controlling the way the image evolves over time. Multiple visual elements can have their own way of improvising and generating unique surface renderings set around the deep structure established by the performer.

Generative processes in Performing Animator provide what is perhaps the most dynamic relationship between the human performer and the machine. A variety of automatic processes are possible at the three levels of image manipulation described above. Performer inputs can take the form of simple mouse clicks and movements within the

frame as well as gestural controls in two-dimensional

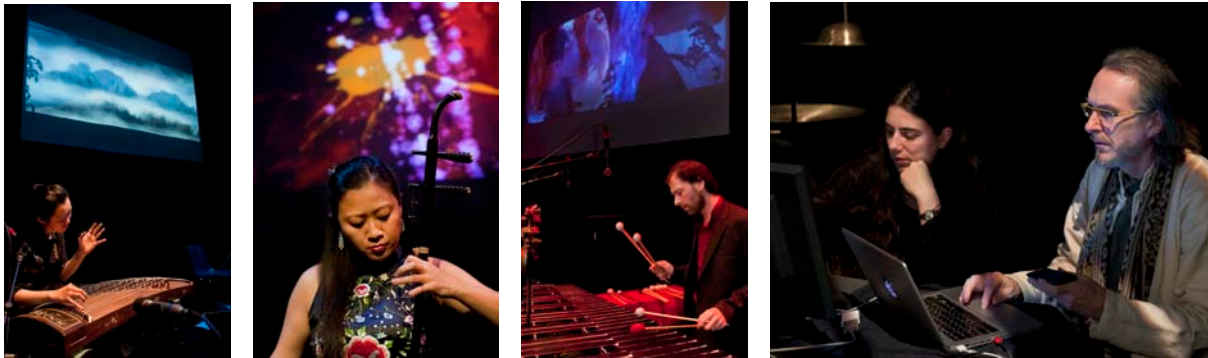determine mappings of particles to marks, colors and typo-

Figure 7 . *Mountain High River Flow ...without end. left to right: Yu -chen Wang – zheng Lan Tung* **-** *erhu; Jonathan Bernard – percussion; Aleksandra Dulic – live visuals and Kenneth Newby – live electronic music;*

interface panels mapped to a variety of parameter spaces. Following are brief descriptions of some of these processes, their inputs and mappings to visual outputs

3.3.3.1 Performer Inputs

A variety of performer inputs have been explored to provide access and interaction to the Performing Animator. The following is a list of the kinds of inputs used:

- mouse, keyboard
- MIDI control surfaces (knobs, sliders, two-dimensional touch surfaces)
- iPod Touch / iPhone / iPad multi-touch interfaces (TouchOSC)
- mapping from MIDI scores to visual structures
- analysis and mapping of live musical performance
- machine vision analysis and mapping
- frame grabbing of performer drawing, animating, etc.

3.3.3.2 Paths

Any visual document can be piloted along a user defined or algorithmic path. As the "play space" of Performing Animator is a three-dimensional virtual space these all include movement in the z axis to provide depth and atmosphere effects. Paths are defined as either simple linear or continuous curved paths. Easing functions are applied where the appearance of more natural motion is desired. Paths can be generated algorithmically or shapes can be specified in advance as presets or entered gesturally using an input device.

3.3.3.3 Mappings Particles Procedures

The simplest application of paths is their mapping onto low-level visual elements such as movement through color space and transformation (translation, scaling and rotation). Some of the more interesting procedural techniques for generating paths make use of variations on the flocking algorithm first created by Craig Reynolds to simulate a variety of flocking and swarming effects on large numbers of independent visual elements. Other procedures provide an analysis of an image to determine its component parts or

graphical elements in an image enabling grouping behaviours.

The combination of these procedures with particle systems, are capable of producing a wide variety of performed gestures with swarms being able to be guided in real-time through the visual space of the performed animation. Swarms of particles are easily mapped to the shapes of images or typography. A set of shapes making up a composition can be broken into its component parts and re-

Figure 8 . *Mountain High River Flow ...without end; This image shows compositing and editing example created within Performing Animator.*

animated.

3.3.3.4 Frame Players

At the highest level Performing Animator makes use of what we term "frame players". A frame player is a specification of the way the frames of a movie clip—pre-

recorded or generated in performance—are played. Making use of a variety of playing styles it is possible to generate a lot of variety from a limited number of frames, making it an important strategic technique that supports the use of animated gestures produced in a live context. The styles we've found useful are simple specifications of one-shot (single play), looping (forward, backward, palindrome), random walks through a set of frames, and a windowing technique of modulating loops through a subset of frames within a longer clip.

Figure 9. *Mountain High River Flow …without end. This image shows the example of frame players that display character loops (bird, horse and lion). Each character is animated across the screen with Performing Animator's algorithmic path animation behavior.*

The combination of a skilled visual performer with a procedurally enabled animation system such as the Performing Animator has allowed a novel situation for the normally production-bound medium of animation. The balance of procedural automation with skilled human input enables a dynamic relationship to the live performed situation. The provision of a set of procedural tools at the various levels of image production for moving image capture, processing and display allow the performer to control the weaving of compound threads of visual processes in concert with other media threads in the creation of a resultant braid of situated media in performance.

4. Conclusion

As a work of artist software the Performing Animator Instrument is able to undergo significant alteration and development with each subsequent interdisciplinary performance production, serving the different needs that each project requires. The concept of a cinema of braided processes inspired by the study of Balinese shadow play theatre practices provides underlying structures for the development of both our instrument and performance productions.

Recording and linear automation technologies in both music and film eliminated the magic of presence — the power of interaction among performers and audiences that happens only during a live performance. Computational aesthetics embedded in a postmodern art practice enables recorded material to be modulated and integrated in a performance context. This new situation enables filmmakers to build new relationships with their audience and respond to the events taking place on the stage. As a performance this newly conceived cinema only exists in the presence and

moment of the exchange between artists and audience. The resulting improvisations and open forms facilitate the pleasure both performers and audience take in the unexpected and provide insights into a creative process subject, on the occasion of each performance, to reinterpretation and recreation.

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