Live Cinema: Designing an Instrument for Cinema Editing as a Live Performance

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ABSTRACT

This paper describes the design of an expressive tangible interface for cinema editing as a live performance. A short survey of live video practices is provided. The Live Cinema instrument is a cross between a musical instrument and a film editing tool, tailored for improvisational control as well as performance presence. Design specifications for the instrument evolved based on several types of observations including: our own performances in which we used a prototype based on available tools; an analysis of performative aspects of contemporary DJ equipment; and an evaluation of organizational aspects of several generations of film editing tools. Our instrument presents the performer with a large canvas where projected images can be grabbed and moved around with both hands simultaneously; the performer also has access to two video drums featuring haptic display to manipulate the shots and cut between streams. The paper ends with a discussion of issues related to the tensions between narrative structure and hands-on control, live and recorded arts and the scoring of improvised films.

Keywords

live cinema, video controller, visual music, DJ, VJ, film editing, tactile interface, two-hand interaction, improvisation, performance, narrative structure.

1. INTRODUCTION

The recent years have witnessed an impressive surge of new live visual practices. As with every generation of moving image tools (film in the 1920's, video in the 1960's, graphics-enabled laptop in the 1990's), democratization of access has allowed artists to invent languages and artforms that redefine what cinema can be.

Today, in camera-based cinema, film has been freed from the inherent linearity of the physical tape or celluloid medium. Stored as chunks of data on a hard disk that can be randomly accessed, film no longer needs to be presented in a linear, deterministic way, as a static sequence of shots on a one-dimensional timeline; rather it can be presented as a connected constellation of shots in a multidimensional narrative or performance space, that can be traversed in multiple ways, generating a different interpretation of the same film each time.

With traditional cinema, the time flow is imposed. This means that in any polymedia collaboration (e.g. projection in opera, dance, music), film is the unchangeable part of the performance requiring all other performers (actors, dancers, musicians) to time themselves to it. With live cinema, the film elements, controlled by association and algorithmic behaviors, exist as a loose structure adaptable to real-time conditions as the performer improvisationally creates the projection live.

In live cinema, the performer is essentially editing and sequencing previously recorded digital video on the fly while at the same time being on view to an audience. This situation introduces some real constraints on the design of a performance system. This new practice, combining the nature of live and recorded arts, is part of the emerging time-based performance artforms called *Live Cinema* or *Performance Cinema* [24].

In this paper we present a novel instrument, for cinematic editing as a live performance. Our Live Cinema instrument is the hybdrization of a tangible interface to perform electronic music and an editing tool for motion picture. The instrument must allow a performer to assemble a feature-length film from beginning to end in front of the audience, suggesting relevant shots at the right time, based on various time- and context-based organizations of the footage prepared in advance by the performer in the live cinema score.

The design of video instruments, although not a new practice, is not an established field and has been the subject of very little writing. However, because of the many analogies that can be drawn between audio and video domains, all instruments for the production of time-based media in live conditions share common design attributes.

This paper is organised as follows: In Section 2, we provide a short survey of live video practices and an overview of current available tools. In Section 3, we expose the problem and the design criteria, learning from the DJ in section 3.1 for the performative aspect, and from the motion picture editing tool in section 3.2 for the organisational aspect. In section 4, we describe the live cinema instrument and its implementation.

2. BACKGROUND

Live Cinema can be described as any performance involving the *presence of a human performer* manipulating moving images projected for an audience. We attempt here to give a fragmentary survey of the different genres and communities that are represented today among these emerging experimental practices:

- Abstract synthetic cinema

Made with mathematical models and procedural programming, abstract synthetic cinema becomes live when some of its parameters are controlled by a performer. Working with simple elements of rhythm, colour, shape, it is also called *light art*, or *visual music*, aiming at "the development of a visual dynamic language", a "pure graphic choreography" [33]. There is a long tradition of mechanical devices for such color-music performances, such as the *clavecin oculaire*, the pyrophone, the color organ, the Clavilux, the Musiscope and particularly Fischinger's Lumigraph (for a history and bibliography on these instruments, see [4, 10]). The first electronic models were analog video synthesizers [28] ; followed by Laurie Spiegel's digital programmable VAMPIRE [22] - although it is unclear whether they were ever used in a live context. Today artists use the live video software packages mentioned below with MIDI devices, or their own code or sensors, like Golan Levin [10] or Jasch.

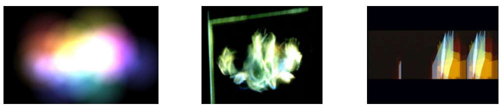

Figure 1. Abstract cinema

- Graphical cinema

Emerging from the rave scene of the 80's, this genre belongs to club culture and music video aesthetics. Originating with the 'demo', real-time fly-through 3D worlds that hackers competed to make in the smallest code size, its material now comprises flash animations and other fast-paced 2D/3D computer graphics. Video projectors have started to invade clubs, making the VJ (video jockey) a natural extension of the DJ in the visual domain. The nature of the visuals comes from the sampling culture, graphic design, pop art and psychedelia. For more information on the abundance of VJ tools, events and communities, see for example [28, 38].

Figure 2. Graphical cinema

- Camera-based cinema

This category describes the work of experimental filmmakers or video artists whose raw material in a live performance is mostly footage captured with a *camera obscura*. Using personal or found footage, these artists compose time-based collages of an often dream-like surrealist nature. Others repurpose footage borrowed from commercial movies to revisit them, remix them or to make video pop art. On the most narrative end, some artists are starting to make film productions specifically for live shows, often performing simultaneously with narrators, musicians, actors, dancers. Our project is designed for this type of live cinema.

Figure 3. Camera-based cinema

The combination of recorded film and live performance is not a new concept. Before the "talkies", film projection was always accompanied by musicians, from a pianist to a symphonic orchestra. Early manual techniques for film performance (still used today) consist in using multiple 16mm projectors, running loops of celluloid through them, moving filters and translucid objects in front of the lens, etc. The first interactive cinema experiments in the 60's with audience voting had a human operator appearing on stage [14].

Steina Vasulka, founder of the Kitchen, an experimental performance space in New York City, started in the mid-70's to perform video by using her violin to control real-time image processing – technique she still uses today with a MIDI-enabled violin controller [25]. In the 80's, Nam June Paik created several live video editing performances.

In the corporate television world, there exists a range of switching and effects consoles developed for editing live broadcasts, which we will not expand on here; the role of the live TV editor as a narrator was analysed by Eco [6].

In the late 90s, the home computer became mature enough for live cinema, facilitated by powerful graphics cards, image compression standards, fast and large hard disks and the firewire standard. Many electronic artists started building their own software and later licensing it : Steim's Image/ine [32], David Rokeby's softVNS [37], Netochka Nezvanova's nato [3], PD's gem, Cycling74's jitter [29], Marc Coniglio's Isadora [34], Meso's vvvv. For other tools and further details, ask these mailing lists [27, 34]. The latest tendencies can be witnessed in European electronic art festivals (club transmediale, sonar, onedotzero..) and new media festivals (deaf, ars electronica, FCMM, viper..). Two recent noteworthy events dedicated exclusively to the art of live cinema were Sonic Light 2003 in Amsterdam [21] and the San Francisco Performance Cinema Symposium [20].

Stage arts are also being transformed by live video : projections are increasingly becoming part of the scenography of theatre, danse and opera pieces [17]. Although most companies use static video (La Fura dels Baus, Wooster group, Station House Opera), some are increasingly using live dynamic video (Dumb Type, Cie Incidents Mémorables, Troika Ranch). Other strategies to have on-stage performers control video include vision-based motion tracking [25] or motion capture (Merce Cunningham).

Alas, in the very conservative world of narrative industrial film as we know it, only very few daring filmmakers have recently attempted to do live editing : Morten Schjødt controlling his interactive film "Switching" and Mike Figgis remixing the sound tracks of his 4-screen feature "Timecode".

3. DESIGN

Our objective was to build an expressive tangible instrument that would allow a filmmaker to come to a venue with all the shots on a hard disk and assemble the film in front of the audience. Such an instrument has to be performative, allowing fast, accurate, expressive manipulations of the image; and have a capacity for organisation, so that shots can be easily browsed and retrieved. We adopted the following approach :

1. Analyse the activities of the DJ and try to replicate them in the visual domain.

2. Study industry-standard film editing tools, determine their shortcomings and rethink them in a performance context.

3. Build a simple prototype with existing products and perform extensively with it in real conditions.

3.1 The DJ analogy

Skilled hip-hop DJs know so well their record collection that they are able to perform musical collages sample by sample [18]. If you replace these sound samples by film shots, you have a simple live cinema tool. The basic equipment of a DJ is :

- a rack of records, sorted by genre, beats per minute or other personal classifications schemes, where spatial memory and personal organisation are of utmost importance.

- two turntables, each featuring random-access (the arm can be positioned anywhere on the disc by increments of a revolution) and speed control; a sound mixer, optionally with equalizers and effects.

The task of a DJ can be decomposed into the following three operations :

1. choose record (media retrieval)

2. preview the record on the headphones and find the right track or sample within it; adjust speed, filters, effects (preview and adjustment)

3. incorporate the material into the existing stream being played and manipulate the material by scratching, cutting, backspinning (live manipulation)

Step 1 and 2+3 are two different problems, each one requiring their own interface.

Step 1 is an organisational problem - a time-critical video retrieval problem, but not classical in the sense that the artist is very familiar with the raw material and has classified the database according to her own criteria. The interface must provide some hierarchical classification and a browsing mechanism at least as efficient as thumbing through a rack of vinyl records. Finally, a search engine should behave more like a *suggestion engine*, featuring some fuzziness in order to stimulate improvisation and creative exploration rather than deterministic execution. Step 2+3 are problems related to the design of a musical instrument [1]. The interface has to be hands-on, expressive and accurate for live manipulations of the media.

3.2 First functional prototype

We wanted to make a first prototype based on a simple mapping of the DJ activity into the visual domain, but robust enough to be used in a real performance context. There is a plethora of commercial VJ tools that can do exactly that [28] : video samplers where each sample can be triggered by MIDI. However, mapping each shot to a different key was not a useful solution. We decided to implement our functional prototype in a flexible environment and opted for Max with Jitter ; our patch is shown in Figure 4.

We have a rack of clips at the top, two video players and a crossfader. For each player : timeline random acces, speed control, YRGB colour control, zoom and pan. In addition, we have a subtitle module that allows the performer to type live subtitles as a narrator. As a tactile interface, we used a wacom tablet (allowing fast and accurate movements for scratching), the computer keyboard (to start, stop, cut and change direction) and 16 midi sliders for continuous controls (colour, zoom, pan). The PowerBook G4's dual graphics card allows for the use of one screen as the workspace and the other to output the visuals.

This prototype was used for about 20 performances in festivals and clubs across Europe and the US, accompanying DJs or electronic musicians. The limitations of these laptop performances can be summarized in the following two main problems :

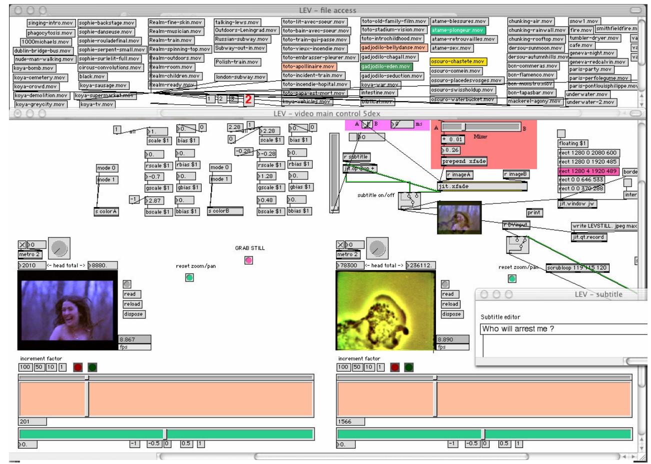

Figure 4. Screenshot of the live cinema prototype.

The first problem is related to the organization of the footage, which was not dealt with in this prototype; this directly determines the content of the performance. Visibility of all clip names on screen does not imply it is easy to find the right one ; besides, in the heat of a performance, decisions have to made extremely fast, with a high factor of serendipity. What the tool is missing is an understanding of the time and state of the performance, so that it would suggest a critical subset of relevant material at the right time.

The other problem, familiar to electronic musicians, resides in using the laptop as an instrument. During our shows, most non-specialist audience members assumed video was prerecorded and did not understand the performer's role on stage. We concluded that the interface needs to be : *transparent*, because the audience wants to see the process. It wants to see the performer's actions and understand what is happening behind the scene; and *performative*, so that the audience can be engaged in the performer's effort and perceive how it is related to the images and sounds produced.

Figure 5. Laptop performance at Le Placard, Paris, 5 am.

3.3 Revisiting the editing tool

The other line of research that this project inherits from can be traced in the genealogy of non-linear film editing tools, who started to appear with video in the late 80s. During the past five years, almost all film editors have moved from analog to digital postproduction tools. Before that, they were working with celluloid, scissors (film splicer) and glue (transparent tape). These mechanical editing machines (Steenbeck, Moviola, Kem) were essentially composed of a motor to carry the film and a projection system to watch the frames. After a generation of cumbersome tape-based tools (Ediflex, Montage I/II/III, EMC2), non-linear editing tools started to appear thanks to image compression standards and large random-access storage devices such as the hard disks. Avid has been leading the market, followed by Lightworks and Apple Final Cut pro.

This first generation of computer-based postproduction tools is still a very literal translation of their analog equivalent; they were not redesigned to take advantage of the very distinct properties of digital media. In order to comprehend these problems, we interviewed the renowned French film editor Joële van Effenterre. We report here her main criticisms :

- With the exception of Lightworks, software editing tools are based on a desktop interface, where shots are represented as files in bins with no tangible representation. Because they were made in existing operating systems, their GUI is limited to the WIMP conventions : mouse, menu, window, file, which are office work - not film – metaphors.

- The screen real estate is obfuscated by too many one-use buttons and information not relevant to the editing tasks ; the only elements really needed are the images and a way to cut and paste them. Important elements shoulds be visually emphasized.

- Dexterity is constrained by the mouse (and to USB jog wheels, or Lightworks' Steenbeck-style wheel controller). In physical space, organization of the material and spatial memory were much richer. The proprioceptive evaluation of the length of a celluloid strip gave a much more intuitive sense of time.

- Images are far too small and look very different from what will appear on a cinema screen (the resolution of a frame of celluloid is orders of magnitude higher than that of a computer screen).

- Last, the importance of the accident is underestimated : coming across lost rushes was one of the main sources for creative combinations in the task of editing. The technological drive for speed and efficiency has ignored that.

In addition to these reflections, we took into account the key research questions posed at the MIT Media Lab Interactive Cinema group [5], where experiments in interactive editing systems have been ongoing since 1982. Key issues therefore include :

- How to think of novel visual representations of the footage, besides the traditional "bin and timeline" metaphors, in the organization, browsing and assembly of the footage ?

- How can the editing tool have a sense of the narrative structure, have more intelligence about what cuts and shots mean, to assist the editing by suggesting shots ? What is the influence of the tool on the content ?

4. DESCRIPTION

Taking the above into account, we describe here the system we have built and for each of its components we explain our design choices and some implementation details.

Our Live Cinema interface consists of a large translucid canvas, on which the performer can grab and move images using the two hands simultaneously. Images representing shots float across the screen and react upon touch. By moving them to the bottom of the screen, they can be explored in detail and routed to the main projector by using the two tangible video drums featuring haptic display.

4.1 Image canvas

A general inspiration for the design was the editing system conceived by John Underkoffler for Spielberg's film Minority Report : a large display area, a gestural choreography using the two hands.

Since we wanted to retrieve and manipulate two-dimensional shots for projection on a two-dimensional screen, it made sense to work with a flat interface surface. We wanted gestural control but haptic feedback (unlike Justin Manor [11]). We wanted the performer to be able to touch the images and move them around, taking advantage of the two hands for different operations.

Because the canvas is translucid and held vertical, audience all around the room are able to see and have an understanding of the performer's operations. The display is very large, sharp (depending on projector definition and distance to screen), and has a full viewing angle (unlike flat LCD screens).

Using vision-based tracking for pointing, the two hands can be used with distinction between left and right – a powerful additional degree of freedom for the interaction design. We designed small battery-operated LED thimbles that the performer has to wear on each pointing finger. To be able to discriminate between left and right hand, we use different color LEDs (blue for left, red for right). The offset between the LED and the fingertip is corrected in software during calibration.

Implementation details

We use rear-projection on a high-contrast Reversa screen (extruded acrylic containing diffusing polymer beads). Finger tracking is vision-based. A color camera is pointing at the back of the screen, so the LEDs can be seen through when the fingers are very close to the screen. To reduce CPU load, we filter optically as much as possible : 1. by perpendicularly polarizing projection and camera with filters, so that only LEDs are seen and not the projected image ; 2. by closing down the shutter to the minimum so that the captured image is black save for small clusters of

Figure 6. our Live Cinema instrument.

colored dots for each pointer.

Fast software tracking is done by performing 4x4 RGB subsampling on the captured image, identifying loci of highest brightness and comparing red and blue components for hand differentiation. The bandwidth of this pointing interface is limited by the sampling frequency of the camera and capture card (here 50 interlaced frames per second - PAL). A 4-point calibration is performed at each system startup by asking the user to touch the four corners of the screen.

4.2 Video drum

While the image canvas is very adapted for exploring the footage, it is not very appropriate for hands-on, fast, expressive and accurate live manipulations. Therefore once a shot has been selected for playback, it can be controlled by a physical *video drum* (Fig. 7).

Time only has two topologies : linear or circular [9]. In our prototype, we were using a linear controller. Here, we decided to use a circular disc-based time controller, bringing back the looks of old-fashioned Steenbeck editing decks.

Figure 7. Video drum.

The video turntable has the following functions :

- *speed haptic control*. There is a direct bidirectional relationship between the speed of the disc and the speed of the video it represents; if slowed down or sped up, the disc will continue spinning at this new speed (and so will the video).

- *frame-by-frame position control*. The high-resolution motor encoder allows to navigate the shot at the frame increment, for accurate positioning, scratching or other non-linear time motions.

- *hit sensitivity*. To switch (cut) to a video stream, one can hit on the corresponding drum. Hitting hard causes a subliminal cut (flash cut).

- *haptic display features*. In future developments, we are working on haptically displaying other features in the shot, such as cuts (automatic scene change detection in the video) [19].

Note that there exist a few simple commercial systems that allow to turn a conventional turntable into a rough video controller, using a barcode disc and replacing the pickup head by an optical encoder [30, 36].

Implementation details

We use direct drive for the disc, using a Maxon motor mounted with an optical encoder. The encoder is used to measure movement and speed manipulations; to insure accurate speed control in a feedback loop; and for haptic display features. We designed our own electronics board to control and drive the motor, detect hits and communicate using RS-232 with the main CPU. Hits are picked up by an electret microphone, filtered and amplified on the board and processed by a PIC microcontroller. The disc is covered with Kevlar for a good grip.

4.3 Interaction design

Interaction design for the image canvas is a work in progress. We present here the ideas in development.

Our minimalist visual interface is only made of moving images – their relationship is represented by their size, colour, behaviour and haptic display. The cinema score is represented as a network of shots drifting across the screen, where invisible springs between the icons will eventually represent a sense of narrative coherence. We are studying visual representations of narrative structure and semantic classification of shots [13], in order to display a dynamic mesh of shots clustered by space, time, character, emotion, narrative arc. The performer needs to be offered just in time a relevant subset of clips while keeping an overall sense of the unfolding narrative. We hope to go beyond hierarchical and timeline classifications (such as the concept of *scenes* that sound and lighting designers use on their consoles to store their presets for a live show).

Two-handed interaction offers many options for intuitive manipulations [8] : e.g. one hand can hold an image and the other be used to rotate/scale it, or a shot icon can be expanded to its time representation by pulling on both its ends.

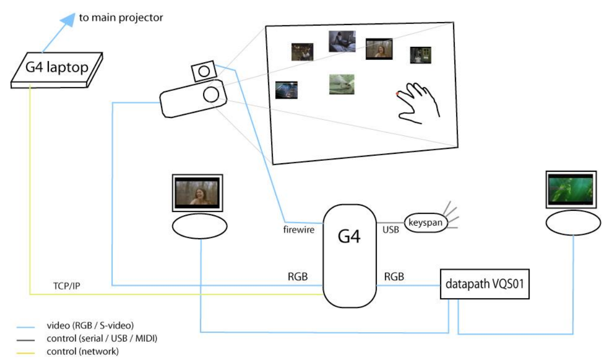

Figure 8. General diagram.

Implementation details

Vision tracking plus constant hard disk polls to display the movie icons require the need for a second computer in charge of the final projection output (see Fig. 8). While the interface (master) computer has low-resolution copies of the video clips (for preview on the image canvas), the projection (slave) computer has high-resolution copies for the big screen. This guarantees fluid projection to the audience at full frame rate. The master only sends control information when needed to the slave through UDP/IP : clip reference, frame number, speed, colour correction, zoom, pan, alpha value for each layer. On both machines, software is written in java with QuickTime and OpenGL. It is possible to connect additional MIDI or serial controllers.

5. CONCLUSION

With recording technologies, both music and film have lost the magic of the presence, the instant, the construction, the performance. But postmodern art practices show it is possible to make a performance art based on the playback of recorded material. With Live Cinema, we want to bring back the filmmaker in touch with the audience; try to make film *allographic*, as art theorist Nelson Goodman would call it [7], so that it would be different every time it is shown. As a true performance, the film would only exist in the presence of its author. Why live arts ? For the contact, the act of gift between artists and audience [12]; For the risk, the thrill of the audience toward the unexpected, the accident, the insight into the construction process; For improvisation and open forms, because text and recording are not holy and should be subject each time to reinterpretation and recreation.

Finally, the live cinema instrument has sound-only applications, if video samples are replaced by sound samples. We hope to use it for the live creation of *musique concrète* soundscapes for theatre. This project raises questions about designing computer-based instruments working at high structural levels, where manual control is not mapped to the production of individual sounds but to the conducting of sound-producing processes. Between the key-to-sound mapping of the sampler and the rigid determinism of the sequencer, there is a range of instruments to be developed for live improvisation [15] ; the composition of material by the author on these instruments would be done in partnership with a generative program [23, 31] based on open structures breaking the linearity of the traditional written score ; the musician would steer through these structures during the live performance.

For more information on the Live Cinema project, go to http://www.mle.ie/~michael/research/livecinema.

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7. REFERENCES

[1] Andersen, T. H. Mixxx: Towards Novel DJ Interfaces. In *Proceedings of NIME*, 2003.

[2] Beekman, René. *Composing Images*. Lier en Boog, Series of Philosophy of Art and Art Theory, Volume 15 Screen-Based Art. http://www.xs4all.nl/~rbeekman/l&b.html

[3] Bernstein, J. *a discussion of NATO.0+55+3d modular*. bootsquad.com, 2001. http://www.bootsquad.com/nato/

[4] Collopy, Fred. Designing an Instrument to Perform Abstract Animation in Real-Time. *Proceedings of SFPCS*, 2003.

[5] Davenport, G. and Murtaugh, M. Automatist storyteller systems and the shifting sands of story. *IBM Systems Journal*, vol. 36, no. 3, pg. 446-56. November 1999.

[6] Eco, Umberto. *The Open Work*. Cambridge: Harvard U.P., 1989.

[7] Goodman, Nelson. *Languages of Art: An approach to a theory of symbols*. Hackett, Indianapolis, 1976.

[8] Kabbash, P., Buxton W. and Sellen A., 1994, Two-handed Input in a Compound Task. In *Proceedings of CHI'94*.

[9] Le Poidevin, Robin. Relationism and Temporal Topology. In Travels. In *Four Dimensions: The Enigmas of Space and Time*. Oxford: Oxford University Press, 2003.

[10] Levin, Golan. *Painterly Interfaces for Audiovisual Performance*. MS Thesis, MIT, 2000.

[11] Manor, Justin. *Cinema Fabriqué : A Gestural Environment for Realtime Video Performance*. MS Thesis, MIT, 2003.

[12] Mauss, Marcel. *The Gift*. New York: W.W. Norton, 1950.

[13] Metz, Christian. *Film Language: A Semiotics of the Cinema*. New York: Oxford University Press, 1974.

[14] Naimark, Michael. *World's First Interactive Filmmaker*. Interval trip report, 1998. http://www.naimark.net/writing/trips/praguetrip.html

[15] Nemirovsky, Paul and Watson, Richard. Genetic Improvisation Model : a framework for real-time performance environments. In *Proceedings of EvoMusArt* 2003, Gloucester, UK.

[16] Patten, J., Recht, B. and Ishii, H. Audiopad: A Tag-based Interface for Musical Performance. In *Proceedings of NIME*, 2002.

[17] Picon-Vallin, Béatrice. *Les écrans sur la scène*. L'Age d'Homme. Lausanne, Suisse, 1998.

[18] Smith, Sophy. Compositional strategies for hip-hop turntablists. *Organised Sound* 5(2):75-79, Cambridge University Press, UK, 2000.

[19] Snibbe, S. and MacLean, K. Haptic Techniques for Media Control. In *Proceedings of UIST 2001*.

[20] San Francisco Performance Cinema Symposium. http://www.kether.com/SFPCS/index.html

[21] Sonic Light 2003. http://www.sonicacts.com/

[22] Spiegel, Laurie. Graphical Groove: Memorium for a Visual Music System. *Organised Sound* 3(3): 187-191 1998 Cambridge University Press.

[23] Ward, Adrian and Cox, Geoff. The Authorship of Generative Art. Proceedings of *Generative Art*, 2004.

[24] Warwick, Henry. Towards a Theory of Performance Cinema. In *Proceedings of San Francisco Performance Cinema Symposium*, 2003. http://www.kether.com/SFPCS/

[25] Winkler, Todd. Fusing Movement, Sound, and Video in Falling Up, an Interactive Dance/Theatre Production. In *Proceedings of NIME*, 2002.

[26] Youngblood, Gene. *A Meditation on the Vasulka Archive*. Vasulka Archive. http://www.fondation-langlois.org/e/collection/vasulka/archives/essais.html.

[27] 0xff mailing list. http://www.music.columbia.edu/mailman/listinfo/0xff

[28] Audiovisualizers. http://www.audiovisualizers.com

[29] Cycling 74, jitter. http://www.cycling74.com

[30] EJ. http://www.scientifikent.com/scratchTV/

[31] Generative. www.generative.net

[32] Image/ine. http://www.image-ine.org/

[33] Iotacenter. www.iotacenter.org

[34] Isadora. http://www.troikatronix.com/isadora.html

[35] LEV mailing list. http://music.calarts.edu/~cchaplin/lev/lev.html

[36] Miss Pinky. http://www.mspinky.com

[37] SoftVNS. http://www.interlog.com/~drokeby/softVNS.html

[38] VJcentral. www.vjcentral.com