Visual Music Instrument

Aleksandra Dulic*
Media and Graphics Interdisciplinary Centre,
University of British Columbia
Forest Sciences Centre Building
FSC 3640 - 2424 Main Mall
Vancouver, BC,
CANADA V6T 1Z4
Tel: 1-778-858-2553
Fax: 1-604-822-8989
E-mail: adulic@interchange.ubc.ca
*Corresponding author

Keith Hamel
School of Music,
University of British Columbia
6361 Memorial Rd.
Vancouver, B.C.
CANADA V6T 1Z2
Tel: 604 822-6308
E-mail: hamel@interchange.ubc.ca

Abstract: Innovations in form and technology are fuelling the contemporary experimentation with musical, visual art and animation. The visual music expression through interactive computational media unites music, visual art and animation both in terms of their phenomenal experience and in terms of their elementary structure that consists of flexible and dynamic information flows and code. The flexibility and dynamism of coded processes readily support both performance and improvisation within interactive visual music and provides exciting compositional and expressive opportunities. In our visual music work synæsthetic composition, computational expression and the dynamics of performance provide three elementary research axes.

Keywords: shared memory parallel programming; task graph; task scheduling; compiler optimisations.

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Biographical notes: Aleksandra Dulic, PhD. is media artist and experimental filmmaker working at the intersections of multimedia and live performance with research foci in computational poetics, interactive animation and cross-cultural media performance. Dr Dulic is active as artist, writer and curator and is currently working as a post-doctoral research fellow at Media and Graphics Interdisciplinary Centre (MAGIC).

Keith Hamel, PhD. is a Professor in the School of Music, an Associate Researcher at the Institute for Computing, Information and Cognitive Systems (ICICS), a Researcher at the Media and Graphics Interdisciplinary Centre (MAGIC) and Director of the Computer Music Studio at the University of British Columbia. Dr Hamel is a composer specializing in interactive computer music with numerous commissions and international performances to his credit.

1 INTRODUCTION

"One day I must be able to improvise freely on the keyboard of colors." Paul Klee (1961)

Visual music as an art form immerges through the application the abstract, non-representational and emotionally evocative aesthetic of music onto the visual arts. It constitutes the distinct aesthetic tradition based on shaped percepts and metaphysical aspiration to achieve kinetic and nonrepresentational art that reaches towards instrumental music. The impulse for dynamic expression of musical forms through visual language has transcended the limits of traditional media and has inspired much of the contemporary computational multimodal and interdisciplinary performance (Evans 2005, Dannenberg 2005). More specifically, interactive visual music performance has developed into a significant current within contemporary art (Snibbe and Levin 2000; Dannenberg 2005;), though not as a formalized movement, but rather as a trend that shares common aesthetical concerns.

Contemporary computational media installations and performances are realizing the aspirations expressed by painters almost a century ago (Klee 1961). Innovations in form and technology — from electric illuminations, abstract analogue and digital film as well as interactive, generative, and process-based digital media — are fueling the experimentation with musical analogy and synaesthesia (blending of senses) in visual arts. The visual music expression through interactive computational media represents both a fulfillment with early compositional aspirations and a fundamental departure from it. In computational media, music, visual art and animation are truly united, not only in terms of their phenomenal experience but also in terms of their deep, elementary structure, being both formed of flexible and dynamic flows of electronic information and infinitely interchangeable code. The flexibility and dynamism of coded processes readily support both performance and improvisation within interactive visual music and provides exciting compositional and expressive opportunities. In our visual music work synæsthetic composition, computational expression and the dynamics of performance provide three elementary research axes.

2 GENEALOGY OF VISUAL MUSIC

The genealogy of visual music lies beyond the origins of mechanical reproduction. Visual music performances can be found centuries before the computerization of time images. Markers within this shifting field are: ancient screen-based performances of projected light and shadow; numerical research of perception of harmony; the painterly explorations of musical ideas; instruments for projections of colored light; abstract film and video.

The idea of integrated visual and aural expression is deeply engraved in human psyche. We are, after all, moving, noise making, improvising, and creatively expressive bodies. This is evident when we look at the artistic forms within contemporary traditions that have vast, historically unbroken and continues multi-media manifestations, such as shadow play performance. In various countries, at various times, shadow-play performances were presented in remote rural villages, urban streets and squares, or in the palaces of the royal court. Artisans and performers in India, China, Thailand, Cambodia, the Indonesian and Malay archipelagos, Egypt, Persia, Turkey, Greece, France, England, and central Europe adapted local story-telling, musical, and decorative art styles to the presentation of shadow plays. The repertory of Shadow Theater is mythical and mystical, showing magical transformations, super-human endeavors, histories, legends, folktales and incidents of everyday life. Traditional shadow puppetry uses flat leather figures, often ornately carved and painted in bright colors, made opaque or transparent, with articulated joints. The puppets are positioned between a light source and a cloth screen and may be operated by rods from below, as in the Javanese theatres, by rods held at right angles to the screen, as in the Chinese and Greek theatres, or by threads concealed behind the figures, as in the European theatres. The screen, most often, separates the audience from the puppeteers. As a media form, shadow play integrates multilayered expressions in light, shadow, movement and music in an improvised manner. For example in Balinese shadow play performance one puppet master manipulates all the puppets, delivers dialogues and narrations, sings songs, and creates percussive sound effects. The performances of Balinese master puppeteer Wayan Wija (Dulic 2006) present the visual music stimuli in flickering coconut-lamp light and shadows combined with the music into an exciting improvised and abstract expression. While the Balinese shadow play is structured as a narrative form that aids socio-communal ritual setting, it nevertheless spans across from normative narrative form to purely abstract and non-representational performance moments. Wija, as a fine musician and mover of puppets, within the supportive accompanying musical ensample, builds dynamic, performative and improvised moments of pure audio-visual abstract stimuli. Those abstract performance moments in light, shadow and voice can be thought of as an original interactive visual music performance.

The understanding of perceptual power of integrated stimuli in light, movement, sound and other sensory perceptions has engaged much research dating back from the earliest scientific and philosophical records. The ancient Greeks theorized about color harmony through an observation that color range in rainbow appears in cycle analogue to cycle of tonal scale. Based on the analogy of the seven musical notes and the seven known planets they constructed a scale of colors divided into seven parts, with all colors derived from black and white. A concept the *Music of the Spheres* attributed to Pythagoras (c.569 – c.475 BC) refers to the relationship between the structures of music and the physical world, as form of music composed by the movements of celestial bodies as they advance along their inevitable path (Stanley 1701). This silent music is an expression of harmony created as the planetary orbits follow their laws, which can be expressed in number. The universe is seen as a song that moves between consonance and dissonance to create an ultimately beautiful musical composition. The beauty is perceived when the complexities of individual parts have ordered harmonious correlation. Pythagoras explorations of laws of that govern consonance and dissonance in music, guided the discovery of a divine geometric order of musical harmony, expressed in simple ratios of integers. This numerical ordering of perceptual aesthetics laid down the foundation for scientific understanding of the connections between perception and art.

In his theoretical reflections on color harmony Aristotle proposed transference of tonal intervals to colors through numerical ratios (Aristotle, De sensu et sensibilibus; Benson 2000;). Renaissance artist inspired by rediscovery of Greek philosophy, also explored the idea of color music and harmony. Leonardo da Vinci made sketches of the relationship of color to music (Whitney 1980; Jörg 2008;) and Arcimboldo inspired by Leonardo's work and writing created a first instrument for color music (Gage 1993). Athanasius Kircher experiments in *magic lantern* led him to create a system of harmony associating relationship among light, color and music as well as a system for correlating color with tonal intervals (Kircher 1650). In 1672 Newton associated tonal intervals with the color bands of the spectrum (Newton, 1675) based on his prismatic experiments. Louis-Bertrand Castel, a French mathematician and philosopher, rejected the color scale based on Newtonian physics, simplifying the relationship between colors and tonal intervals to a relationship between colors and notes. In 1730 he created an Ocular Harpsichord, which actually linked each note on the musical scale with a specific color, finally giving the color theory a musical dimension. When key is pressed on the instrument a channel would open up through which colored light passed (Peacock, 2001; Jörg 2008;).

During the nineteenth century, the wide spread interest in the instruments for playing color culminated with Alexander Rimington's *Colour Organ* of 1893. In Colour-music: The Art of Mobile Colour Rimington (1911) described the organ and color theories on which the instrument was based. In parallel to Rimington's publication Alexandr Scriabin composed *Promethius, The Poem Of Fire,* that included both orchestral score and a device to perform color, called the *Tastiera per luce*. The early 20th Century was fueled with experimentation and creation of instruments that play color in conjunction with performed music (Peacock, 2001;). Vladimir Baranoff-Rossine's invented *optical piano* in 1916; Thomas Wilfred's composed *Lumia* performances for color organ *Clavilux* he invited in 1922; Ludwig's Hirschfeld-Mack developed color organ called *Farbenlichtspiel* with Kurt Schwerdtfeger at the Weimar Bauhaus school at in late 1920's; Charles Dockum created *Mobile Color Projector (1936);* Oskar Fischinger's designed *Lumigraph* in 1948; and Jordan Belson composed *Vortex Concerts (*1957). The listed initiatives represent just a fraction in a vast see of fascinations with the ability to play and compose the color and image like instrumental music.

In parallel to the exploration of instruments for color and visual music an idea emerged that various aspects of musical form could be represented in a painting. This idea of creating a musical analogy in painting originated in the late 19th century, but its full potential was only realized in the early 20th century when European and American artists began to "compose" paintings and films that emulated the abstract purity of music (Moritz 1986, Maur 1999). Painters explored this analogy in works such as Marc's *Sonata for Violin and Piano* (1913), Giacometti 's *Chromatic Fantasy* (1914), Klee's *Instrument for new music* (1914), Kandinsky's *Fugue* (1914), Kupka's *Fugue in Two Colors* (1912), Valenessi's *Spring Symphony* (1832), and Russell's *Four Part Symphony* (1915). While these works were radical in their break from figuration and striking in their formal expressiveness and audacity, they lack the time dimension that is so crucial in music structures. A painted composition is closer to a single musical instance than it is to musical composition.

Perhaps in response to his shortcoming, abstract film, which does have a time dimension, built upon painterly explorations and previous experimentation in color organ instruments. Many early filmmakers were attempting to develop a non-narrative language of light. These experimental visual music films were composed by artists such as: Germans Walter Ruttman, Viking Eggeling, Hans Richter and Oskar Fischinger; American Harry Smith, John and James Whitney, Mary Ellen Butte, Stan Brakhage, and Jordan Belson; Canadian Norman McLaren; Australian Len Lye; among others. Abstract film brought form, color and sound together to create fully synaesthesic experience which took place in time.

Throughout its genealogy the concept of visual music, as a time-based visual imagery that establishes a temporal architecture in a way similar to music, has enjoyed multiple meanings. For some artists and thinkers it meant the creation of a synæsthetic experience where sounds and visuals are combined into a holistic unity (Castel's *Ocular Clavichord,* Scrabin's *Promethius, The Poem Of Fire;* Jordan Belson *Vortex Concerts)*. For others it meant a silent visual expression that carried the potential for dynamic composition whose temporal sophistication is equal to that of instrumental music (Thomas Wilfred, Oskar Fischinger and Charles Dockum). On the other hand for artist exploring a non-temporal forms it meant compositional exploration of pure color and form based on musical analogy.

The history of abstract animation, color music and light performance points towards an aesthetic of temporal abstraction gracefully extending towards dynamic computational compositions. The use of computers to represent images closely linked to musical concepts is evident in the work of contemporary artists such as John Whitney, Larry Cuba, Robert Snyder and Edward Zajec. Golan Levin and Scott Sibbe explore the use of interactive audio-visual expressions through gesture, dynamic visualizations and image animation. Golan Levin, through his painterly interface metaphor, explores the variety of gestural expressions for the performance of dynamic imagery and sound.

Interactive computational media enables music and visual art to be combined and correlated in terms of their basic coded structure, and through flexible and dynamic information processes. This provides many opportunities for compositional and expressive exploration of visual time-based media in relationship to instrumental music and performance.

3 COMPUTER CODE AND ARTISTIC COMPOSITION

The pixel and sample architecture of the computer audio-visual display, and its extensions into points, lines, plains, rhythms, sounds, phrases, etc., provide the basic elements of computer-mediated art, where the composition is animated by various coded processes. Contemporary computational media artists often chose to reach beyond available compositional frameworks towards the design the instruments that provide a nexus for their own creative vision and artistic methodology. Taking advantage of the emerging potentials of a computational environment, the design of an interactive instrument promises a new creative model for audio-visual time-based composition, one that is iterative, transformable and enables a fresh perspective on performative audio-visual thinking.

In the context of computational artwork expressed by the means of code the code is interpreted as *artistic material* that articulates the artistic concepts and processes, while the computational technology then becomes the carrier of the artistic image by means of the code, and in this way it acts as a *medium* that enables the work of art to be experienced. The challenge with this approach is to articulate poetic, embodied and intuitive artistic ideas into coded, logical information structure. Coding translates a certain level of abstraction and modeling of the creative process and embodied knowledge into a formal model. In this context the process of coding is defining a framework for the articulation of an artistic methodology. The process of coding enables the development of artistic methodologies and instruments that best serve a particular emerging practice, especially once we look at the practices across cultures.

Coding affords a way of working with technology that is appropriate to artistic process. This way of working acknowledges the evolution of the idea into code, and allows for improvisation and active response within the process of creation. Within the context of artistic code, practice is defined as procedural knowledge, algorithmic, experimental, and improvisational. Practice deals with embodied knowledge that is manifested through skill, as well as incorporated knowledge, based on the mutually agreed-upon problems recognized within a community of practitioners. Artistic skill depends on a knowledge that incorporates body memory, virtuosity and coordination in a significant way, such as playing a musical instrument, dancing, drawing or painting. Writing, or writing code, also requires creative skill, but it is not as much related to the body memory and virtuosity of movement techniques. The act of coding artistic process forces us to make explicit that which is merely implicit, aspects of ourselves that remain largely invisible to ourselves as long as they remain "inner" and operate at the level of intuition. In this context the embodied creative methodology needs to be treated and analyzed as a model that can be achieved in code. Artistic coding practice informs innovation in that it deals directly with outcomes demanded by an engagement with creative process. The implication of art-software and code as art research practice provides an insight: formal procedures and the compositional intelligence of the artist/programmer are articulated through code within in the computer system.

The computer is designed to manipulate symbols in a logical fashion with the software patterns representing ideas that facilitate the variable potentials of the computer. Heidegger's suggestion that idea is the essence of technology finds an echo here. Technology as idea is made explicit in his characterization of the essence of technology as a mode of revealing. For Heidegger (1977) technology "comes to presence in the realm where revealing and unconcealment take place, where aletheia, truth, happens." The physical computer itself is unavoidably passive without the insertion of symbolic patterns of code-ideas that allow the hardware to reveal the inner logic of the algorithm. Technology reveals its potential only when an idea is inserted into it as coded procedure, as a set of instructions that the hardware will perform in the execution of these procedures. Coded procedures guide the particular unfolding or unconcealment of the truth through a hermeneutic process open for interpretation.

4 INSTRUMENT AND CULTURE

The process of coding provides an artistic methodology for composition using computing technology, while the performative potentials of computational media forms are a major consideration in the development of the artistic whole. Since practices are coded through time, history and language artists shape codes that emerge from the culture they are a part of. By shaping the cultural codes, as well as instruments used to express cultural information we are shaping the culture and creative process itself. Instruments reflect culture and are culturally specific, and thus artistic involvement in the design of the systems within which the creative processes take place provides benefits and rejuvenates artistic processes, methodologies and consequently the work of art. In this context the design of an instrument extends to a design of the creative process and methodology.

An instrument can be thought of as a membrane through which we think as much as act, acting as it does as a nexus for not only the sensations and feelings but also philosophical concepts and understandings of the world that it mediates. In the context of computational media an instrument becomes an interface between composed artistic environment and performers. The instrument thus defines how we perceive and navigate artistic content as well as it shapes our understanding of the content. It characterizes how we perform while engaging with it as well as how we feel while interacting. In the context of interactive media, the culture becomes something we perform while engaging with the performance instrument. The computationally expanded instrument provides a doorway to the world of information coded into an artistic system. It allows performer to apply their expressive artistic knowledge to the abstract realm of information, thus enabling the abstract information to become corporal and empirical, through the use of familiar metaphors that approximate simulations of the real world. These familiar metaphors allow performers to make decisions and handle information in intuitive ways. It is important to note that this familiarly with metaphors is also culturally specific.

Every interaction performed within given culture has some form of cultural encoding embedded in it and thereby carries cultural information. One ramification of this is that the cultural codes perform differently and elicit different responses when used outside its native cultural context. Musical tuning systems across cultures, for example, are significantly different and these variations characterized significant differentiations of one culture from another. There is a profound difference between the tuning system of the instruments of the Indonesian bronze-keyed gamelan orchestra and the tuning system of the instruments of the European symphony orchestra. Similar cultural differences exist in terms of language, color symbolism, vocal characteristics, song forms, rhythmic structures, costumes, gesture styles, masks, makeup, choreography and a host of other codes used to generate meaning in artistic expression. These differences constitute a form of cultural information, after Gregory Bateson's (1972) definition of information being a difference that makes a difference, or a difference that is significant in some way.

Richard Anderson's (2004) open definition (Weitz 1979) of art as a *culturally significant meaning* offers understanding of artistic expression applicable across diverse cultural contemporary traditions. He puts forward a definition of "Art is culturally significant meaning, skillfully encoded in affecting sensuous medium" (Anderson 2004). Individual arts, artifacts and instruments vary in the emphasis placed on each of these qualities, argues Anderson, and these variations are permitted by open definitions. People understand, communicate and create meanings. The common values of meaning in art can be found in the contributions that art makes to spiritual, philosophical or ethical areas of life, a meaning skillfully coded to affect our senses. Art reaches the highest purpose when it conveys and expresses cultural meaning of significance for a particular tradition or a group. The work of art is significant if it supports, transmits or transforms cultural values, if it teaches or administrates culture.

To embed this kind of cultural information into an instrument means to situate it within the culturally specific expression. It implies the transformation of mouse, keyboard and display interface into culturally meaningful instruments and artifacts. The computationally expanded instrument then evolves into an object in which the technology animates the particular cultural forms. An instrument embodies a complex layer of cultural encoding in that it is used to articulate concepts, feelings, and sensations at a high level expressing a cultural form.

One of the significant considerations in our work is a design of a computationally expanded instrument that acts a locus where computer technology intersects with a culturally significant meaning. The core idea in the design of performance instrument is that it acts as an object coherent with the information it enables one access.

5 COMPLEXITY AND FORM IN VISUAL MUSIC

Visual music can be thought of as time-based visual imagery with a composed temporal architecture. In our work the emphasis is placed on integrated audio-visual compositions that unfold in the contexts of instrumental performance. In this section we cover some basic considerations with regard to compositional synergies and independences across visual animation and music.

Creating works for integrated media poses some difficult compositional, perceptual and technical problems within the computational environment. The perceptual experience of correlated dynamic animation of visual elements and music within any given performance cannot be reduced to a simple addition of image and sound. When these elements are combined they intertwine into a unified experience that presents the viewer/listener with new levels of perceptual complexity. Images, sounds, and their impressions are therefore considered as an integrated structure, because the perception of each element is actively affected by their relational positioning. Although many parallels can be drawn between music and animation, and the synaesthetic possibilities are very attractive, visual events do not work the same way sound events do. The integrated compositional articulation needs to account for both differences and similarities in the perceptual, formal and technical characteristics across aural and visual domain.

In the context of an integrated composition within a computational environment one of the key similarities across aural and visual (animated) form is that they both act as a multi dimensional parameter spaces. In sound domain the low-level parameter space is defined through the elementary fragments such as samples, frequency, amplitude, spatial position, etc. that work together in the articulation of sound. Medium-level music parameters can be defined at the event level including elements such as notes, dynamic changes, and timbral modulations. At the event level the elementary time and frequency structures are grouped together into perceivable events. High-level structures of sound include gestures ornaments, phrases and musical sections. In animation domain low-level visual parameters form the elementary structure of the image with point, line, plane, vector and color, while elementary animation parameters are elements such as direction, duration, position, and velocity. Medium-level parameters in image also function at the event level and are composites of low-level image elements that form structures such as visual gestures, translation, shapes, masses, volume, depth and drawing of image elements both in time and in the two-dimensional space of the individual frame. High-level compositional parameters of animated visual imagery refer to compositional structuring of the time-based image with elements such as montage, sequence, motion vector definition and the synchronization of shape elements within the image.

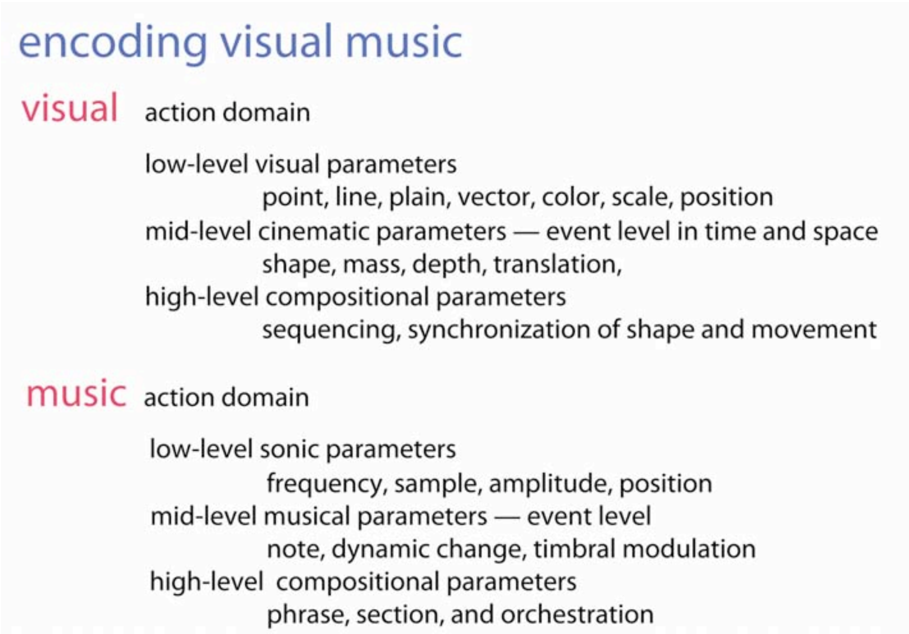

Figure 1 Visual music action domain

If we compare the multi-parameter space in aural and visual domain across these three levels we can identify both similarities and differences between these two media on each level. At the very low level the pixel in image corresponds to the sample in sound, which is technically the way image and sound are constructed, but are such small elementary form that are consciously not perceivable as individual fragments. The synergy across low-level parameters within music and animation can be identified in duration and movement direction while the scale in visual domain corresponds to amplitude in sound domain. The independence of elementary low-level form is evident in the technical comparison of a drawing frame rate of image in relation to sampling frequency architecture of sound, which happens at different time, a phenomena that can influence the timing synchronization of an image and sound. The frequency in sound and frequency in color result in different perception: octave perceived in music does not exist in perception of color, while multiple colors always mix to crate one distinct color, multiple pitches, with frequency value that are sufficiently apart are in most cases perceived as separate. In the mid to high level parameter space the time-based tempo, rhythm, proportion in time, intensity, morphing, the spatial movement, the relational positioning, definition of pitch harmony and definition of color harmony are related compositional concepts that can be applied across both domains. The key difference is that in visual imagery there is a spatial focus and in aural imagery there is a field focus.

Computation easily affords the literal and simple connections between image and sound especially in the low-level parameter space. However, the one-directional direct mapping among musical and visual elements is not sufficient in creating the most satisfying aesthetical experience. There are number of examples in interactive visual music that are primarily based on what is readily apparent, perceivable in the moment and easily analyzed incoming sound information that drives the generation of visual animation. The low-level to mid-level musical parameters, such as frequency, amplitude, duration, and rhythmic impulse in the sound domain are dynamically mapped to low-level and mid-level visual parameters, such as color, scale, direction and duration of animation. These examples are found in screensaver aesthetics of algorithmic music visualizations that are attached to a number of programs for visual music display (Windows Media Player, WinAmp, iTunes etc.). From the research perspective these kinds of mappings are not as interesting because they fail to take advantage of higher-level connections.

While the low-level mappings can affect the level of expressivity that is perceived from moment to moment, more significant challenge lay in the relations between image and sound that is based on higher-level compositional structure and on the fundamental emotional experience embedded in the composition. The representation of emotional qualities requires analogue representations across visual and aural domain that is rooted in structural, qualitative and interpretive compositional processes. An approach where connections are made across compositional structures and conceptual framework enable sound and image to act together in an integrated aesthetical experience. This facilitates the emotional, expressive and abstracted appreciation of overall compositional concepts that unfold in time and are embedded in the formal structure of the image.

The harmony across the shape, color, movement, sound and melody is achieved by setting their relationships into a unified system that is balanced across the various levels of mapping. The congruent mapping across low-level, mid-level and high-level elements within the composition creates the complexity that acts simultaneously at different scales. The significant compositional challenge is to organize the correlated elements into themes that are developed clearly and progressively. A particular correlated audio-visual gesture is more evident when it is presented in relative isolation and well developed before blooming into its full expressive complexity. Once the aural and visual correlation within the individual thematic gestures is established it is possible to move towards the more complex interactions across different individual gestures, parses and sequences, because the individual thematic units will remain perceivable.

The search for structural balance — between complexity and direct correlation — allows the composition to span across wide dynamic range of emotional and conceptual expressivity. There are many compositional possibilities in exploration of contrast in audio-visual form, which can be achieved by building the tension and release through dissonance and consonance in form. The moments of unity in aural and visual composition established by some mutual signs can be contrasted with the moments of intended digression from the unity, when aural and visual elements come into thought out conflict. The idea of audio-visual counterpoint provides a strategy for achieving contrast and conflict among various compositional elements and themes. Multiple layers of activities can be composed aurally and visually to create different streams that work independently but are related to one another. In musical counterpoint one voice is perceived as independent form another voice and connections across voices are established linearly, in time. The unfolding of the image elements through movement in time constructed in a contrapuntal structure refers to composition of multiple graphic elements and animated voices that work independently in support of a larger compositional structure. In the visual domain the contrapuntal relationships can be achieved trough a contrast in the movement direction, scale, shape, volume, masses and depth. The time organization of these visual design materials into tension / release contrapuntal structure facilitates the composition of the contrasting forms into a unified system.

Interactive Visual Music composition can be described as highly organized multidimensional elements of sound and image that exhibit flexible and dynamic time-varying structures in the frequency (pitch, color), shape, position and time domains. Within the coordinated composition there are many different ways in which image and sound can interact and can be mapped across visual and aural multidimensional parameter spaces. In the interactive performance context the mapping can be established in several directions: 1.) The sound can drive the animation and formation of the image, with analysis of music providing the basis for the graphical rendering of its analytical forms; 2.) Visual elements can drive and create the sound, with image analysis of various levels of an animated composition providing a basis for musical rendering of its analyzed forms; and 3.) Mapping the analysis of external gestural source to drive both media, such as gesture analysis of performing instrumentalist, dancer or live animator. These combined in a multidirectional improvisational arrangement between image, sound and performers, where all have the ability to influence each other and all have the level of independence, forming an intertwined contrapuntal structure provides the most interesting mapping results. The built in intelligence into a visualizer and sonfier that has capacity to responds to one another and to the performers in a complex way, where components are not just executing a predetermined mapping structure but are responding contextually within the entire compositional arrangement, provides the most comprehensive visual music pallet.

Another option is to compose an abstract structure that acts as a controller for both sound and image generation. This approach is analogous to a score in music, which is an abstract representation of what needs to happen over time. It is also possible to combine a looser notion of a score with the performance-based inputs to create a structured improvisatory system. Whether the score-based approach is fixed or composed as an improvisatory performance arrangement, it can be understood as a deep compositional structure which is gradually revealed over the course of the composition.

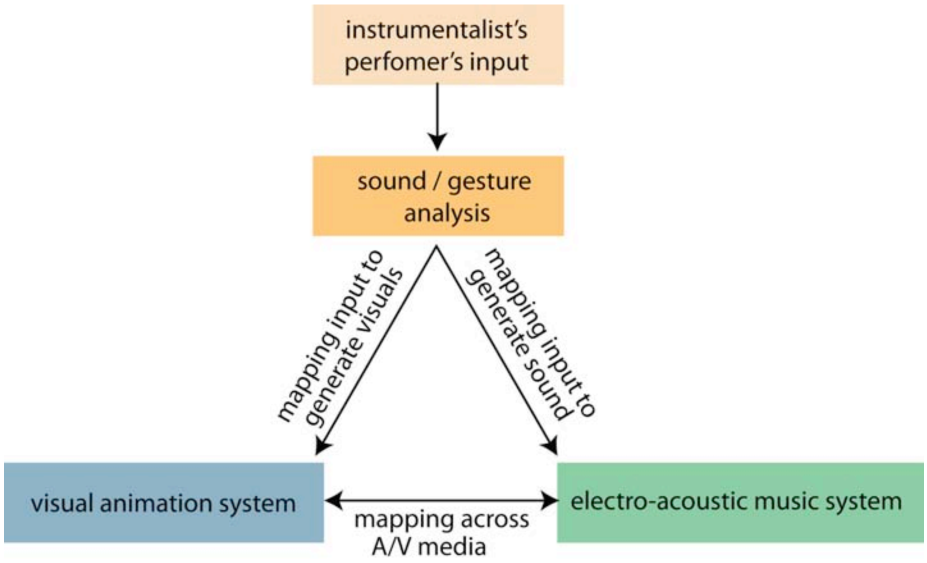

Figure 2 Mapping across performer, image and sound

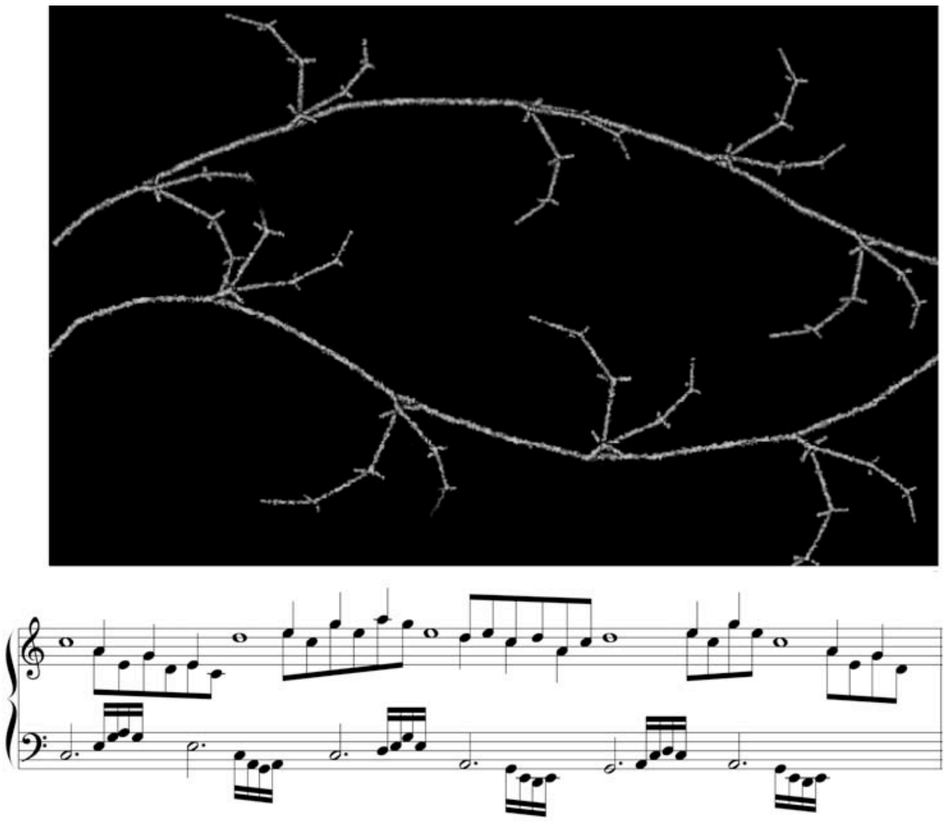

Figure 3 Musical and visual structure defined by Lindermayer system fractal.

Javanese musician and theorist Sumarsam (1975) proposed the concept of the inner melody to describe the heterophonic organization of a piece of complex Javanese orchestral music. In Javanese Karawitan complex sonic lines fill time at different levels of scale. Each player elaborates on a deep structure or inner melody according to conventions specific to the instrument being played. Players of the ensemble play their part with reference to a series of common tones defined by inner melody. Each phrase ends on this common tone bringing the whole orchestra into focus in that moment at a point of unison. These pillars of order frame the chaos implicit in the heterophonic organization of the Javanese gamelan orchestra resulting in a model of complexity in balance—a dynamic steady-state (Sutton 1982). Sumarsam's idea of inner melody can be extended to organization of media elements that embraces chaos by using a hidden deep structure to frame a complexity of simultaneous yet independent performances of the various voices embedded in the composition.

6 VISUAL MUSIC INSTRUMENT DESIGN

The design of our visual music instrument is based on the idea of performing correlated audio-visual imagery. The core design consideration is the creation of a real-time improvisatory performance instrument. Our aim is to take advantage of the nuances and variety of the performer's gestures and augment them in an audio-visual field. Our visualizer and sonifier have the capacity to generate original material, sequence and animate preexisting media, as well as modify and transform the real-time input coming form the performer. The software modules described in this section are written mainly in the Max MSP and Jitter programming environment, and include custom made objects for Max written in C.

The three-level positioning across audio-visual multi-dimensional parameter spaces is reflected in the software design that encompasses our visual music instrument. Those three levels form the basis of the modular design of software components both in aural and visual domain. Author 1 sound modules on the low end deal with audio samples to produce sound effects, such as delay, reverb, flanging, harmonization etc. The medium level sound modules generate sound at the note level receiving data, such as pitch, velocity, duration and other characteristics of the sound on the note level. The high level modules generate phrases, melodies, gestures, pitch structures or sample structures and their output is a time-based sequence of note information. One of the key considerations in the modular design is that all the components within any given level have consistent data structures so that the modules at any level are interchangeable. High-level modules never generate sound rather they generate structured note information, so that any high-level modules can be connected to any mid-level object or a group of mid-level objects and any mid-level objects can be connected to any low-level object or a group of low-level objects.

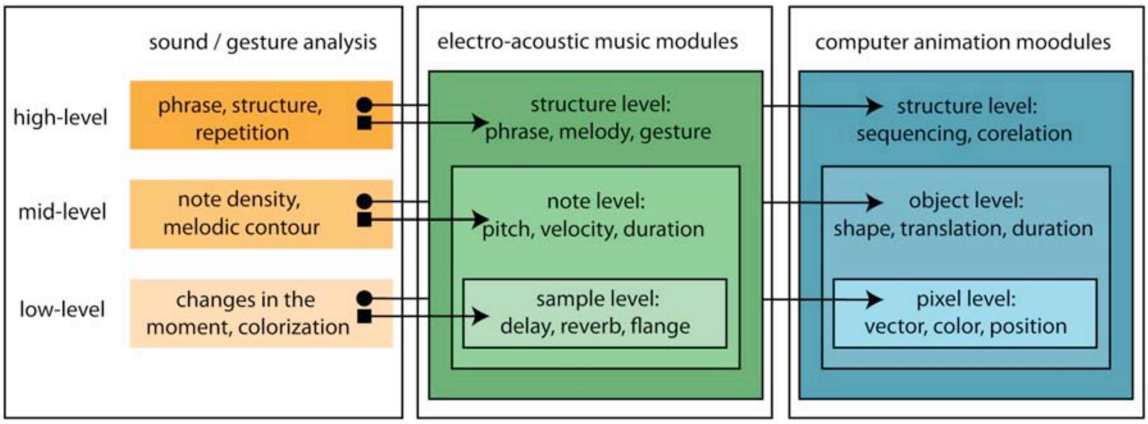

Figure 4 Relationship among different levels in audio, visual and analysis modules.

The visual animation modules, created by author 2, also operate on those three levels, though the structure of modules is somewhat different to accommodate the drawing in three-dimensional space (Figure 4). At the low end the modules operate on the pixel level generating vectors, color, scale, position, points, lines and planes.

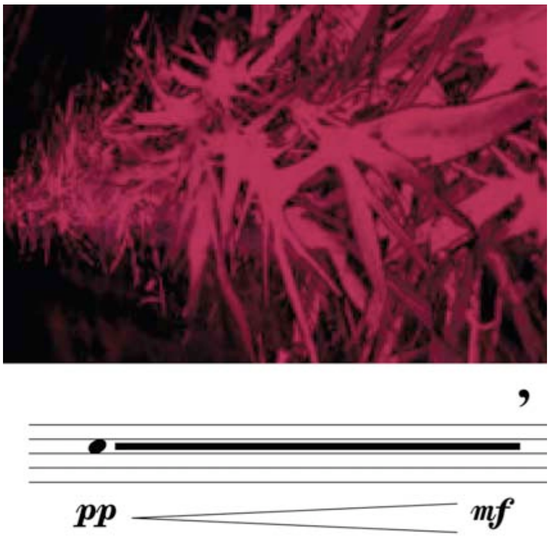

Figure 5 Mapping of low-level audio parameters to animated and textured ribbon in 3D space.

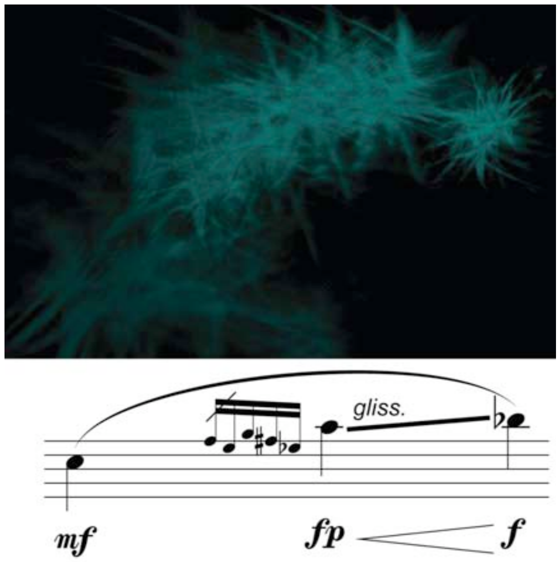

Figure 6 Mapping of mid-level audio gesture to a group of textured particles in 3D space.

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 ribbons, particles, groupings of movie objects as well as the real time stop-motion animation that is keyed and displayed in an integrated manner in three-dimensional space.

The high level modules generate object groupings, time structure and behaviors such as motion vectors and time-based ornament structures. Every mid-level object receives the same kind of information, such as position, translation and scale, so that any high-level module can control layering of any mid-level module or group of modules and any low-level object modifies the elementary fragments of the overall animation.

The high-level objects provide the compositional structures and event organization, with the capability to organize time-based occurrences at a global level (Figure 3). The high-level object can be specific to the needs of audio or animation, but can act independently as an abstract structure that provides either fixed-in-time or flexible external compositional frameworks that drive the synchronic and diachronic relationship of various sound and animation events. This abstract structure is hidden from surface renderings of audio-visual form and acts as an inner melody of the visual music composition controlling the way the sound and image interact with one another. The contrasting, conflicting and contrapuntal relationships among the audio-visual events are established by composed independence of image and sound elements. For example the inner melody (Sumarsam 1975) can define the overall moments of unity sufficiently spread in time, so that the structure becomes invisible. Each component, aural and visual, can have its own way of improvising and generating its own unique surface rendering set around the inner melody. This way the entire composition can span from conflict established by an independent, but contextually aware, improvisational logic of each element to moments of unity and alignments set by the structure of an inner melody.

The modular software structure allows multidirectional mapping flexibility between image and sound. Flexibility between the aural and visual dimensions is critical since the mapping from sounds to image and vice versa is a compositional and interpretive decision specific to the particular composition. The three level audio-visual parameter space acts as a conceptual matrix that allows interchangeable mapping to be established in any direction: performer to sound and image, sound to image, and image to sound. The analysis and coherent messaging within each level is necessary so that the mappings can be established across different levels in any direction. The modular software components are designed to act as an artistic pallet that enables different elements to be grouped together and influence one another. The design of compositional building blocks across the three levels provides a framework for visual music expression, which serves different artistic experiments, compositions and performance contexts (Figure 2).

The expressiveness of the visual music instrument is enabled by gestural control over visual and sonic parameters driven by the 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.

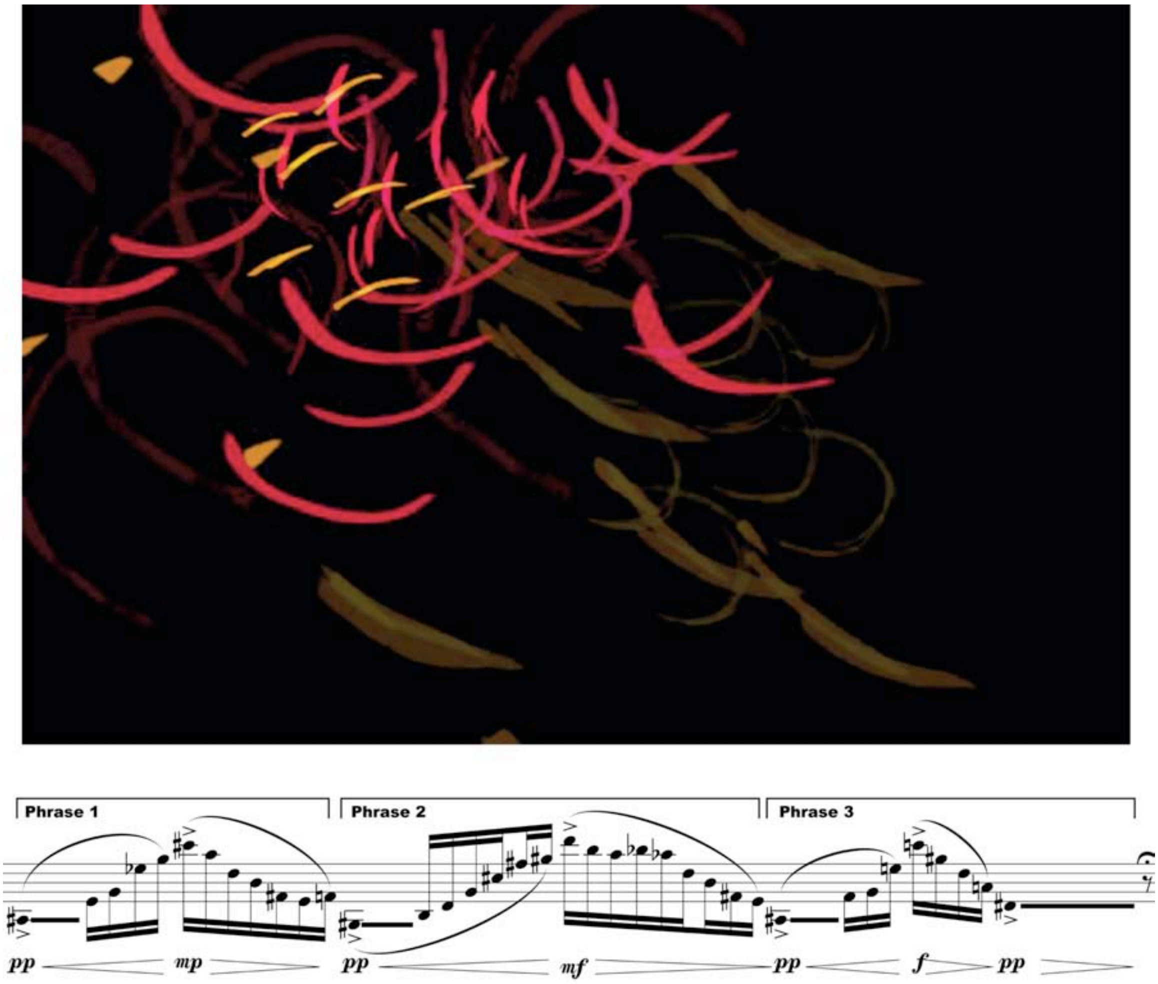

Figure 7 Mapping of three audio phrases to three groups of animated gestures in 3D space; in this image each visual gesture is distinguished by its unique color: pink, yellow and dark red.

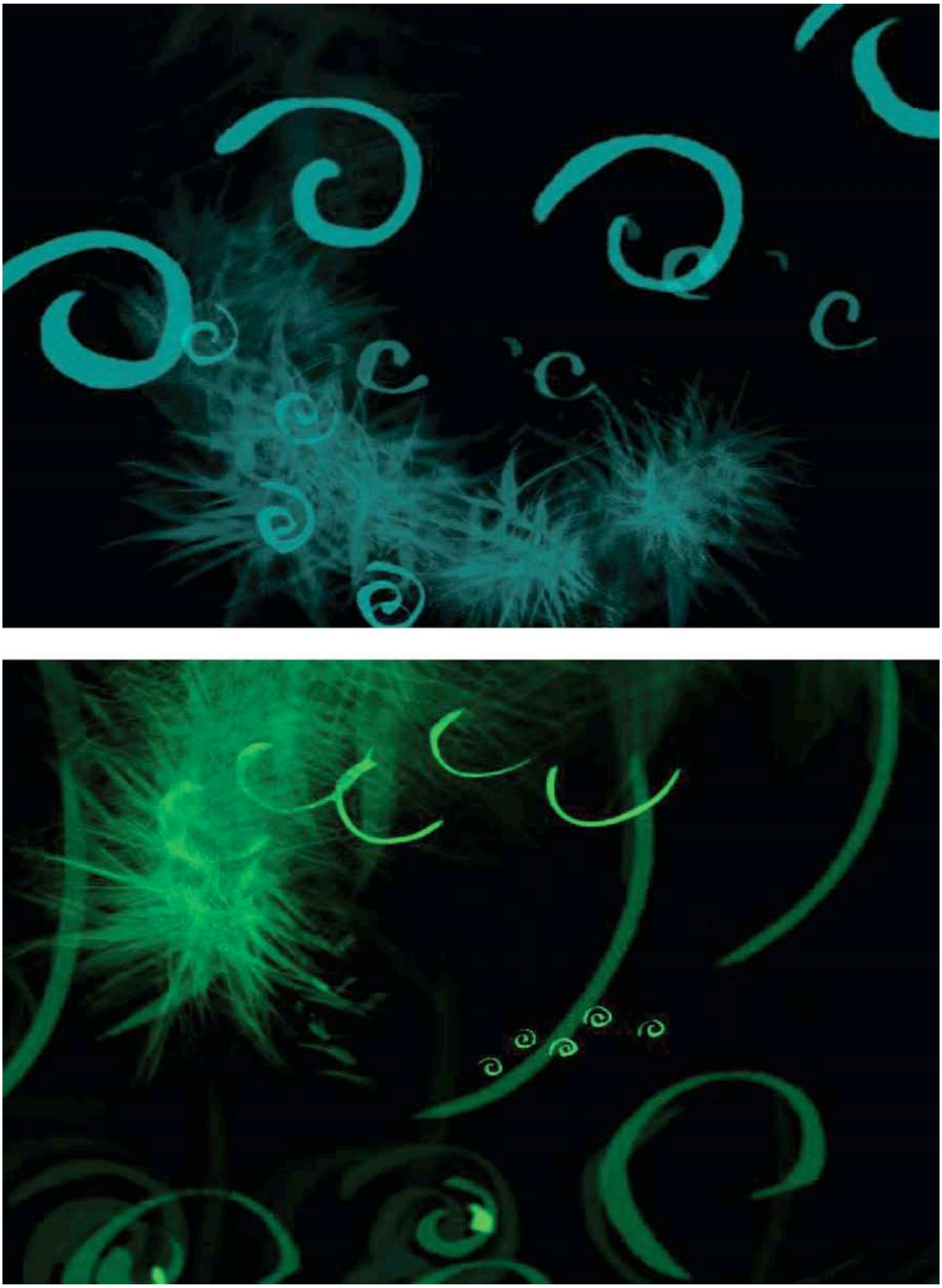

Figure 8 Two animation frames showing the combination of several animated gestures combined together into a visual composition. The color space of the overall image in each frame is defined by the changes in the pitch space of musical gestures.

7 CONCLUSION

Throughout its historical and contemporary development visual music has been rendered in various ways: as audio-visual time based stimuli, silent visual exploration in time as well as a single still image that explores compositional aesthetics of music. Contemporary computational visual music composition is a field with many exciting developments, for we are witnessing the birth of a unique integrated form prompted by capabilities afforded by computation.

In our work we focus on coordinated audio-visual composition integrating the flexibility and dynamism of coded processes to enable performance and improvisation within interactive visual music. We presented both the theoretical and software design framework that drives the integrated composition of our visual music work. The modular design of software components can be combined together into a number of different instrument configurations.

This approach provides us with flexibility to modify our instrument in various ways in order to serve the variety of particular needs defined by each individual composition. In this way the mapping strategies across image sound and the performance gesture can vary with each compositional initiative.

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