Published in the Proceedings of Non-photorealistic Animation and Rendering (NPAR 2000). Annecy, France. © 2000 ACM.

Interactive Dynamic Abstraction

Scott Sona Snibbe
Interval Research Corporation
1801-C Page Mill Road
Palo Alto, CA 94107
snibbe@interval.com

Golan Levin
MIT Media Laboratory
20 Ames Street Room E15-447
Cambridge, MA 02139
golan@media.mit.edu

ABSTRACT

The history of abstract animation and light performance points towards an aesthetic of temporal abstraction which digital computer graphics can ideally explore. Computer graphics has leapt forward to embrace three-dimensional texture mapped imagery, but stepped over the broad aesthetic terrain of two-dimensional interactive dynamic abstraction. Several experiments in using pure human movement as the interface to dynamic abstract systems are presented with the goal of creating *phenomenological interfaces* that engage the unconscious mind directly. These applications are visual instruments that allow immediate understanding of a dynamic system, but point towards infinite challenges in their mastery as any good artistic medium. The lessons from these experiments can be applied to computer animation, human-computer interface and the aesthetics of time-varying light.

KEYWORDS

Abstraction, Animation, Art, Computer Graphics, Cognitive Science, Human Factors, Philosophical Considerations, Visual Communication

HISTORICAL BACKGROUND

Those pioneering expression with the time-varying and interactive aspects of digital media have often seen themselves to be exploring virgin aesthetic territory. The introduction of the first integrated keyboard, bitmapped display and mouse in 1974 with the Xerox Alto is seen by many as the beginning of the personal computer era [1]. For the first time, a graphical user interface allowed access to the media manipulation capabilities of this new machine. This class of desktop computer then and now has been described in terms of its three main hardware components: input devices, output devices and information processing. However, if we look at the computer instead as a mechanism for translating information from one sense phenomenon into another, we can step much further back.

Pythagoras first explored the notion of synesthesia around 500 BC [2]. His intuition of the analogy between vibrations in tone and vibrations in light led him to imagine the *Music of the Spheres* as the sounds created by the perfect movement of heavenly bodies as they proceed along their inevitable course. These analogies between perceptual modes caused Pythagoras to imagine that true spiritual transcendence comes through the re-uniting of the senses, revealing divine geometric harmony and the similarity of all universal form. This spiritual underpinning of perceptual aesthetics has been rediscovered or reinvented over the centuries as a means for understanding the connections between both perceptual phenomena and artistic media.

Wassily Kandinsky embodied the aesthetic and the psychophysical notions of synesthesia in his work and writing [3]. It is now understood that one in one hundred thousand individuals have a condition that automatically translates their senses as they perceive reality. The most widespread form of clinical synesthesia is the translation of sounds to colors [4]. We now understand that Kandisky's adamant labeling of shapes with colors (e.g. triangles are yellow) in *Concerning the Spiritual in Art* were caused by this condition. Many viewers at first found abstract painting impenetrable and imagined it as an acquired taste requiring education and adaptation. However, recent psychophysical experiments [5] indicate that the abstract synesthetic experience is accompanied by a significant *lowering* of cortical brain activity. The implication of this research for abstract expression is that it is quite possible that such abstract perception is part of our lower perceptual mechanisms and that abstract form and color might in fact be akin to pure musical tones – innate notions of beauty shared by all human beings.

Figure 1. *Three Sounds* by Wassily Kandinsky, 1926.

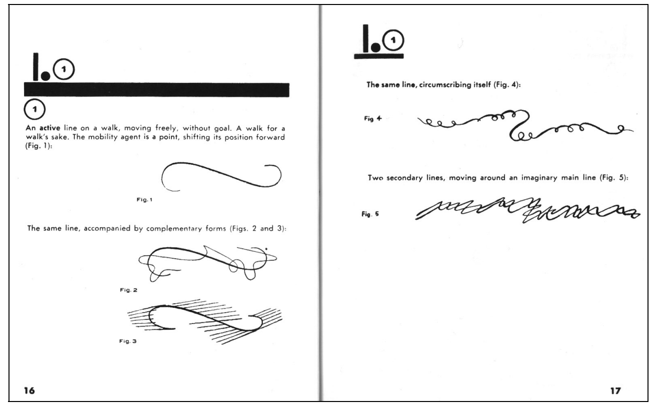

Figure 2. *Pedagogical Sketchbook, Chapter 1* by Paul Klee, 1920s.

Kandinsky's paintings were the first and arguably still the strongest to explore this connection between form, sound and color in *synthetic abstraction* – abstract painting which is entirely nonrepresentational. *Three Sounds* (Figure 1) in its name and formal structure clearly shows the artists deliberate use of musical metaphor and analogy. Kandinsky was part of a spiritual movement that crystallized the notions of Pythagoras into a more formalized belief system called *Theosophy*. As a theosophist, Kandinsky believed that certain combinations of color and light could bring on spiritually transcendent experiences. Theosophist religious books were filled with colored forms that they believed would bring on such experiences. Those sharing Kandinsky's belief system included many of the prominent artists of his generation and, significantly, one of the great patrons of abstraction, Hilla Rebay, curator of the Guggenheim Foundation from the 1920s through the 1950s.

Paul Klee's paintings represent a movement towards the dynamic in abstract painting. Although fixed in static form on Canvas, Klee embarked upon a program of discovering the dynamic perceptual qualities of color and form. His thoughts were formalized while teaching at the Bauhaus in the 1920s, where he wrote the Pedagogical Sketchbook – a complete course in the dynamics of static form (Figure 2). Like Kandinsky, Klee used musical analogy in describing his work. A practical answer to this transference of terminology is that music was the only developed abstract medium. Furthermore, many of these abstract painters were musicians before they became visually fluent. However, there is one essential element missing from these static paintings that is intrinsic to music: time.

The first abstract animators used celluloid film to achieve time-varying abstraction. Walter Ruttman has the distinction of creating the first publicly presented abstract animated film, *Lichtspiel Opus 1* in 1921, which was created by sequentially photographing turning clay forms, mirrors and hand-painting celluloid. He formed part of a small group of fervent believers in the power of temporal abstraction. Viking Eggeling began a systematic study of abstract composition, attempting to discover a "universal language of abstract images," and, borrowing from Hans Arp, "the rules of plastic counterpoint". Eggeling's *Diagonal Symphony* of 1924 embodies some of these formal ideas, but his early death prevented him from richer articulation.

Oskar Fischinger is regarded by many as the master of abstract animation. Trained as an engineer, Fischinger was profoundly affected by this early milieu and dedicated his lifetime to artistic expression. His work, created frame-by-frame, represents the type of control and inspiration that a master composer wields over musical form. His early series of films, drawn frame-by-frame with charcoal, are numbered like musical composition, and later films all had musical accompaniment (Figure 3). However, these films are not visualizations of the music, but provide visual counterpoint, becoming another parallel expression and interpretation rather than simply mimicking the temporal structure of the music. *Study No. 7* from 1931 manages to hold its own as a visual accompaniment to Brahms' Hungarian Dance No. 5. For Fischinger, the process for making such films was much like that of a composer. He even worked with visual scores from which he carefully timed and executed his films. The language of his scores is personally idiosyncratic – there is still no universal notation for any temporal form other than music. Edward Tufte has documented and analyzed a wide range of examples in the history of temporal notation outside of music [6].

Len Lye of New Zealand pioneered the first cameraless animations where the abstract filmmaker creates a film by directly painting, drawing or scratching on film. The quality of such work is frenetic and biomorphic. For the first time the hand and the spontaneous mind are visible on celluloid – like watching the inner thoughts of the artist.

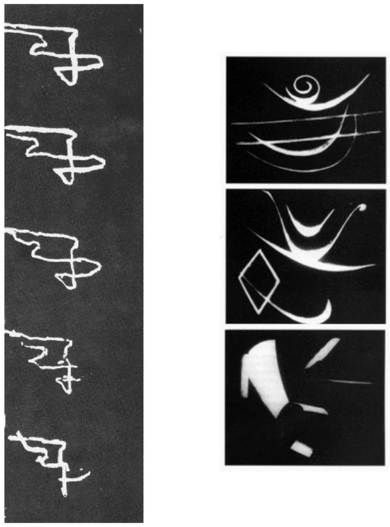

Figure 3. Len Lye's *Free Radicals*, 1957 (left) and images from Oskar Fischinger's Study No. 7, 1931 (right).

Free Radicals (Figure 3), made in 1957, is Lye's masterwork. Produced entirely by scratching onto black film leader, the film portrays three-dimensional linear forms twisting and coming in and out of existence as an homage to the then exploding understanding of biochemistry and the microscopic fights for survival within living organisms.

The filmed abstraction of these 20th century pioneers can be seen as strong analogies to musical composition and recording. A good overview of their work can be found in Cecile Starr's excellent history of abstract film [7]. However, still missing from the filmed medium is the role of the live performer. Many if not all of these pioneers were aware of this gap in their expressive potential and made attempts at creating a *color organ* – a device for performing with light.

The notion of a color organ presents a curious idée fixe in history. Adrien Bernhard Klein wrote in 1927, "it is an odd fact that almost everyone who develops a color-organ is under the misapprehension that he, or she, is the first mortal to attempt to do so." The first historical record of a color organ is Father Loise-Bertrand Castel's *Ocular Harpsichord*, built in 1734 [8]. A regular harpsichord with candles placed behind colored glass windows and pulleys from the keys of the keyboard created small panes of color as a musical composition was played. Castel falls squarely into the realm of visualizing music rather than a contrapunctal *visual music*. His work embodied his own theories of sound/color correspondence in an instrument.

The 20th century brought the technology to make pure light performances. Thomas Wilfred created the *Clavilux* for large-scale light performance [9]. These devices consisted of lenses, mirrors, lights, and colored filters for projection.

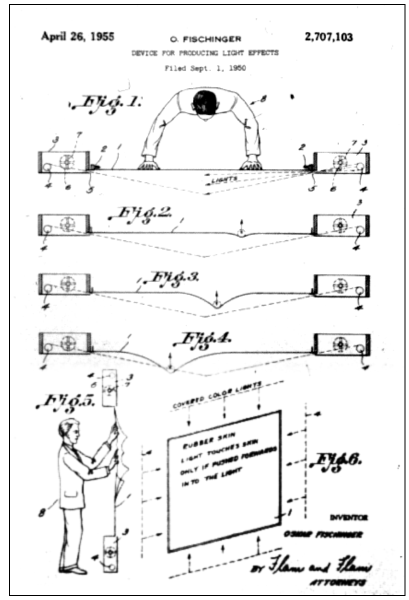

Figure 4. Patent diagram for Oskar Fischinger's Lumigraph.

Starting in 1923, he began a series of public performances that he referred to as *Lumia*. Although sometimes accompanied by music, these performances were temporal works of art in light on their own. His *Home Clavilux* from the 1930s is worth noting as an attempt at a personalized cabinet mounted device for consumers to enjoy abstract light performances in their home. In these days before television, the notions of home entertainment were still available for broad speculative exploration. In an unintentional look forward to John Cage, he named each of these devices with their loop time, such as the 1936 *8 hours, 15 minutes, 42 seconds*.

Oskar Fischinger also created his own color organs, after his health was severely damaged from the under-the-camera oil painting of *Motion Painting No. 1*. His *Lumigraph* of 1953 was presented at the groundbreaking show *Art In Cinema* at the San Francisco Museum of Modern Art [10]. The Lumigraph consisted of a taut cloth sheet that could be pressed into from behind with hands or objects to intersect thin sheets of light controlled by foot pedals (Figure 4). Similar to Wilfred, he hoped that his device could achieve widespread success and he took the time to patent his invention.

The latter half of the 20th century holds several followers of Wilfred and Fischinger's pioneering efforts. Although they used similar technology, each of these artists pioneered unique aesthetics of their own. Charles Dockum created the *Mobile Color Projector* in the 1940s for performance of hard-edged abstraction. Along with Wilfred and Fischinger, he also supported the spiritual notions of Theosophy and found support from Hilla Rebay. Jordan Belson brought light peformance into the

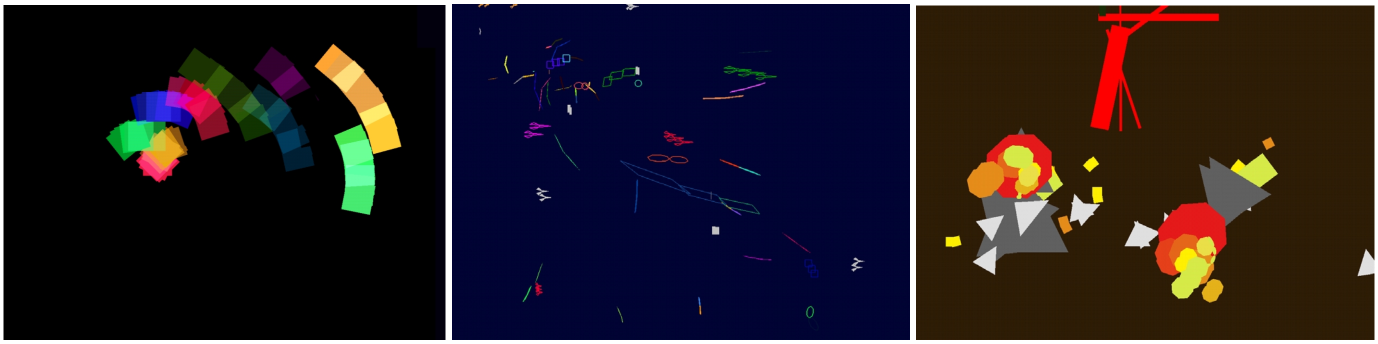

Figure 5. Time lapse from *Motion Sketch* (1991) and stills from the *Motion Phone* (1995). With both programs, human movement is directly translated into abstract dynamic form and color. The motion phone allows abstract visual communication through a network connection. The two images at right are stills from two-person collaborative animations.

psychedelic era with his *Vortex Concerts* in San Francisco in the 50s and 60s. His work is the precursor to the light and rock shows that are still part of large-scale musical performance. Beginning in the 50s, John Whitney created a series of influential abstract films created with custom mechanical devices and analog computers.

It is impossible to cover the myriad further aesthetic steps in abstract film or light performance. However, it is frustrating to note that this clear line of expression, unique to the sensibilities and technologies of the 20^{th} century still remains without a name or written history. Bill Moritz remains the foremost historian of abstract cinema and light performance [11], but his draft of the history remains unpublished. The association with the spiritual fringe may also be responsible for the marginalization of this movement. Walter Benjamin might suggest that the inability of the art establishment to commodify such intangible work could account for its continued marginality [12]. Perhaps the next century will witness the widespread rediscovery of these masterworks.

DYNAMIC ABSTRACTION

The physical color organs face two difficulties in producing imagery: creating detail or hard-edged imagery requires specificity – e.g. templates or slides; while creating a more general expression of color and light necessitates amorphousness – soft, ethereal forms. Free from the limitations of physics, mechanics and optics, digital computer graphics promise an unprecedented palette of color, light, form and animation. However, the majority of computer graphics tools accurately mirror the mathematical processes required for animated production, rather than the aesthetic. Computer animation typically requires several stages. The creation of a two- or three-dimensional model, the manipulation of this model through setting mathematical keyframes for the geometric properties of each model component, and the batch rendering of animations to film or videotape. The process is as time consuming as traditional animation, but the animator is not using his mechanical dexterity for expression, but rather his cognitive problem-solving skills.

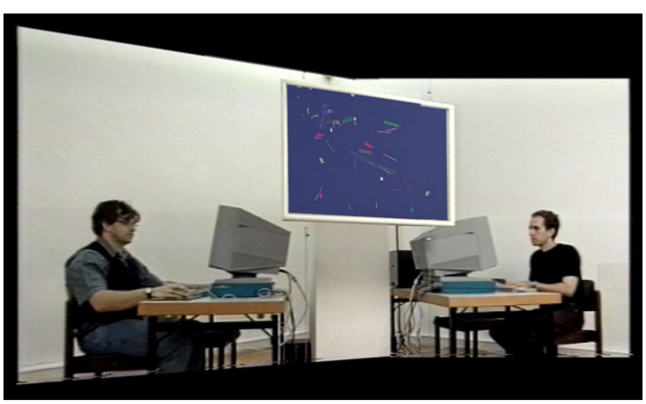

Figure 6. Motion Phone installed at Ars Electronica 96.

Faced with these tools when I began exploring abstract computer animation in 1989, I realized that the medium needed an important step backward – computer graphics moved too rapidly to stereoscopic three-dimensional texture mapped polygons of virtual reality. What was expressible with two-dimensional graphics and direct expression through your body?

MOTION SKETCH AND MOTION PHONE

The first tool I developed was *Motion Sketch*, a digital animation loop which runs continuously while human movements made through a mouse or tablet are recorded into the loop (Figure 5). On a desktop computer, you may notice that the most interesting object on the screen is the cursor, moving with personality and non-mechanical sophistication. Motion Sketch simply allows this movement to take center stage, transformed into abstract dynamic form. Although the loop is short (about a second), the compositions created have a great deal of sophistication, since as the loop re-cycles, more marks are added to the screen. Thus, it is possible to create sophisticated rhythms of form, color and light – a temporal painting.

The process of animation, rather than painting, informs the tools of Motion Sketch. By taking the numerical derivative of successive screen positions, the shapes are made to orient in the direction of movement. Squash-and-stretch – the cartoon notion of motion blur, is accomplished by skewing the shapes in the direction of motion, proportional to velocity. Finally, the entire system is non-modal. This non-modality is at the heart of the program's construction – simply enable the animator to draw while playing and you have created Motion Sketch. Similarly, the other controls over size, color, shape, etc. are all non-modal – the program functions like an instrument (in the sense of a musical instrument) rather than a machine or desktop computer application. A further advantage of non-modality is the ability to chord changes – for example size and color can change simultaneously while performing your animation.

In 1995 I developed a networked version of Motion Sketch called the *Motion Phone* (Figure 6). With this software, multiple machines, networked via the Internet, can communicate together, working at once in the same dynamic canvas. This represents an interesting step away from the virtuosic one-man shows of the master light performances. A duet, trio or even orchestra of simultaneous expression is possible.

As an experiment in abstract visual communication, the Motion Phone presents a few social rules. Instead of a fixed size canvas, the Motion Phone provides an infinitely zoomable plane, much like Ken Perlin's Pad system [13]. Multiple "conversations" or compositions can take place at any position or scale within this virtual world. However, this results in a perceptual problem – each performer cannot be certain what the other is looking at. Similarly, performers have independent control of frame rate. If one person sets their frame rate low, they can seem to run circles around the other – creating at miraculous speed and with incredible temporal precision. Each player can only erase their own work, and one can also choose to not display anyone else's work if privacy is desired. However, the background color is set to the last person's choice so that there is at least one aesthetic decision to fight over. Changes to background color are instantaneous and startling.

Most attempts at distance communication concern themselves with reducing latency. Even in the best videoconferencing or phone systems, the speed of light remains a bounding factor. By working from a shared temporal model, the Motion Phone avoids the issue of latency. The steadily running loop on each end of a conversation assures that the canvas is always alive. As soon as new material arrives, it is added to the dynamic canvas. The act of communicating is like a set of commentaries – as long as material arrives within a few seconds the process remains lively. It is worthwhile to imagine extending this metaphor to video, audio and other communications realms – how might we expand our notions of communication to allow asynchronous connection through a shared temporal model which maintains the feeling of simultaneity?

The Motion Phone has been shown at a series of art installations from 1995 through 1998 [14]. In publicly installing the piece, my perception of the work moved from that of an intuitive animation tool to providing insights into human-computer interface. My first surprise in public use was that a significant minority of people stayed on with the system for long periods of time. Some individuals used the system for hours and came back every day over the course of 3-day to 3-week installation times. What about the process made the experience worthy of long-term attention? After some thought, my hypothesis is that the Motion Phone short-circuits the normal cognitive loop of computer interfaces. The *process* of interacting is also the *product* of interaction – namely the movement of your hand. By short-circuiting this cognitive loop, a person is brought into a flow experience – one moment leading directly into the next. This is most commonly found in video games, with the constant goals of the particular game pulling you forward. Similarly, the work of creative artists in all media from painting to film can induce similar states. However, the Motion Phone manages to induce a flow state without a concrete goal and without the expertise required of an aesthetic practitioner.

The second observation of users' behavior is that as people become comfortable with the tool, unique styles emerge reflecting their personalities. Instead of the short demonstration that I imagined the piece to be, the work suggests that this is in fact an expressive medium allowing the personality of the creator to come through. Users are capable of becoming successively better and more fluent in the system's expressive potential.

DYNAMIC LINE

Observations of the Motion Phone experience prompted a series of new explorations specifically targeted at achieving a balance between the seemingly contradictory design goals of *instant knowability* and *infinite masterability*. Most software systems are either easy to learn with limited expressive potential, or extremely powerful with an interface which is difficult to learn and master. However, in the physical world there exist many such instantly knowable, infinitely expressible instruments, such as the piano and the pencil. Although almost any four-year-old can quickly discover their basic principles of operation, it is common for an adult to spend many years practicing these tools, and still feel that more mastery is possible or that more compositions remain to be expressed. Such systems, moreover, have the property that an individual may eventually reveal a unique and personal voice in that medium. We all have our own spatio-temporal signatures, our own unique ways of moving through space; successful instruments bring the character of these traces into relief and reflect them back to us. In the work that follows I sought to design visual instruments that could possess these qualities of simplicity, intuitiveness and possibility. To support this I deliberately restricted myself to the design of continuous interactions with purely synthetic 2D graphics, situated in a "cinematic" screen-space free of distracting sliders, menus, and buttons.

The first set of experiments was done with the aesthetic collaboration of Golan Levin in 1997. Inspired by Paul Klee's *Pedagogical Sketchbook*, we embarked upon an exploration of the line's potential for dynamic expression. Klee's instructional drawings strongly suggest how a line might be brought to life. Among his first words in this book are, "A line is a walk for walk's sake." Our work would emphasize the *process* of creation over the product. Finally, instead of statically recording movement, we would create dynamic interaction with a computational model, using human movement as the driving impulse (Figure 7).

Streamer represents our first collaboration. A curved line emerges from the movement of the pen as long as the button is down. This curved line is rapidly exaggerated and amplified, similar to smoke from a cigarette, although our algorithm is linear rather than chaotic. Each line segment between successive mouse movements serves as the vector along with the endpoint is pushed from frame-to-frame, proportional to the segment's length. The positive feedback of this process results in rapid exaggeration of gesture, with curved trails overlapping and quickly flying in all directions away from the cursor. As soon as the button is released, the line dissolves into blackness – the temporal model is an ephemeral one, like ripples in water momentarily disturbed. The curved line itself is constructed by connecting a Catmull-Rom spline through the successive pen points.

A second piece, *Escargogolator*, represents a different temporal model. In this piece, a process is set up on screen which can then be observed without further interaction (if one so desires). The movements between pen down and pen up are sampled and a set of parallel lines are drawn between samples with length proportional to the speed of drawing and perpendicular to the direction of movement. From frame-to-frame, the line is evolved based this time on its curvature. Thus this work is handed – a counter clockwise movement results in an inward collapse and inversion, while a counterclockwise movement results in expansion. The quality of motion, suggested by the name, is like that of a twisting snail. There is much expressive potential in this application – an interesting exercise is to write in cursive and watch the letters evolve into a meaningless scribble.

On the way towards Escargogolator, we introduced an off-by-one error in the computation of the line, along with a bug in the queuing of points. The resulting piece we saved in intermediate form as a work in its own right called *Schizosticks*. Schizosticks presents rapidly evaporating thin lines. As soon as a segment is ended, it is frozen in time. In the foreground, new segments may be drawn. If a single click is made, however, it suddenly springs the frozen lines to life in a shattering explosion. We unintentionally recreated one of Oskar Fischinger's masterful motifs. In many of his early works a choreographed set of lines will move with one motif of music. When that motif switches, the lines will not disappear, as sound must, but rather hang waiting in the background, then come back to life when the motif reappears. The recognition of "mistakes" is an important part of computational creation, often dismissed in other engineering disciplines. However, the discipline of the arts sees this as a different type of thought – thinking through the process, the interaction of the artist with his medium. Computer code is no less such a medium than paint or stone and invites the give-and-take familiar to those fluent in other media.

Several other experiments in dynamic line were done together, along with independent work of Levin of increasingly refined sophistication after he began his study with John Maeda at the MIT Media Lab [15]. While doing this work, we arrived at a set of criteria for evaluating our success and rejecting near misses:

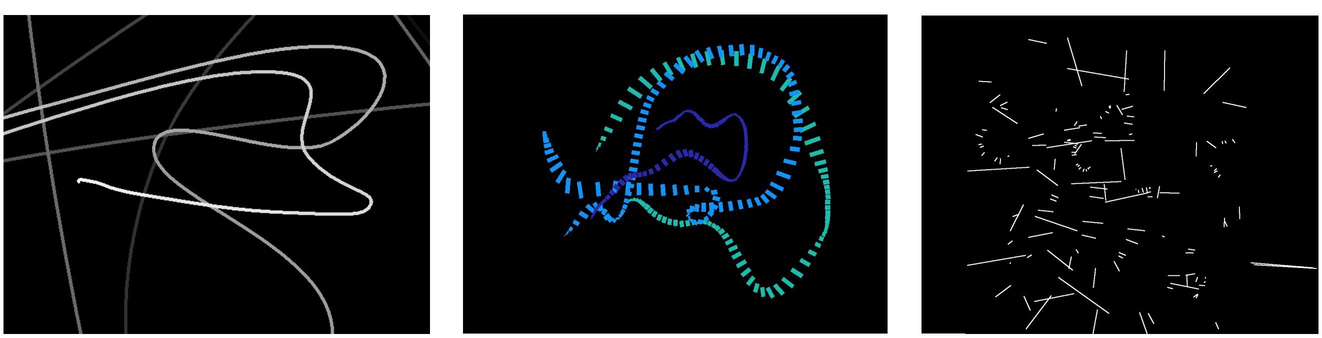

Figure 7. Stills from *Streamer, Escargogolator* and *Scizosticks.*

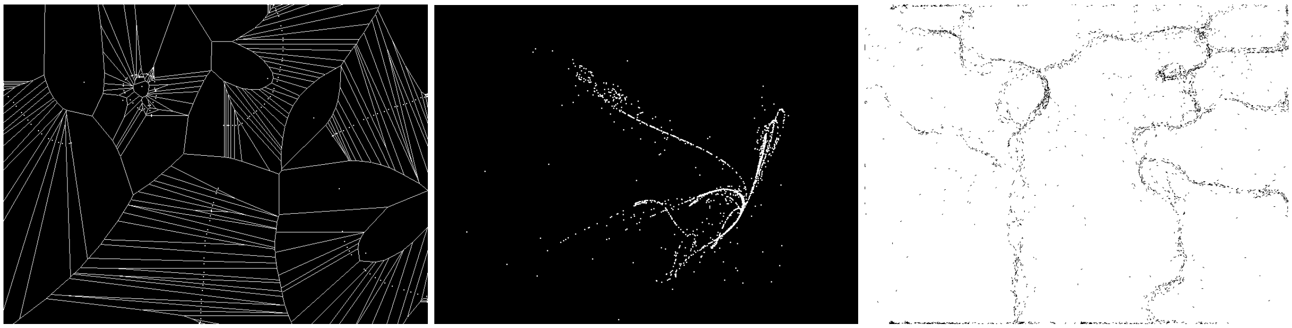

Figure 8. ***Bubble Harp*****,** ***Gravilux*** **and** ***Myrmegraph*****.**

- Can you use the instrument with no instructions?
- How long can you use the instrument?
- Does your personality come through?
- Can you get better at using the tool?

Additionally, we came to develop an antagonistic relationship to the Cartesian grid. The commonplace decision to map x- or y- input coordinates to visual controls is one that relies on an abstract and artificial convention, rather than on geometric intuitions that are more analogous to the natural world. Although Cartesian coordinates are convenient for input and output, the reactions and processes of nature obey an organic logic which is often poorly described by relationships to the Cartesian grid. We therefore adopted the more perceptually oriented primitives of pre-Cartesian geometry as the building blocks of our graphic environments: direction, velocity, orientation, and curvature.

COMPUTATIONAL AND ALGORITHMIC INSPIRATION

Following on from this work, I began exploring some of the tools and techniques that I had learned while a graduate student in Computer Science. Quite often, the intermediate results of algorithms seemed intrinsically more compelling than the problems they were solving. In particular, computational geometry offered a set of richly complicated structures constructed for the solution of planar and spatial geometric puzzles. The Voronoi diagram [16] holds particularly strong appeal for its relationships across natural and human disciplines. These diagrams are constructed about a set of points such that a polygon encloses all of the area around each point that is closer to that point than to any other point on the plane. This diagram can then be used to solve, for example, the Nearest Neighbor problem, which seeks the closest point to a given point on the plane. This diagram mimics the structure of bubbles, the patterns of animal and community dominance, the patterns of cells and honeycomb, fishes scale patterns, the drying of desert sand and, in the first know drawing of a Voronoi diagram, Descarte's analysis of the gravitational influence of stars in 1644. Even in the world of marketing, these diagrams find use in analyzing the distance of consumers to the nearest fast food restaurant.

The *Bubble Harp* is an instrument that uses Voronoi diagrams as aesthetic territory. As long as the pen button is pressed, the exact temporal and spatial movement of that point is recorded. When the button is let up, the point repeats this motion endlessly. As successive points are added, a Voronoi diagram is dynamically constructed around these points. Since each point's playback duration differs, the repeat period of this system is very large. This is analogous to Brian Eno's tape loop experiments [17] that used multiple cycling audio tapes with their own varying durations to create complex and unanticipated temporal interrelationships. With a second button on the pen or mouse, the creator can draw out a string of points emerging at short intervals from their movement. The compositional process of this system is not strictly additive or subtractive as the media of painting or light. As points are added, they successively *add* lines, but, depending on their placement, they may *subtract* space, creating openness instead of more complexity.

Particle systems represent an almost endless technique for exploring the interactions of matter large and small. A recent Hubble image of galaxies colliding exemplifies the temporal and spatial complexity of such systems (Figure 9). *Gravilux* attempts to address the notion of what it would be like to draw with stars. A field of individual masses is simulated, such that gravitational attraction is computed between the cursor position and all of the individual stars' positions. Although the system is physically based, it is not physically realistic. Mutual attraction between all points is not computed, as in a true gravitational system. Further, the addition of viscous damping causes the points to come to a halt when not being manipulated. The space itself is two-dimensional rather than three-dimensional, though the simulated movements suggest three-dimensional forms. The space wraps on the top and sides, creating a toroidal topology that always contains the full set of about 10,000 points. Finally, anti-gravity may be applied with a second button, ripping through the space. As one becomes fluent with the tool, one starts to tease out lines by leading on the system at its densest points. Further possibilities include particle-

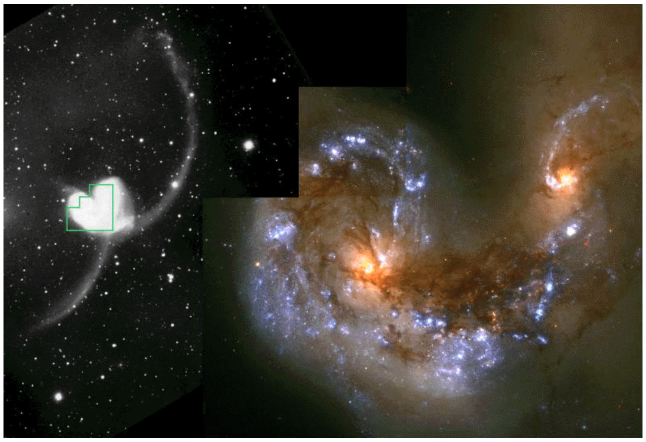

Figure 9. Colliding Galaxies NGC 4038 and NGC 4039. October 21, 1997. B. Whitmore and NASA.

accelerator like phenomena that can be achieved by clicking directly on a dense section. Numerical instability near zero creates this explosion, which was deliberately left in as a pleasing aesthetic effect.

Myrmegraph is the only representational piece of the series. Drawing from the emergent group behavior of ants, this piece uses a combination of lattice and particle system. As the performer draws, he lays down both pheromone and ants. These ants are particles that obey a simple set of rules – they follow pheromone gradients stored invisibly in the image and have limits on their speed and turning to give them lifelike movement. From moment to moment, they can change their heading to better pursue the trail of pheromone. The chaos of the natural world is tamed into an expressive medium. Unlike the real world, however, you cannot kill the ants. By pressing with the second button, you can erase the pheromone and release the ants from their trail, but you cannot destroy them.

The final screen-based piece, *Lasso* draws from the realm of signal processing. Digital filters are used to modify signals for the practical purposes of cleaning or extracting useful information. Kernel-based filtering passes a small convolution filter along a set of samples to achieve different effects based on the filter weights. For example, the blur and sharpen filters in Photoshop are both kernel filters with different weights. By passing a simple 3-element kernel filter over a line *while* you are drawing it, it is possible to add character to the line, while admittedly distorting the artist's form (Figure 10). The purpose of the tool is the process of interacting with this filter, rather than the final drawing. A center-weighted filter results in a smoothed line – no matter how crooked or idiosyncratic your line, it dissolves into a 1950s style pleasing soft abstraction. With a filter weighted toward the end, the line becomes lazy. Instead of the instant snapping to attention of computer drawing programs, this line has some inertia. This is more than simply amusing – imagine adding physical qualities to drawing programs so that you react against a system, rather than exerting exact, instantaneous control over the form.

IMPLEMENTATION

The platforms under which these tools were developed strongly influenced their aesthetic and expressive range. The original Motion Sketch was written for a Sun Sparcstation c. 1989 which allowed direct access to the framebuffer and mouse without a windowing system. Such an environment provided a great place to build up graphics from scratch – something becoming increasingly difficult with the layers of windowing software now mandatory under most operating systems. The Motion Phone was implemented on an SGI Indy with OpenGL and Motif for deployment on any number of Indys. The rest of the applications described here were written on a PC with a standard graphics card using the DirectDraw API. Although the number of graphical primitives is limited, this constrained space serves a useful function of honing ones ideas to their essential components.

Java ports and some downloadable versions of these programs are available for online exploration at http://www.snibbe.com/scott.

A PHENOMENOLOGICAL PERSPECTIVE

These aesthetic experiments point towards a larger set of principles that may be more broadly applied to animation, drawing tools and computer interfaces. Within the philosophical world there has been much exploration of the realm of perception that is immediately apprehensible to

Figure 10. ***Lasso time series.*** Kernel-based filtering of a dynamic line.

the body, rather than the rational mind. *Phenomenology* is the study of how perception presents the world directly to consciousness. The dynamic abstract work presented here demonstrates a set of successful experiments in creating phenomenological user interfaces that directly engage the body.

Edmund Husserl [18] invented and mapped out the territory of Phenomenology – the first substantial philosophy centered on an individual's unique perceptual apparatus and his knowing of himself. Husserl broke perception into the unreflective *life-world* which is the stereotypical accepted reality of the world and *irreality*, the subjective nature of experience. It is this subjective experience that this work in dynamic abstraction attempts to explore in non-representational form. By acknowledging these fundamental principles of perception, we can open up possibilities already present in screen-based dynamic media. Progress in animation and graphical interface need not be a straight arrow of technology pointing into the future, but should also include an inward pointing arrow whose starting point was given to us early in this century by both these philosophers and the abstract animators and artists of pure light.

ACKNOWLEDGEMENTS

Golan Levin, my co-author, provided many hours of fruitful discussion and aesthetic collaboration while working on the dynamic line pieces with me in 1997 at Interval Research. Adobe Systems and Silicon Graphics supported the Motion Phone while I worked at Adobe as a member of the After Effects team from 1994 through 1996. Andy van Dam and many members of the Brown University Computer Graphics Group helped me become educated in the language of computer graphics while an undergraduate and graduate student. Larry Cuba, Elfriede Fischinger and Bill Moritz are all wise mentors who have critiqued my work and broadened my knowledge of abstract light performance and animation history. Bill Verplank has been a constant mentor, source of inspiration and dedicated user of these tools. Perry Hoberman introduced me to the world of interactive art installations, where I learned from watching people use these tools. Itsuo Sakane, Machiko Kusahara and Michael Naimark are colleagues from the world of interactive art who have supported me and pushed me to refine and add sophistication to my naïve early experiments.

REFERENCES

[1] Chuck Thacker, Edward McCreight, Butler Lampson, Robert Sproull and David Boggs. *Alto: A Personal Computer*. Xerox PARC Technical Report. August 1979.

[2] Iamblichus, *Life of Pythagoras* (translated into English by T. Taylor). Los Angeles. Theosophical Publication House, 1905.

[3] Wassily Kandinsky. *Concerning the Spiritual in Art.* New York. Dover Publications, 1912.

[4] Lawrence E. Marks. *The Unity of the Senses / Interrelationships Among the Modalities*. New York: Academic Press, Series in Cognition and Perception, 1978.

[5] Cytowic, R.E. *Synesthesia: A Union of the Senses.* New York: Springer Verlag, 1989.

[6] Edward Tufte. *Envisioning Information*. Graphics Press, 1990.

[7] Robert Russett and Cecile Starr. *Experimental Animation: Origins of a New Art* (2nd edition). New York, Da Capo Press, 1988.

[8] Castel, R.P. *L'optique des Couleurs*. Paris, Briasson, 1740.

[9] *Thomas Wilfred: A Retrospective*. Concoran Gallery Exhibition Catalog. Washington, 1972.

[10] *Art in Cinema*. Exhibition catalog. San Francisco Museum of Modern Art. 1947.

[11] William Moritz, "The Dream of Color Music," in *The Spiritual in Art : Abstract Painting 1890-1985*. Los Angeles County Museum of Art. Abbeville Press, 1986.

[12] Rochlitz, R. (translator). *The Disenchantment of Art: The Philosophy of Walter Benjamin*. Guilford Press, 1996.

[13] Perlin, K. "Pad: An Alternative Approach to the Computer Interface." *Proceedings of SIGGRAPH '93*.

[14] Schöpf, Christine (ed.). *Prix Ars Electronica 96*. Springer-Verlag, New York, 1996.

[15] Levin, Golan. *Interface Metaphors for Audiovisual Performance Systems*. M.S. Thesis, MIT Media Laboratory, June 2000.

[16] Okabe, A. and Boots, B. *Spatial Tessellations : Concepts and Applications of Voronoi Diagrams*,. John Wiley and Sons, 1992.

[17] Brian Eno. *Discreet Music*. Editions E.G. Records, 1975.

[18] Maurice Natanson. *Edmund Husserl; Philosopher of Infinite Task*. Northwestern University Press, 1973.