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Creating a responsive, real-time, malleable environment for dancers

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Creating a responsive, real-time, malleable environment for dancers

by

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CHAPTER 1 INTRODUCTION and OVERVIEW

Dancers are intelligent creative people, but in the traditional and current system of training, choreographers and directors often fail to recognize and utilize these qualities in the dancer. Modern dancers are trained to use their bodies and mental abilities in an expert way, but not always their creative abilities. Besides technical training for their bodies (being strong, coordinated, controlled and flexible), they are trained to recognize patterns, memorize instantly, and physically copy what they are shown. They are not generally trained to exert an opinion or initiate an idea. The hierarchical nature of the dance performance system means that choreographers are accustomed to being in charge of everything, treating the dancers as tools for their vision, so the dancer's minds are not always credited with native creativity and self-expression. The dancer should be able to dance expressively from the internal impulse and not always to be forced to respond to the external stimulus of lighting and sound cues.

A stage is essentially an empty space, with lighting instruments that can be placed and aimed anywhere, amplifiers and speakers so the audience as well as the dancers can hear the sound, and consoles set up for technicians to control the timing and levels of light and sound. Current traditional stage technology requires that the dancers serve the technology, rather than the technology serving and supporting the dancer. Dancers are expected to 'hit their mark' (literally to be on a certain mark on the stage) when the music or lighting dictates, with little acknowledgement of the dancer’s internal connection to the dance and the other dancers. Technologies now exist than can reverse this relationship. Cameras, sensors, and even simple wireless microphone transmitters can be used to give the dancers some control over, for instance, when lighting cues change, or when music begins. In more complex situations, dancers' movements can even control what music is played. Because the stage environment can be set up to suit almost any situation, cameras can be placed behind the dancers, above the stage, or any place where so that the stage can be 'seen' and translated into XYZ coordinates (as long as the camera is not looking directly into lighting instruments).

Technology is part of our lives, a trend that will only increase in the future. Dancers are fond of standing up straight and saying that this, indicating the body, is all we need to dance. And that is true, but that attitude doesn't take into account the collaborative nature of dance as performance, nor the explorative nature of the choreographer. Dance has developed as a form of expression for religious rites, for social purposes, for spectacle, and for physical fitness. The pure impulse to move as an expression of life is left behind in many of the institutions that use dance for both education and art. Dance, as a performing art that requires only a body and an expressive impulse is still generally very far from the fact that traditional technologies function to create and maintain mechanical staging rather than the expressive nature of dance as performance. Traditional technology has produced a very top-down orientation; directors specify, and dancers obey.

If dancers are to have greater creative expression in performance, they will need to have some control of the stage environment and technology. Being in charge of the body is enough for beginning dancers, but more advanced dancers can consider other aspects of the space and time on stage. When the dancer knows she is able to control sound with her movement, she has the freedom to choose what movement to do and when to do it. She moves and initiates sound, then is affected by that sound she makes. The conversation between the technology that creates the sound and dancer become synergistic.

Technologies are now emerging that can give dancers more control of the stage environment, but so far they have been problematic. The enormously attractive immersive environments like the C6 at Iowa State University's Virtual Reality Application Center (VRAC) is also enormously expensive and requires programming skills that are beyond the usual choreographer. The Wii system is relatively inexpensive and can be used in conjunction with commonly available software for interactive purposes, but it is too bulky for the dancer to wear and doesn't have a wide enough range for use on a stage. The Xbow Mote transceiver is a good size, but requires additional hardware to send data, as well as additional programming for linking that data to interactive software. Separate sensors are also required, such as flex sensors or piezo sensors. Those sensors are individually inexpensive, but they are also relatively fragile. A $10 sensor that lasts only one or two rehearsals rapidly becomes relatively expense. There are spaces, like Dance Theater Workshop in New York City that are designed with interactive technologies in mind, but they are few and far between and tend to be connected with universities and unavailable to the independent dance companies.

A key step is to make interactive technologies accessible, easy to use and inexpensive, and then make them available to dancers in all stages of development, from beginners to professionals. Most of the current systems do not give real-time feedback, are not interactive, and require computer programming skills that are not taught in dance class.

Interactive technology systems give the user (dancer) the ability to control events on stage; however, the systems currently available are generally:

- too expensive for a modern dance company
- sensors are too fragile for modern dancers
- not user friendly
- neither interactive nor real-time

Dancers are hard on equipment; they sweat and roll around on the floor, jump and lean on each other. Dancer's flexibility means that they can bend more than most equipment can handle. Because they move in ways that ordinary humans do not, sensors can be difficult to wear, wires can be obtrusive and electrical equipment can actually be harmful. Most choreographer/dancers are not trained as computer programmers, but most of the available interactive software programs are best used as programming environments and thus require programming skills. If choreographers have the good fortune to collaborate with a programmer, they can use more complex software, but if not then there are few programs simple enough for general use.

Purpose

The focus of the work constituting this thesis, therefore, was to find/develop a less expensive and more robust way to put the modern dancer in control of the dance product on the stage environment. That control of the stage environment includes using the dancer's movement to affect the sound, lighting, and visual backgrounds in a way that respond to the dancer. The setup of the interactive technologies and sensor system should be simple, intuitive with easily available components. Hardware is already available; for instance, webcameras are ubiquitous and wireless microphones are common. Interactive software which don't require writing code is also readily available, in forms that range from programming environments like Isadora that have a user-friendly graphic interface, to Max, which requires more programming knowledge. The time has come for technicians to move out of the lab and into the dance studio, and for choreographers to acknowledge some of what is happening in the world of technology.

CRITERIA FOR A NEW RELATIONSHIP BETWEEN DANCE and TECHNOLOGY

In the traditional rehearsal process, the choreographer supplies the main idea, the movement, the artistic vision, the music, and the designers. The dancers bring their bodies, their training, and their sensibilities. The dancers are, in essence, the choreographer's tool. In accord with this system, early dance training generally concentrates solely on the physical aspect of dance. It is true that modern dance choreographers, more than ballet or other dance forms, generally have asked the dancers to bring an engaged imagination and the creative skill to express their own sensibilities or “opinions”. Still, the director/choreographer provides the main idea, any choreographed movement, and the sound score for the performance. Thus, although modern dance is not a corporate system of codified movement, but rather includes individual choice, the traditional hierarchy of creator and performer generally applies, and dancers are trained to expect that system.

In the paradigm shift adopted by my research, the director/choreographer sets up environments for dance performances that require the dancers’ active creative direction as well as physical execution. Interactive technology allows the dancer to manipulate the environment to comply with her own expressive gesture, rather than being forced to “fit in”, however “expressively”, with the sonic and visual environment set up by the director. The music starts when the dancer approaches a certain place on the stage, rather than the dancer needing to be at that place at a certain time; likewise, the lighting changes in relation to the dancer's movement. Video tracks to where the dancer is on stage. The dancer is thus able to move authentically, to dance *freely*, without the restriction of hitting a particular mark when required by external stimuli. The environment responds to the dancer, not the dancer to the environment.

My recent works as a choreographer meld live performance, rendered video and real-time video and sound to create a malleable visual and sonic environment for dancers that allows them to move both responsively and expressively; i.e. to respond to the environment but also to alter it with their movement. The performer thus becomes the director of the performance space. An excerpt from *Blue* (*Grace,* 2010), illustrates one way that the dancers movement changes the visual environment. (http://www.vjw.biz/thesis/Grace3-21Blue2Cr.wmv)

Figure 1.1 A frame from a video clip of *Blue* (*Grace,* (2010).

Technology and the Dance Company

Dancers are fond of standing up straight and saying that this (indicating the body) is what dance is about, and is all that the dancer truly needs to make dance art. But for the interest of the audience (and the performers), we also use music, costumes, sets, lighting, and arrangements of the performing space that suit our vision for a performance. Technologies, and especially interactive technologies, provide another avenue for the expressive communication of an idea to an audience.

With the advent of electrical light on stages at the end of the 19th Century, Loie Fuller introduced the use of lighting effects to enhance her staged dance performances. In the 1950s, Alwin Nikolais pioneered the use of slide projectors to artfully color a stage, creating a magical environment. Contemporary modern dancers and dance companies have become increasingly interested in using video to help communicate an idea, and with high profile dance companies like Bill T. Jones/Arnie Zane Co. using video, more audiences are exposed to the combination of dance and what is essentially a virtual set.

Today's dancer/choreographers and audiences have grown up surrounded by technology, and interacting with technology from smart phones to computers. The question becomes not, “Should we use technology?” or “Do dance and technology mix?” but rather “What kind of technology shall we use?” and indeed, “What kind of technology can a dance company afford?” Obviously, ease of use and affordability are the primary determinants, but versatility and robustness also play a part.

A video camera is one of the simplest technologies for use in the process and product of dance. Cameras have been ubiquitous in both rehearsal and performance, and dancers are accustomed to using them as recording tools; likewise, it is common to use video to make static and moving backgrounds and projections for use in performance. It is less common to use cameras as interactive tools, even though webcams are common, relatively inexpensive, and are generally plug and play and simple to use. The ability to connect a webcam to a computer is also fairly trivial, and many laptop computers now come equipped with built-in cameras.

Technology allows the choreographer to work outside the rehearsal hall. Adding performers to a scene using programs such as Isadora™ or DanceForms, is a simple programming task and allows the choreographer to get a sense of the work outside the studio, as well as to provide a clear example of an idea for the dancers. Merce Cunningham used Life Forms (now DanceForms) to assist his choreography when he became too physically disabled to be in the studio for any length of time. There are other programs available that allow a choreographer to simply place people represented by 'X's in space, link those 'X's with music, and play it back to assist the choreographer in seeing a floor pattern.

Sensors other than cameras (microphones, accelerometers, electronic gyroscopes, magnetometers, flex sensors) can give the dancer immediate feedback about the fact of and level of control. Those instruments that send physical data from the dancer's movement give the dancers a feedback about that movement that the dancer can translate into aesthetic decisions. Mark Coniglio (Troika Ranch) created the MidiDancer to allow the dancer's movement to send signals wirelessly, but had problems with the robustness of the flex sensors. Troika Ranch has moved from sensors for local control, to the environmental control of infrared lighting and sophisticated motion tracking with EyesWeb. Robert Wechsler (Palindrome) uses a wide array of sensors that include hard-wired circuits that the dancers close with person to person contact. Nintendo's Wii sets a standard for robustness and cost, but is too large and insensitive for a dancer's purposes. Dr. Stephen Holland, Wen-Chieh Chang and Valerie Williams have created a sensor system, the VDancer, that is smaller and programmable, uses rechargeable batteries, and is comfortable for the dancer to wear in rehearsal and performance.

Chapter 2 includes an overview and review of technology I've used, including information in Chapter 3 on the VDancer.

Dance versus Dancing

'Dancing' needs only the body, but 'dance' as a serious theatrical art doesn't require, but uses a combination of the body with costume, sound, lighting, visual images, words, and other elements to manipulate and move an audience. Expressive movement is part of the human repertory and becomes an outward expression of an inside feeling or sensibility. Dancing is that subverbal human impulse that allows self-expression, socializing and the venting of excess energy. Dance, the artful use of human movement for performance purposes for ourselves and others, changes with fashion, but dancing, as expressive movement, is simply part of the human condition and always will be. Robert Wechsler says that "Dancing boasts an ageless tradition of undermining the intellect. Therein, it is said, lies its power. From this perspective, the computer, as the ultimate tool of the intellect stands diametrically opposed to the art of dance." (Robert Wechsler says that "Dancing boasts an ageless tradition of undermining the intellect. Therein, it is said, lies its power. From this perspective, the computer, as the ultimate tool of the intellect stands diametrically opposed to the art of dance." (Leonardo Magazine, Fall 1997) But dance need not set itself apart from the intellectual. Interactive technology allows us to establish situations, or "algorithms", as it were, for dancing, so dancers of any experience level can move expressively in a unique situation. The programming can be obvious and transparent to an audience watching dance, or it can be invisible and intuitive for the individual or group dancing. A virtual playroom allows people to experiment and play with movement that may become dance, or may simply be an enjoyable short-term activity.

In the video clip titled SdMoving (sound/moving), the dancer's movement initiates sound. As the dancer walks into a space towards stage left, the horn starts and the dancers reacts to the sound.

Figure 1.2 Frame grab from SdMoving.wmv (www.vjw.biz/thesis/SdMoving.wmv)

Redefining the role of the choreographer

As Sarah Rubidge says, “Although there are some similarities in the choreographic procedures used in digital dance, postmodern dance and video dance, working in the digital domain, particularly in the domain of interactive work, requires that choreographers rethink their understanding of choreographic 'logic', and of the role of the choreographer.” (*Digital Choreography*, 10)

Choreographer Merce Cunningham (1919-2009) asked his dancers to play with the form of his choreography by instituting chance: teaching the dancers a series of phrases and then asking the dancers to choose numbers from a hat to determine the order of the phrases. Each performance was different. Cunningham was interested in dance as dance, not as narrative, or emotion or even as dynamic line. He and collaborator John Cage abandoned traditional form and created music and dance separately and combined them at the last minute and frequently without rehearsal.

Cunningham's *Suite for Five* (1956-58) gives some insight in a chance approach to choreography. As Cunningham describes it,

> “The space was done by taking pieces of paper and marking the imperfections in each piece—if you look at any piece of paper…you see little dots—I would number these dots, and by chance means decide where somebody started in space and to what space he went next, the next one and so on. Each dancer had

> different dots. I superimposed them to see if there were any points that came together, and where they did, I would have sequences with people together… The time was done in seconds. I gave some kind of allowance for how long a given movement or sequence of movements might take. Say the person is here doing a certain kind of movement, and he's going to end over there—the chance means would say how long that would take…Now in the course of that, they might cross somebody else's path, and I would allow for some kind of connection, a lift or a pose. . . ." (*The Dancer and The Dance*, 90-91)

This structure, or set of rules, allowed Cunningham to concentrate only on the movement and not concern himself with narrative or traditional form, while at the same time providing a definite form to the dance. The form came from chance, not from the traditional forms ballet and then modern dance choreographers inherited from music.

One might ask whether the dancers of Cunningham's "chance" choreography felt similarly empowered in this expression, or whether they still regarded themselves only as interpreters of the choreographer's intention. Do dancers feel a different sense of empowerment when they are more immediately involved in the process of dance creation? I explored this question through interviews of dancers, and report the results in Chapter 4.

Cunningham's later collaborations with artists such as Paul Kaiser and Shelly Eshkar, of the Open Ended Group, used motion capture, but treated the result mostly as décor, until he worked with the 3-D software program Life Forms and various forms of movement capture that allowed him to expand his ideas outside of the human body. Cunningham notes in *Four Key Discoveries*,

> I like to produce movement that seems out of range, to enlarge the range and add things to what we think of as dance…. From the beginning — like the other discoveries, such as separating music and movement — the software has constantly brought up other possibilities. I've always felt that there is a limit to the structural activity of the human body: once we stood up on two legs, we were caught and have to work that way. But there is always some other way to do it…. That's been the history of movement; dance is another way someone has found to deal with the question of what movement can be. The computer has opened it up to me. It has broadened what I think of as possible in dance. (110-111)

To paraphrase Cunningham, the digital domain has extended my vision of what authentic movement can be.

What is, then, the role of the choreographer in a digitally interactive performance? In the digital domain, the choreographer behaves less as a dictator than as a director and setter of movement. She is still responsible for the audiences' entertainment, so she may make choices about the order of events, and/or particular sequences of movement, and/or movement design, but the dancers become responsible for certain decisions in rehearsal and while performing. When dancers have an understanding of the basic philosophy and content of a dance, they are able to choose particular movements (what), tempi (when), or qualities (how a particular movement is performed).

In an installation, where the audience and performer/s occupy the same environment, the audience or performer/s can make choices about movement, order, and structure, only because the choreographer has built those choices into the artwork, much the way a programmer builds branches into a program. For a simple instance, the choreographer may assign different sound pitches to different spaces on the stage; knowing this parameter, dancers can move in space accordingly to create their own soundscape. The choreographer's technical role in establishing the parameters or "environmental grammar" is indispensable, even as the dancer enjoys the main expressive role in choosing where to be, how to get there, and indeed, what sounds will accompany her movement.

In an interactive digital work the choreographer controls the images, but she cannot control the order or even if the images are presented. In a more sophisticated program, there may be a narrative involved, requiring the dancer to make choices that affect not only the ending of the theatrical event, but may involve a 'conversation' with the program. Again, the initial choices have been made by the choreographer, but the end result becomes the dancer's. As described by Sarah Rubidge, a major innovator in the field who specializes in creating interactive installations that have a choreographic sensibility,

> The choreographer working in the digital domain, particularly in interactive works, must accommodate this type of structure in his or her thinking. S/he must acknowledge that the micro-sections of movement material, and (in some works) their 'framing' on the screen, are the main elements of the work over which the choreographer has total control. (*Digital Choreography*, 11-12)

In some cases the choreographer can set up 'rules' that the dancer learns and then uses to create a satisfying experience for both the dancer and audience. A rule might mean asking the dancers to react a certain way to a particular instance ("when you meet Silvina in this space you must interact with her using x qualities of movement," or "in that space change the elements of time"). Or it may be a requisite response to a recognized movement throughout a dance ("whenever you finish this particular sequence, you must do my movement phrase facing a different direction"). This situation requires the dancer to be very experienced in creating a dynamic line for a dance. In this situation, the choreographer or the dancers can set up the content, then the dancers are free to improvise with form and abstraction, or with time, or with the movement itself. In a non-performance situation, the choreographer may use the rules to allow the dancers to experiment and rehearse performing.

A Personal View Regarding Designing a Dance Concert

When I begin to choreograph a concert of dances, I start with an idea. That idea may come from any external or internal stimulus (writing, art, other performances, comments from people, large ideas, etc), but I find that for creating a concert, I require a starting idea around which all aspects of a performance can cohere. I research that idea from many points of view, reading as much as I can on the idea, looking for images, and discussing the idea in rehearsals with the dancers. While in this part of the process, I also consider the stage environment (sound, set, specific dancers), and think about how the look and actions of one affects the others. Only then do I begin to create movement sequences for the specific dancers involved in the show. The resulting dances sometimes force an editing of the basic idea, which requires editing the environment, which circles around to editing the movement, because in a successful concert, all aspects of the performance serve each other. The dynamic line of each section of the concert helps make up the dynamic of the full concert.

The question of whether or not to use interactive technologies usually comes into play while considering the stage environment. One of the challenges of mixing live performance and interactive technologies lies in deciding how transparent the use of the technology should be. There is a "golly gee-whiz" aspect to the use of technology that can attract an audience and add to the audience's experience, but there is an equally valid argument that exposing the nuts and bolts of technique might distract from the impact of the theatrical experience.

In the intermediate stages of design, I map out the large idea of the concert and think about what kind of dances will fill out that large idea. I create a framework for each of those dances, but also bring the dancers into the internal conversation I am having about the idea. As I am setting movement, I discuss the large idea and my "sub-ideas" for each of the dances that make up that large idea, or concert. Frequently, if I have an idea but am not sure how best to approach it, I will ask the dancers to improvise with that idea. I can then hone that idea into a small enough piece that allows the creation of appropriate movement. Honing the idea means that boundaries, or rules must be set, so that the dance is cohesive. The dancers and I create the sets of rules together. This loosens the hierarchical relationship of choreographer and dancer, and because the movement is founded also on the dancers' sensibilities, becomes a stronger dance, a collaborative expression of an idea rather than the "translation" of an idea. The dancers' explorations of the idea are a vital part of the design process. Working with interactive technologies allows me to alter the rules easily and allows us to immediately see what will happen when the rules change. It allows me to try different kinds of sound with ease and allows the dancers to move expressively instead of trying to meet a less understood objective. Martha Clarke says in the PBS film, Light and Dark (1980) that she prefers to wear music more like a cloak and less like a glove, "because if we have to go for beats and timing and the music is on tape … if we have to wait for a sound we lose the internal connection, performing-wise and it'll kill the piece." This metaphor is an apt description of the visual and auditory echo effect that digital feedback creates: a cloak swinging with the dancer's movement, repeating an arc of movement (and inspiring another), but not defining it.

Merce Cunningham's solution to the problem Clarke describes is to perform only with live music. Finances preclude most of us from using live music for every performance but we can structure our dances so that the dancer is able to reveal him or herself from within that cloak. For less practiced dancers, the technology allows the choreographer to structure a visually interesting dance and still allow the dancer to control the timing of the movement.

In the video clip *Capture Bits*, from *She* (2009), the software finds the brightest object (the dancers costumed in white) and tracks the video to it. The video is triggered for play when the dancers move to a certain place downstage. This allows the inexperienced dancers who performed this particular dance to pay more attention to each other than to the music;

the stage responds to them.

Figure 1.3 Frame grab from *She* (2009) (www.vjw.biz/thesis/SheCapBitsBit.wmv)

More experienced dancers are able to control their own expression and more elements of the stage environment. In *Crowd*, the dancer is able to control the volume of the sound by the placement of her arm in relation to gravity. The movement impulse is intuitive, but movement choices are made deliberately to communicate the feeling of being uncomfortable in a crowd.

Figure 1.4 Frame grab from *Crowd* (*Grace*, 2010) (www.vjw.biz/thesis/Crowd.wmv)

Because this field of study is so new, published information is sparse. Nevertheless, there is much experimenting with technology going on in dance and theater companies around the world. The entertainment industry is replete with interactive exhibits and installations, formal and informal, such as the panel displays in Detroit's Metro airport of rose petals that fall to the bottom of the display as a viewer approaches. However, there are very few people working with interactive technologies as a tool for the creative process.

Organization of this document

In Chapter 2 I will note some of the history of interactive technologies, precedents for my work, and review a wide variety of existing sensor systems.

Chapter 3 will explore the VDancer interactive system and its implementation.

Chapter 4 includes an analysis of a concert work using simple interactive technologies, the VDancer and my current work with that system.

Chapter 5 looks ahead to future work and study.

Chapter 2. LITERATURE SEARCH, PRECEDENTS AND HISTORY

Academics are accustomed to writing about their work, but professional choreographers and performers are not; their work speaks in performance. If it is meant to be repeated, it is taught by the choreographer or a representative of the choreographer to another performer, or it is preserved on videotape or digital video for future reference. Reviewers may write a knowledgeable reaction to a performed work, but that review is expected to be an opinion from that specific reviewer. Choreographers engage in research on an ongoing basis, but rarely write up their results, instead it all goes into the choreography and the choreographer's store of knowledge. The craft involves taking that research into the rehearsal studio and using it to create a dance and/or concert of dances. The performance is the publication. Many choreographers, such as Robert Wechsler, Dawn Stoppiello, and Thomas DeFrantz regularly use interactive technologies in their work, and even build work around a particular technology. Much of my literature search has involved watching performances (live and on video), analyzing technology and the relationship of the technology to the choreography, and when possible, talking with the choreographers about their work and their technologies. I looked not just at specific use of technology in dance performance, but also at its use in the process of creating and teaching dance.

Choreographers, videojockeys, and musicians use various software programs to allow us to control the performance environment in ways that are outside the physical realm. Traditionally, physical settings are used, such as lighting and costumes, to affect the audience's understanding and senses of the performance. The performer's job is to take the audience out of their usual lives and into the choreographer's opinion. The choreographer's job is to set up an environment for that opinion, including choreography, narrative, and any other performance aspect that supports that opinion.

I began my work as a search for a technology system that would let the dancer have more control over the environment so that the dancer could move expressively, from an inner impulse; so that music and lighting cues would obey the dancer's ability to be creative and not only interpretive. I have come to learn that working this way changes the paradigm and working relationship between dancer and choreographer, teacher and student. I had to decide not only what interactive technologies could do for performance, but also for the rehearsal process. In that exploration I found many opinions about what constitutes 'interactive'. Sarah Rubidge points out the difference between interactive and reactive experiences and works with software that 'learns' from experiences. (Rubidge, 2003 International AILA Conference on Literacy, University of Ghent) She notes that interaction is constituted by the perceiver and the environment. Robert Wechsler believes interaction as a primarily psychological phenomenon that by definition is controlled by humans. Mark Coniglio has created software that allows the choreographer to set up either a reactive or an interactive relationship between movement and the computer processing of various forms of electronic signal input. For the purpose of this thesis, I will define interaction as any real-time 'conversation' between live performer and a system of computer, software, and hardware peripherals such as cameras and microphones.

Motion Capture, Motion Tracking, Motion Sensing

Some definition of terms is necessary when speaking of motion capture, tracking and sensing. Motion capture is generally regarded as the recording of movement and is most often used for non-realtime applications. The IGS Motion Capture suit is a good example of 3-D movement data collection. The movement data can be used to create animated characters and can be placed in any digital situation, frequently used in action films. Video tape captures motion in 2-D and is used in projections and installations such as Biggs and Rubidge's *Halo*. (See Chapter 2 for more on *Halo*) Motion capture systems can be used for movement analysis, for designing industrial machinery and for mixing with live performance. For my purposes, I will define motion capture as the recording of movement as XYZ spatial data that can be used and interpreted out of real time.

Motion tracking usually refers to a set up with cameras connected to a computer that can find and follow an object in a particular place, such as a stage. Motion tracking is also done with sonic echoing and light beam interruption. (Liz Phillips, *Echo Evolution*, 1999) Motion tracking can locate an individual in space and allow that individual's movement to initiate an event. For instance, a camera connected to a computer is focused on a stage floor and the software in the computer recognizes when the performer enters the Upstage Right quadrant (rows 5-10, and columns 6-20) and initiates a particular piece of music.

Choreographers, theater directors, and installation artists use motion tracking to allow the user (performer, audience, watcher) to affect the environment.

Frieder Weiss (2002) used the term “motion sensing” as a better description for what we do with remote, or external sensors (cameras, microphones) because it is a “system designed to give a sense of the motion, rather than exact data on position and motion.” (Wechsler, “Performance and Technology, p. 3) Local sensors (those worn on the body) can fall into the same definition because they “sense” the motion of the wearer. When that data is sent, it can be used in any number of ways by the choreographer, including memorizing it for later use. Memorized motion could be considered captured motion, but for my purposes the distinction will be made between motion captured for use in the immediate real-time performance or installation and that captured for post-production work.

USES OF TECHNOLOGY IN PERFORMANCE

Mixing lighting effects, video, sound and dance in live performance has a long history, from Loie Fuller's experiments with the then new electrical lighting at the turn of the 20th century, to Alvin Nikolais' use of slides and illusions in the middle of the 20th century and finally to the 21st century “interactive” innovations of Troika Ranch and Robert Wechsler. The following descriptions are representative of the history of dance work with technology, as well as a look at interactive technologies, from the technician's, choreographer's and the audience's points of view.

Although human and computer interaction in live performance settings is relatively new, the result of most of that interaction is an increased level of automation, not true interaction. Computer aided technology behind the scenes doesn't actually interact with the performer, but helps the designers achieve the same look as the technology used by Fuller and Nikolais. It has been used decoratively, to enhance a work's thematic or visual texture – essentially the same goals sought by the earlier designers in their use of more technology. Using computers and software to engage in real-time interaction between dancers and the stage environment is relatively rare.

Loie Fuller (1862-1928), dancer, lighting pioneer

Loie Fuller was among the first to experiment with the newest technology in the theater: incandescent lighting. She projected colored light onto her voluminous silk costumes, in tune with the sensuous aesthetics of Art Nouveau; by taking the attention off the human body and putting it onto drapery, motion, and color, she helped make dance acceptable to the middle class. An astute business woman, she patented her innovations in stage lighting as well as costumes, particularly the use of certain chemical mixtures for gels and slides and the first use of luminescent salts (Conner and Gillis, The Early Modern Project Development Team). Fuller used lighting to create magical effects for the audience, but the lighting was programmed and static, not "interactive", or responsive to movement, position, or costuming.

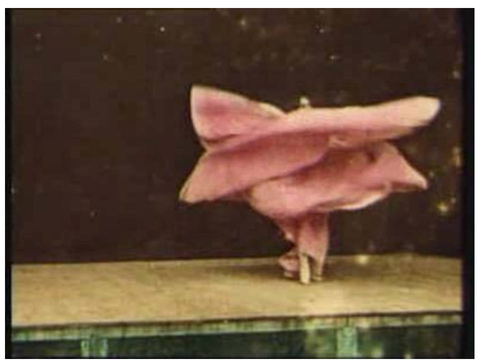

Figure 2.1 A frame from the Lumiere film depicting Loie Fuller's Serpentine Dance.

Fortunately, Fuller's innovations were captured by another, equally innovative team, the Lumiere Brothers, who began experimenting with the new technology of filmmaking in 1892. The brothers filmed Loie Fuller's famed "Serpentine Dance" in 1896. This film was hand colored to mimic the lighting effects Fuller used on stage. (http://www.youtube.com/watch?v=UkT54BetFBI)

Alwin Nikolais (1910-1993), dancer, director, designer

Alwin Nikolais, known as the father of multi-media theater, used light, costume, music and movement to create his dance theater. The only interaction he employed was that between a receptive audience and the active dance production, but he was known as an imaginative user of the technology available at the time. Among his best known performances are "Masks, Props, and Mobiles" (1953), "Totem" (1960), and "Count Down" (1979). He explored abstraction in every aspect of the theater and influenced dance in the USA and across Europe. He created slides for projecting color on the dancers as well as the stage and made illusions that while simple, forced the audience to see movement and human bodies in a different way. His costumes and lighting effects could make the dancer seem a part of the projected set, could change the apparent arrangement of the dancer's limbs, could disguise the dancer's shape, or change the dancer's shape, size and proportion. Nikolais used dancers as another aspect of the theatrical experience for the audience.

Interestingly, Nikolais choreographed from a theory he called "decentralization". By this he meant the depersonalization of the dancer with complicated sets and costumes. Thus, "decentralization" had nothing to do with relinquishing power or sharing decision-making with the dancers themselves. Nikolais's abstractive choreography, in which the body and its parts became freed from its unified form and limitations, reflected the philosophy of postmodernism and its questioning of the unified "self". His work is also a precursor to the later digital artists' use of the human body in projection, including a disregard for gravity and the biomechanics of the real body. The effect Nikolais' technological masterpieces have on an audience is still remarkable; he understood what takes our eye and what keeps it. Still, he retains the role of the classical director; the choreography is very set, with no room for improvisation or expression by the dancers. As such, his use of technology is more manipulative than interactive; the technological elements and dancers do not respond to each other, but exist in the same space and time. In fact, he could program his visuals very specifically only because the well-trained dancers would hit their marks unerringly. Even today, each performance looks like the others.

Nikolais' *Crucible* still attracts attention for its distortion and fragmentation of the human body; its title referencing a kind of alchemical re-fusing of parts. Nikolais set up a mirrored plank and used hand-colored slides projected on the dancers to achieve the visual abstraction central to this theme. Other works, captured in Fig. 2.3, use the dancers more as moving props, as another aspect of the theatrical experience for the audience. He viewed the dancer not as an artist of self-expression, but as a talent who could help him investigate the properties of physical space and movement.

Figure 2.2 Image from *Crucible*   (www.nikolais.org)

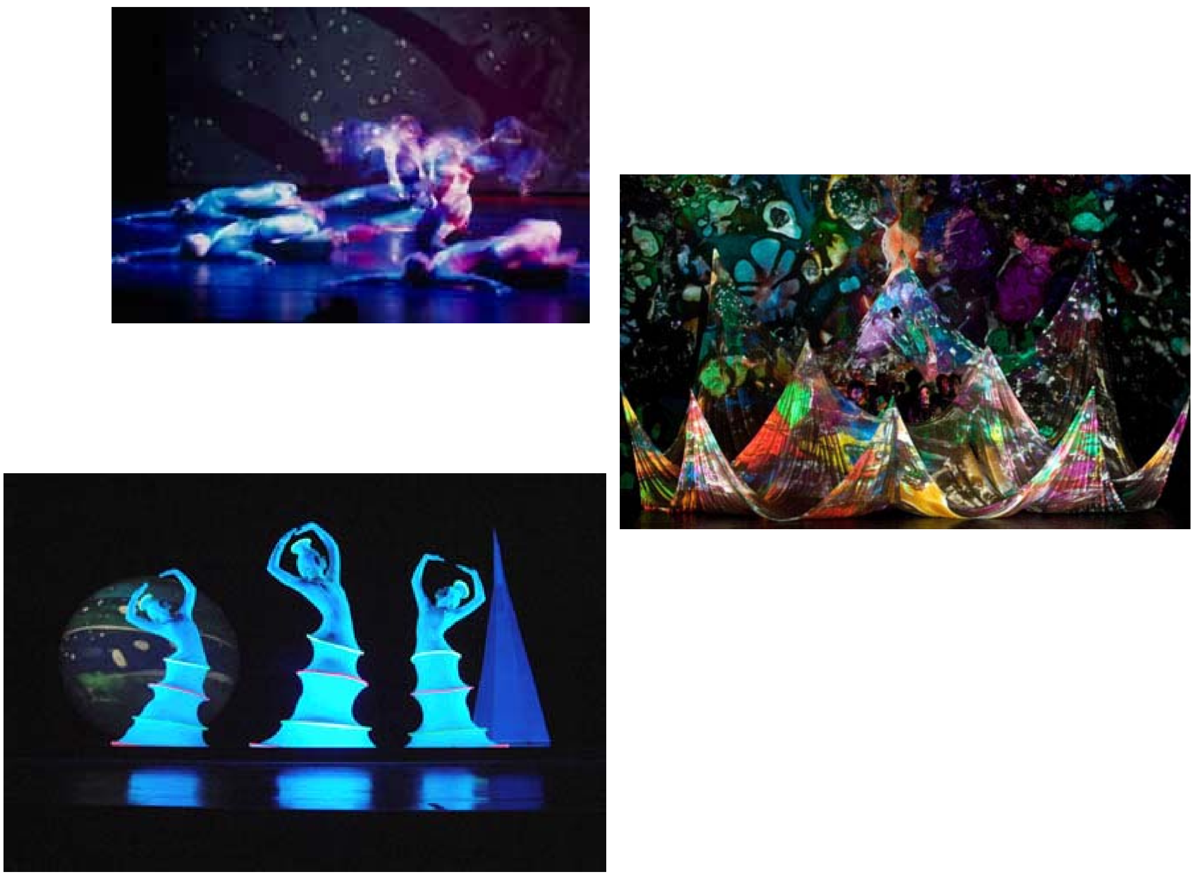

Figure 2.3 Images from *Pond, Tent*, and *Allegory*, clockwise from the top (www.nikolais.org)

Bridgman/Packer Dance Company (formed 1978)

The Bridgman/Packer Dance Company, based in New York state, regularly performs with video and projections that cleverly mix real and virtual dancers. For instance, in a section of *Memory Bank* (Fig. 2.4), a powerful projector (5K lumens) projects pre-edited video images on the dancers. The choreographers meld the real with the virtual performers, creating the illusion of more dancers than the actual two performing, to express the theme of the multiplicity of selves existing in an individual's memory bank. (See video at http://www.bridgmanpacker.org/repertory/repertory.html). Bridgman/Packer's work in dances such as these, evocative as they are, is not about the dancer controlling the stage environment with technology, but rather about the choreographer controlling what the audience sees. Their work includes creature interaction in the psychological sense that Robert Wechsler mentions in an essay on why we work with technology:

> the instinctive back-and-forth of energy that occurs when animals gather to speak, gesture, touch or, in the case of human beings, create art. Interaction is engaging – the heart rate goes up, facial muscles tense and a slew of social rules kick in concerning posture, spacing, timing, gesture and speech. (www.palindrome.de; "Five Questions: Why")

But while the projected human forms and the real human forms *portray* interaction, between selves or versions of self, they do not genuinely *interact*; both elements of the composition are scripted.

Figure 2.4 Image from Memory Bank (http://www.bridgmanpacker.org/repertory/repertory.html)

One Bridgman/Packer work that pushed the envelope of interactivity into real-time feedback was *Seductive Reasoning*. In this piece, a simple handheld video camera is rotated during the dance, projecting an image of the dancer with real-time feedback creating multiple images of the dancer, for an intriguing performance. However, the real-time interactivity is not controlled by the dancer, but by the camera operator. Much like Alwin Nikolais' early experimenting with light and color to create illusions on stage, Bridgman/Packer's work turns our expectations of how dancers relate to physical necessities like gravity on our collective ears, but unlike Nikolais, doesn't change the scale of the human body. While the virtual and real dancers seem to float, appear out of nowhere, multiply, change costume, rotate magically, and interact with each other, they are always the same size as their real counterparts. It is the cleverness of the scripted interacting of real and virtual dancers that takes the audience's attention.

Figure 2.5 Image from *Seductive Reasoning* (http://www.bridgmanpacker.org/repertory/repertory.html)

Mark Coniglio (b. 1961), musician, composer, designer, software designer, director

Mark Coniglio, co-artistic director with choreographer Dawn Stoppiello of Troika Ranch, a New York City based company founded in 1994, that works with technology to such an extent that “media” is part of the “troika” (threesome)--dance, theater, and media--referenced in its name. Coniglio started life as a self-described "geeky kid interested in computers and music". While at the California Institute of the Arts, he became interested in the integration of live performance and interactive digital technology. In his early years with Troika Ranch he created the Isadora™ software to provide real-time media manipulation that provides interactive control over digital video and sound for Troika Ranch's performances, and ultimately released Isadora™ to the public in 2001. (http://www.troikaranch.org)

I will describe and discuss Isadora™ software in Chapter 3. Briefly, Isadora™ can be used for simple presentation of video and audio in performances, and it can be used for many-layered interactive responses to movement and sound by dancer and audience. This technology also allows the choreographer to engage movement with a virtual stage setting. (See Fig 2.6) Projected images can change in an instant, provide color on the stage and on the costume, and show objects that are expensive and ungainly to use when actual or 'real'. And it allows for improvisation, or spontaneous expression from the dancer/s. Rules are set for the environments, then the dancers create movement freely within those rules. There is more on Isadora™ software in Chapters 3 and 4, as I use it in both performance and rehearsal.

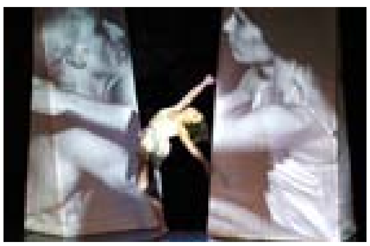

Figure 2.6 Image from *Surface*. Almost European in scope, TroikaRanch's performances use large scale, but simple settings to reflect projections. (www.troikaranch.org)

Despite the technological opportunities for improvisation, Coniglio and Stoppiello create works that are highly choreographed, only using the interactivity to enhance visual and sonic effects in performance. Coniglio and Stoppiello use video projections that supply grandiose images and stage lighting with interactivity meaning that the lighting finds and follows the dancer, rather than dancer needing to be a certain place on the stage (a 'mark') to meet the lighting. Even though the choreography is set, the environment always reacts to the dancer. For example, in *16 [R]evolutions* (video clip online at www.troikaranch.org), the motion tracking (paired with EyesWeb) allows projected stripes to be projected onto the dancers' bodies rather than the dancers having to find a specific mark on the stage floor so that they can meet the projection. However, although the dancers can move expressively because the environment responds to them, they work in a traditional manner in the rehearsal process, with the choreographer working alongside, but not with the technology.

Although the work has a rather grandiose theme, *New York Times* critic John Rockwell among other critics found the theme “tacked on” and not at all integrated with the technology:

> Mr. Coniglio and Ms. Stoppiello apparently don't have faith that their technology will provide enough variety or meaning to sustain interest over an hour. So we have a superimposed choreographic concept that purports to trace mankinds' evolution from the ages to "post-intellectual humans who have lost touch with the animal drives of their prehuman ancestors, "in the words of the a program note. What this means is a lot of obscure trivia (a shoe fetish, one man's obsession with making little boats out of cloth napkins, a family sitting around a table), too much of it anonymously choreographed and devoid of the enlivening technological trickery. (January 20, 2006)

In the case of this work, the ascent of technology led to the death or dearth of expressive dance elements.

Figure 2.7 Image from *16 [R]evolutions*. http://www.troikaranch.org/gallery16Rev/g-16rev.html

Another TroikaRanch work, *The Future of Memory*, was more favorably received, as--like Bridgman/Packer's "Memory Bank"--the technology furnished, this time more immediately, a visual expression of the mind's "layering" in the recording and replaying of memories. This work features streaming video of dance sequences performed just moments before, along with the collaging of more symbolic images and sequences from the characters' "memories". Susan Yung, a reviewer at *Dance Insider*, was able to spin out the theme as providing a meta-commentary on the dance itself:

> The movement itself served as a constant reminder about the active process of memory. ON a fundamental level, the choreography must be committed to memory both mentally and physically....(It seems that dance has always been underrated on an intellectual level, that the sheer skill of memorizing an hour or two of movement is an astonishing feat.)"

Clearly, memory is one theme that lends itself to portrayal in real-time interactive videography. Yet a truly useful medium and method should be far more versatile than that.

Robert Wechsler (b. 1953), dancer, director, ideaman

Robert Wechsler studied molecular biology at Iowa State University in the 1970s and performed experiments on using hand-held devices producing "interactive" sound in Ames before moving to New York City and training as a dancer for 10 years. As founder and director of Palindrome Dance Company, now Palindrome Intermedia Performance Group in Weimar, Germany, he experiments with and uses a wide variety of interactive technologies ranging from extremely localized motion tracking, to dancers standing on wires to complete electrical circuits. Technology is central to his art form, yet he writes frequently with passion about the tensions between technology and dance. Wechsler currently produces dance concerts, choreographs and performs with his dance company, and is involved with using technology as a tool for expression for handicapped people. (www.palindrome.de; Project with Handicapped) Wechsler believes that motion tracking technology can allow anyone, with any degree of mobility, to creatively control a personal expression.

Wechsler believes that interactivity is a psychological phenomenon and writes in his web site (www.palindrome.de) "Interactivity is the instinctive back-and-forth of energy that occurs when animals gather to speak, gesture, touch or, in the case of human beings, create art."

Such a definition, foregrounding the human, living aspects of a term that has been co-opted largely by machine-based media, belies his particular interest in staging "interactivity". Yet Wechsler has found himself making dances that are showcases for a particular technology. In his essays, Wechsler relates the frustration of keeping up with technology.

> … I started having this feeling that Palindrome needed a change. My work with Frieder and his computer programs was continuing to yield successes, commercial and otherwise, but our work together was confusing me artistically. On the one hand I felt lucky: how many choreographers can claim access to such a constant supply of remarkable technological devices! But this was part of the problem! He would come up with new and still newer systems and I was still trying to make sense out of technologies from 5 years old -- what to an engineer is Schnee von gestern (german for "yesterday's snow") and I started to have the feeling that it was my job to put technology

on stage, rather than make art. (2007)

He and his collaborators create more and different toys to play with, but applying that technology into an aesthetically pleasing dance requires that the choreographer and dancers use the technology enough to find the depth of the basic art piece. Starting work on a dance production that is intended as a demonstration of the technology's capabilities leads to frustrated choreographers who feel their work is role is solely justified by the technology being used.

Wechsler has gone so far to state that that even using video, or any moving picture, interactive or not, distracts from the dance. (http://www.palindrome.de; Project This!) But directors know that using certain images and connecting those images enhances the 'cool' factor of a dance performance. Wechsler believes that when artists use technology, that technology should be based in the concept that guides the choreography, rather than using the dance to show the technology. So, using technology to support the live performer and enhance the experience for both dancer and audience becomes the primary challenge for the experienced choreographer. Wechsler uses sophisticated motion tracking to initiate sound and manipulate projected video with software called EyeCon, which he developed in collaboration with Frieder Weiss. Here, "motion tracking" can be defined as anything that controls sounds, images, music and lighting through human movement. Motion tracking is frequently used to monitor activity, or track the movement of an object and then apply that data to another object, rather than as part of the process of making a dance.

Watching Robert Wechsler and Palindrome in a video excerpt from "*Human Conversation*" lets us see a view of interactivity where the system serves to let the dancers dance expressively, outside of the dictates of recorded, or external, music. The dancers 'create' or initiate sound by standing on wired electrodes and closing the circuit with a touch. The work also uses very localized motion tracking or sensing to 'see' very small movements, such as focusing the eyes from forward to the left, opening the mouth, or closing the eyes.

There seems to be a dancer/computer interaction, but by Rubidge's definition of interaction the system is reactive (see Chapter 1). The focus of the "conversation" is the two subjectivities represented by the human dancers; the reactive technology simply amplifies the degree to which "body language" is inter-subjective.

(www.palindrome.de, click on Videos, then Human Conversation)

Figure 2.8 Wechsler's *Human Conversation* uses very tight motion tracking to allow dancers to control what sound plays and when it plays. (http://www.palindrome.de)

Wechsler, like many choreographers, also uses technology to simply create visual and sonic environments for the audience rather than including any interaction. Looking at an excerpt from Wechsler's "*Heisenberg's Uncertainty Principle*", one sees a projection that is used as a set, or decoration. The movement of the letters in the front projection give the impression of 3-D because they seem to surround the dancers, and thus seem to be reacting to the dancers' movements, but it is used to created an environment that expresses the theme of the dance in much the way of Nikolais's projected slides. (www.palindrome.de, click on Videos, then Heisenberg's Uncertainty Principle)

Figure 2.9 Image from *Heisenberg's Uncertainty Principle* (www.palindrome.de)

Shadows, on the other hand, uses real-time projections of the dancer's movement, as well as delayed motion capture, with scripted multiplications of the dancer's image to create a clever composition that directly links the dancer's movement with the projected images. It seems to simultaneously comment on both the interaction of human and technology and the interaction of individual and dance composition.

Figure 2.10 Image from *Shadows* (www.palindrome.de)

Sarah Rubidge and Simon Biggs

Sarah Rubidge, a British choreographer who creates choreographic installations that allow the audience to become creators of the performance, has been instrumental in joining dance and interactive technologies. An early adaptor of interactive technologies, her primary work frequently does not include dancers as performers, but rather the viewers take the place of the performers, as a real-time improvised performance/event. She explores interaction between humans and computers, humans and the physical environment, software and the environment, and asks/requires participants to be an active part of the performance of the installation, rather than depending on dancers to interpret her vision. See an example of her early work, *Passing Phases,* for a brief description of many elements within an interactive installation. (http://www.red56.co.uk/archive/art/passingphases.html)

Rubidge makes comparisons between postmodern artistic practices and computer programming through their use of fragmentation, modular structures, open forms, and network models. In "Reflections on the Choreographic Process in the Digital Domain," she says: "As such the process of developing a programme to serve an artistic idea is, at heart, little different to working with a more tangible material, such as clay, paint, or human bodies to serve an artistic idea." The computer program is the conceptualization of the art work. Choreography, the art of making dances, is instead used as a structuring device for the performance/event, and the body becomes a separate image, divorced from its original source.

Rubidge says, "it will behoove us, as choreographers, to look at shared compositional strategies if we are to understand the role of the choreographer in the digital domain. This role is complex, and varies in different circumstances. Indeed, the digital choreographer may lean towards many modes of artistic expression, drawn from many media, when working within the context of digital dance.

This is, in fact, no different in live choreography, for the organising principle and the structures through which a dance work is realised, are recognised as an equally essential part of the art of choreography as the generation of movement materials." (Reflections on the Choreographic Process in the Digital Domain, p. 6)

Rubidge believes the reason that postmodern artists and computer programmers work together easily is that they use similar structures for their work, which also informs their thinking.

Simon Biggs is a visual artist and computer programmer who creates installations in 2d and immersive environments that use both video and interactive elements. In 1998, Biggs and Rubidge collaborated on *Halo*, which exists both as an installation and as a performance. The installation mimics an immersive environment with projections from four projectors and four computers. Projected images of figures falling and flying are on four walls. As a viewer approaches a figure, that figure "comes to earth" and walks with the viewer.

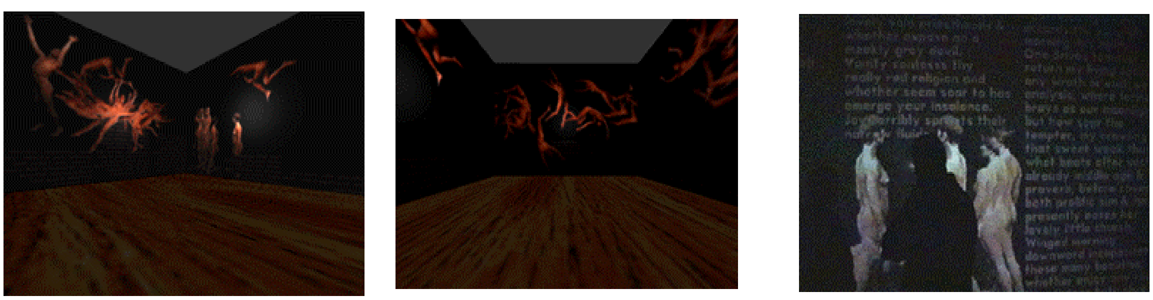

Figure 2.11 Images from *Halo* http://www.littlepig.org.uk/installations/halo/halo.htm
See a video excerpt at http://www.littlepig.org.uk/installations/halo/halo4.htm

Eros~Eris is a live dance performance that uses an abstracted projection of the dancer's movement to create a barrier between the male and female dancers. This projection is captured in real-time, but like a song in a musical theater production, the projection expresses the dancer's interior monologue. It is not interactive, but reflective of the dancers in real-time.

Figure 2.12 Image from Eros~Eris
See video excerpts from Eros~Eris at http://www.sensedigital.co.uk/EE1.htm

Other Work

Bill T. Jones' movement was captured and the resulting images layered with drawings for an ethereal animation by Cooper Union alumnus **Shelley Eshkar** and **Paul Kaiser** of the New York City based new media studio of Riverbed. Their work resulted in an exhibition and installation at Cooper Union's Houghton Gallery in 1999. The installation works because Jones is a spectacular and iconic dancer, and because Eshkar and Kaiser's post production work is detailed and true to Jones' movement style. It does not pretend to be work in real-time, nor does it pretend to be a performance, but simply an exhibition that lets us admire creative work and be manipulated emotionally. This work is hailed as interactive, but the interaction is between the dancer's movement and the artists and doesn't include any control by the dancer over the outcome of the images. (http://www.cooper.edu/art/ghostcatching/)

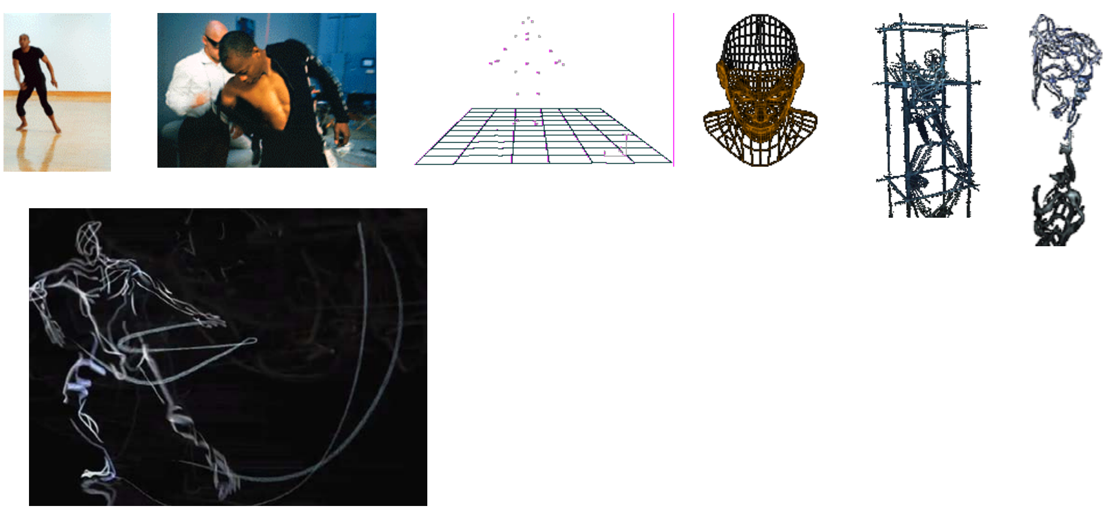

Figure 2.12 Images from *Ghostcatching* (http://www.cooper.edu/art/ghostcatching/)

Patrice Regnier choreographs and produces performances, films and video that uses, among others, motion capture, computer graphics, and electroluminescent costuming, in both real-time performance and set film and video. The collaboration of movement, décor, lighting, and technology appear seamless, which can only happen with constant communication between all creative participants. She states that she is in interested in "humanizing the machine rather than mechanizing the people" in her work with technologies, but she steps back when the technology is starring in a performance and simplifies movement for dancers to the point that the only point of interest on the stage is the technology. Using film editing and motion capture, she further disembodies the dance, putting control into the director's hands, rather than the dancers, much like Nikolais. She uses technology, but for the audience's sake, not the dancer's. (http://www.patriceregnier.com)

Carol Cunningham, working at Purdue University with dancers, computer programmers and motion animators, created a dance that looks at emotion in movement and whether an animated character can project human characteristics. This project started with movement, then developed animated characters that were used to interact with dancers in a choreographed performance. The dancers and programmers collaborated in the development of the animated characters so that they were related to the dance, not just cool looking characters that were given to the dancers. Looking at Carol Cunningham in this motion capture suit from 2003 reminds us why movement looks stilted and makes one ask whether it is truly a motion capture suit, or a motion restricting suit. Dancers have so many movement capabilities that any restriction becomes unnatural. The technology has since improved, but motion capture suits are still restrictive. See below for a description of the IGS Motion Capture suit and system.

Figure 2.13 Image of Carol Cunningham in motion capture suit.
http://news.uns.purdue.edu/html4ever/030421.Cunningham.vpa.html

The **Dance Technology Project** (www.imtc.gatech.edu/projects/culture/dance.html), with collaborators Georgia Tech Interactive Technology Media Center and dance companies and choreographers including the Atlanta Ballet, Lisa De Ribere (Springing Grass, 1995), David Parsons (1996), Nicole Livieratos and the GardenHouse Dance Company (Desire, 1998), Beacon Dance (E-Motion, 1999), presented performances using interactive technologies and live dance performance. The choreographers collaborated with computer programmers and technicians to create performances that used interactive technologies in various forms, including motion capture in both real-time and animations, linking real-time animated projections of movement with live movement on stage. The project has not continued because the programmers discontinued their work. This is a perennial problem for choreographers who are not programmers: the technology savvy generally seem less interested in the broader work, and when those technologically savvy are students, they complete a single project and then graduate, leaving the choreographers without the ability to continue a particular interest in dance and interactive technologies. My work in creating an affordable and usable system for dancers was prompted by my own need to lessen dependence on technicians. The VDancer, discussed in Chapter 3, was developed to meet both that need, and my impulse to give the dancer more control over the stage environment, as well as aid the rehearsal process.

Summary

All of these choreographers use technology to create environments on stage, to add depth to the movement, and to enhance the audience's experience. Most of the contemporary choreographers mentioned also use technology interactively to join the movement directly with the aural and visual environments. They also are either computer programmers, or work with computer programmers to implement their ideas.

DANCE EDUCATION AND TECHNOLOGY

Technology in dance education generally refers to using the internet for research, but that may be because there are not user friendly applications for dance and general education teachers. Even though there is a required technology component to every aspect of public K-12 education there is little mention in dance curricula of any creative use of technology, nor of the use of technology to enhance creativity.

The Institute on Technology Transfer in Education (http://www.nsba.org/sbot/toolkit/tiol.html) examined the impact technology has on learning. This interesting site by Apple and the US Department of Education presents 10 year studies (1986-1995) on technology use in learning in public education. The studies are old, but present expected results: that students' test scores are not affected as much by use of technology as by their motivation and abilities to work independently and collaboratively. I was struck again by the lack of technology use with movement, even though Howard Gardner's multiple intelligences (Howard Gardner, Frames of Mind (New York: Basic Books, 1983) were referenced in terms of technology in education. Rather than use technology for creative learning and setting up situations for creative thinking, computers were the only technology listed and used mainly as physically passive learning tools, even though they were widely used in other content areas.

The Center for Educator Development in Fine Arts (http://finearts.esc20.net/dance/dance_strategies/da_strat_tech.html), in the Texas public school system, asks questions about how technology can be used in dance education. No mention is made of using technology as an opportunity for interaction, rather it seems to be used only to justify purchasing equipment. Mention is made of collaboration, online research, email communication, and using a computer as a tool to support problem solving and thinking skills, but with no specific plans, and no engaging of the imagination.

Technology can be used in creative ways to teach and experience higher order thinking skills, and it can be used to create content, and relieve the tedium of discipline for the beginner. There is a trend toward a core curriculum for most of the states as well as the federal department of education. Planning for 21st century skills is an important part of that curriculum and becoming empowered with the technological knowledge and skills to learn effectively and live productively is mentioned in the curricula from Iowa, New Jersey, and Utah. New Jersey and Utah listed dance as a separate content area and included technology as a component of dance content, but again, without specific plans. Whether this is because of a lack of applications for available technology for education uses, or if instructors are unprepared to use contemporary technology creatively is the subject for another paper.

Core Curriculum can be found online at:

Iowa	http://www.corecurriculum.iowa.gov/
New Jersey	http://www.state.nj.us/education/cccs/
Utah	http://www.uen.org/core/

OVERVIEW and REVIEW OF CURRENTLY AVAILABLE TECHNOLOGY AND HARDWARE

Is there a tradeoff between cost and practicality in the use of interactive technologies? Does the amount of money spent on interactive technology equal the efficacy of interaction? Is ease of use related to cost? In this section, I will look at past experiences with a variety of technologies and their use with live performance.

High Tech/Large Money = High Excitement/Many Programmers = Less Practical

Large research institutions have wonderful opportunities to study the most recent and cutting edge technology. The C6 at the Virtual Reality Applications Center at Iowa State University is an example of the best available. But most modern dance companies do not have the financial wherewithal or the contacts to work in that situation. Modern dance and modern engineering are made for each other; each work on the cutting edge, each are always seeking new forms to use. However, the number of programmers required to create even a simple interactive situation was unaffordable; the size of the C6 meant the dancers could only work in virtual space; which meant their movement had to be either recorded or projected from another space; and the expense of running the C6 restricted the time allowed in the space. The restrictions were too onerous to continue in any form but research.

Motion Capture = still lots of money, but cool results

Motion capture can be done by referencing the body in space from fixed points, either from fixed cameras watching the body in space, or from the moving body sending information about where it is in space. Motion capture is most often associated with the film industry, but recreational sport is also a user of motion capture, as is physical therapy and other medical applications. Most motion capture is not done in real time, but usually from choreographed movement, which is then viewed or processed and placed in an environment.

Kinesiologists have been using fixed cameras to capture movement, but that movement is generally repeated memorized sequences of movement, or short bursts of movement in a confined space. The movement is captured and analyzed later for study of the mechanics of that movement.

IGS 3D Motion Capture Suit

Video cameras capture movement but can't allow transfer of that movement to a 3D environment. They can map to a 3D character, but cannot become 3D. Sophisticated mapping of 3D models with video will allow us to see individuals moving, rather than an anonymous character. The College of Design (CoD) at Iowa State University purchased an IGS 3d Motion Capture system from MetaMotion and allowed me to make use of it. This system uses a Nylon/Lycra® suit (separate pants, top and hat) with 19 wireless inertial measurement units placed not on the joints but on the bones of the wearer. An algorithm translates 3-D data to a virtual skeleton. A photograph is taken of the wearer to create individual 'skeleton rig', and allow mapping the motion data to that individual skeleton. While easy to use, and an efficient way to capture movement with three-dimensional information, the CoD's system is not usable in real-time. After movement is recorded, the drift of data from the noted start point must be 'cleaned' so it not only resembles real movement, but is usable in any 3-D software (like 3dsMax, Cinema 4-D) as well as in virtual reality. This takes specialized software, a lot of time, and a knowledge of basic physics and biomechanics. The system works best with simple movements, such as walking, but is a spectacular tool for capturing full body movement. I used it to capture movement by Silvina Lopez Barrera and then mapped that movement into different characters built in 3ds Max. In the near future I intend to revisit that motion data and build a more poetic and dance specific character.

Figure 2.14 A mapping of Silvina's movement onto different characters built in 3ds Max in Motion Builder. In the video, note how the character occasionally slides in the space; this is more apparent when there is a fixed environment around the character, and the motion capture data needs to be processed to anchor the character. (Video at www.vjw.biz/thesis/ArDncrCombo.mov)

Medium Tech/Medium money = Great! (if the dance company is in residence at a university and has access to knowledgeable people and labs with equipment)

Medium Money can include motion tracking, but at this financial level sensors are generally used for motion sensing rather than motion capture. Sensors placed on the dancer's body allow the dancer to use movement to affect his or her environment. They generally communicate wirelessly and require a transmitter and receiver connected to a computer, with software that can interpret the data sent from the sensor.

In general, sensors located on bodies are less successful because all dancers sweat, and modern dancers change level frequently, including rolling around on the floor. We've experimented with Xbow Mote Systems to wirelessly transmit of motion data from flex sensors on the dancers' elbows and knees joints. The Xbow systems are relatively easy to use and they can accommodate several sensors (such as flex sensors) on a single unit, but each of those sensors needs to be hard-wired to the Xbow transceiver. Then there is the challenge of translating the data from the flex sensor to Isadora.

A complex system has more reasons for something to go wrong:

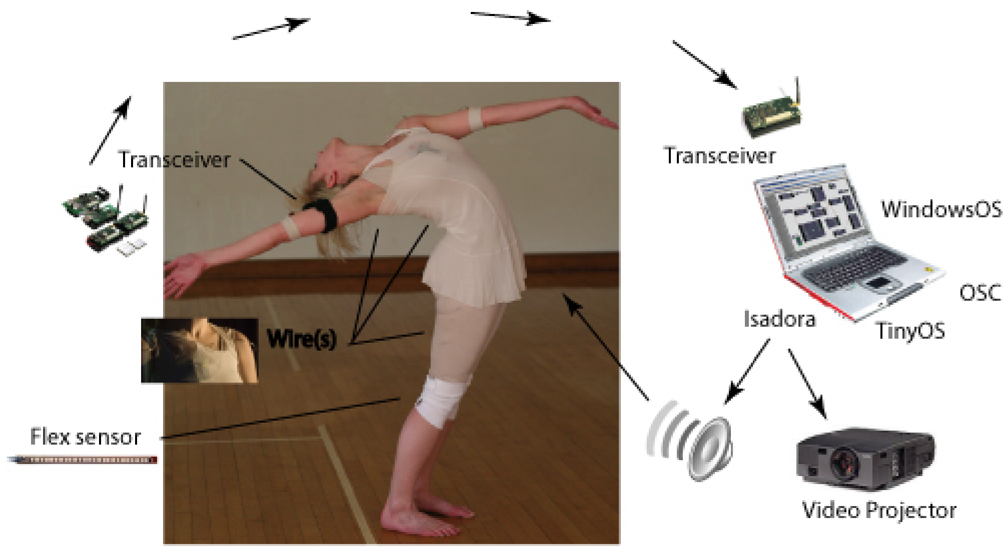

Figure 2.15 A complex system has many places where things can go wrong

Figure 2.16 Xbow mote transceivers

Components of the complex system

Flex Sensors

Flex sensors send a signal based on the resistance change by bending the sensor. Because dancers move in extreme flexion and contraction, the sensors were constantly stressed. The best reason to use a flex sensor is that it can send a continuous signal, allowing for more gradual changes in the environment.

Transmitters and Receivers

Simple radio frequency transmitters were the most robust and easily used. It was easy to connect a microphone, a piezo sensor, or even a flex sensor to the wireless transmitter. They are readily available and relatively inexpensive. It was easy to program with Programming was easy and they compatible with any computer with a microphone jack. While transmission range is directly related to price, even inexpensive transmitters and receivers have enough range to cover a stage and auditorium. However, they are also less comfortable for the dancers because of the size of the commercially available covering box, and require batteries that need to be replaced frequently.

Software

Isadora™

Developed by Mark Coniglio, Isadora is a powerful and flexible graphic programming environment (www.troikatronix.com) for Macintosh and Windows that provides interactive control over digital media, with special emphasis on the real-time manipulation of digital video. Isadora was initially created to realize the performances of Troika Ranch, a media intensive dance company co-directed by Isadora's creator, composer and media-artist Mark Coniglio. Isadora™ is especially created for real time interaction, with easily edited input and output values in a graphical interface of 'building blocks' that can be linked together in nearly unlimited ways. For use in signal manipulation, programming experience is necessary, but code writing is not. Isadora™ allows sensory input or control over external devices (MIDI, Serial [RS-232], TCP/IP, and Open Sound Control [OSC]).

Eyes Web

Motion detection and tracking software that uses infra-red light and cameras, an example is provided by Troika Ranch's production of *16 [R]evolutions* uses Eyes Web software in conjunction with Isadora™ to track the dancer without external sensors. Infrared light floods the back of the stage; a camera with an infrared filter 'sees' the silhouette of the dancer and tracks the thumb of that dancer. Isadora™ software uses that tracking to project ribbons of colors based on the dancer's movement. Go to http:// to see a bit from *16 [R]evolutions*. The effects seen were programmed with a combination of Isadora and Eyes Web. Choreography by Dawn Stoppiello.

Low Tech/Low Money = Equal Access for Anyone

A computer and a web-camera are the only necessary components for simple interactivity. Cameras allow for motion tracking and sensing and are generally not in a position to be struck or sweat upon. Web-cams are ubiquitous and generally plug and play. They can 'look' at the space and transmit data that can be translated by the software into projections or sound in real-time. Depending on the experience of the choreographer/technical director, software can range from Max /MSP ($699) and Isadora™ ($225-350), to Pure Data (free download), and can be used to manipulate either visuals or sound in a programmed or free manner. All of this hardware and software are readily available and relatively user-friendly with good tutorials, so awareness and desire, not access would be the reason for not engaging with interactive technologies.

Most contemporary computers have fast enough processors to run the software needed for interactive technologies, but a slower (and less expensive) computer will not be able to run as many programs simultaneously as a faster computer.

Conclusions and **Looking Into the Future**

Robert Wechsler's frustration with feeling that his choreography was aimed at presenting technology rather than making an artistic statement seems echoed in other's experiences, including my own. Looking at interactive technologies from the dancer's point of view rather than the technician's became more interesting. Starting from the choreographic process and involving the dancers in the experience from the beginning seems to counter the need to follow the technicians.

Co'Motion Dance Theater's experiments with a wide variety of sensors and systems indicate that I needed to find the conjunction of low cost and high usability, with a low learning curve. After looking at, experimenting with, and creating several different systems, I decided that I needed a system that would send a continuous stream of data (like the flex sensor), be comfortable and small enough to be unobtrusive (like the small Xbow Mote transceiver), be easy to use (like the piezo and RF transmitter), and meld easily with already available protocols (like OSC and MIDI), and with software (such as Isadora™ and Ableton Live). To that end, I continued reading and nagging various engineers with my needs. Dr. Stephen Holland responded by asking me to look into Basic Stamp's collection of sensors. A professor in Aerospace Engineering at Iowa State University, Dr. Holland was also interested in inertial measurement units for his own research. Piggybacking the two concerns made me realize again that everything is related. My work with the VDancer and external sensors has yielded a number of applications that I have made available to selected students and teachers who are interested in experimenting with them.

Chapter 3 VDancer

I began my work with interactive technologies in 2000, when virtual reality was all the rage, but there seemed a disconnect between the real person in the cave and the mechanical interface. I was interested in involving more intuitive movement in the C6, using the entire body, not just a wand pointing at a virtual object. Initially, we called our work *Dance Driving*, with the goal of investigating how movement could be the driving force in a virtual reality environment. The terrorist bombing of the World Trade Center on September 11, 2001 forced a reaction from the entire community and gave us a new focus for our work, which we renamed *Ashes to Ashes*.

The *Ashes to Ashes - Dance Driving* project at the Virtual Reality Applications Center (VRAC) at Iowa State University (ISU) presented a new medium that blended music, dance, visual design and the advanced emerging computer technologies of real-time immersive virtual reality and collaborative spaces. The process of creating the *Ashes to Ashes - Dance* Driving project was similar to any other project. It began with an idea, brainstorming that idea, identifying personnel to complete different aspects of the production, planning the production, managing the production, and finally, realizing the product.

The project resulted in a performance in 2002 and an application for the C6 at the Virtual Reality Applications Center at Iowa State University, but the motion capture was unwieldy, the space constrained, and the motion capture suit confining. The dancers were not able to move fully and the mapping of video to virtual objects in the C6 was almost impossible at that time.

Besides these technical difficulties, there was something inherently problematic about the collaboration between my professional dance company and the university student programmers. First, the number of people required to complete the project was prohibitive. A particularly frustrating aspect of the process was that the performing artists had their work done well before the programmers, although both groups were creating entirely new work. I could speculate as to why that was, how the work culture of the two collaborating groups and their commitment to the project differed. Instead I decided to continue investigating sensor systems that would work for a small modern dance company, one that performers and directors could control on their own to achieve the effects they sought, on their own timelines.

I have spoken with many engineers and directed projects in collaboration with numerous artists and technicians in my quest for a "virtual" experience onstage. The first such project after *Ashes to Ashes* was *Assisted Living*, in 2004. The same problems emerged: difficulty bridging the dance and tech "work cultures"; sensors that broke and had to be re-soldered after every rehearsal; technicians controlling the performance from backstage while dancers onstage struggled with costumes into which we had painstakingly woven the wiring. The result was the opposite of "virtual reality", the dancers did not control the environment, but the environment controlled them. Finally, a chance conversation with Dr. Stephen Holland took me down the path that would lead to the VDancer.

Before a discussion of the VDancer, I will present a comparison of sensors.

Figure 3.1 Assisted Living, backstage and on stage. Note the wires woven into the costume fabric, and the fuzziness that indicates stereo projection.

Types of Sensors

There are essentially two types of sensors, external and local. An **external** sensor is installed in the environment; in a stage setting, it is often hung from above the stage. Its "job" is to monitor the environment (think of motion-detection lights). Cameras are the most common external sensors used in onstage applications, but a sound pickup can also be used.

A dancer's position in relation to the stage can be detected by an external sensor. A **local** sensor is worn by the user and detects fine details about the movement the user executes. Local sensors would be part of the glove or motion-capture suits that the users of the earliest virtual reality wore. Onstage, the local sensor detects the type of movement the dancer executes. Depending on where it is worn, it can detect the motion of an arm, a leg, or the whole body. Table 3.1 describes the types of sensors and their uses in a dance context.

Both external (installed in the environment) and local sensors (sensors worn on the body) can be described as motion sensors because they sense any sort of motion. The data from that motion detection can be used in a myriad of ways, either through interpretation in a computer program, or by direct use. In a performance or rehearsal setting, any sensor (camera, microphone, accelerometer, electronic gyroscope, magnetometer, flex sensor) can give the dancer immediate feedback about her gestures and what they accomplish. Depending on the programming, they can also give the dancer a level of control over the environment.

Table 3.1 Pros and cons of Different Local Sensors

Sensor	Pros	Cons
Abrams Gentile flex sensor	easily available from a number of sources stiff, so the sensor needs to be in a sleeve to stay in contact with the body	stiff, when they are bent they tend to hold that shape relatively expensive
FlexPoint flex sensor	very flexible, so didn't require a sleeve standard connecting ends are already on the sensor the company is very willing to work with customers to create a usable product. Flexpoint added a layer of polymer to strengthen the sensors for our use.	while they bend easily, they also ruffle easily and lose sensitivity when they hold their bent shape.
Piezo (pressure sensors)	simple easily available inexpensive	without a robust connection point, the soldering comes undone with use. We found that the piezos needed to be covered in clear packing tape to keep them from giving sweaty dancers a mild 'burn'.
Wii Remote Inertial Measurement Unit	simple easily available relatively easy to connect with programs like GlovePie measures movement in 6 degrees – XYZ of translation and XYZ of rotation	bulky not very sensitive low range data must be

There is a difference between a sensor and a sensor system. The sensor detects the motion, but this signal must then be translated into a signal that is recognizable by other communication systems, such as Isadora™. There is circuitry, software, and casings involved. Furthermore, there must be a power source. No existing IMU sensor system had the specifications needed for use on a dancer in a responsive dance performance environment. To my knowledge, no one else has designed a system such as the VDancer before.

Table 3.2 Table of Communication System pros and cons

System	Pros	Cons
Xbow Mote System	robust low power required so batteries last a very long time good power and range	requires specialized programming for communication with interpretive software such as Isadora packaging is difficult relatively expensive
Wireless Microphone Transmitter	robust reliable simple plug and play can easily accommodate different sensors good power and range inexpensive and available	packaging can be too large can send only one signal over only one band doesn't work well with flex sensors that require a separate amplifier
VDancer	robust low power required so batteries last 8-10 hours range about 60' relatively inexpensive (component parts are about $200) flexible firmware makes reprogramming easy	requires specialized programming for communication with interpretive software such as Isadora packaging must be created non-commercial, so must be made on site

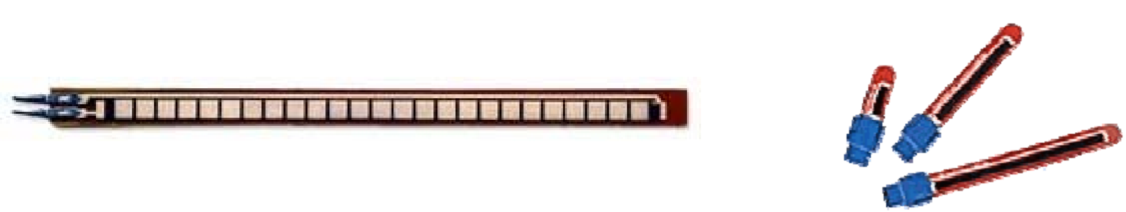

Figure 3.2 Pictures of (left to right) Abrams Gentile flex sensor, and the Flexpoint flex sensor

Much of the early work with “interactive” technology described in Chapter 2 used external sensors, such as cameras and projection. Though I rely on such tools as well, my main focus in creating a dance space under the dancer’s control has been to find an adequate local sensor system that will hold up to daily rehearsals and still achieve the effects I seek. The various types of local sensors have their built-in advantages and disadvantages. Flex-type sensors are linear-shaped devices that operate based on the resistance in the curve of the material. When the strip is bent, the resistance increases, and this signal is captured electronically. Flex sensors are used in gaming gloves, fitness products, assistive technology, joysticks, and so on. None of these applications is as versatile as a dancer’s body, and, as Table 3.2 indicates, the flex sensors do not hold up. By contrast, a piezo sensor is essentially a “pressure button”; press it, and it sends a signal. While it is not strictly limited to “off” and “on,” it is not particularly sensitive, and is restricted to one reading and thus cannot reflect the duration of a movement.

It was Dr. Holland who introduced me to a different kind of sensor, the inertial measurement unit, or IMU. Accelerometers are key component of IMUs, which are best known for their use in spacecraft and guided missiles, as well as being used in sports technique training. They detect acceleration in three directional axes, and can detect rotational acceleration around the axes as well. Thus, the IMU sensor can measure, not just the bending of an arm or leg (the creation of resistance), but movement in *x*-*y*-*z* space. When I learned about this type of sensor, which can be a small as a dime, I wanted to pursue its use in a sensor system

The VDancer System

The VDancer came about through many discussions with Dr. Stephen Holland, assistant professor in Aerospace Engineering at Iowa State University, about my research at the time and my reactions to all the systems I created or tried. Dr Holland designed the circuit with size and robustness in mind, using easily available component parts. The software translation developed by Wen-Chieh Chang, PhD candidate at Iowa State University, was written in Python to translate the Bluetooth packets into Open Sound Control (OSC) and eventually into the Isadora™ programming environment.

(www.opensoundcontrol.org)

The VDancer is a small wireless system for measuring motion, rotation, and orientation. A triple-axis accelerometer and triple axis gyroscope measure the rate of motion and rotation respectively. A triple axis magnetometer (compass) provides a direct measurement of orientation with respect to the Earth's magnetic field. An on-board computer processes the measurements and transmits them via a Bluetooth radio with a range of 10-20 meters. The VDancer is fully self contained, with batteries, sensors, computer, and radio all fitting within a 2” by 3.5” by .5” packet (approximately credit card sized) that fits comfortably on the dancer. The full assembly, shown below, is tough enough to withstand the knocks and moisture of a performance. The VDancer eliminates the need for wires and breakable flex sensors.

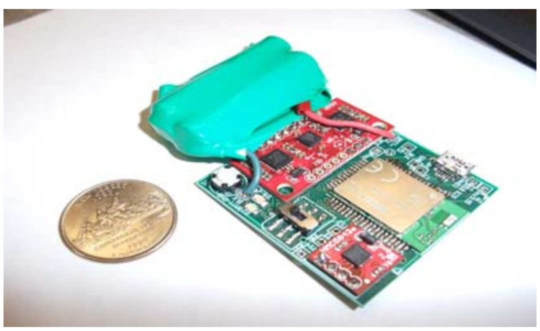

Figure 3.3 The VDancer sensor system unsealed.

The VDancer is local, specific and very sensitive. It measures translational acceleration in three dimensions, and rotational acceleration around three axes. A Bluetooth radio module transmits data to the remote computer, which uses Open Sound Control to communicate with Isadora™ software. The dancer's movement is reported by the VDancer, the environment responds accordingly, and the dancer responds to these environmental changes, creating a new set of signals. Thus, an evocative feedback loop is created. Fig. 3.5 provides a schematic of this basic concept.

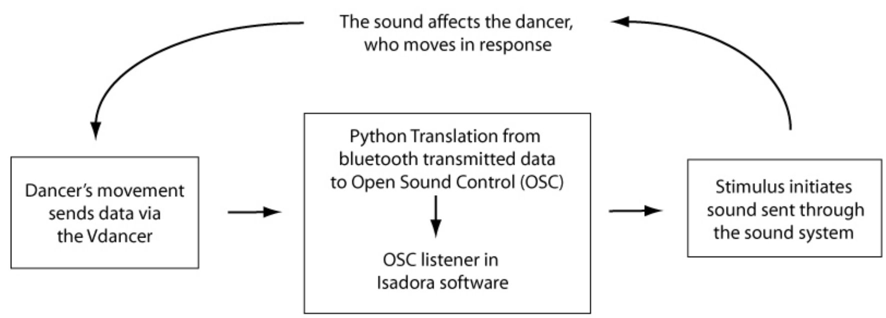

Figure 3.4 Feedback loop

In my work, *Singing Bowls* (www.vjw.biz/thesis/SingingBowls4.wmv), the dancer could control sound in two ways, through an external sensor and the local sensor she wore. The dancer controlled the type of sound (e.g. descending scale or pitter-patter sounds) by selecting which part of the stage she occupied; the specific sound file is linked to a particular area of the stage. An overhead camera (external sensor) divided the stage into *x* and *y* coordinates. The volume was controlled by the movement data from the VDancer. Moving faster (increasing the energy in the movement), or changing the rate of acceleration, increased the level of volume; less energy lowered the volume. The camera allowed one kind of environmental manipulation, but the truly expressive elements of the dancer's movement are captured by the VDancer. In fact, the VDancer lets us track the difference between movement qualities (how and dancer moves and what energy a dancer uses, such as sustained or percussive movement) in a way that no other system can. In this way, changes in the visual and aural environment are not just decorative, but should reflect the content of the idea, as well as the movement and intent of the dancer.

The video "Perc/Sus" (www.vjw.biz/thesis/PercSus.wmv) demonstrates how VDancer can capture the difference between a sustained movement and a percussive movement. Allowing the dancer to control the sonic environment with movement quality (how we move) as opposed to location (where is the dancer) is a new concept, and a new application of motion sensing.

Importantly, with the VDancer, any feature of the environment can be linked to any type of motion without advanced code-writing skills.

The VDancer can add a general control, for instance changing the volume with the speed of the dancer's movement, or it can add a specific control: when such and such a motion is made, this happens. Several types of "rules" can be used at once; for example, because the VDancer is sensitive to gravity, translation in the z-axis can be used to alter pitch while the movement in the x- and y- axes control other elements of the video projection or stage sound.

For example, in the solo dance "Crowd" (www.vjw.biz/thesis/CrowdEdit.mov), created as a reaction to crowds and the dislike of being crowded, the emergence and disappearance of an imaginary crowd around the dancer was represented by her movements. This motion was easily enhanced by the VDancer's program settings. Specifically, lifting the arms as if to shield the head, (rotation around the x axis of the V-dancer, which was attached to one forearm) increased the volume and speed of the percussion sound track, mimicking the physiological responses to stress. When the dancer's arm is motionless, the volume and speed dropped to zero.

Laura Test

The first working version of the VDancer was programmed to send data from the rotation in the *x* axis, so it was named 'Laura', after choreographer Laura Dean whose minimalist work including spinning and rotation has won many awards. Subsequent units are named in honor of both historically important and contemporary choreographers, but also because of differences in the makeup of the units and/or programming. 'Martha', 'Ruth', and 'Manu' include compasses; 'Bill' and 'Ruth' include a ¼ gain for larger gesture measuring.

Table 3.3 VDancers

Sensor name	Compass	Gain
Laura		
Martha	X	
Ruth	X	X
Merce		
Doris		
Bill		X
Manu	X	

An application (Laura Test) was developed to allow dancers to manipulate sound and video projections on any stage. This manipulation is made possible through the use a computer, Isadora™ software, the VDancer, webcameras, microphones and the computer's built in microphone. The VDancer sends a continuous signal via Bluetooth transmission, with a working range of 10-15 meters. Actual range can be up to 20 meters. The signal can be received through stage curtains, and is automatically picked up when occluded by structures or bodies on the stage.

How do we measure success? The VDancer units are successful when they respond to the programming and to the environment in a predicted manner; when they work as needed by the dancers and programmers, and when they pick up and send a signal reliably. But how do we measure success for the dancers using the VDancer? While aesthetic considerations are important in assessing dance performance, that is not the focus of this paper. Instead, it is about telemetry, use of motion data, and motion detection and within that context, success can be measured if the dancers are actually using the VDancer to create work, are excited about the possibilities for use, and develop applications using the VDancer.

Usability of the VDancer

Considerations for the structure of the VDancer included size, weight, durability, robustness, and range. Battery length was a concern because the unit would be on for the length of a rehearsal and a concert (approximately 4 hours for a rehearsal, and 4-6 hours for a concert).

Creating a circuit board that is small enough to be comfortable and unobtrusive, but still large enough for human hands to work with meant a unit about the size of a credit card. Putting two nickel metal hydride rechargeable batteries on the end of the unit added about an inch to the length. The various sensors used were small enough to keep the VDancer to a finished size smaller than a credit card, about 3” x 2” x .5”. That size is small enough to be relatively hidden on the inside of a lower arm or lower leg. The largest and heaviest components are the batteries, nevertheless the VDancer weighs in at only 1.5 ounces.

Durability of the VDancer was addressed by including as few “moving” parts as possible, and designing several different packages. The first iteration included a micro USB female end (needed for programming the unit) that was cut up and soldered on the unit. Subsequent iterations used just the port end soldered directly onto the circuit board, taking up less space and contributing less weight. We looked at several packaging ideas and after trying different hard plastic containers, and soft plastic wrapped containers, decided to try simply shrink-wrapping the batteries, then the entire unit, cutting a hole in the shrink wrap for the on/off switch. We were initially concerned with condensation inside the unit if we covered the entire unit in plastic while wearing, so tried it without another covering. We've had no problems with condensation because of the openings in the shrink wrap, nor with sweat/moisture getting into the circuit board.

The VDancer has been in use for 7 months without failing. The programming has been changed, and the firmware updated on several occasions without any negative repercussions. Later versions of the VDancer will have a Bluetooth transmitter with more power, because of upgrades to that equipment. Battery life should remain the same.

Placement on the dancer is a serious concern because the VDancer needs to be unobtrusive and comfortable for the dancer and safe for both. Initially, a simple sleeve was created to hold the VDancer on the dancer's lower arm or ankle, but this proved less comfortable for the dancer and less easy to put on and remove. A simple double sleeve of nylon/Lycra® fabric made placement of the VDancer on the dancer very easy.

Other Applications

Dr. Stephen Holland was interested in using the VDancer to send data directly to a MIDI source, thus avoiding involving a computer and interpreting and programming software. He created a Bluetooth-MIDI converter that 'converses' with a MIDI keyboard. The dancer creates a gesture whose unique XYZ motion data is memorized for the short term in the MIDI keyboard and associated with keyboard strokes played on the MIDI keyboard. Each time the gesture is repeated, the sound is played.

To see video of Silvina using Manu to first memorize a gesture and associate that gesture with a sound, then repeating the gesture to repeat the sound, go to www.vjw.biz/thesis/ManuSilDemo.3g2. See www.vjw.biz/thesis/ManuEw3.3g2 for video of Elizabeth, after she has learned to use the gestures to create the sound. You'll see that she is controlling when the sounds happen, but is also reacting to the sounds. The technology allows her to accompany herself, but also to have a movement conversation with the sound.

Although I have not explored therapeutic applications, the VDancer could be used for any application when specific motion feedback is desired, in both medicinal therapy and education. In education situations, interactive software and hardware also allow the programmer/choreographer/teacher to set up situations for dancing, rather than only learning dance movement from the teacher, encouraging creative use of the tools, and a way of thinking about composition and choreography that goes beyond most composition classes. The VDancer is probably too complex for primary and possibly secondary education applications, but systems like it are used in tertiary education. Unfortunately, so far applications that I found are created only for production, not for process. The VDancer requires the dancer/choreographer to consider movement with interactive tools within the context of the larger idea of the finished dance and performance of that dance.

What can the dancer control, and how?

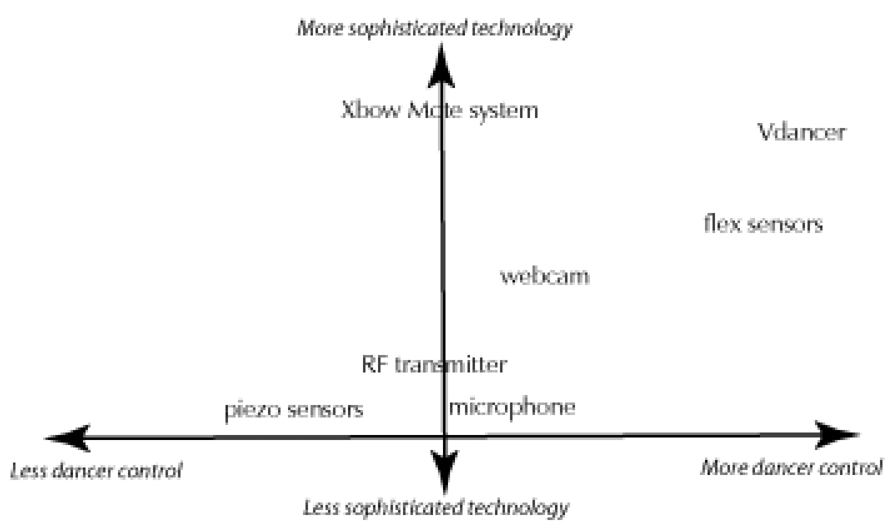

Figure 3.5 The relationship of dancer control to sophistication of technology.

Control is an important part of all dancer training. Even young dancers learn to control not only their bodies in space and time, but also to control the general atmosphere on stage and to some degree, the audience's reactions and feelings. The figures and tables below are an effort to scale the degree of control the dancer can exert over video and sound. By control, we mean that the dancer's movement can consciously or unconsciously alter the sonic and/or visual environment, the narrative, or other aspects of the performance environment with her movement. Figure 3.5 looks at the relationship of technological sophistication to dancer control for each system, and Figure 3.6 looks at the ratio of ease of use to dancer control.

Looking at Figure 3.5 shows a considered placement of sensors and systems based on both how technologically sophisticated the hardware is and how precisely the dancer can control the effects of using the hardware while moving. The Xbow Mote system is very sophisticated; it can accommodate many different sensors, and can be linked wirelessly with other motes for long distance communication. It is small and can be worn anywhere, By connecting sensors to the Xbow Mote transceiver (hard-wired), the dancer can send a continuous stream of data and with a little bit of training use movement to control sound or video. It received a lesser control rating than the VDancer because it is the sensors connected to the transceiver that are controlled by the dancer. The VDancer is a self-contained sensor and transmitter that allows the dancer to place it anywhere on the body. Although it has an orientation to gravity, it can be used facing any direction on the stage. Flex sensors allow the dancer a fine control, but are also easily damaged, in which case there is no control available. The webcamera is a relatively simple technology (in its ubiquity and ease of setup) but because its lens is not that big, it is less easy for the dancer to control the environment in a large setting such as a stage, and the lighting differences in a stage production requires the programmer to set up patches differently for each lighting situation. An RF (radio frequency) transmitter ranks low on the sophistication scale because it requires no special programming, is a simple package and easily understood by most people. Piezo sensors are simple and easy to place anywhere on the dancers body, although they must be hard-wired to a transmitter. They are not as sensitive as flex sensors or the VDancer, and to activate require a more determined touch. A microphone can be clipped anywhere on the dancer's body, but unless it is near the mouth (for voice activation) is not very sensitive. However, the dancer can easily control how much movement is required for activation of this sensor.

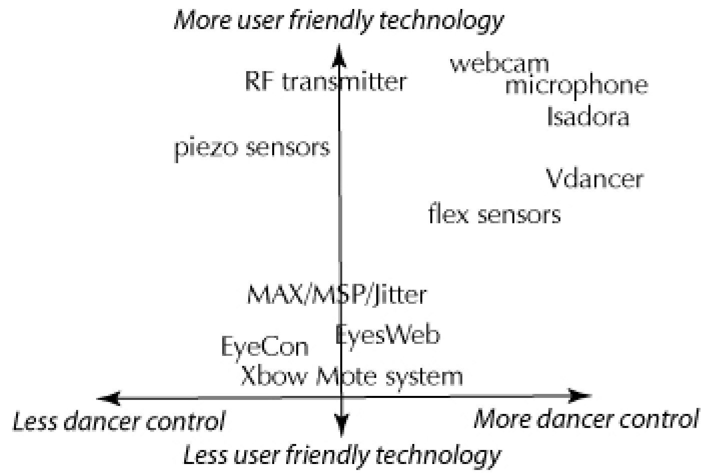

Figure 3.6 The relationship of dancer control to ease of use of technology.

In terms of hardware, the webcamera is the most user friendly of the technology presented because it is simple to set up, simple to connect to the computer and software, and its use was intuitive because the Windows XP operating system was set up for webcamera use. A microphone attached to a RF transmitter was also simple to use, simple to connect to the computer and software, and its use was also intuitive because the Windows XP operating system was set up for its use. Piezo sensors required assembly and soldering, but once put together were simple to use, and simple to connect to the RF transmitter and then to the computer. Isadora (www.troikatronix.com) is especially formed for manipulation of the visual environment and requires programming, but no code writing, and unlike MAX/MSP/Jitter (http://cycling74.com), has a graphical user interface that is intuitive. It includes excellent beginning tutorials and an active user group and forum for questions and is priced at $225-350 (2010). It is available for both Apple and PC platforms. The VDancer is easy to use, but sends data via a Bluetooth radio which has a shorter range (up to 60' in studio and theater tests) and requires line of sight accessibility from sensor to Bluetooth receiver. Flex sensors required more assembly than did the piezo sensor system, but the parts were not as readily available and they required frequent maintenance. They also required using a system like the Xbow Mote system to send data, and that required a special program to translate the data from the Xbow transmission to Isadora. Max/MSP/Jitter is a highly flexible program for control of sound and video, but is priced at $699 (2010). Like Isadora, it works with objects, so code writing is not required, but advanced programming knowledge is required. There are good tutorials, and an active user group. The Xbow Mote system requires assembly of circuit boards, use of TinyOS, and a translation program from the data sent to Isadora or Max/MSP/Jitter. It also required hard wiring of sensors to the mote transceiver, which meant that the dancer spent more time 'suiting up than with any other system', and because there is no packaging, it must be used carefully on the dancer's body so that it doesn't become damaged. That much programming and assembly makes use of the Xbow Mote system very time consuming and learning intensive. Although it was robust, it was also complex and required many different elements to use effectively. Thus, it is on the bottom of the user friendly index.

Conclusions

While there are many interactive systems that allow the dancer to alter the stage environment with her movement, a simple (quick setup, fewer parts to connect) inexpensive (including software, computer and peripherals such as a camera, cable and batteries) system that is robust enough to last through rehearsals and performances is the most attractive and will ultimately be actually used. The VDancer has proven to be easy to use, easy to package, small enough to be comfortable, and can be placed anywhere on the body without wires. Its Bluetooth radio has a wide enough transmission range to cover most stages, and can be used to deliver MIDI messages directly to a MIDI instrument, bypassing the expensive software, and even a computer. The onboard computer can be programmed for sensitivity and the type of data packages sent. While programming in Python language is required to change the firmware in the VDancer, once the use of the VDancer is set it requires no maintenance.

Table 3.4 External Sensors (Sensors in the space)

Sensors	Components	Action	Example of use
Cameras	Web cams, camcorders	Views the stage environment	Dancers initiate a sound file when approach a particular place, measured in columns and rows
Sound pickup	Microphone built into computer, microphones placed on the stage and wired into the computer	Picks up any sound in the environment	Audience's sound changes the video projection

Table 3.5 Local Sensors (worn by the dancer)

Sensors	Components	Action	Example of use
Flex Sensor system	Flex sensors, transceiver, cable	Sends a continuous signal based on the bend of the dancer's limb	Bending a knee can change the amount of reverberation in music, giving the music a different atmosphere
Piezo sensor system	Piezo sensors, cable, transmitter, receiver	Sends a one-time signal based on the pressure of touch	Falling to the floor can add a sound that layers with the base music. Touching another dancer can elicit a sound.
VDancer		Sends a continuous signal based on the dancer's movement Sends a signal direct to MIDI	Moving sharply can project a certain image; moving in a sustained manner can dull the edges of the image. Gesture recording and recognition sends a signal to a synthesizer which plays a recorded sound
Wireless Microphone	Wireless microphone, RF transmitter, receiver	Sends a signal based on the sound the dancer makes – vocally, or by pressure	Speaking on stage can raise the volume of the accompanying music

Chapter 4 Project - *Grace*

This chapter focuses on the development and performance of *Grace,* a modern dance concert using the interactive technologies previously discussed in this thesis.

Figure 4.1 Image from *Grace*, with interactive projection behind the dancers. Photograph by Samuel Wormley

Imagining a space that reacts to the dancer, sending sounds and images because of the dancer's actions, I choreographed and produced *Grace* for performance at the Ames City Auditorium on February 20-21, 2010. I was interested in the idea of "grace" in its many definitions, and in how dance, visual art, music and technology could be used to poetically illustrate grace. An act of grace is frequently defined as something good unexpectedly bestowed simply because of the faith of the receiver of grace. We have faith that technology can make our lives easier and more interesting, just as we have faith in the abilities of dancers to intrigue us and excite our senses. I was interested in exploring the connection of those seeming opposites - the machines and the humans. I conceived *Grace* as a modern dance experience of effortless beauty (which is another definition of graceful) with the vivid abstract artwork of Hiromi Okumura projected across the stage and original music recorded by Matthew Coley. Professional dancers Elizabeth Ferreira and Silvina Lopez Barrera engaged in intricate duets and solos in a space that responded to them, and which emitted sounds and video dependent on their actions. Aided by interactive technologies, the stage became a giant playroom where dancers moved through projections and created a sensory synthesis of dance, music and visual art. See Table 4.1 for a listing of the technology used.

Because a thematic concert of dances doesn't spring fully formed to the stage, an extensive rehearsal period is required in which ideas are explored, expanded and finally formed into dances. Dancers are accustomed, of course, to bringing characters and atmospheres alive with their dancing, and have all the strength and control necessary to do that, but these dancers went beyond the traditional learning and performing of modern dance to improvise with the sound and video that the technologies made possible, and then made that improvisation look polished and complete – what we call “dancing in the moment. The dancers rehearsed with the interactive technologies and were able to fully use them in a creative way.

The dancers began the performance in stark black and white costumes that I designed to blend in with the first projections (black and white), and then to stand out from the colorful projections that finished the show. A combination of black tops and colorful leotards allowed contrast as well as blending with the projections and lighting, but also a progression from the starkness of black and white to the cheerfulness of color. The white in the pants also allowed the cameras to more easily sense the dancer's motion in low light. The stage at the Ames City Auditorium is 35' wide by 30' deep, and was set up to accommodate three different cameras and a video projector projecting to a white curtain (cyclorama) at the back of the stage. (Figure 4.2)

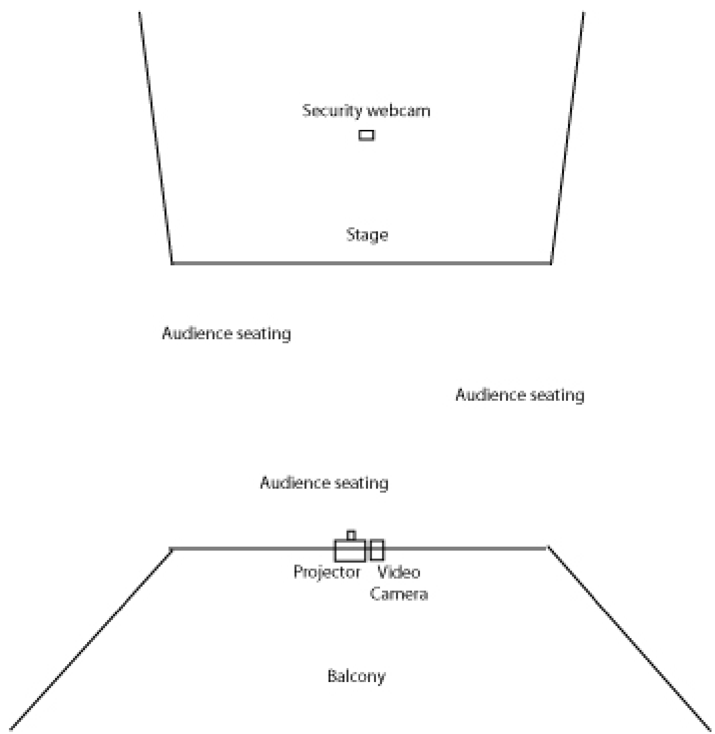

Figure 4.2 Stage setup for *Grace*

Table 4.1 Listing of technology and how it was used

Technology	Description
Isadora	programming environment for patching the technology
VDancer	wearable sensor system; used to send data signals based on the dancer's movement
Video Camera	a Sony video camera was placed in the balcony and focused on the stage to capture a clear view of the dancers on the stage space
Analog webcam	Radio Shack Security camera was placed above the stage; used to sense movement and translate to XY coordinates of the stage
Microphone	worn by the dancer; used to initiate movement on the projected background, based on the volume of the dancer
Wireless webcam	portable spycam; carried by a dancer to sense light to begin and end scenes; used to focus on the dancers on stage, to capture an image of the dancer

THE PROJECT

Using a blackbox theater as an example, I created a malleable visual environment for professional dancers. A blackbox theater is just that, a big box that allows lighting, sets, and seating to be placed anywhere so that the performance setup changes with the nature of the performance. For this project, titled *Grace*, the set was virtual, provided by video projection. *Grace* was scripted both for an installation, with specific events happening in a specific order, and responsive in live performance, with the performers altering the visual and sonic environment with their movement and placement on the stage space. The installation became more like a film or visual art exhibition, and less like a malleable environment, so I stopped working on that and concentrated on the performance and the performance space.

I am not as interested is concrete spaces as I am in the emotional space. A video projection, especially one that has movement, can create an emotional reaction in the viewer which then shapes how the viewer perceives the dance performance. Performance spaces can be shaped by our perceptions. People feel before they think, so any space must first create an atmosphere that charges the viewer. The dancer's space takes on various shapes in the viewer's eye because of the way the dancer inhabits that space. Lighting, movement and, in this case, video projection shape the viewers' emotions, predisposing the mind to a particular "color" of interpretation.. Video projections change our perception of the space and create a virtual set in which the dance takes place.

Figure 4.3 Here we see the dancer closed in by the multiple squares of video. The video image in each of the squares is a real-time image of the dancer, frozen at certain intervals determined by her place on stage. Those images changed as the squares were refreshed when the dancer changed place on stage. The sound, from pre-recorded pieces by Matthew Coley, is also initiated by where she was on the stage, sensed by the placed over the stage floor (see Stage Setup, Fig. 4.2) (www.vjw.biz/thesis/GraceMultiVid.wmv)

For *Grace*, I chose to use mainly cameras and microphones as tools for interaction.

The VDancer and another motion sensor on the dancer's body was used in rehearsal, but the latter did not prove robust enough for performance. The VDancer was used briefly in performance, and only to allow the dancer to control volume. Both sensors were used in rehearsal to encourage the dancers to control sound and create sounds, but in the short time we had the sensors before the production dates, the dancers did not move beyond being completely aware of the sensors, so their movements seemed contrived, not authentic. Martha Graham famously commented that dancers need to rehearse enough to be spontaneous, and we did not have the luxury of that much time with the VDancer. Because I was interested in unrestricted movement and unrestricted minds, I chose to develop programming generally for the non-contact sensors that were then working easily. Choreographically, I defined grace several ways, but developed programming from the definition and inspiration of effortless beauty. That idea lead me to make patches in Isadora that supported the dancer's movement, allowing the dancer to work in an effortless environment. I was not interested in the translation of body movement into visual art, as is *Biped* or *Ghostcatching* (see Figures 4.5 and 2.12), but rather that the technology provide an environment for the dancers. The dancers were meant to be seen as human movers; the environment as an aid to the dancers, and as a background setting for the audience's eyes.

In Fig. 4.4 (frame shots from *Singing Bowls*), the dancer controls the type of sound that is heard by performing movement in a certain place on the stage. An overhead camera 'sees' the stage and divides it into XY coordinates of columns and rows. The dancer initiates a prerecorded sound by moving into a certain combination of columns and rows. The projected image of the dancer is “exploded” when the real dancer moves with a certain quickness or speed, above a determined level. That energy is determined by looking at the real-time difference in pixels from frame to frame.

Figure 4.4 Images from Singing Bowls. (http://www.vjw.biz/thesis/GraceSgg1.avi)

The performance successfully demonstrated the versatility of my concept of a malleable environment that dancers shape by their “in-the-moment” decisions, and personal expression. The audience was witness to live improvisation, as evidenced by the fact that the sequences performed onstage and their timing were different from those in rehearsal, and different from performance to performance. Furthermore, the thematics of the dances were not restricted to “memory”, perhaps the most basic function (i.e., recording) that technology can perform. Rather, it had the interactivity of, for instance, the Internet, where the mind “at play” shapes the information or images it receives. “Grace” is elemental to dance. If a technologically enhanced environment can reveal grace, it can likely be applied to any artistic goal.

Of course, I faced the problem described by Wechsler of creating a dance that “showcased” a new technology. Because this technology was truly “interactive”, however, this fact did not become a creative constraint or damper on me, much less on the dancers. They were free to “play” with a new parameter, just as Loie Fuller or her dancers might have “played” in the costumes she designed, to discover what motions enhanced the billowing of silk and the play of light against it, or indeed just as a child might discover a new world of motion and experience by learning to ride a bike. They were “empowered” to become directors.

RESEARCHED DESIGN FORMS FOR TECHNICAL DEVELOPMENT

Part of the research that any choreographer does when creating a dance concert is to look at and consider other work. Whether that work has a direct effect on any individual's work is subject to debate, but any thinking artist will add observations of other's work to at least the thinking pile. All our work can be considered a compilation of our backgrounds, training, upbringing, and observations. Each of the following works has had some influence on my thoughts, if not on my on my own work, either because of its place in the development of an idea or because I consider it master work. The images represent either a visual display, a movement form, or an example of technology use that intrigued me.

One of the most widely known early examples of motion capture in modern dance came from Merce Cunningham's *Biped* (1999). Cunningham began working with choreography on a computer in 1989, using software that is now called Life Forms. Cunningham works with dancers as pieces on the stage, but the projection of *Biped* somehow adds an element of humanity as the symbolism of the projected images dwarfs the dancers. Paul Kaiser and Shelley Eshkar created the projections for *Biped*, using motion capture and 3-d drawings. Kaiser and Eshkar also work with choreographers Bill T. Jones, Trisha Brown, Wayne McGregor, and William Forsythe. Kaiser and Eshkar with Marc Downie have also developed software called the Choreographic Language Agent that uses language and grammar as the stepping off point for generating original movement material (http://openendedgroup.com/index.php/in-progress/choreographic-language-agent/)

Biped shows an example of motion capture in projected images interpreted by the software from the dancer's movement. The movement data is used to animate gesture drawn avatars which are projected on gauze hung downstage . Projecting through a transparent or translucent curtain is a way to approximate 3-D images.

Figure 4.5 Images from *Biped* (http://www.cunningham.com

Bridgman/Packer Dance Company have used video and still images to both provide a context for the dancer's size and to toy with the viewer's sense of reality. The projection of a real space and real humans in normal scale changes how the viewer perceives the dance. Suddenly it becomes a recognizable space that anyone can inhabit, and the dance becomes prosaic, not poetic. Fig 4.6 and 4.7 show images that play with the viewer's perception of what is real. In *Grace*, I chose images that alternately dwarf the dancer, and allow the dancer a space to inhabit.

Figure 4.6 Image from *Point A to Point B (You Can't Get There From Here)* (http://www.bridgmanpacker.org/gallery/gallery.html)

Figure 4.7 Image from *Memory Bank* (http://www.bridgmanpacker.org/gallery/gallery.html)

Both Bridgman/Packer's work with "life-size" human forms, and Kaiser and Eshkar's work projecting the "human write large" in a kind of symbolic evocation of the pathos of motion, encouraged me to try the opposite, shrinking the dancer into an Andy Warhol-like tableau in the section of *Grace* entitled *Singing Bowls* (Fig. 4.3). Warhol's soup cans, his first major works, showed the art world how beauty can be found anywhere, even on the shelves of supermarkets. This idea is similar to that of "grace". The beauty of human motion can be captured everywhere by the eye that seeks it out.

Troika Ranch's productions use images and real-time projections as part of the choreography. I was inspired by the monumental settings and the way size is used poetically, to create an atmosphere that surrounds the dancers, and is large enough to be noticed by the audience, but simple enough to not distract.

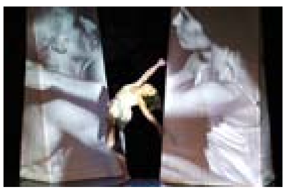

Figure 4.8 *Surface* shows an example of the choreographer using simple and monumental shapes as projection walls. (http://www.troikaranch.org)

Figure 4.9 Here the image implies 3-D because it is front projected on the dancers' bodies. (http://www.troikaranch.org)

Alwin Nikolais used images and dancers as part of the image to not only intrigue the eye, but to change the viewer's perception of reality. Because the projections were almost always from the front, he used the dancer's shadows as part of the image, and placed the dancer in the set when he wanted to include the dancer as simply part of the visual art. Figures 4.10 and 4.11 show what a difference it makes. For *Grace*, I gave careful consideration to the placement of the video projector; whether it should be placed in the balcony so it would project on a steep enough angle to put the image behind the dancers (and minimize shadows) or in the front of the house so the projection would be low enough to use the dancer's shadows on the backdrop as part of the image.

Figure 4.10 A front projection almost always shows the shadow of the dancer as part of the projection. For this reason, rear projection is used when the dancer needs to be separated from the image. (http://www.nikolais.org)

Figure 4.11 Image from *Tent*. Video projected on bodies plays with the viewer's perception of what is real and what part the dancers play in the dance. (http://www.nikolais.org)

Forms for *Grace*

Dancers use form the way artists in other disciples do, except that in a dance performance the form only becomes apparent over time. Unison, canon, ABA, repetition, rondo, accumulation, and others, are forms that are used to develop a movement sequence into a dance. For *Grace*, I used a theme, and variations on that theme; deforming the original movement sequence, representing the past, by applying abstractions until it evolves into a dance sequence that is more representative of the present. Video projections and virtual dancers show the inner monologue, and the performance becomes poetic. The scenario begins with a dancer being acted upon, and through a series of dances is re-formed into an active participant in the environment. The interaction between technology and dancer reflected the same process; at first, the technology leads the dancer, rather than be lead by the dancer. It exists in its own time and the dancer responds to the technology. As the performance progresses, the dancer interacts with the technology and finally engages in a conversation with the dancer: the dancer creates a movement, the technology responds with sound and visual projection, then the dancer responds to that sound, which prompts the technology to respond to the dancer, and so on.

Grace used projections to define the space and thus the viewer's perceptions of the characters onstage.

For several of the dances, I created rules for the structure of the dance, and then asked the dancers to improvise within those rules. This is a common way to maintain cohesion throughout a dance, but still give the dancers freedom for self-expression. In Digital Choreography, 1998, Sarah Rubidge states:

> “In dance similar devices were used by Cunningham and post-Cunningham dance artists. The latter created pieces in which the performers learned phrases of material which were then used as a base for improvised performances which operated within the constraints of a set of parameters determined by the choreographer.”

Each performance is different, but the choreographer's intent remains the same.

In *Shooter* (excerpt from *Grace*), the dancers improvise on a particular floor pattern, creating their own locomotor movements, and altering their movement in terms of time (speed, rhythm, variations on quick and slow, etc.). The projected colors are generated from rules of 3-D color depth (red appears closer; blue appears farther) and echo their visual illusion - the closer the dancer gets to the audience, the warmer the projected color (red), the farther from the audience, the cooler the color (blue). Later in the dance, the colors give way to a projection of a painting by Hiromi Okumura that gives the sense of dancing within and surrounded by the colors. Again, I was working toward creating an environment that supported the dancer, allowing the dancer to exist effortlessly in a performance space.

Figure 4.12 Image from *Shooter*

Interactive dance and technology can engage the viewer because of the relationship of movement and sound, or movement and image. Some audience members find this intriguing and some find it distracting.

EVALUATION OF *Grace*

As with any art performance, most evaluation is subjective. During the rehearsal process, I asked Janice Baker, dance faculty at ISU the following questions:

- is it engaging? are you taken somewhere?
- does the visual environment add to the emotional environment?
- does the visual environment attune to performer's 'mood'?
- is there a visceral engagement?
- does it tickle the eyes?
- does it tickle the mind?

Her answers to those questions shaped the composition of the concert and the selection of images, but not the choreography. Because of the nature of this concert, the dancers had free rein to create movement in some sections, and worked in a more traditional rehearsal in others. Ms. Baker responded to the dancers' movement choices with comments such as:

"that left me cold"
"too long"
"not enough dynamic changes"

In other words, she behaved like an audience member (albeit a very informed audience member) and responded to the movement in a spontaneous manner. I used her responses as I would any outside eye, and made changes as I saw fit in the choreography, the composition of the concert, and the image selection.

Sarah Rubidge (Digital Choreography, 1998) discusses evaluation not of choreography, but of composition and interaction from the critic's point of view:

- Did the piece draw attention to the haptic systems, did it appear to generate an emergent choreographic form?
- Did the work have content or was it merely a display of technological virtuosity?
- Was the piece accessible? If so how did the artists achieve this? If not, why not?

Grace was not created as a research project, so evaluation of the performance took place as an afterthought, unlike the normal evaluation during the rehearsal process. There is an ongoing conversation about whether the audience should see a direct relationship between movement and the sound or visual projection that is the result of the interaction of movement and technology. I believe that the theatrical experience is more important than the awareness of interaction, and thus I pay more attention to the relationship of sound and image to thematic content than to whether the audience has a more than visceral knowledge of the connection of interaction and dance.

Do Interactive Technologies Empower Dancers?

How do we validate that the feeling of empowerment occurs, and that the product is good?

Interviews of professional dancers indicate that the use of interactive technologies adds a level of challenge that enhances the dancer's enjoyment of rehearsal and performance. The dancers that use them, report enjoying the sensors that allow them to alter the environment, and enjoy developing the skills that allow them to use sound as an accompaniment rather than as a taskmaster. Those dancers interviewed also discussed the difference in the creative skills required to use, rather than be used by interactive technologies. Dancers that regularly use interactive technologies also indicate a level of impatience for the setup and teardown time, and a dislike of technology that doesn't work or is uncomfortable. Waiting for a computer to reboot, or for the wiring necessary to keep a flex sensor on a costume, or re-soldering a connection tends to negate the attraction of the challenge and control.

Sarah Rubidge, in a report on her project *Fugitive Moments*, notes the wide variety of dancer/programming interaction in the piece. Note that there are two meanings of the word "interactive". In the context of the dance the choreographer/programmer can give the impression of interactivity when the system is strictly speaking reactive, by structuring the programming so that the computer system and the participants seem to interact, for example, the dancers respond to the programming that their own movement has created. Computer sciences would define an interactivity as a change in the very structure of the program by an outside stimulus. This typically occurs when the program code itself adapts or "learns" from an outside stimulus—a situation that, in the dance context, may be realizable by the non-programmer in the future, but is not currently. For present purpose, the realtime conversation of system reaction and dancer behavior change is what shall be understood as interaction.

Choreographer/dancer Robert Wechsler believes that interaction is essentially psychological, and is present when different groups or systems are combined with a real-time give and take, rather than memorized action. In Artistic Considerations in the Use of Motion Tracking with Live Performers: a Practical Guide, he states: "In all cases, interactivity depends on a certain degree of looseness, or openness in the artistic material, which allows for a convincing exchange to take place." (p. 5)

The questions of whether the interaction between a dancer and a computer system is good, and whether the interaction should be unconstrained are not addressed by this thesis. Rather the more important questions, it seems, are how interaction is used. In any setting, from education to professional performance, there is interpersonal interaction between dancers and choreographer/directors, and interaction between audience and performers. Each party serves as the mirror to the other, expanding self-knowledge, or as teacher of the other, opening possibilities, or as two parts of a bridge. The questions should address what kinds of interactions make better art, or better performers, or better learners.

Dancers can use interactive technologies to control their environment in class and rehearsal. Not only can interactive technologies be used on stage to enhance the audience's experience, but they can also be used in class and rehearsal to train the dancers to think about their roles as creative artists, and to give immediate feedback, as mirrors do in a more traditional rehearsal space. In order for dancers to take advantage of that creative environment, they must come to rehearsal with a mindset that includes participating in a way that goes beyond being a tool of the choreographer. Interactive technologies can aid in training dancers (especially modern dancers) to include more than just movement technique and space/time/energy concepts in their education. Silvina thinks she is making the same gesture, but the VDancer doesn't respond with a sound, so she knows that her gesture is not accurate. Elizabeth believes her floor pattern is interesting, but the resultant music is discordant, so she chooses a different floor pattern.

Experiences I had as a guest artist, working with elementary school students in an introduction to modern dance and creative movement originally motivated me to ask whether people can be trained to make those creative choices in rehearsal. Is there a difference in learning when interactive technology is used? Although I use interactive technologies with professional dancers on a regular basis, I was curious about using technologies with less-experienced dancers.

An Experience with Young Students

In an effort to connect student's movement in space with the space itself, I created a simple program that looks for movement and associates the place where that movement happens with a piano-like pitch. Using a video camera and a computer running Isadora® I allowed the students to freely improvise in the space.

With the camera hung overhead and looking down at the stage space (approximately 30 by 20 feet), the students were able to change the pitch and volume of the pitch by moving to different places on the stage space. The camera 'sees' the space; the eyes module in Isadora® interprets those pixels in terms of a user specified number of columns and rows, in this case 100 columns by 60 rows.

Gymnasium setup:

Figure 4.13 Diagram of the gymnasium setup for using interactive technology in class.

What I found is that everyone, children and adults alike, is enamored with making as much sound as possible by moving in front of the camera. During the first improvisation, no one paid any attention to their movement choices; no one even listened, much less listened critically, to the sounds they made; they just moved to make noise, the equivalent of “banging on the piano”. I quickly became impatient with the noise and reduced the MIDI program to piano sounds. A dancer remarked that she felt like a cat on a piano, so we named this 'dance situation' “The Cat”. I then asked the students to create a short dance that initiated or combined sounds that they liked. Very few students were able to abstract elements from the improvisation to form a composition. When asked, they created dances that were commensurate with their composition experience, but created with little regard for the sounds they were making. I came to the conclusion that more training was necessary to teach the students about the elements of dance composition including sound. Then I taught a simple dance that involved a very narrow movement vocabulary (walking, running, leaning, flicking hands and feet, looking different places in the room) with time inserted for their own, shorter, compositions. The combination of my structure and their additions made a satisfying dance that allowed them to gauge the product in their own opinions. They were then able to create their own dances using interesting floor patterns.

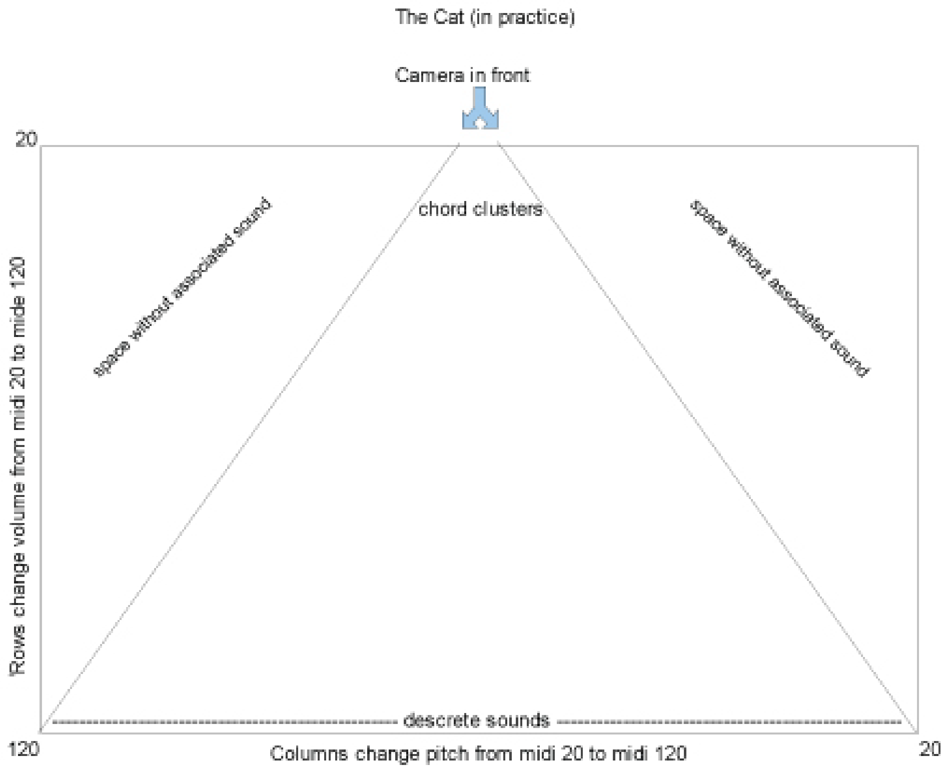

Figure 4.14 A diagram of the revised gymnasium setup

The same dance in a different gymnasium did not allow for hanging the camera overhead, so the camera was hung as high as possible, but looking at the space from a diagonal. In fact, that configuration turned out to be the norm in all subsequent gymnasium spaces. The difference in camera angle meant that the rows the camera saw included the vertical space (Z), not simply the XY of the floor. This also meant that instead of a rectangular space, the dancers worked in a conical space, with the result that the farther from the camera one was, the more stable the standard of one pitch per column was. As the dancers approached the camera, however, there were many pitches per column which resulted in tone clusters. That turned out to be a happy accident as the dancers were able to control the sound density as well as its pitch and volume.

I intend to try this again, with a group of young dancers who meet regularly and I will integrate composition training with the interactive technologies.

Chapter 5 Future Work

I set out to develop a system that uses interactive technologies to give the dancer more control over the stage environment. Based on the work I have done in the creation of a malleable, real-time, responsive system that a dancer or company could both afford and use, I have found that there are uses in rehearsal, performance, and dancer training, as well as applications for general education, and entertainment.

I see several areas for further investigation beyond continuing work with my own company: promulgation of the system for dancers and dance companies; possible commercialization of the VDancer as part of that promulgation; further study of responsive environments in the training of dance makers; creation of applications for teachers; a longer term study that looks at the effect of interactive technologies on the creative process. There are also practical problems that need to be addressed, such as creating an instruction manual, or at least a coherent collection of notes from our experiences.

Technology is in evident use on the stage and in entertainment venues, and as designers, directors, and choreographers seek out technologies that support their work, interactive systems will become more common. Through the use of the VDancer in performance and in my work with students, I will continue to show audiences and performers some of the possibilities that exist for interactive technologies.

There are applications for interactive systems beyond dance, and I would like to investigate other areas that may find interactive systems helpful. For instance, therapeutic uses of interactive systems are in use in hospitals, nursing homes and other medical environments, and I believe the VDancer would work well in those and other situations. This would involve commercializing the VDancer so that it could be used and abused by the non-dance population.

Before anyone can use the VDancer, either commercially or in controlled situations, applications need to be created and tested. Because of the work I've done with interactive technologies especially over the past five years, I have created several applications that now need to be put together as a product and publicized for use by others. There is an interest in general education for using interactive systems, and have worked with a teacher in a talented and gifted program to develop an application for her students, but publishing that application is the next step.

The qualitative aspects of the study I conducted proved more interesting than the quantitative. I am interested in developing a longer term study of the use of interactive technologies in both dancer training and in general education that looks at whether there is any increase in the acceptance of dance, any increase in the depth and creativity of the dances made, and any increase in student's enjoyment of the processing of making dances. This will not only inform the use of interactive technologies, but with a larger sample size, will indicate whether there are any lasting effects from the use of interactive technologies.

I discovered that interactive technology systems behave differently on stage than in the studio. Although we have tested all the systems we use thoroughly in several different settings, including testing the Ames City Auditorium for "ambient electricity" that might disrupt the radio frequencies, the systems frequently exhibit quirks in performance. A more robust stressing of the interactive systems before dress rehearsal is in order, but because of expense and time constraints, we (and other companies) cannot spend much rehearsal time on any stage. Every effort is made to anticipate problems before moving into the theater, but consistent problems indicate that finding ways to stress the system must be created outside the stress of rehearsals, and then studied to find consistencies or inconsistencies.

Because these systems are so new, there is also only memory and occasionally notes, but no instruction manuals. For instance, the order in which the computer, the projector, the software and the external sensors in cabled and turned on is important, but also different for different makes and ages of projectors. Creating an instruction manual is in order.

APPENDIX

KEY TERMINOLOGY

Form:
Canon - same thing at different times
Random - different things at the same time
Unison - same thing at the same time

Hitting a mark
Literally standing on a mark on the floor. Performers hit the mark for to be in the correct physical place for a light cue; the correct place and time for a choreography cue; the correct place and time for a sound cue.

OSC (Open Sound Control)
"OSC is a protocol for communication among computers, sound synthesizers, and other multimedia devices that is optimized for modern networking technology. Bringing the benefits of modern networking technology to the world of electronic musical instruments, OSC's advantages include interoperability, accuracy, flexibility, and enhanced organization and documentation." (www.opensoundcontrol.org)

Patch
A combination of programming that sets a video projection or sound presentation.

Tone cluster
A simultaneous collection of musical sounds comprising at least 3 consecutive tones in a scale

MIDI (Musical Instrument Digital Interface)
"...an industry-standard protocol that enables electronic musical instruments (synthesizers, drum machines), computers and other electronic equipment (MIDI controllers, sound cards, samplers) to communicate and synchronize with each other. Unlike analog devices, MIDI does not transmit an audio signal — it sends event messages about pitch and intensity, control signals for parameters such as volume, vibrato and panning, cues, and clock signals to set the tempo. As an electronic protocol, it is notable for its widespread adoption throughout the music industry. MIDI protocol was defined in 1982." (wikipedia)

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SOFTWARE DOWNLOADS

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EyesWeb	http://www.infomus.org/EyesWeb/EywPlatform.html
DanceForms	http://charactermotion.com/products/danceforms/

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