A CASE STUDY OF MERCE CUNNINGHAM'S USE OF THE LIFEFORMS COMPUTER CHOREOGRAPHIC SYSTEM IN THE MAKING OF *TRACKERS*

by
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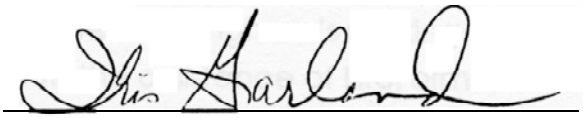

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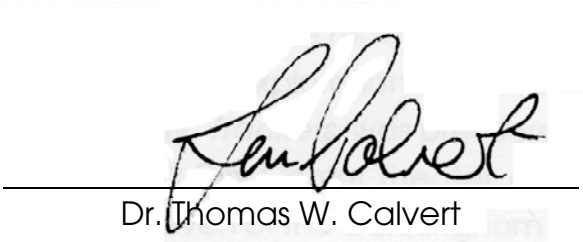

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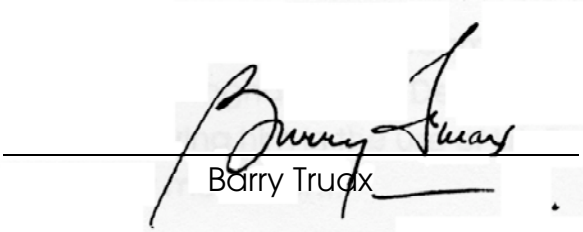

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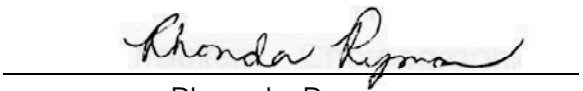

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A Case Study of Merce Cunningham's use of the LifeForms Computer Choreographic System in the Making of *Trackers*

Thesis for M.A. Under Special Arrangements
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Abstract

The thesis examines Merce Cunningham's making of the dance *Trackers,* which was created with the assistance of LifeForms, a computer choreographic software tool developed at Simon Fraser University in the computer graphics research lab. LifeForms provides an interactive, graphical interface that enables a choreographer to sketch out movement ideas in space and time. The making of *Trackers* is an example of an ongoing process of exploration in Merce Cunningham's work with computer technology. *Trackers* was premiered on Tuesday, March 19, 1991, at the New York City Center Theater, and was performed by Merce Cunningham and eleven of the Cunningham Company dancers.

The author, a member of the LifeForms design team at Simon Fraser University, has worked with Cunningham since December 1989 for a period totaling seventy five days, tutoring him in the use of LifeForms and supporting his creation of new movement.

The history of dance and the use of computers is examined in order to provide technological context and supporting material to the case study of Cunningham's making of *Trackers.* Choreographic process as it occurs in the studio is explored, in order to assess how computer technology can be used as a supportive tool in the creation, recording and interpretation of dance. This provides a background to the description of computers systems that have been developed for dance.

The case study examines the evolving versions of LifeForms used by Merce Cunningham since December 1989, and describes in detail the system used by Cunningham to create *Trackers*. It investigates how the study of design process has affected the implementation of LifeForms. It also describes the history of the Cunningham/ LifeForms relationship: Cunningham's use of chance procedures, the installation of the computer system and software, Cunningham's learning process, and the creative process and methods used by Cunningham to make the movement within LifeForms to create the dance *Trackers.* The study concludes that computer technology can enrich the creative experience of choreographers by providing new methods to explore movement compositionally and recommends further directions for choreographic research.

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Chapter I. Introduction

"We have noticed a growing communication among intellectual disciplines that takes place around the computer.... But surely the computer, as a piece of hardware, or even as a piece of software, has nothing to do directly with the matter. The ability to communicate across fields -- the common ground -- comes from the fact that all who use computers in complex ways are using computers to design or to participate in the process of design."

H.A. Simon [1]

"The necessary foresight for the solution of our age must come not only from the deepest scientific thought but also from the deepest of artistic thought."

H. Shore[2]

The following study examines Merce Cunningham's making of the dance *Trackers,* which was created with the assistance of LifeForms, a computer choreographic software tool developed at Simon Fraser University.[3] The making of *Trackers* is an example of an ongoing process of exploration and discovery in Merce Cunningham's work with computer technology. *Trackers* was premiered on Tuesday, March 19, 1991, at the New York City Center Theater, and was performed by Merce Cunningham and eleven of the Cunningham Company dancers.

This study has taken place over a time period from December 1989 to September 1992. The author, a member of the LifeForms design team at

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1 Simon, H. A., (1981). *The Sciences of the Artificial*, The MIT Press, Cambridge, Massachusetts, 1981, p. 159.

2 Shore, H., (1986). "Beyond TRON: The Technological Challenge to the Arts", *Art and Reality A Casebook of Concern*, Talonbooks, Vancouver, October 1986, p. 5.

3 See Calvert, T., Welman, C., Gaudet, S., Schiphorst, T., Lee., C., "Composition of Multiple Figure Sequences for Dance and Animation", Visual Computer (1991) 7:114-121, Springer-Verlag, 1991, and Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", InterChi proceedings, InterChi Conference, Amsterdam, April 1993.

Simon Fraser University, has been responsible for installing the LifeForms software in Cunningham's studio in New York, tutoring Cunningham in its use, and supporting his creation and exploration of new movement with the LifeForms system. During the time that Cunningham has been using LifeForms, the author has traveled to New York to work with Cunningham on thirteen occasions and worked with Cunningham for a total of seventy five days. The installation of the LifeForms choreographic software in Cunningham's Westbeth studio in New York city in December 1989, and the learning and creative process that ensued, has spanned a three year period as of this writing. The working method between Cunningham and the author evolved during the first year in which LifeForms was installed in Cunningham's studio. Cunningham would generally work for two to three hours in the afternoon with the author. During these sessions it was the author's role to facilitate Cunningham's use of the system by exploring features of LifeForms and supporting him in his creation of movement. In addition to participating in, and observing the learning and working process of Cunningham, the author also had a number of discussions with Cunningham that focused specifically on the making of *Trackers* in which Cunningham shared detailed observations, choreographic notes, and explanations of how movement phrases were created using LifeForms, how these phrases were rehearsed in the studio with the Cunningham dancers, how working with the software affected his choreographic methods, and most importantly how LifeForms enabled him to extend his imagination and expand possibilities for creating movement.

Chapter 2 of this study reviews literature in the area of computer technology and dance. It is intended to provide technological context and supporting material to the case study of Cunningham's making of *Trackers* with LifeForms.

Chapter 3 examines the evolving versions of LifeForms used by Merce Cunningham since December 1989, and describes in detail the system used by Cunningham to create *Trackers*.

Chapter 4 describes the history of the Cunningham/ LifeForms relationship: Cunningham's use of chance procedures, the installation of the computer system and software, Cunningham's learning process, and the creative process and methods used by Cunningham to make the movement within LifeForms to create the dance *Trackers.*

Trackers is the first of the three new dances that Cunningham created in 1991 (all of which were conceived in part using LifeForms). Cunningham has commented on the computer's ability to re-define the imaginable, or even the possible. "I have had the same fascination with movement that I've had all my life. I find it all just as maddening, mysterious and exhausting. The point is that dance need not refer to something else. It is what it is. But you can get fixed ideas, and it can get restrictive. So, I try to put myself in a precarious position."[4] Cunningham's work with LifeForms is a continuation of his ability to move beyond the restrictive to the precarious position embodied by exploration.

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4 Jennifer Dunning, quoting Merce Cunningham in "For Cunningham, Dance is as Mysterious As It Ever Was", *New York Times*, March 11, 1990.

Chapter 2 History and Literature Review

> *"It would be possible to describe everything scientifically but it would make no sense; it would be description without meaning, as if you described a Beethoven Symphony as a variation of wave pressure."*
>
> *Albert Einstein*[1]

2.1 Introduction

Over twenty years ago, Merce Cunningham imagined the design of a computer technology that would enable three-dimensional figures to be displayed on a computer screen. He spoke of these figures moving in spatial relationship to one another, thereby enabling a choreographer to visualize dance stored on the computer. Cunningham referred to this at the time as a form of electronic notation:

> I think a possible direction now (in 1968) would be to make an electronic notation...that is three dimensional.... it can be stick figures or whatever, but they move in space so you can see the details of the dance; and you can stop it or slow it down.... (it) would indicate where in space each person is, the shape of the movement, its timing. [2]

At the time Cunningham made this statement, computer technology to create or to display movement for three-dimensional human figures did not yet exist. Yet Cunningham's projections describe very closely features of the LifeForms computer choreographic system as it was designed years later.

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1 Clark, Ronald, W., citing Albert Einstein in *EINSTEIN The Life and Times*, World Publishing Company, 1971, p. 192.

2 Merce Cunningham, "From Notation to Video" *The Dancer and the Dance,* Marion Boyers Inc., 1980, pp. 188-189. In this excerpt Cunningham refers to his earlier statement about computers and notation that appears in *Changes: Notes on Choreography*, Edited by Frances Starr, Something Else Press, Inc. 238 W 22d St. New York (1968).

This chapter reviews literature in the area of computer technology and dance, to date. It is intended to provide technological context and supporting material to the case study of Cunningham's making of *Trackers* with LifeForms. The design and implementation of the LifeForms choreographic software, and in fact, the notion of computer compositional systems for movement itself, is strongly interdisciplinary. In the area of dance and computer technology, existing knowledge and theory in a number of overlapping academic disciplines have informed the design of LifeForms. Among these are Movement Analysis, Compositional Theory, Design Theory, Computer Human Interface Design, Linguistics, Computer Graphics and Animation, and Dance History. The scope of this literature review is limited to the area of computer technology and dance that has presaged and informed the design of LifeForms, and has made possible the creation of Cunningham's dance *Trackers*.

Before specific areas of technological development in dance are cited and examined, it is important to review how choreographers work with dancers in a studio to create dance. Therefore, this chapter first discusses important elements of the choreographic process as it occurs in the studio without the computer, in order to later assess how computer technology can be used as a supportive tool in the creation, recording and interpretation of dance.

2.2 Traditional Choreographic Process

Choreographers create dances beginning with some creative impulse or idea, and then physically work out this idea in the studio with dancers. Merce Cunningham has noted that "dance is most deeply concerned with each single instant as it comes along, and its life and vigor and

attraction lie in just that singleness."[3] Conceiving dance is `of the body', and therefore has a large non-verbal creative component which can be made manifest only through the ephemeral physicality of the body. With regard to this, Evan Alderson has stated:

> dance scholarship has struggled against the ephemerality of dancing, when what perhaps it should also be doing is trying to comprehend, from the deep perspective, something of the nature of those many aspects of dance and movement that resist stability, that are inherently kinetic and that cannot be fully extricated from the bodies that made them.[4]

A dancer provides the choreographer with a living physical instrument from which to create. Merce Cunningham recognizes this when he says of his dancers, "I conceive of a phrase... and I watch what each dancer does to bring it to life. I don't give instructions, like `Act like a man who is drunk!' The way of dancing comes from my dancers, not from me."[5]

In general, when the choreographer begins to work, the initial creative impulse can take many forms. Choreographers can begin their work from a specific physical movement, observed, imagined, or created. The creative impulse can take the form of a question, such as "How can I explore falling movement?" Or the creative impulse can begin with a musical phrase, a visual image, or a particular state of mind. Even in the case of movement or an idea without particular pre-formulated context, what can be called "pure dance", the choreographer frequently develops thematic material through an exploratory structuring technique. Or the choreographer may develop the initial movement idea through

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3 Merce Cunningham, "The Impermanent Art", *7 Arts* No 3, Indian Hills, CO, 1955, p 314.

4 Evan Alderson, Proceedings of the *ADUCC (Association for Dance in Universities and Colleges in Canada), Conference,* Concordia University, Montreal, October 1991.

5 Merce Cunningham quoted in "Great American double-act back on the tracks", *Guardian Weekly: Le Monde*, October 27 1990.

some event or comment in the environment. If there is a specific context, such as a particular exploration of space, a striking dream image, or a piece of music or dramatic plot, the choreographer may draw out or illustrate spatial possibilities on paper, may simply think or muse about the image, or may listen to the music or observe the story and absorb its "sense", its dynamic qualities, its tempos, or in the case of expressive dance its statement of emotional flow. From all of the stimuli, the choreographer explores and develops the generative idea either intuitively or constructively[6], using chance or deterministic structuring procedures. Or, a choreographer may interpret music, image, feeling or narrative, creating or finding movement that seems to successfully capture its essence.

In Merce Cunningham's creative process, he acknowledges that all movement or gesture is inherently expressive, regardless of the choreographer's intention, and says that for him, attempts to "interpret" meaning are unnecessary. In 1955, in the wake of the modern era of dance, which brought forward such greats as Martha Graham, Cunningham stated:

> ...in reference to the current idea that dance must be expressive of something and that it must be involved with the images deep within our conscious and unconscious, it is my impression that there is no need to push for them. If these... archetypical images lie deep within us, they will appear, regardless of our likes and dislikes, once the way is open. It is simply a matter of allowing it to happen. So if you really

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6 Koenig uses these terms to describe compositional approaches in music, and suggests that there are two ends in a continuum between "intuitive", on the one end, which can be thought of as right-hemisphere synthesis, and "constructive" on the other which tends toward the left-hemisphere analytical. Koenig suggests that composition moves between these two extremes freely, but that a composer may tend to create more predominantly on one end of the continuum. See Koenig, G.M. (1980). *Composition Processes*, in Computer Music, M.Battier & B. Truax, eds., Canadian Commission for Unesco, Ottawa, 1980.

> dance--your body that is, and not your mind's enforcement--the manifestations of the spirit... take on the shape of life.... If it is there, it is there; we do not need to pretend that we have to put it there.[7]

At the same time, Cunningham has also acknowledged that there are many different ways to create, and that no one way is better than another-- they are simply "different". When asked in an interview what he thought of postmodern dance that was supposed to be so much more radical than his own work, he stated:

> I have never rejected movement, which I feel to be the foundation of dance.... I am perfectly willing to accept other approaches, such as those developed from images or ideas. What I care about is the quality of the movement. [8]

In the studio the choreographer works with the dancers to build the piece by physically creating and structuring movement[9]. The dancers may improvise with the choreographer's initial compositional material to create movement. Some choreographers may work with notes, sketches, and floor plans, and some will record work in progress with a video camera to act as an objective eye and a memory aid. This is an iterative and interactive process and proceeds over a period of weeks or months until the dance is complete. Some choreographers begin first with broad spatial outlines and then go back to develop the detailed movements, while others will begin with some specific movement material, then develop phrases, and then sections. Many do both simultaneously. Structurally, a choreographer will always need to move between the design of the

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7 Cunningham, Merce, "The Impermanent Art",*7 Arts* No 3, Indian Hills, CO, 1955, p 311.

8 Merce Cunningham quoted in "Great American double-act back on the tracks", *Guardian Weekly: Le Monde*, October 27 1990.

9 For further reading on choreographic process see Blom, A.L. and L.T. Chaplin (1982) *The Intimate Act of Choreography*, University of Pittsburgh Press, 1982., or Humphrey, Doris, *The Art of Making Dances,* New York: Grove Press, 1962.

overall dance and the design of the more detailed levels of section phrase and particular movement or gesture. In addition to this, the incidence of unforeseen elements introduced either by the dancers, or by the process of creating movement itself often affects the making of dance. In choreography, as in all creative disciplines (including scientific experiment and discovery), error and mistake often play a crucial role in the creative process. Some choreographers have distinguished between the initial creative idea(s) and the composition or construction of the dance. For example, the choreographer Murray Louis has said:

> Until I taught Composition I had always equated good choreography with creativity. I know now that this is not the case. Creativity is the source.... composition is a skill, a craft that can be taught and learned, the means and method to structure creativity.[10]

Computer based systems are designed to assist, not to replace the compositional process. Dance itself is a kinesthetic experience and cannot be replaced or replicated by technology. The role of the dancer as the physical instrument through which dance is experienced has never been intended to be displaced, deprived or supplanted by the use of computer technology. Researchers and designers of computer systems for dance have been concerned about issues of creativity, representation, and mechanization in their exploration of the possibilities of using computer technology for dance:

> One can wonder about the accuracy of *expression* which will be possible. Can the *soul* of a dance be animated? Or is this too much to ask.... this aspect could lead to interesting studies in body language and communication. Can the *effort* of a movement be computerized?.... there is potential value in

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10 Louis, Murray, (1980), *Inside Dance*, St. Martin's Press, New York, 1980, p. 119.

> (computer systems) being developed in regard to dance.... we must always remember that dancing is for people.[11]

In the literature review that follows, designers of computer based software tools for dance, have shared a common goal of supporting dance through the creation, recording or interpretation of movement, whether the computer based system has been to provide a means of editing notation, analyzing movement, or composing dances.

2.3 Existing Computer Systems and Dance

Researchers in the area of computer technology and dance have recognized that the knowledge of dance is distinct in experience and representation from the knowledge of computer systems. Designing computer systems for dance has provided many challenges in bridging these different methods of accessing knowledge. In order to accomplish this, it is necessary to codify and embody the language of dance so that it can be represented in the language of the computer system. This is not an exercise in simple and direct translation. It requires nothing less than a synthesis of physical dance knowledge with logical analytical computer science knowledge. This synthesis requires an interdisciplinary approach that recognizes systems design theory, computer graphics theory, computer user-interface design concepts and, perhaps most importantly, choreographic and compositional knowledge. From a systems design theory standpoint, this synthesis is a challenge in understanding the relationship between the human body as an expressive instrument and the design of computer technology, a product of the human design process. From a computer graphics standpoint, this requires programming techniques that adequately represent and model the human body

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11 Calvert, T.W., J. Landis and J. Chapman (1979). "Notation of Dance with Computer Assistance", *New Directions in Dance,* D.T. Taplin ed., Pergamon Press, Toronto, p. 175.

internally in the computer system, as well as techniques that specify human movement in a way that appears realistic and expressive to the choreographer.[12] From a user-interface design standpoint this is a question of mapping the internal mental model[13] of the choreographer's compositional process onto the mental model represented by the software interface so that the computer system can transparently interact with the choreographer as they create, and with the dancer as they learn movement phrases. And from the choreographers' and dancers' standpoint, this is an experiment in exploring new approaches to composition that affect and alter the choreographic process.[14]

> In perhaps no other application of computers is there such a disparity between the modes of thought of the users and of the system designers. The challenge to bridge this gulf is likely to benefit humanity as a whole.... Computers can be humanized. How to do this may become clear from trying to `dance' on a computer.[15]

Researchers in the area of computer systems for dance have intended these systems to provide an extension, to open out possibilities, to supply a working tool that provides a visual idea generator, and to support the

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12 Calvert, T.W. "The Challenge of Human Figure Animation", *Graphics Interface '88 Proceedings,* 1988, pp 203-210.

13 A mental model is the internal conceptual model that a human being constructs in order to understand the world. In his book, *Mental Models*, Harvard University Press, (1983), P. Johnson-Laird has combined theories in cognitive science, experimental psychology, linguistics and artificial intelligence. In the area of computer interface design, Donald P. Norman in his book *The Psychology of Everyday Things,* Basic Books, Inc. New York (1988) discusses the importance of mapping the mental model of the computer user, with the mental model of the computer designer in order to produce computer interfaces designs that enable clear communication between the user and the computer system.

14 Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", juried paper to appear in the *InterChi Proceedings*, InterChi Conference, Amsterdam, April 1993.

15 Herbison-Evans, D., "Dance, Video, Notation, Computers", *Leonardo,* Vol. 21, No. 1, pp. 45-50, 1988.

iterative and interactive nature of the choreographic process, on many levels.

There are two functional domains which will be examined in the area of existing computer systems for dance. The first, (shown in Figure 2.1) contains computer systems for dance notation. These systems have been implemented to facilitate the entry, storage and retrieval of dance notation scores. In addition to the entry of notation, some computer systems also interpret notation scores stored on the computer, by animating or simulating the human movement which is represented by the notation.

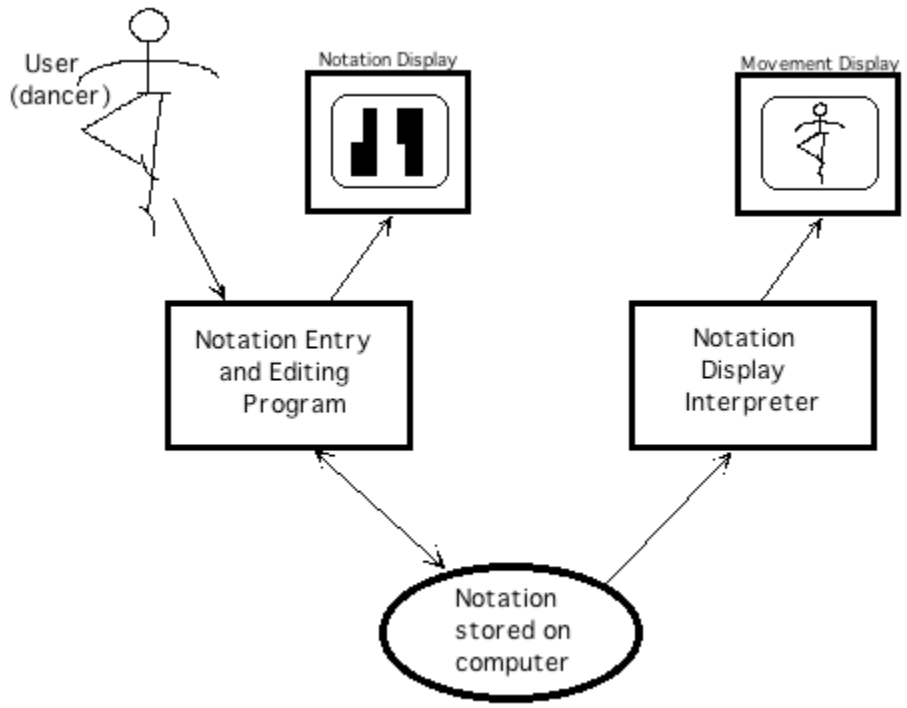

Figure 2.1. Computer systems for Notation Entry and Interpretation

The second functional area of computer systems for dance, consists of systems that are designed for dance composition and choreography. These systems differ from the entry and interpretation of dance notation in that the computer is used during the compositional process and its use affects the outcome of the dance. These systems are designed to assist the choreographer in visualizing and experimenting with movement during the creative process. In contrast, systems for dance notation are generally used to archive, preserve or document notation scores of the dance in order to provide a record of the choreography.

2.3.1 Existing Computer Notation Systems for Dance

Historically, notation systems for dance were the first interactive and graphical movement systems to be implemented for the computer. A number of systems for computer editing and interpretation of movement notation were developed and implemented in the mid to late 1970's. This development paralleled the arrival of interactive computer technology which enabled input and visual display via a computer terminal. Unlike standard music notation, in dance there is no single movement notation system in use today. Since commonly used movement notation systems[16] are represented symbolically and therefore are graphically based, it was necessary for computer systems to evolve to the point where they were able to visually represent the notation scores. The first notation systems adapted to the computer did not interpret or display the human movement that was symbolized by the notation scores, but did allow the

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16 Although a myriad of movement notation systems exist, Benesh notation, Labanotation, and Eshkol-Wachman notation are among the most commonly used movement notation systems that exist today. See: R.Benesh and J. Benesh, *An Introduction to Benesh Dance notation*, A.C. Black, London, 1956; A. Hutchinson, *Labanotation*, Theatre Arts Books, 2nd edition, New York, 1980; N. Eshkol and A. Wachman, *Movement Notation*, Weidenfeld and Nicholson, London, 1958.

entry, storage and editing of notation. Movement notation systems are detailed and often quite complex, because human movement is extremely complex. Notation systems provided an existing symbolic and analytical representation of human movement, and defined a language system sufficiently descriptive and concise that the notation system was translatable to a computer language structure. Notation systems also provided a higher level description of movement than the underlying mathematical models which described the human body and its movement in computer readable form.

Brown and Smoliar (1976) at the University of Pennsylvania[17] were among the first to develop an interactive graphics editor for dance notation. Labanotation symbols could be entered, stored and retrieved through the editor. Input consisted of commands typed in via a keyboard in order to create and edit Labanotation symbols. The importance of developing a more direct and intuitive user interface was recognized and it was thought that the development of a "natural language" which allow the user to type in natural language sentences consisting of actions (verbs) and body parts (nouns) would provide a more intuitive access to the notation score than having to remember the specific graphical symbols[18].

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17 Brown, M. and S.W. Smoliar (1976). "A Graphics Editor for Labanotation", *Computer Graphics*, Vol. 10, No.2, Summer 1976, pp. 60-65.

18 *Ibid*. p 64.

At the University of Waterloo, Savage and Officer (1977)[19] developed Choreo, an interactive computer model initially intended for choreography, which included both an editor for entry of notation and an animator which simulated a moving two-dimensional figure based on the notation scores. Interactive input was initially based on the Massine[20] method of notation because of the "recognizable correspondence between the notation and the mathematical methods of the computer model"[21]. Since Massine is not a commonly used form of dance notation, shortly afterwards a version named Choreo-L was implemented, based on the more popular Labanotation. At that time, an improvement of the user interface was one of the first modifications to be suggested:

> At first it was thought that the figure could be used for experiments in choreography. Although the goals have now been altered, it was apparent that a suitable method of interacting with the computer was imperative if dancers were to be stimulated by the concept. It was clear that dancers could not be expected to become knowledgeable of the computer in order to effectively use it.[22]

It must be understood, that at this time, computer interface design was in its infancy. A typical "state of the art" computer interface consisted of entering a series of low-level numerical codes, an incomprehensible set of alphanumeric characters, or a precise mathematical formula. The graphical desktop metaphor, which exists today, was not yet in existence.

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19 Savage, G.J. and J.M. Officer (1977). "CHOREO: An Interactive Model for Choreography", *Proceedings: Fifth Man-Machine Communication Conference*, Calgary, Alberta, Academic Press Inc. (London) Limited, pp. 233-249, May 1977.

20 Massine, L., *Massine on Choreography*, Faber & Faber, London, 1976.

21 Savage, G.J. and J.M. Officer (1977). "CHOREO: An Interactive Model for Choreography", *Proceedings: Fifth Man-Machine Communication Conference*, Calgary, Alberta, Academic Press Inc. (London) Limited, pp. 233-249, May 1977.

22 *Ibid*. p 234.

Initially it was the Systems Design department at the University of Waterloo that approached the Dance department about the possibility of exploring the usefulness of the human model software in choreography. The computer interface required a simplified representation of a human figure to be manipulated by entering the mathematical co-ordinates and angles for each one of the body parts. This does not easily map to the physical language of dance, and it was recognized at once as being impractical and cumbersome in choreographic terms[23]. Perhaps Albert Einstein described this dilemma best when he said, "It would be possible to describe everything scientifically but it would make no sense; it would be without meaning, as if you described a Beethoven Symphony as a variation of wave pressure."[24] As a compositional tool for choreography, the method of input was recognized as being too tedious and time-consuming, and the length of time involved in entering data was observed as being too long to keep the physical creative movement idea alive in the dancer or choreographer using the system. Although the system was not used for choreography, because technological advancements in hardware, software and interface design had not yet caught up to the concept, the vision of the possibility already existed. It was the recognition of the inadequacy of using a mathematical mental model as input in a choreographic tool which spurned the development of the dance notation interface. In the Labanotation version of the interpreter, the dancer described the dance by selecting the Laban symbols from a menu using an acoustic pen. This work was successful at a very basic level of movement description, but could not handle locomotor commands such as walking and jumping, or very intricate or detailed physical movement.

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23 *Ibid.* p. 234.

24 Clark, Ronald, W., citing Albert Einstein in *EINSTEIN The Life and Times*, World Publishing Company, 1971, p. 192.

Again at the Moore School of Electrical Engineering at the University of Pennsylvania, computer specialists Smoliar and Badler worked in cooperation with Laban specialist Lynne Weber (1978)[25] [26] to further evolve the Labanotation editor begun in 1975, focusing on the development of a data structure that could be the standard interface between an interactive graphic editor for Labanotation and the syntactic analysis of a compiler used to interpret the notation and simulate human movement for display. This was the most extensive work done to date, enabling far more detailed notation sequences to be entered, edited, and compiled (or translated) into a computer data structure that would then drive the display of the human figure. One of the important outcomes of this research was to show that it was possible to define human movement in such a way that it could be represented on a computer system. Reports of the work noted that "in seeking a digital representation of human movement, established movement notation systems provide a wealth of well structured information."[27]

At Simon Fraser University, Calvert et al (1979, 1982)[28] [29] developed a notation system for dance in which the computer was seen as a tool which could aid in the composition and editing of a movement notation

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25 Smoliar, S.W. and W. Tracton (1978). "A Lexical Analysis of Labanotation with an Associated Data Structure", *Proceedings ACM Annual Conference*, Vol. 2, pp. 727-730, 1978.

26 Weber, L., Smoliar, S.W., Badler, N. I., (1978) "An Architecture for the Simulation for Human Movement", *Proceedings of ACM National Conference Proceedings,* 1978, pp.737-745.

27 Badler, N.I., O'Rourke, J., Smoliar, S., Weber, L., *The Simulation of Human Movement by Computer,* Movement Project Report No. 14, September 1978, University of Pennsylvania, The Moore School of Electrical Engineering, p 93.

28 Calvert, T.W., J. Landis and J. Chapman (1979). "Notation of Dance with Computer Assistance", *New Directions in Dance*, D.T. Taplin ed., Pergamon Press, Toronto, pp. 169-178.

29 Calvert, T.W., J. Chapman and A. Patla (1982). "Aspects of the Kinematic Simulation of Human Movement", *IEEE Computer Graphics and Applications*, Volume 2, pp. 41-50, November 1982.

score, and as an interpreter which could animate that score. The principal goal outlined was in developing a system for computer-assisted composition. The program which interprets the Labanotation commands was based on original work by Zella Wolofsky[30]. "From the dancer's viewpoint, the main task is getting the figure to move naturally.... most dancers/choreographers would probably prefer to work with the reality of people than with the artificiality of the computer-driven figure. As long as the computer is used merely as a tool and not the means of expression, there is potential value in the system being developed in regard to dance."[31] At that time, it was further recognized that in order to program or create movement, a very detailed and exact specification of timing and body part placement had to be established. This is an extremely low level description of movement in comparison to the physical language in which the dancer usually converses. In order to relieve the choreographer from excessive detail, thereby introducing a certain level of intelligence into the system, the use of notation *macros* were evolved to simplify notation scores. This development highlights the importance of high-level abstraction in user interface design. The choreographer's creative process is supported when movement ideas can be realized on the computer system at a conceptual level that matches more closely the creative level of abstraction utilized in creating movement. For example, when a choreographer wants a dancer to walk, he or she may simply state "walk starting with the left foot". A high-level macro could be designed to specify walk left, then walk right, in a walk cycle that continued for a number of iterations. The notation produced from this macro would create reasonably accurate angle changes in the upper leg, lower leg

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30 Wolofsky, Z., (1974) *Computer Interpretation of Selected Labanotation Commands.* M.Sc. thesis, Department of Kinesiology, Simon Fraser University, April 1974.

31 Calvert, T.W., J. Landis and J. Chapman (1979). "Notation of Dance with Computer Assistance", *New Directions in Dance*, D.T. Taplin ed., Pergamon Press, Toronto, p. 175.

and foot. In the studio, a choreographer does not need to specify angle changes in each joint of the dancer's limbs in order to create movement, but this information is required by the computer to simulate the walking movement accurately. Another contribution to the research was the implementation of a system which sampled physical movement directly using a form of instrumentation. which attached electrogoniometers to a dancer's joints[32]. Although this system was somewhat cumbersome due to the bulkiness and proportions of the goniometers (roughly, they were about the size of a tennis ball), and the cabling which tended to inhibit movement, it established the possibility of sampling movement directly from a dancer's body, and the possibility of using physical analog movement data to drive an animated figure's display. At the time, Calvert recognized that a body stocking with smaller "integral strain-gauges" could be developed which would allow for greater range of motion. Indeed, today, a datasuit manufactured by VPL, Inc. exists and is commercially available[33].

At the University of Waterloo, Ryman, Singh, Beatty, and Booth (1982, 1983)[34] [35] developed a graphics editor for Benesh Movement Notation. This work was seminal in the importance ascribed to the user interface design. The user interface was recognized as "the most visible aspect and the only channel of communication between the system and the choreologist (user). The success of a system is entirely dependent on the

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32 Calvert, T.W., Chapman, J., and Patla, A., "The Integration of Subjective and Objective Data in Animation of Human Movement", *Computer Graphics.,* Vol 14,, No. 3, August 1980, pp. 198-203.

33 VPL, Inc., of Redwood City, California, manufactures a Datasuit, which is available commercially for about $80,000 US.

34 Ryman, R., J.C. Beatty, K.S. Booth and B. Singh (1983). "A Computerized Editor for Benesh Movement Notation", *CORD Dance Research Journal*, 1983.

35 Singh, B., J.C. Beatty, K.S. Booth and R. Ryman (1982). "A Graphics Editor for Benesh Movement Notation" CS-82-41, Computer Graphics Laboratory, University of Waterloo, December 1982.

success of the user interface. However, user interfaces are the most difficult and the least understood part of interactive systems."[36] As a result of the attention to detail given to the design and development of extremely important user-interface concepts this Benesh Editor was the first to be ported to a personal computer system (an Apple Macintosh in 1984). Some of the user-interface concepts incorporated into the design of the editor included recognition of the importance of selecting a conceptual model that incorporated familiar movement concepts to the user, the introduction of graphical icons to support system initiated conversational dialogue, consistency, simplicity, and feedback response.

At the University of Sydney, McNair, Herbison- Evans and Neilands (1980)[37] developed a movement language based on Benesh notation. More recently, Politis (1987)[38], also at the University of Sydney, has also developed an interpreter based on Benesh movement notation.

At Ohio State University, Lucy Venable and Scott Sutherland developed LabanWriter, a Labanotation Editor that has been implemented on the Apple Macintosh computer.[39]

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36 *Ibid.,* Chapter 5*,* p 29.

37 McNair, B.G., D. Herbison-Evans and N. Neilands (1980). "Computer Assisted Choreography Teaching", Proceedings of the 11th Australian Colleges of Advanced Education Computing Conference, May 1980.

38 Politis, G. (1987). "A Computer Graphics Interpreter for Benesh Notation", PHD Thesis, University of Sydney, March 1987.

39 Venable, Lucy, "Archives of the Dance (13): LabanWriter - There Had To Be A Better Way" *Dance Research,* The Society for Dance Research, Vol., IX, Number 2, Autumn 1991, pp 76-87, Oxford University Press.

2.3.2 Computer Systems for Choreography

The first known use of computers in the creation of a choreography occurred in 1964 when Jeanne Beaman and Paul Le Vasseur at the University of Pittsburgh[40] used a computer to generate random, performable dance sequences. They fed 20 different time variations, 20 different spatial directions, and 20 different types of movements into the computer which printed out 70 dances in verbal form, in a period of four minutes. This material fell into the aleatory category of composition, which Merce Cunningham had been using since the early 1950's (in Cunningham's case he had been using the I Ching to make random selections rather than a computer). The printed output gave directions such as: "Three medium beats, half turn clockwise, arc backward", or "6 slow beats, jump, diagonally back." As was the case in Cunningham's earliest explorations with chance, this movement material randomly produced by the computer stretches the imagination. The choreographer is challenged to find a physical reason or intent to produce what is suggested by the chance or random operations. In the case of the computer-produced list, the idea is to focus on the freedoms, not the limitations of the instructions. Choice in the use of dynamics was left open to the choreographer interpreting the score. The resulting dances could relate to existing music, co-exist with unrelated music, or could have music composed especially for the piece. Using this program, Beaman and LeVassuer made such dances as "Stationary Dance", "Cluster at the Centre", and "Circling Counter-Clockwise". This technique of randomly selecting compositional elements with a computer, closely paralleled approaches in computer music composition which were being explored at that time.

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40 Cited in "Computer-programmed choreography." *Cybernetic Serendipity,* 1967.

Michael Noll's visionary article published in DanceMagazine (January 1967)[41] was the first to suggest that a computer could be used as a visual scrapbook in the construction of dances. He proposed that dancing stick figures could be interactively controlled by a choreographer in order to visually design dance sequences, and that these sequences could be stored, retrieved and edited under the choreographer's control. In addition to these projections based on the existence of very new computer graphics technology, Noll also made a three minute animated film of a group of stick figures which performed movement selected randomly by the computer. Although his suggestions could not be implemented at the time, he foresaw that such a system would allow research into the choreographic process, and recognized that separate movements could be put together in different combinations and that various elements of randomness and chance could be used.

In 1978, Architect John Lansdown[42], saw possibilities for experimenting with computers and dance after observing computer experiments in composing music and poetry. Initially, Lansdown attempted to use Benesh notation, but soon became aware that the movement vocabulary needed to be greatly expanded to equal the results of a human choreographer in quality and scope. As was initially suggested by Merce Cunningham in 1968, and as had occurred with other experimenters, Lansdown turned to the visually immediate and direct representation of the human figure. The choreographic idea was for the computer to compose dancer's positional orientation keyframes at specific points in time, allowing the dancer to create the intermediate movements. The instructions included the specific spatial location on

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41 Noll, M. (1967), "Choreography and Computers", *Dance Magazine*, January 1967.

42 Lansdown, J., (1978), "The Computer in Choreography." *IEEE Computer* Vol. 11,No.8. August 1978, pp. 19-30.

stage, the direction faced, and the number of beats before the next key frame. Results of these experiments were performed by *Another Dance Group*, and led Lansdown to develop techniques for computer generated videotaping directions[43].

In Boston, Peggy Brightman (1984)[44], explored the use of *Choreo*, a computer compositional program combining Laban's work in Effort/Shape with a random generator. *Choreo* was a simple BASIC[45] program, modelled after a music composition program called *Project One* (1977)[46], by the composer G. M. Koenig. *Choreo.* printed an output list consisting of a series of events, which functioned as the choreographer's score. Each event was described in terms of the Laban Effort qualities of time, weight, flow, spatial effort, and use of space. The existence of Laban's work in Effort qualities provided the detailed analytical description of a set of movement parameters required in order to define a precise and rich movement language that could be codified via a computer. The program *Choreo* also permitted the choreographer to use procedures for the "degree of variation" which would be produced in the movement phrases output by the computer. These procedures selected by the choreographer were: repetition, random, retrograde and fragmentation. In concept, Brightman's work was similar to the work Jeanne Beaman and Paul Le Vasseur at the University of

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43 Lansdown, J.,"Computer choreography and video", in *Computing in the Humanities*, Lusignan, S., and North, J.S., editors. Proceedings of the Third International. Conference. on Computing in the Humanities, Waterloo, Ontario, Canada, August, 1977, pp 241-252.

44 Brightman, P. (1984), "Making Dances with Algorithms: Towards a Theory of Choreography, based on the Use of Computer Programs and Laban Concepts", M.A. Thesis, Columbia University, 1984.

45 BASIC is a high-level programming language which became popular in the mid-70's as a result of the growth of mini-computers. It enabled programmers to utilize interactive real-time programming as a viable alternative to large mainframe systems.

46 Koenig, G. M., "Project One", *Electronic Music Reports*. Amsterdam: Swets & Zeitlinger, B. V., 1977.

Pittsburgh in 1964, in that it listed out a series of randomly selected movements chosen from a defined set of events specified by the choreographer, in which the detail would be worked out from the list once it was produced. *Choreo* differed however in that it interactively prompted the choreographer for choices as to effort parameters preferred, and to procedures used in the random generation of those events.

Approaching the task from a much higher-level standpoint, Bradford and Cote-Lawrence (1988) developed a system called Animate Tokens[47] which enabled a high-level description of movement energy flow and dynamics to be animated in real-time, without specifying the detail of the physical human body model. This system utilized a visual graphical representation of movement rather than the static verbal list based systems described above. Dancers are represented by abstract tokens which can be animated in space and time. Dancers are not visualized in their human form, but as patterns of energy. This research addresses much higher level choreographic and system design concerns. Examples of these questions of representation are: how can the "broad sweep" of the dance, the overall compositional movement concepts be represented visually in a high-level abstract way; and also how can a choreographer's internal visualization of relationships between dancers, and the relationships between sections in a piece be represented graphically on a computer screen, in order to facilitate the creative exploration of these relationships.

47 Bradford, J. and P. Cote-Laurence (1991), "Animate Tokens, Their Design and Application", *Leonardo*, Vol 24 No 5, 1991, pp 557-562.

2.4 Cunningham's Early Vision

In 1968, Merce Cunningham, in his book *Changes: Notes On Choreography*,[48] described a system for notation which he explained could be used for choreography. It is apparent from his discussion, that over twenty years before he was to begin his work with LifeForms, Cunningham was already open to the possibility of using a computer as a creative tool:

> It seems clear that electronic technology has given us a new way to look. Dances can be made on computers, pictures can be punched out on them, why not a notation for dance that is immediately visual? [49]

It seems that Cunningham was aware of some of the earlier explorations that had occurred with computers and dance. It also is clear that he envisioned a computer system as a possible choreographic tool able to provide visual representation of the body and of movement:

> There have been some slight experiments that I know of made in this direction,... a situation that strikes me as being immediately accessible to the dancer would be... like this: on the... screen, images in stick-figures.... This screen is the notation. The shapes move in depth giving accurate details as to the movement, the time is indicated on the side by conventional musical score or by second, minutes-hours, the space is defined by outlines indicating edge of stage, wings if needed, downstage etc. if the space is unconventional this also can be indicated. Objects in the space having to do with decor or natural such as trees could be indicated. There are refinements necessary.... the face, for

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48 Cunningham, Merce, *Changes: Notes on Choreography*, Edited by Frances Starr, Something Else Press, Inc. 238 W 22nd St. New York (1968). This book does not contain page numbers. This quotation and those following in this section are cited from the page which describes Cunningham's ideas of computers and notation systems for dance.

49 *Ibid*.

> example, the exact positions... distortions of the fingers and the toes, smallnesses not ordinarily registered.[50]

Most notably, Cunningham's 1968 description, while listing many features that have since been incorporated into a system such as LifeForms, also describes areas of research which are still ongoing. For example, areas such as facial animation, and motion description that includes detail representation of hands, fingers and toes are research topics currently being explored. Cunningham remarks, most astutely, that although the technical issues are great, they are not necessarily greater than our own cognitive constraints of imagination. He points out that in order to overcome our constraints of imagination we must allow ourselves to explore beyond our preconceptions of technology and find new ways of exploring the possibilities:

> I am aware there are problems (with) this. But assuming the technological arrangements could be facilitated, and given the pace of change why not this?.... then the only other difficulty is psychological. [51]

Perhaps, most importantly, Cunningham foresaw that such a computer system could be used not only as a method of preserving dance, but also as a compositional system to create or to choreograph movement, and even entire dances with:

> ... it is conceivable (that) one could choreograph with such a device. This appeals to me. More than the museum I like the actuality.[52]

Although Merce Cunningham did not develop or experiment with computers and dance until many years later, his vision was evident

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50 *Ibid.*
51 *Ibid.*
52 *Ibid.*

even in 1968, twenty one years before his first encounter with the LifeForms computer choreographic system.

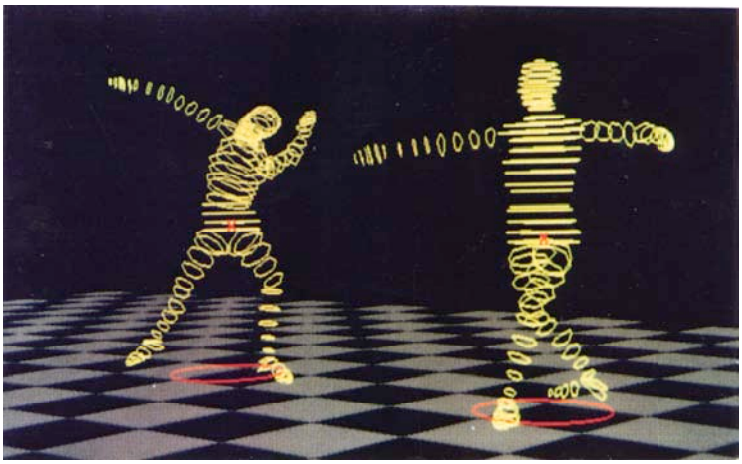
2.5 Summary

It is clear that the vision to support the creation of dance through computer technology has been shared by choreographers such as Merce Cunningham, and computer technologists such as those cited in the literature above. It is striking to note that between such disparate disciplines a common acknowledgment of the human spirit as it is experienced in dance has provided a mechanism which continues to move the possibilities of research in the area of computers and dance forward.

Chapter 3 The LifeForms Software

"LifeForms functions simply as a tool for the artist. The possibilities keep changing and expanding, but results will always depend on the creator's curiosity and resources."[1]
Merce Cunningham

3.1 Introduction



LifeForms is a computer compositional tool for the creation of dance. It has been under development at Simon Fraser University since 1986[2], in the Computer Graphics Research Lab under the direction of Dr. Thomas W. Calvert. Envisioned and developed as a creative tool for choreographers[3], it provides an interactive, graphical interface that enables a choreographer to sketch out movement ideas in space and

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1 Anne Pierce quoting Merce Cunningham in "Cunningham at the Computer", *Dance USA/Journal,* Summer 1991, pp 14-15.

2 LifeForms has been described in Calvert, T., Welman, C., Gaudet, S., Schiphorst, T., Lee, C., "Composition of Multiple Figure Sequences for Dance and Animation", Visual Computer 7:114-121, Springer-Verlag, 1991.

3 Life Forms has also received a great deal of interest from animators, directors, athletic coaches and motion planners, because it enables the user to create, edit and store three dimensional human and character movement sequences.

time. Versions of LifeForms run on the Apple Macintosh and the Silicon Graphics computers.

Merce Cunningham has been using the Silicon Graphics version of LifeForms in New York City since December 1989. While Cunningham's method of creating movement for dance has evolved and expanded as a result of working with LifeForms, the LifeForms system has also evolved in response to Cunningham's interaction and feedback. An important underlying research goal that informs the development of LifeForms is the study of the design or compositional process[4]. In the design of the LifeForms system, it has been observed that computer technology is as much affected by the articulation of dance knowledge as dance and choreography is affected by the articulation of technological knowledge.[5]

In LifeForms, movement sequences can be *keyframed*[6] by directly configuring a body interactively using *inverse kinematics*.[7] The system's

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4 Herbert Simon has suggested that composition can be thought of as a design process and identifies elements that are common in all the disciplines in which design plays a part. See Simon, H. A., (1981). *The Sciences of the Artificial*, The MIT Press, Cambridge, Massachusetts, 1981.

5 Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", juried paper to appear in the *InterChi Proceedings*, InterChi Conference, Amsterdam, April 1993.

6 A keyframe is used by the computer to calculate and display intermediate frames in a movement sequence. LifeForms automatically creates smooth human motion between any two positions, or "keyframes", defined by the user. For instance, one keyframe might show a human figure with its arms held up in the air, while another shows the figure with its arms pointing straight down. The software supplies the "in-between" frames.

7 Inverse Kinematics is a method for positioning the human body model interactively on the screen, The choreographer highlights a chain of limb segments to be pulled into position. For example, if the end of the chain is the hand and the base of the chain is the lower back, the entire chain from the base of the lower back can be moved by pulling on the hand.

large library of predefined movement sequences provides a source of material that can be performed by multiple human figures [8]. These figures can be edited in space, or in time using a simple interactive and intuitive interface. LifeForms supports the hierarchical nature of composition by allowing the choreographer to move flexibly between alternate views and conceptual levels of abstraction. Movement paths can be viewed, and the playback of the movement sequence is automatically interpolated[9] by the computer to be viewed in real time.

This chapter examines versions of LifeForms used by Merce Cunningham since December 1989 and describes current developments of the system.

3.2 LifeForms -- A Brief History

Conceived of as a computer compositional tool for choreography, LifeForms has evolved through a number of design iterations since 1986.[10] Cunningham has worked with three versions of the software. The development of a computer tool for the creation of dance provides several research challenges. For example, dance embodies a wide range of movement possibilities, and often requires great physical virtuosity that extends the limits of a human body's physical ability and training. Therefore, what is learned from a computer tool that is used to create dance can be generalized for other forms of human motion planning.

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8 LifeForms enables the user to define and use skeletons other than the human body with the same ease and flexibility that allows choreographers to create dance. This feature can be used in character animation.

9 Interpolation is a mathematical function which estimates the missing value by taking a weighted average of known functional values at neighboring points.

10 The work with LifeForms is supported in part by grants from the Social Sciences and Humanities Research Council of Canada,

Also, choreography is a compositional design task that requires a set of skills that have to do with creating, structuring, and forming. Building a computer interface which interacts with a choreographer's design skill set requires an understanding of the mental model of the choreographer's design process[11].

Herbert Simon has noted in the *Sciences of the Artificial*: "the ability to communicate across fields -- the common ground -- comes from the fact that all who use computers in complex ways are using computers to design or to participate in the process of design."[12] The observation of how our creative process operates when we interact with computer systems makes it possible to provide a more intuitive, direct and transparent user-interface. It also provides an opportunity to understand the process of choreography more clearly. In dance, where the creative idea is a *movement* idea, the goal is to be able to visualize and create movement on the body model in an immediate and responsive way, so that the computer tool can become a 'visual idea generator'.

3.3 LifeForms as a Model of Design Process

The design process contains elements that are recognized as common to all creative activity[13]. These include: the hierarchical process; alternate representations; use of knowledge and visualization of the compositional idea. *Hierarchical process* [14] is the way in which the choreographer conceptualizes an idea in various levels and layers of abstraction.

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11 Johnson-Laird, P.N., *Mental Models*, Harvard University Press, Cambridge Massachusetts, 1983.

12 Simon, H. A., (1981). *The Sciences of the Artificial*, The MIT Press, Cambridge, Massachusetts, 1981, p 159.

13 *Ibid*.

14 *Ibid*

Although this varies from choreographer to choreographer, in dance there can be the higher level conceptualization of overall shape, spatial relationships and energy flows, and the lower level detail of how the body moves in relation to its parts, shaping space, and the effort qualities in the movement. The importance of *alternate representations* [15] is in the juxtaposition of different frames of reference which allow the choreographer to think in various perhaps unconventional ways about the composition. Arthur Koestler has noted that the act of discovery of creation (which he refers to as the Eureka act), occurs when distinct representations are recognized as depicting the same object, idea or entity[16]. The *knowledge* of the choreographer, is context dependent, and is based on training in the physical kinesthetic experience of dance and movement, and in the compositional elements of choreography. A Choreographer brings to each new dance the history of his or her own previous work. *Visualization* of the work in progress allows the choreographer to view and evaluate the movement and the dance, and represents an important step in the iterative creative loop. With respect to the importance of visualization, Cunningham has said,

> Dancers get their examples visually. Computers offer a way to think directly. What I said twenty years ago--the earliest efforts at something like this--were very primitive and very unclear. Now look at the technology[17]

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15 *Ibid*.

16 Koestler, A. (1964). *The Act of Creation*, MacMillan, New York (1964).

17 Anne Pierce quoting Merce Cunningham in "Cunningham at the Computer", *Dance USA/Journal,* Summer 1991, pp 14-15.

These elements of design process have formed the basis for the functional design of LifeForms.

3.4 Evolving Versions of LifeForms

Since December 1989, three distinct versions of the LifeForms system have been installed on Cunningham's computer. These versions are described briefly in this section, and listed in Table 1, below.

Version	Dates in Use	LifeForms Features
1	Dec 89 - May 90	**Stance** Based LifeForms
2	Jun 90 - Sep 92	**Sequence Editor** Based LifeForms
3	Sep 92 - present	Addition of **Inverse Kinematics** to Sequence Editor

Figure 3.1. LifeForms versions installed in Cunningham's studio in New York.

In the first version of LifeForms installed on Cunningham's computer, dance composition was based on stances. In this early version, single stances or positions could be created, assigned to dances, and moved in space and time. This prototype forms the basis of the model that is currently implemented on the Macintosh. Stances representing single

movement positions are the movement primitive[18] for the compositional process. Menus in this version contain a collection of individual stances or shapes.

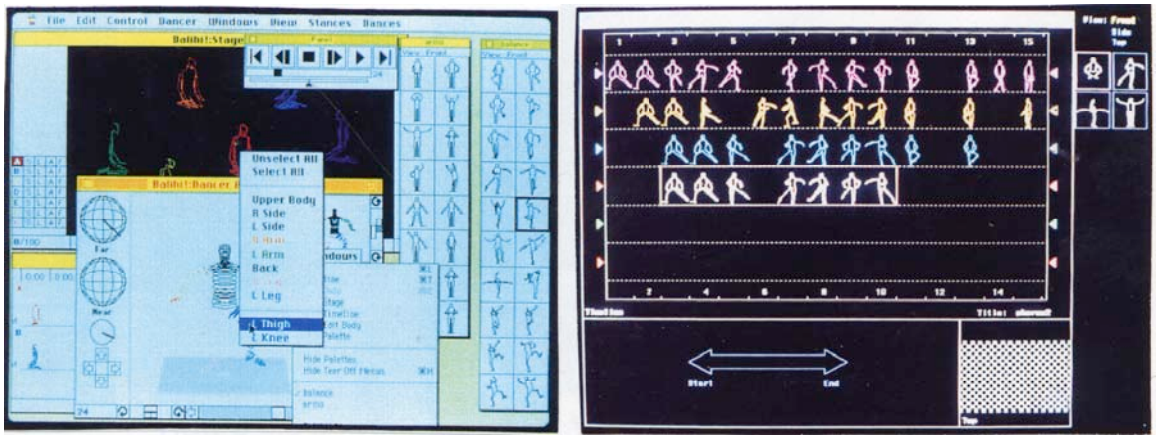

Figure 3.2a. Macintosh Stance Based System 3.2b. SGI Stance Based System - Timeline

Cunningham created *Trackers* using the second version of LifeForms. In this version, the individual stances were replaced by entire sequences of movement, and the Body Editor was replaced by the Sequence Editor. In this version, the choreographer works with a complete movement phrase as a primitive. This modification represented a major conceptual shift and enabled composition to occur on a higher level of abstraction. Cunningham said of this change from stances to sequences:

> What was like photographs is now like film, and what started out as work with positions has developed into work with phrases.... it's remarkable, they keep adding things to it.... it will enlarge it (dance)... the system now has multiple possibilities.[19]

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18 A primitive represents the building block upon which other higher-level conceptual chunks are based. A stance-based system means that the dance must be constructed by stringing together individual positions or shapes.

19 Robert Graskovic, quoting Merce Cunningham in *LA TIMES*, May 15 1991.

In the sequence editor, each menu item displayed on the right side of the screen contains an entire sequence, rather than a single stance.

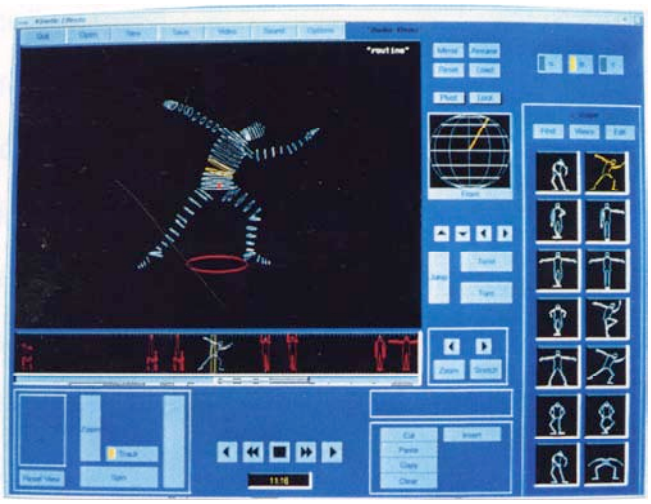

Figure 3.3 Sequence Editor Version of LifeForms

While the incorporation of the Sequence Editor in version two addressed an evolution in compositional support, the addition of *inverse kinematics* in version three addressed a shift in the way in which movement could be defined on the body model. Inverse kinematics enables a choreographer to position a series of related limbs by directly selecting and moving an end point (such as the hand) and affecting an entire chain of limb segments (the whole arm and spine) as a result.

3.5 LifeForms: Functional Description

In describing the essence of dance Merce Cunningham has said: "Dancing is movement in time and space; its possibilities are bound only by our imagination and our two legs."[20] Life Forms maps this viewpoint of

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20 Cunningham, Merce (1968) *Changes: Notes on Choreography*, (edited by Frances Starr), New York, Something Else Press, 1968. (pages in this book are not numbered)

movement in time and space by providing three on-screen windows in which to create dance: 1) a window which allows the creation of **movement** sequences for a single dancer; this is called the `sequence editor' window; 2) a `spatial' window which allows groups of dancers to be arranged and edited in **space**; and 3) a `timeline' window, which allows the dancers' movement sequences to be moved and edited in **time**. These three windows or views are interconnected. One can move flexibly between them using a simple interactive and intuitive interface that supports the hierarchical nature of composition by allowing movement between conceptual levels of abstraction. Movement sequences are created automatically by smoothing the motion between the shapes created on the body. Included with LifeForms are libraries of sequences to provide a source of material that can be performed by many figures simultaneously. Movement paths can be viewed, and playback speed can be slowed down or accelerated. Sound files can be selected, cued to "in" and "out" points, and played in synchronization with the dance sequences.

3.5.1 The Sequence Editor Window

A movement sequence is the design `building block' in the Life Forms system. In dance, movement sequences are also called `phrases' or `movement motifs'. The underlying rationale in selecting a sequence as the building block, is that the user can develop design `chunks'[21] that enable creation to occur on a more conceptual level. A sequence can be created, manipulated, varied and placed together with other

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21 Herbert Simon in *The Sciences of the Artificial*, describes that the capacity of short-term memory can be measured in terms of number of items or "chunks". This number has been shown to be between 4 and 7. The implication In computer user-interface design is that the when level of detail becomes too great (eg. >7), the creative or design process is adversely affected because of the constraints of our short-term memory.

sequences at a rate that enables the visual response to provide a meaningful creative feedback loop. This addresses the need to move away from a level of constant detail that so often occurs with the computer. Without the conceptual distance that is provided by stepping back to a higher compositional level, a choreographer or designer is unable to follow the iterative process that occurs naturally in all creative efforts.

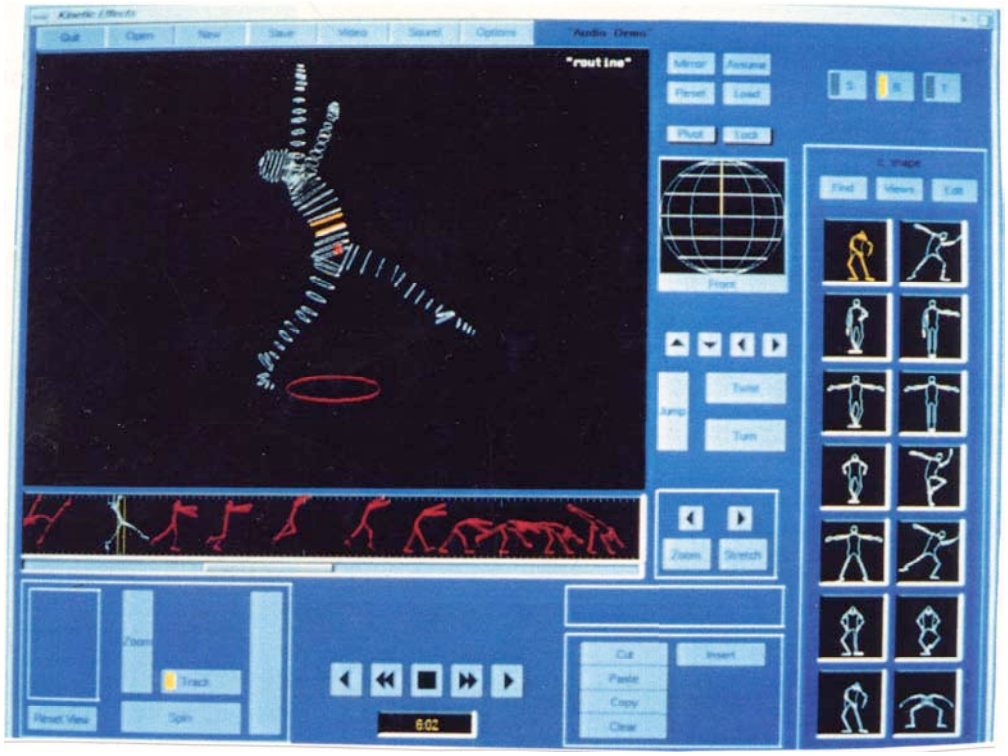

Figure 3.4 -- The Sequence Editor Window

In LifeForms, you use the sequence editor to create a movement phrase for a single figure. A sequence is made up of a number of keyframes, each containing a body shape placed at user defined time intervals. The movement is created by interpolating or smoothing the motion between keyframes. Playback speed can be varied to enable movement to be viewed or analyzed at different tempos.

The sequence editor window displays a three dimensional human body, initially shown in a natural, neutral standing position. Shapes can then be created for the body in a number of ways. For example, a single limb segment can be directly manipulated on the body and positioned in three-dimensional space, or existing body shapes can be copied from the library of stored sequences. Alternately, a chain of limb segments defined by the choreographer can be pulled in place through the use of *inverse kinematics* (e.g. if the end of the chain was the foot and the base of the chain was the lower back, the entire chain from the base of the lower back could be moved by pulling on the foot). Also, an existing position can be mirrored in the left or right plane.

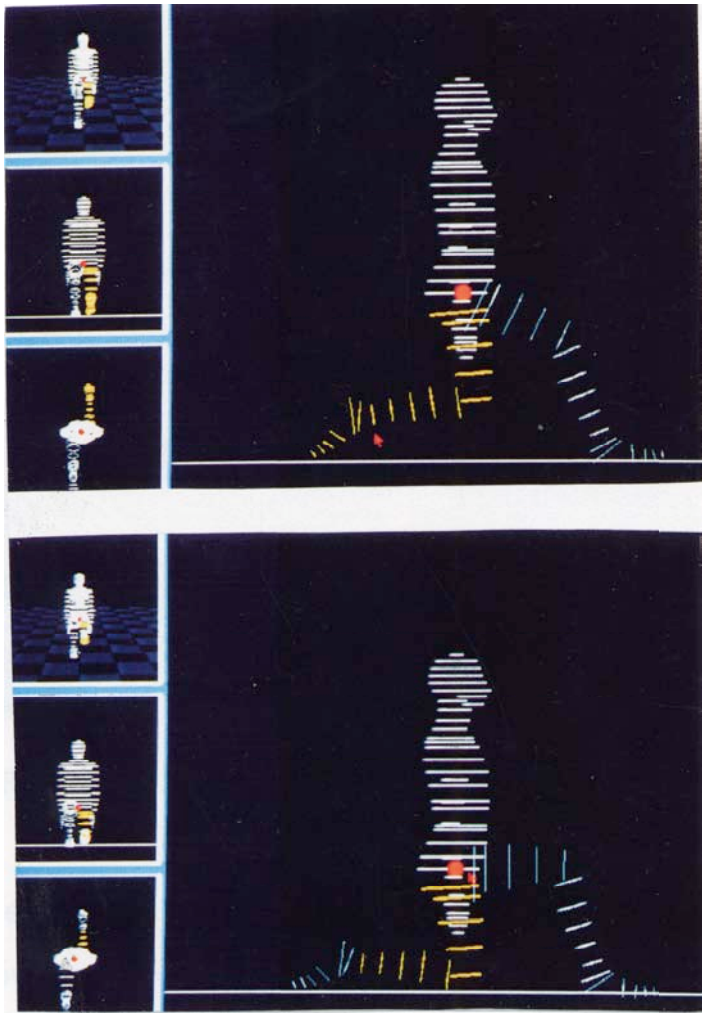

Figure 3.5 Creating a shape using inverse kinematics in the sequence editor

3.5.2 The Spatial View Window

The spatial view, or 'stage', enables the choreographer to spatially plan multiple dancers performing combinations of sequences. A dancer or character can be assigned a sequence, a starting position, and an orientation (or "facing"), by directly positioning the dancer with the mouse. Movement can be viewed from any three dimensional viewpoint, and camera keyframes can be set which enable the viewpoint to change as the composition is played back. These spatial scenes are similar to the series of storyboard sketches used in planning film and video production, but the interactive capability allows the choreographer to zoom-in or zoom-out from the stage and to view the composition from all angles.

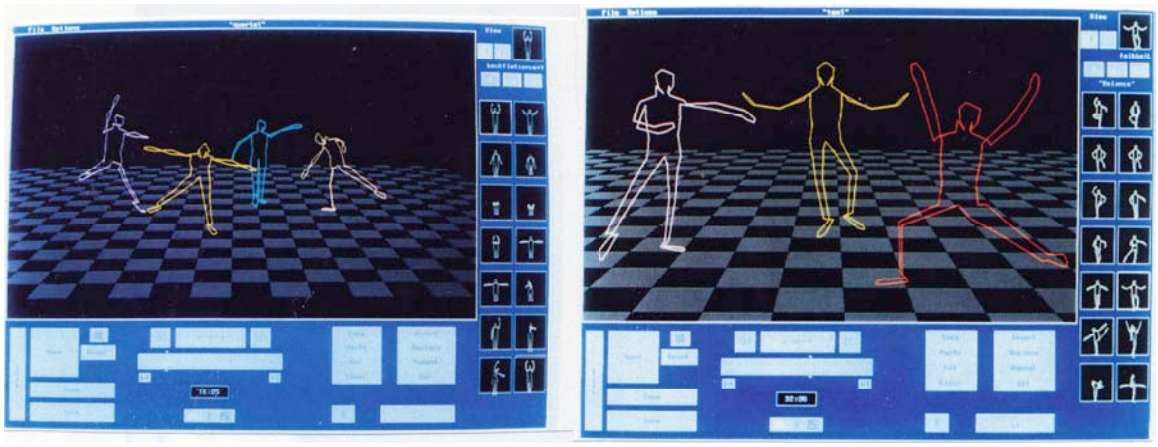

Figure 3.6 Zooming out and in on the Spatial View Window

Movement sequences are displayed in a visual library on the right side of the spatial window. Each sequence can be viewed as a "flip animation", by selecting it with the mouse. This provides a quick visual memory aid and enables the choreographer to quickly select movement that could be used in the composition. The spatial view in conjunction with the

timeline view allows spatial and temporal editing to occur in relation to one another.

3.5.3 The Timeline View Window

The timeline view provides the choreographer with a high-level score-like display that depicts the relationship between dancers and movement sequences. The spatial relationships of the dancers are superimposed upon the timeline display.

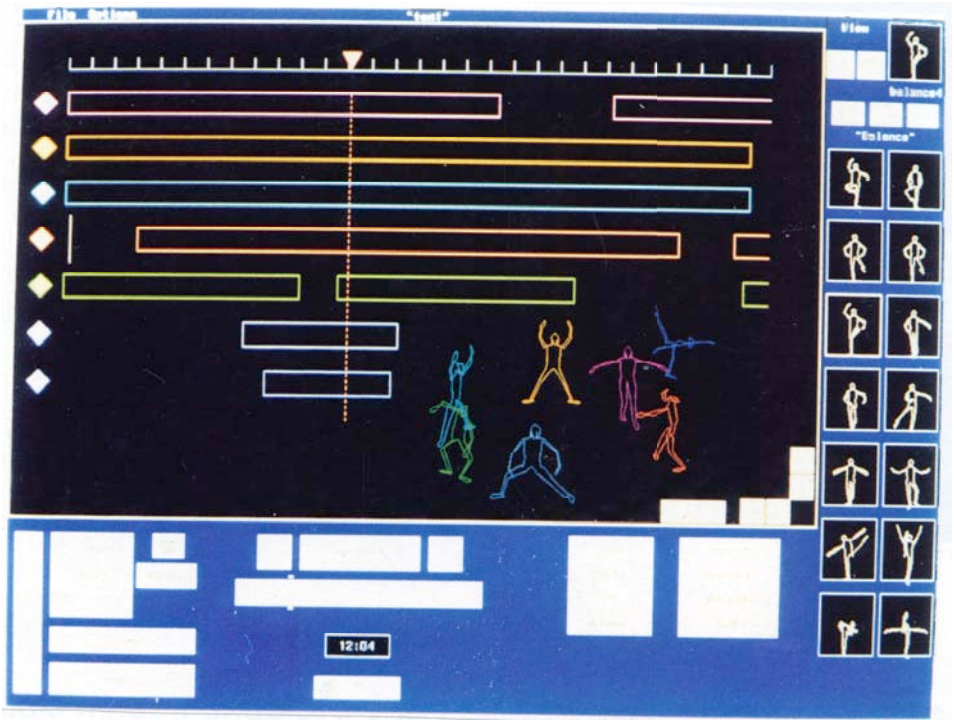

Figure 3.7 The Timeline View Window

Since changes made to temporal relationships between figures and sequences necessarily result in changes to spatial relationships, the overlapping of views addresses this 'transparency' and interrelationship

between space and time and provides immediate visual feedback when changes are made. Cunningham speaking about the use of the spatial and timeline views, said: "I found composing dances on the computer to be marvelous. It suggests possibilities of time and space I've never thought of before."[22]

3.5.4 The Audio Window

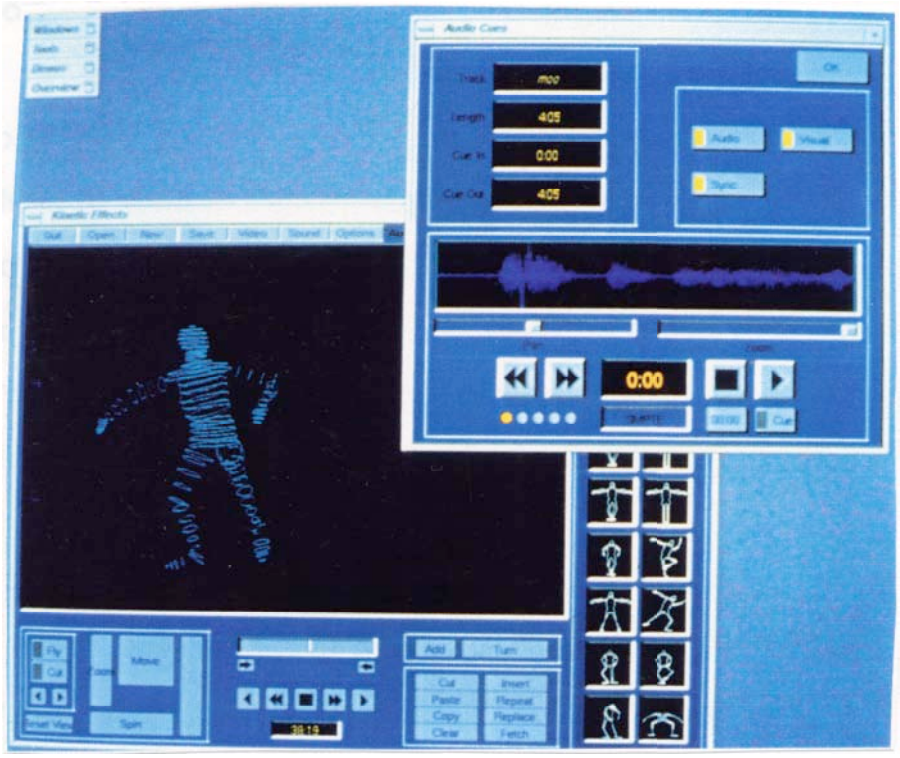

Figure 3.8 The Audio Window

The audio window enables a choreographer to play sound or music files with a single sequence in the sequence editor, or an entire choreography in the spatial view. The audio window is implemented only on the version of LifeForms which runs on Silicon Graphics machines with audio support

22 Anne Pierce quoting Merce Cunningham in "Cunningham at the Computer", *Dance USA/Journal,* Summer 1991, pp 14-15.

such as the Indigo. This window was inoperable on Cunningham's system because his computer hardware did not have audio capability. With the audio window in effect however, sound files can be selected, cued to in and out points, and played synchronously with dance movement. Cued "in" and "out" points can be edited so that movement/sound experimentation may occur.

3.6 LifeForms Future Development

In addition to the work described above, experimentation has begun in connecting LifeForms to MIDI (musical instrument digital interface), to be projected and used interactively in live performance. Research is also underway to connect LifeForms to an interactive 3D input tracking system to enable movement to be sampled in real-time, and stored within LifeForms[23]. Other areas of research include facial animation, rendered bodies, and articulated hand movement.

3.7 Summary

There is an enormous amount of choreographic and artistic knowledge which can enrich ways of using and creating with technology. Merce Cunningham has said, "I think of dance as a constant transformation of life itself."[24] It is not technological constraints that hold us back from using technology in new ways: technology changes at a tremendous rate. Our willingness to explore beyond the constraints of our imagination has the

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[23] This work is being supported by the Media Arts Section of the Canada Council.

[24] Cunningham, Merce (1985) *The Dancer and the Dance*: *conversations with Jacqueline Lesschaeve,* Marion Boyars Publishers, New York, London, 1985, p 27.

greatest effect on 'the constant transformation'. Merce Cunningham's work with dance and computer technology can be seen as an example. As Cunningham has said, "In looking for new movement I would look for something I didn't know about rather than something I did know about."[25] It is clear from the results of Cunningham's work with computer technology, that the design of LifeForms, and the design of the dances created with LifeForms affect one another deeply.[26]

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25 *Ibid.*

26 Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", juried paper to appear in the *InterChi Proceedings*, InterChi Conference, Amsterdam, April 1993.

Chapter 4. Case Study: The Making of *Trackers*

"One can make things with it (Life Forms), one doesn't have to put things in one already knows.... one can make discoveries, and that interested me from the beginning."
Merce Cunningham[1]

4.1 Introduction

In March, 1991, just over a year after he had been introduced to the LifeForms choreographic software, Merce Cunningham premiered a dance piece called *Trackers,* in which about one third of the movement was created with LifeForms running on the SGI Personal Iris computer donated to him by Silicon Graphics Inc. *Trackers* was premiered on Tuesday, March 19, 1991, at the New York City Center Theater, and featured a score entitled *Gravitational Sounds* by Emanual Dimas de Melo Pimenta, with music performed by David Tudor, and with decor by Dove Bradshaw. *Trackers* was performed by eleven Cunningham Company dancers as well as by Merce Cunningham himself.

Cunningham had been using LifeForms in New York City since December 1989, first to learn the software and then to support his exploration and creation of new dance work. This chapter describes the history of the Cunningham/LifeForms relationship: Cunningham's use of chance procedures, the installation of the computer system and software, the author's role as LifeForms tutor, Cunningham's learning process, and finally the creative process and methods used by Cunningham to make the

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1 Merce Cunningham quoted in the CNN television series: *Arts and Technology Report,* March 1991.

movement within LifeForms to create the dance *Trackers*. Cunningham said in a CNN interview, when talking about his use of LifeForms "I think this technology can, in this case, particularly.... open out a way of looking at dance and movement in a way that would be stimulating and invigorating to the whole dance field eventually."[2] Cunningham, recognized as a leading figure in contemporary dance, has continued to embrace technological possibilities as an extension of his exploration of movement as a process, rather than as a fixed goal. Cunningham has paralleled in dance what twentieth-century writers like Joyce, and Eliot have done in literature, which is to include "an extraordinarily wide range of reference..... a long chain of associations"[3]. Cunningham does not find it surprising that his references in dance are mirrored by references seen in technology, and in other art forms such as literature. He has responded to these comparisons to multiple references, images and symbols, by noting that a relationship exists between the development of artistic ideas and the development of technological ideas. Cunningham said:

> (The work of James Joyce) goes from paragraphs, to sentences, down to words--and now to words themselves separated, so you don't have even a whole word, you just have part of a word. And that is quite apparent--and seems to me quite reflected--in our technology. That doesn't mean that they (Joyce, Eliot, etc.) did it because of technology. It just happens that those ideas are in the air. Technology is full of this... the electronic system where they cut things so fine.... you get it on television all the time.[4]

Among many honors and awards, Cunningham has been acknowledged with the MacArthur Foundation fellowship (or "genius") award. Koestler, in *The Act of Creation*, noted that what we recognize as "genius" is often an ability to recognize or discover a hidden analogy that has not been seen

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2 *Ibid*.

3 Nancy Vreeland Dalva quoting Merce Cunningham in *The I Ching and Me: A conversation with Merce Cunningham*, DanceMagazine, March 1988, p 60.

4 *Ibid*.

before.[5] Merce Cunningham has always been interested in expanding possible ways of making new dances. This is revealed in his comment describing his interest in creating movement imagined with the support of a computer: "One can make things with it (Life Forms), one doesn't have to put things in one already knows.... one can make discoveries, and that interested me from the beginning."[6] Merce Cunningham, who has been using chance procedures in making dance since the early 1950's, also incorporated these procedures when creating movement with the computer. For example, many of Merce's movement sequences created in Life Forms determined how the body would move, what body parts would be used, or what physical shapes would be incorporated by the use of chance procedures. When these movement sequences appeared physically impossible, Merce worked with his dancers to discover how they could be made to work. In working out movement using chance questions with the LifeForms system, Cunningham did not decide whether he liked how the movement phrase turned out. Instead, he looked at the movement to see under what circumstances it could be made possible to perform such movement. Cunningham has said: "If a dancer tells me that something won't work, I say, `Try it; if you fall down, you'll find out something about falling down"[7]. Cunningham continues to do his work by dancing, and by making dances. "I may have an idea. I work it out, with all of us (the dancers). If I see the idea won't work, I'm quite willing to move it to another part or bring myself in another way. I don't get stuck, because the whole thing is a process for me. If some possibility comes up where I can be involved, I seize it. Why not? A bird in the hand."[8]

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5 Arthur Koestler, *The Act of Creation*,, Hutchison & Company, 1964.

6 Merce Cunningham quoted in the CNN television series: *Arts and Technology Report,* March 1991.

7 Joseph H. Mazo, quoting Merce Cunningham in *Quantum Leaps*, The Record, New York, March 15, 1992, p E-8.

8 Jennifer Dunning quoting Merce Cunningham in *For Cunningham, Dance is as Mysterious as It Ever Was*, The New York Times, March 11, 1990.

4.2 Merce Cunningham and The Use of Chance Procedures

Merce Cunningham's use of chance procedures is an important part of his work, both historically as it has informed the development of his compositional ideas, and also in its direct relevance to his creation of movement in LifeForms. When Cunningham talks of his work with LifeForms he says, "Like chance, (LifeForms) prompts me to think, well maybe there's some*way* to do that that I hadn't thought of."[9] Since chance procedures and the use of the *I Ching* played an important role in the making of *Trackers,* this section describes Cunningham's use of chance, and his use of the *I Ching* as a tool for selecting elements of movement, space and time in the making of dance.

4.2.1 Cunningham's History of Using Chance Procedures

Cunningham has been working with chance procedures since the early1950's, when the influence of John Cage's new musical practices and the inclusion of the Zen Buddhist ideas that had attracted both himself and Cage prompted him to let go of the notion of imparting a personal meaning to the movement he created in order that the expressiveness inherent within the movement could speak for itself.

Cunningham has said that movement is expressive, regardless of intention of expressivity, beyond intention.[10] Even in the mid 1950's Cunningham did not want to concretize his use of chance as a method of creating movement:

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9 Deborah Jowitt, quoting Merce Cunningham in *He Who Wields the Mouse*, The Village Voice, March 17, 1992.

10 Cunningham, Merce (1985) *The Dancer and the Dance*: *conversations with Jacqueline Lesschaeve,* Marion Boyars Publishers, New York, London, 1985.

> My use of chance methods in finding continuity for dances is not a position that I wish to establish and die defending. It is a present mode of freeing my imagination from its own cliches and it is a marvelous adventure in attention. Our attention is, normally, highly selective and highly editorial. But try looking at events another way and the whole world of gesture, the whole physical world in fact, is as if jabbed by an electric current.[11]

This potential for coming to see new movement ideas in a way that "jab us as if by an electric current"[12] is shown in Cunningham's continued interest in discovering not only what movement, but how movement could be created, danced and performed. These notions led him to explore constructing dances based on the outcome of using the *I Ching* in the early 1950's, and led him to be the first choreographer to explore the use of video as an artistic medium, for viewing movement separate from video's use as a documentary tool. Over forty years later, it is this same interest in discovering how movement can be created in new ways that leads him to explore working with the LifeForms system. When Cunningham began working with chance procedures, consulting the *I Ching* provided him with a method of selecting movement, its spatial placement and its time relationship as single outcomes selected from a range of possible choices, thereby freeing his imagination from its own 'highly selective choices'.

> Using chance to choreograph opens up the possibilities. It allows me to reach beyond the logical and into the unexpected. When you come upon a situation which your own experience would attempt to deal with one way, it closes the door to infinite other possibilities. Chance provides options which, under ordinary situations, I never would have thought of doing. I had to decide to follow the random method no matter where it led. To do that I had

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11 Cunningham, Merce "The Impermanent Art", from *7 Arts*. No 3 Colorado, 1955, p 312

12 *Ibid*.

> to give up two ideas: that I didn't like it, and that it was not possible.[13]

Cunningham's commitment to the random method has also been a commitment to discovering how to form a working model for each given dance that enables a series of random choices to be selected. A selection process implies that a structure exists, and that within the structure elements exist from which one selects. Cunningham's method of working is built upon a careful construction of a set of movements or movement qualities, and a set of spatial or time parameters. From these predetermined sets, random selections occur. These structures and the parameters that describe them vary from dance to dance:

> I use (chance in) many different ways, it's not some kind of strict method, by any means, but chance is in every piece in some way.... The idea of personality (of the dancer) not being there isn't true simply because when the dancers do (the movement), they--in doing it--take it on. It's like a second skin.[14]

In addition to varying his method of using chance procedures, once a method of selection has been decided upon, it is accepted as a way to answer the question that Cunningham is trying to explore in a particular dance:

> there are chance elements everywhere, and the thing about chance, is like the *I Ching,* where you cast your fortune and you accept what the fortune is at that time, in that place.... of course the thing is to put it together. You carefully set up--or I do--I have to set up what I am going to cast from: what kind of material for each dance, something about the time, and something about the space. And then through the chance means, it determined what that movement is and how long it takes and where it is[15].

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13 T. Massari McPherson quoting Merce Cunningham in *Mentor of Motion*. The Anchorage Times, January 23, 1992.

14 *Ibid*.

15 Nancy Vreeland Dalva quoting Merce Cunningham in "The I Ching and Me", *DanceMagazine*, March 1988, p 60.

In the making of *Trackers*, these methods of working with chance are very relevant. For example, in *Trackers* there was a structuring of what categories of movement material would be used, decisions about continuity (which movement element followed the other, and what length of time the movement would take), and also construction of the movement material itself. All of these were derived using chance procedures. An illustration of Cunningham's methodology used in an earlier work that closely parallels how Cunningham structured and created movement for *Trackers* within LifeForms, is from a description of *Untitled Solo,* one of the first dances he created using chance, at Black Mountain College, North Carolina in1953:

> I've spoken often about the solo that I did years ago. It was called *Untitled Solo*. It was one of the first chance pieces. I separated the body into the legs and the arms and the torso and the head, and worked out movements for each of those elements, and then, by chance means again, worked out whether the legs were used by themselves doing a given movement, or, if at the same time, part of the body or the head and/or the arm come in. It went from, say, doing one thing with your legs, to suddenly doing four things, each different, one with the arms and with the body and the head and so on. (It was) Terribly difficult to do. Incredibly, it was impossible.... I would do a little bit of the dance, then sit down exhausted. Finally after about the eighth time, I was sitting down, done in, and David (Tudor, who was playing piano accompaniment for the dance) looked at me from the piano and said, "well, this is clearly impossible, but we're going ahead and doing it anyway. (laughter) So we did.[16]

'Terribly difficult' movement often comes from having to relearn physical body habits and memory. This requires an enormous mental as well as physical concentration in order to learn, understand and finally master.

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16 Marcia B. Siegal quoting Merce Cunningham, in *A conversation with Merce Cunningham*, Dance Ink, pp 5 - 9. Volume 1, Number 1, May/June 1990.

Interestingly enough, comments from the Cunningham dancers while learning some of the more complex LifeForms phrases in *Trackers,* were almost identical to David Tudor's comment "this is clearly impossible, but we're going ahead and doing it anyway". Alan Good, a dancer with the Cunningham Dance Company who danced in *Trackers,* has said of this process with Cunningham and LifeForms, "…. but (Merce) liked that. So here we were doing this (computer generated movement)…. I mean to change those years of training,… it was like you were drawing a straight line in a curved universe, it was very difficult".[17]

Cunningham has always attempted to demystify the use of chance procedures and points out the existence of chance occurrences in our everyday lives:

> Chance plays a great part in many people's lives…. Often when you're in the streets, a chance situation comes up, you meet someone or you see something by chance, a situation you hadn't organized or arranged for but which is interesting or can be interesting to you. I use the chance operations as a way to make the choreography. That is, I make a number of different movements, separate movements, and I write them down--or now I can put them on video and so on, to have them as a kind of material to work with--and then I, by chance operations, organize the continuity. I don't decide which of these phrases are going to follow another, but I use chance operations to decide. In a sense I am coming upon some thing I don't know all the time,…. like when you're in a street (and) you come across things you didn't plan on, but they become part of your day because there they are.[18]

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17 Alan Good, interviewed in *The Late Show*, Interviewed in New York April 17th 1992, a BBC television interview with Merce Cunningham, Thecla Schiphorst, and Cunningham dancers: Alan Good and Emma Diamond. Aired August 1992.

18 Hannah Ehrli quoting Merce Cunningham in *Honor Thy Father: Modern Dance Pioneer Merce Cunningham Discusses Purity of Dance in the Computer Age*, Village View, May 10-16 1991.

4.2.2 Consulting the *I Ching*

Merce Cunningham used the *I Ching* extensively in constructing *Trackers*: in the dance's continuity or ordering of movement categories, in its spatial and time parameters and in creating the movement itself within the LifeForms system. The *I Ching,* translated as Book of Changes, is an ancient Chinese text dating back over three thousand years. Cunningham's process of using the *I Ching* in constructing dances has been as a method of selecting a movement, spatial, or time parameter at a given point in the dance. Cunningham has used the *I Ching* to structure components of the dance, as well as creating specific movement that is contained within those components. In order to accomplish this, Cunningham keeps detailed notes or charts of the outcomes of selection process.

> this (use of chance procedures) involved an elaborate use of charts from which came the particular movements, the rhythm (that is, the division and the duration of the time they were done in), and the space they appear in and how they divide it. There were separate charts for each of the three elements-- movement, time, and space. Then I tossed pennies to select a movement from the movement chart, and this was followed by tossing pennies to find the duration of that particular movement, and following that the space and direction of the movement were tossed for. This method might lead one to suspect the result as being possibly geometric and "abstract", unreal and nonhuman. On the contrary, it is no more geometric than the lines of a mountain are, seen from an airplane, it is no more abstract than any human being is, and as for reality, it is just that, it is not abstracted from something else, but it is the thing itself, and moreover allows each dancer to be just as human as he is.[19]

Originally used as a simple yes/no oracle, the *I Ching* developed to include sixty-four hexagrams or possible outcomes.

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19 Merce Cunningham, "The Impermanent Art", *7 Arts*. No 3 Colorado, 1955, p 312.

> At the outset, the Book of Changes was a collection of linear signs to be used as oracles.... the oldest (types of oracular pronouncements) confined themselves to the answers yes and no. "Yes" (or Yang) was indicated by a simple unbroken line (_____), and "No" (or Yin) by a broken line (__ __).[20]

The current version of the I Ching consists of sixty-four possible combinations of six lines (sixty-four is 2^6). Each of these combinations of six lines is termed a hexagram. Each line within the hexagram can represent a binary value of either "yang" or "yin". The sixty-four hexagrams of the *I Ching* are shown below, in Figure 4.1.

John Cage has said of the structure of the *I Ching:*

> The mechanism by which I think the *I Ching* works is,.... it's dealing with the number sixty-four, with a binary situation with all of its variations in six lines. I think it's a rather basic life mechanism.[21]

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20 Richard Wilhelm, "Introduction", *I Ching,* Bollingen Foundation, New York, 1950, p *xlix.*

21 Gagne, Cole & Tracy Caras. quoting Cage in "John Cage [1980.]" *Soundpieces: Interviews with American Composers* Metuchen, NJ: Scareccrow, 1982, p 298.

Richard Wilhelm's translation of the *I Ching,* The Book of Changes, refers to the fact that the value of a line within a hexagram can "change" to its complementary value. Therefore a line can represent a static value, or can represent a changing value.

When consulting the *I Ching,* the outcome of each hexagram always takes into account its current representation, and its "Changing To" representation. The values of hexagrams, both in their current and changing states, were used by Cunningham to determine the continuity in the making of *Trackers.*

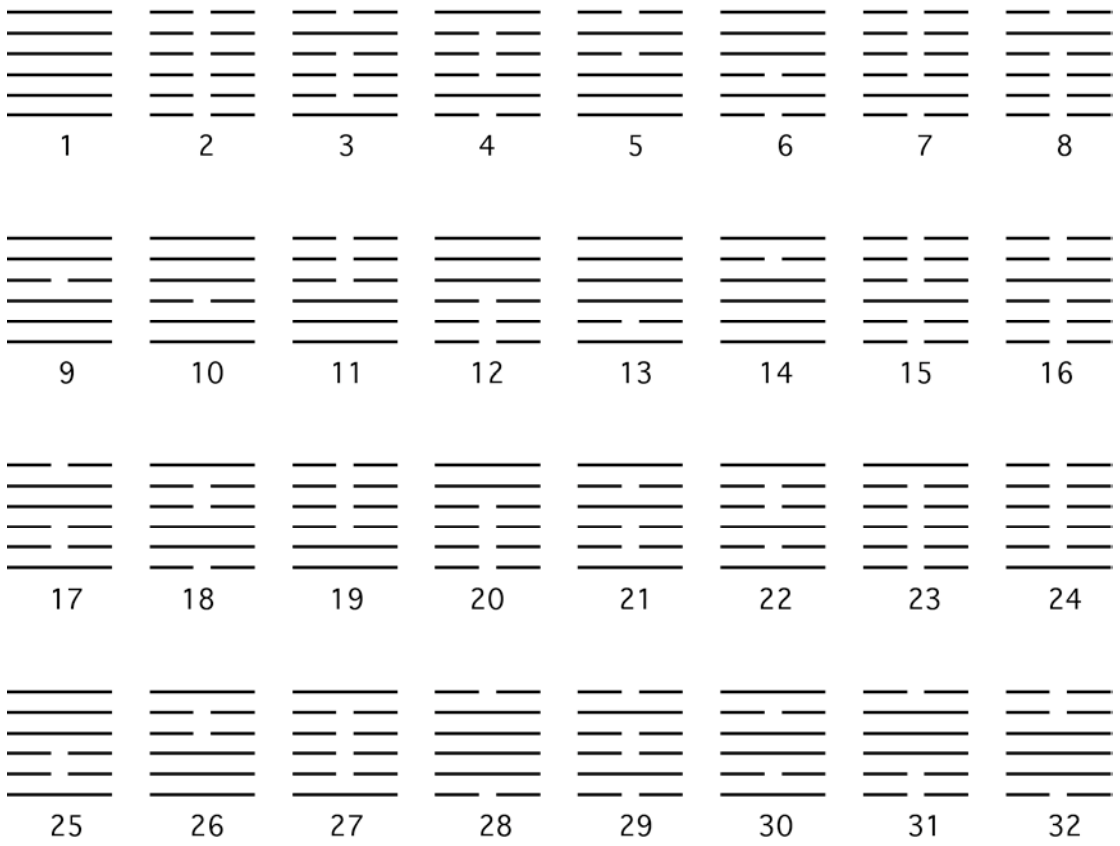


Figure 4.1.a. Hexagrams 1 to 32 of the *I Ching*

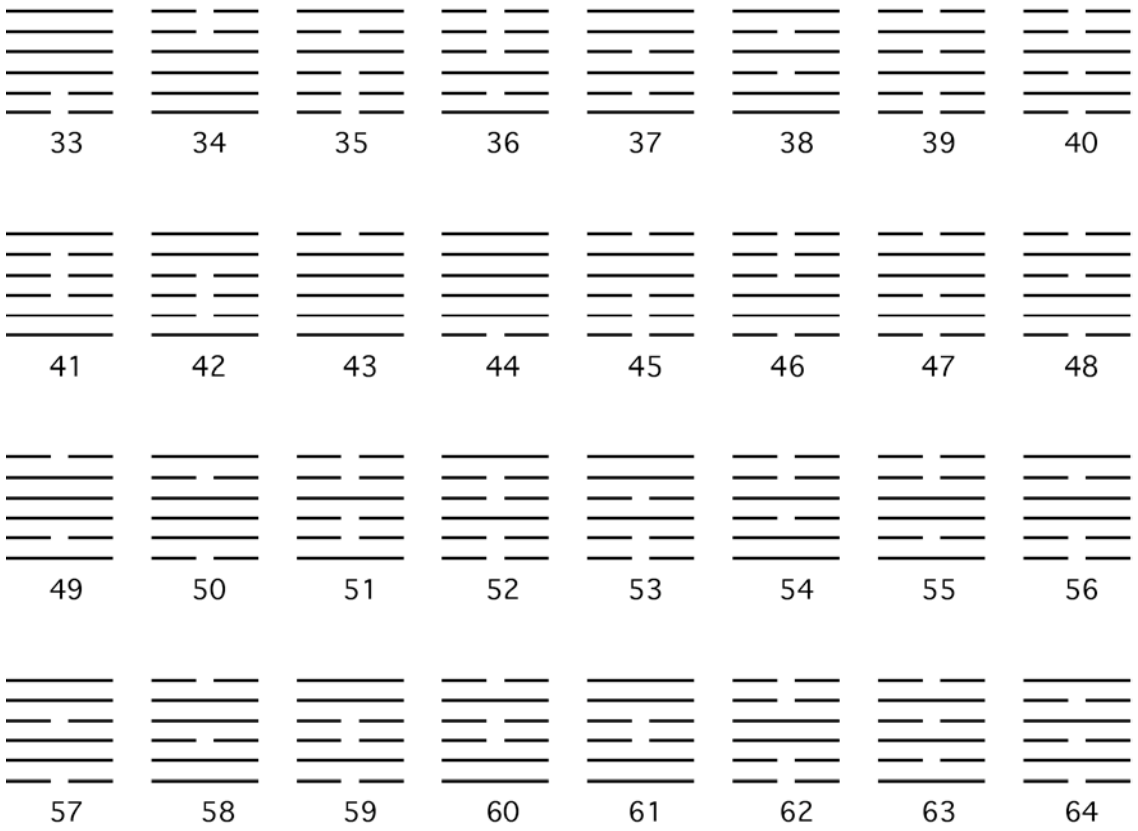


Figure 4.1.b Hexagrams 33 to 64 of the *I Ching*

There are a number of methods of consulting or casting the *I Ching,* including the yarrow stalk method, and the three coins method. Cunningham has often used the method of tossing three coins to determine the outcome of a hexagram, and it is this method he employed to create movement in LifeForms for *Trackers*. Each toss of the three coins determines the outcome of one of the six lines of a hexagram. A hexagram is built from the bottom to the top. The results of a "toss" can be mapped onto the four possible outcomes of a given line, illustrated in Figure 4.2, below: 1) a yang changing to a yin, 2) a yin changing to a yang, 3) a static yang, and, 4) a static yin. Note that the static outcomes are three times more likely than the changing outcomes.

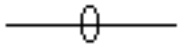
Outcome of Coin Toss	Line Drawn As	Line Changes To
Three Heads		
Three Tails		
Two Tails, One Head		
Two Heads, One Tail		

Figure 4.2. Mapping coin toss to possible hexagram lines

In Figure 4.2, the circle drawn through a yang line indicates that the line is changing to a yin line, and an 'X' drawn through a yin line represents the line as changing to a yang line. The value of the *I Ching* is that it allows a choice to be determined from sixty-four possible outcomes. There are times in structuring a dance that there are a large number of possible choices, and times when there are fewer choices to select from (depending on how Cunningham has decided to structure the dance). When the number of outcomes has been determined by Cunningham to be as few as three or four, it is not always necessary to construct a hexagram to do so. In this case, a single toss of three coins would provide the required solution.

> Just as Merce originally used chance to thwart his own physical habits, he uses it now to undermine the control of he-who-wields-the-mouse: he'll often toss coins to decide what limb the LifeForms figure will move next and in what direction.[22]

22 Deborah Jowitt, *He Who Wields the Mouse*, The Village Voice, March 17, 1992.

4.3 Software Installation and Cunningham's Learning Process

The installation of the LifeForms choreographic software in Merce's Westbeth studio in New York city in December 1989, and the learning and creative process that ensued, has spanned a three year period as of this writing. The working method between Cunningham and the author evolved during the first year in which LifeForms was installed in Cunningham's studio. During that time LifeForms has evolved in response to the needs of Merce Cunningham and other users, as well as in response to software maintenance requirements such as the fixing of "bugs" that limited or obstructed the intended functionality of the software[23]. This required that LifeForms software upgrades be re-installed on a number of occasions, and that new features of the software be explored with Cunningham. Cunningham would generally work for two to three hours in the afternoon with the author, and then review and experiment alone, after the day's working session. Often questions that were raised during Cunningham's review sessions would fuel the direction of the next day's working session with LifeForms. During these sessions it was the author's role to facilitate Cunningham's use of the system by explaining features of LifeForms and supporting him in his creation of movement. In addition to participating in, and observing the learning and working process of Cunningham, the author also had a number of discussions with Cunningham that focused specifically on the making of *Trackers*. In the sessions discussing *Trackers,* Cunningham shared detailed observations, choreographic notes, and explanations of how movement phrases were created using LifeForms, how these phrases were rehearsed in the studio with the Cunningham dancers, how working with the software affected

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[23] Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", juried paper to appear in the *InterChi Proceedings*, InterChi Conference, Amsterdam, April 1993.

his choreographic methods, and most importantly how LifeForms enabled him to extend his imagination and expand possibilities for creating movement.

Appendix I chronologically outlines the history of the LifeForms related work that occurred in Cunningham's studio in New York City, from the initial meeting and installation through to software upgrades, tutoring, working and exploratory sessions between Cunningham and the author.

4.4 Elements Used in Constructing *Trackers*

In the making of *Trackers*, Cunningham created a structure for the dance based largely on chance procedures. The sequence of events that contributed to the creation of the dance can be divided into the following component parts: *Categories* or elements of movement that would make up the dance, the *Continuity*, or sequence in which these categories of movement are ordered throughout the piece, and *Sequences*, the movement phrases which belong within a particular category.

Merce Cunningham began work on *Trackers*, on January 2, 1991, by constructing what he terms the Continuity or the ordering of movement categories and phrases within the structure of the dance. This process began two and one half months before the dance was premiered at the City Center Theater in New York City.

4.4.1 Categories of Movement

Cunningham decided to use seven categories from which to select movement that would make up *Trackers*. Out of these seven categories, three categories were based solely on movement generated in LifeForms, and it is these three categories that constitute the scope of discussion in this section. The categories named by Cunningham are shown in Figure 4.3, below.

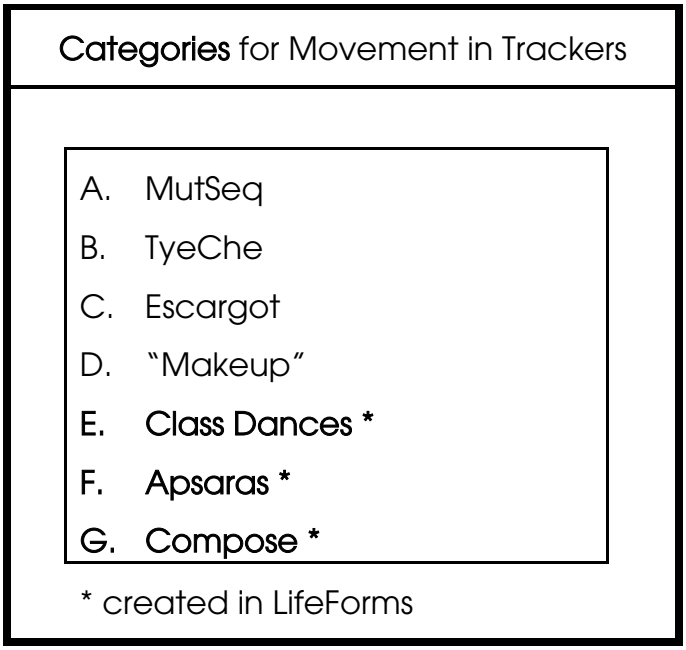

Figure 4.3. *Trackers* Movement Categories

Class Dances, the first LifeForms movement category named above (Fig. 4.3.E) contained movement phrases created by Cunningham for use as class exercises. Movement in the category Class Dances was created both as a way to learn and to practice using the LifeForms system, and as a way of generating movement that could be taught to dancers in the

studio. Cunningham has often used class exercises as a way of working out choreographic and movement ideas.

> When I'm working on a piece and I'm working out material for it, I often take in phrases that I would eventually use in the dance and make exercises for the class.... then later I take it as material for the piece.[24]

Most of the sequences in the category Class Dances were generated using chance procedures to determine which part of the body would move (e.g. head, arm, leg, back), how many limbs would move simultaneously (e.g. head with the shoulder and with the arm), what type of movement would occur (e.g. fall, jump, plie). As with the use of all chance procedures, the particular set of movement elements that defined the dance would always be decided by Cunningham. In the case of movement in the category Class Dances, whole body movement and locomotor activity (movement that travels from one spatial location to another), as well as movement categories such as jump, fall, and turn were all included as elements which could be selected from using chance procedures.

The second LifeForms movement category, named *Apsaras,* (Fig 4.3.F) was devised specifically for *Trackers,* and embodies the idea of motion taking place at a stationary point in space. The word *Apsaras,* describes the female partner of the soaring divine couple *Gandharva* and *Apsaras* of the fifth century A.D. Indian stone sculptures[25], and in Merce's words "it was the idea of being stationary, and dividing the body the way that the Indian sculptures do that are so extraordinary, when they use the hip, and

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24 Merce Cunningham quoted in, "On Teaching and Video: Merce Cunningham", *Dance Teacher Now,* April 1987.

25 Joseph Campbell, *Oriental Mythology, The Masks of God,* Viking Penguin Inc., New York, 1962. This era was termed the Indian Golden Age.

then the shoulder.... that's why the word came up".[26] *Trackers* was made shortly after the Cunningham Dance Company returned from a performing tour in India, so that it is likely that Cunningham was drawn to the idea of the type of movement could be made given the stillness, and the odd juxtaposition of the body parts that is embodied within these Indian statuettes. Again, all the movement in the Apsaras category was created in LifeForms using chance procedures. Since the idea of a stationary body was given as a starting point, the outcomes of the chance procedures created vastly different results in the Apsaras movement category, than it did in Class Dances.

The third LifeForms category, called Compose[27] (Fig. 4.3.G), contains both sequences and stances previously created in LifeForms. This category can be thought of as 'found' computer movement. In the case of existing stances, movement sequences were constructed by stringing together a number of stances, selected from the menus using chance procedures, so that first the menu was selected by tossing the coins, and then the stance or shape within the menu was selected, again by tossing the coins. Cunningham applied this method with great rigor, and did not include menus from the selection that contained stances or shapes that did not interest him. Existing movement sequences did not have to be constructed, and were selected from the existing menus in LifeForms using chance procedures. This was done by first determining the menu they were contained in, and then by determining which sequence within the menu would be used. These sequences were created either by Cunningham at a previous date, by the author, or by programmers and

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26 Merce Cunningham quoted in conversation with the author, April 5, 1992.

27 LifeForms was at this time called Compose. Its name was changed in January 1991 when Kinetic Effects incorporated and selected a new name for distribution and marketing purposes. This occurred before the *Trackers* premiere in March 1991.

previous LifeForms users who had contributed to setting up Cunningham's original menus for the initial December 1989 installation. Cunningham's original menus were constructed at Simon Fraser University prior to the first installation and were based on shapes entered by viewing his dance technique class video-tapes.

Specific sequences, and methods of creation will be examined later in the section entitled Sequence Generation.

4.4.2 Continuity

The Continuity of a dance is the ordering of categories of movement by section or division. Cunningham devises parameters and assigns values to them by tossing coins. *Trackers,* which is approximately 35 minutes long, is divided into 34 consecutive sections or divisions. Parameters assigned by chance procedures to each section include: which category will be performed during a given section, how many movement categories will be performed at once during a section, how many dancers will perform phrases from each category, what movement sequences will be performed within each category, will the dancers perform movement phrases simultaneously (as in duet, trio or quartet), or alone as a solo, and also the length of each section:

> The length of the piece is determined by the material and working it out. When I'm working on phrases (with chance) I include the length of time it takes to do that phrase. I've learned finally... I didn't use to write it down, but I've learned to do that. So that the idea of time comes in right from the beginning, of how long something should be[28].

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28 Marcia B. Siegal, quoting Merce Cunningham,in *A conversation with Merce Cunningham,* Dance Ink, Volume 1, Number 1, May/June 1990, pp 5 - 9.

Since Cunningham had decided upon seven movement categories, and since Cunningham's method of using the I Ching to determine the outcome of a chance operation results in one of sixty-four hexagrams, a mapping structure was created to map one of sixty-four possible outcomes to one of seven movement categories. The simplest mapping technique, and the one that Cunningham used, was to divide sixty-four by seven, giving seven ranges, each containing a progression of contiguous integers as is shown in Figure 4.4 below.

Hexagram Range	Category Number	Category Letter
1 – 9	1	A
10 – 18	2	B
19 - 27	3	C
28 - 36	4	D
37 - 45	5	E
46 – 54	6	F
55 - 64	7	G

Figure 4.4 Mapping Hexagrams to Movement Categories

Cunningham designed *Trackers* continuity in a number of iterations. In the first iteration, he assigned two parameters to each one of thirty-four sections: 1) the number of concurrent categories which would be performed during that section, and 2) the names of the movement categories. Both of these parameters were assigned by chance. Cunningham decided that the number of concurrent categories that would appear at any one time in the dance could fall between one and four inclusively.

The procedure for selecting the names of the movement categories consisted of tossing three coins, six times to obtain one of the sixty-four hexagrams of the *I Ching*. As is outlined above, in section 4.2.2 Consulting the *I Ching,* tossing the coins results in a six line hexagram which is either static (that is changing back to itself), or is changing to another second hexagram (hence the name *The Book of Changes*). Both the original and the changing hexagram numbers are used to select movement categories for the dance. In this way, tossing the three coins six times produces two hexagrams, and therefore, two movement categories for the current section of the dance. An excerpt from Cunningham's first iteration of continuity for *Trackers* is shown below in Figure 4.5. The excerpt shows the first 8 divisions or sections out of the total of 34 consecutively numbered sections in *Trackers*. The number of categories assigned by chance falls between one and three in the first eight sections. Cunningham decided upon a maximum of four movement categories to be performed at once. A differentiation of the four possibilities could be selected using three coins, since the outcome of a single toss would be either 1) three heads, 2) three tails, 3) two heads, and a tail, or 4) two tails, and a head.

Trackers Continuity – example of first iteration

Section	Number of Categories	Hexagrams 1st	-->	2nd	Mapped to: Number	Letter	Category Names
1	2	61	-->		7	G	Compose
			-->	42	5	E	Class Dances
2	3	12	-->		2	B	TyChe
			-->	35	4	D	"MakeUp"
		49	-->		6	F	Apsaras
			-->	15	2	B	TyeChe
3	3	12	-->		2	B	TyChe
			-->	35	4	D	"MakeUp"
		9	-->		1	A	MutSeq
			-->	44	5	E	Class Dances
4	3	19	-->		3	C	Escargot
			-->	41	5	E	Class Dances
		35	-->		4	D	"MakeUp"
			-->	1	1	A	MutSeq
5	3	9	-->		1	A	MutSeq
			-->	9	1	A	MutSeq
		63	-->		7	G	Compose
			-->	3	1	A	MutSeq
6	2	28	-->		4	D	"MakeUp"
			-->	32	4	D	"MakeUp"
7	2	12	-->		2	B	TyChe
			-->	24	3	C	Escargot
8	1	58	-->		7	G	Compose
			-->	62	7	G	Compose

Figure 4.5 *Trackers* continuity, first iteration

The number of movement categories in a given section determines the number of hexagrams that must be derived. Every series of tossing three coins produces two hexagrams. For example, in section 7 of Figure 4.5, hexagram 12 changing to hexagram 24 was drawn by tossing three coins. Therefore, to derive either one or two movement categories, the coins must be tossed once, as was the case in section 7 of Figure 4.5. To derive either three or four movement categories the coins must be tossed twice, as can be seen in section 4 of Figure 4.5. In section 4, on the first series of tosses Cunningham arrived at hexagram 19 changing to hexagram 41. This generated two movement categories, but three were required in this section.

It is necessary therefore to toss the coins once more to arrive at hexagram 35 changing to hexagram 1. In the case where an odd number of movement categories was required, Cunningham selected one from the final two that were drawn, so that the remaining movement category remained unused. Cunningham has used this method to create a framework, or structure that enables him to extend beyond his personal imagination. Cunningham has said in describing his work with chance procedures:

> Some people think that it is inhuman and mechanistic to toss pennies in creating a dance instead of chewing the nails or beating the head against a wall or thumbing through old notebooks for ideas. But the feeling that I have when I compose in this way is that I am in touch with a natural resource far greater than my own personal inventiveness could ever be, much more universally human than the particular habits of my own practice. [29]

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29 Merce Cunningham, "The Impermanent Art", *7 Acts*, No 3, Colorado, 1955, p 311.

The guidelines of the structure are intended to produce a method of working that invokes a problem solving approach, to explore movement possibilities, relationships, and juxtapositions.

In the second iteration of constructing the continuity for the dance, Cunningham derived the number of dancers performing movement from each category, whether dancers would perform movement simultaneously (as in duets, or trios), or perform different movement phrases, and in the case of the category named Compose, whether sequences would be constructed from stances, or selected by chance procedures from the menus. A partial segment from the second iteration of *Trackers* continuity is illustrated in Figure 4.6. As can be seen in Section 1 of Figure 4.6, the first category, Compose, has six dancers performing movement selected from one stance and two sequence constructions, while the category Class Dances has two dancers performing movement as a duet. This brings the total dancers performing during this section to eight. All of these parameters were selected using chance procedures. The continuity shown here is a method of building a framework within which to work out how, where, and for how long each dancer will perform movement. The construction of a relationship between continuity as an initial structure and the outcome of the dance is determined by Cunningham. As can be seen in Section 2 of Figure 4.6, he allowed himself opportunities to have one movement category lead to another within a section. The inclusion of moving from one category to another within a section is one of the options that Cunningham allowed for in the chance procedures. Also, in section 2 of Figure 4.6, it can be seen that there are a total of three movement categories to be included.

Trackers Continuity – example of second iteration

Section	Number of Categories		Category Names	Number of Dancers (per category)		(total)
1	2	G	Compose	(6)	1 stance + 2 sequences	(8)
		E	Class Dances	(2)	1 CI Dance #20 (duet)	
2	3	B	TyeChe	(1)	+ (2) gotoApsaras	(8)
		D	"MakeUp"	(6)	in "MakeUp"	
		F	Apsaras	(2)	1 from TyeChe	
		B	TyeChe	x		
3	3	B	TyeChe	(1)	from section #2	(8)
		D	"MakeUp"	(5)	from section #2	
		A	MutSeq	x		
		E	Class Dances	(2)	duet, same time	
4	3	C	Escargot	(7)		(9)
		E	Class Dances	(2) (1)	separate, then to single CI Dance, then to MutSeq	
		D	"MakeUp"	x		
		A	MutSeq	(1)	after single CI Dance	
5	3	A	MutSeq	(3)		(7)
		A	MutSeq	(3)		
		G	Compose	(1)		
		A	MutSeq	x		
6	2	D	"MakeUp"	(6)		(6)
		D	"MakeUp"			
7	2	B	TyeChe	(1)		(9)
		C	Escargot	(8)		
8	1	G	Compose	(1)		(1)
		G	Compose			

Figure 4.6 *Trackers* continuity, second iteration

This results in one of the four movement categories previously determined by the hexagrams, in this case *TyeChe*, to be discarded. This is indicated in Figure 4.6 with an "x" beside the unused or discarded movement category.

4.4.3 Sequence Generation in LifeForms

In the three *Trackers* movement categories created in LifeForms: Class Dances, Apsaras, and Compose, Cunningham used five identifiably different ways of creating or generating sequences. These were: 1) creating sequences from existing stances, in the LifeForms menu by selecting stances by chance procedures, and then working in the studio to determine how a dancer would move through these shapes, 2) selecting existing sequences from the menus by chance procedures, 3) creating movement by learning to use the LifeForms system and by gaining a familiarity with features and operations available, 4) creating totally new movement using chance operations to select which limb moves, along with which other limb, and what types of movement the body moves through, and finally, 5) adding to or modifying existing locomotor patterns such as a simple walking pattern using chance procedures to create movement with highly complex rhythms. These methods of sequence generation are shown in Figure 4.7, below.

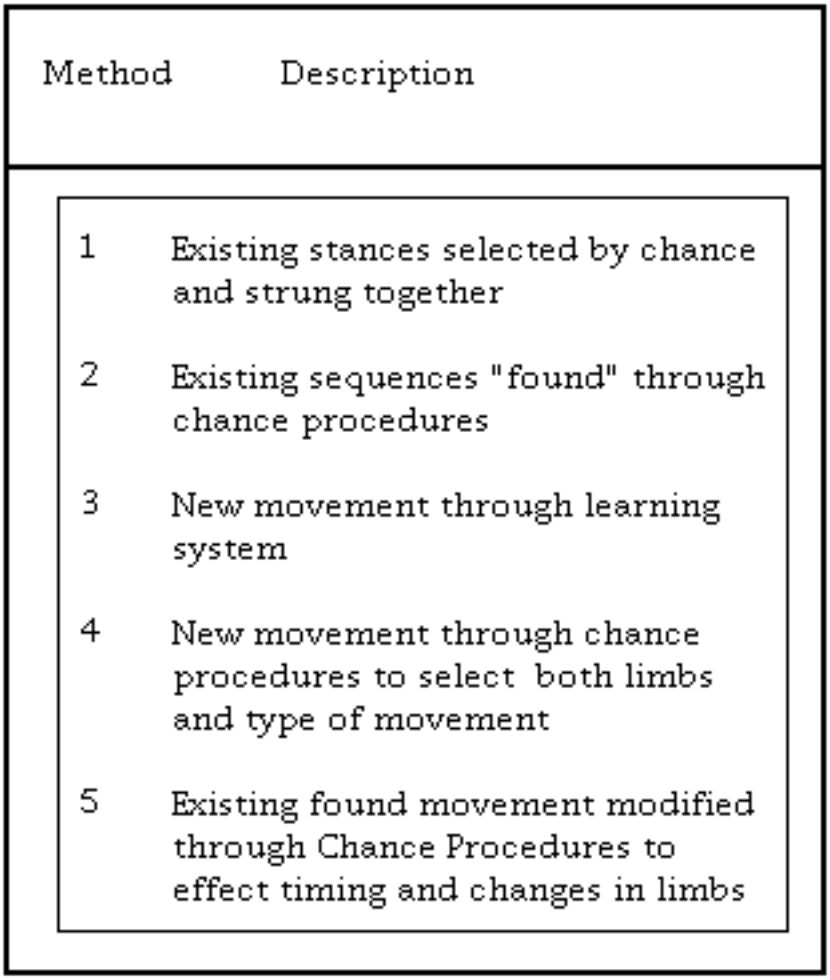


Figure 4.7. Methods of LifeForms Sequence Generation

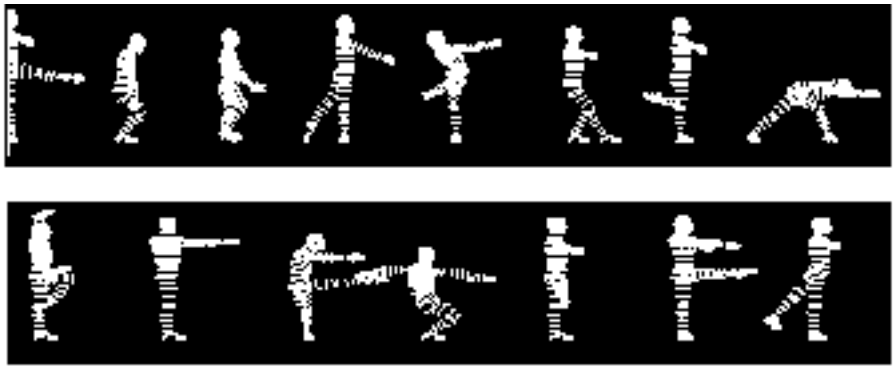
An example of the first method (Fig 4.7.1), selecting existing stances through chance operations and then chaining them together, occurs in the movement phrase entitled "CKExitStances", in the *Trackers* LifeForms menu. This is a movement phrase performed by Chris Komar, and is from the Class Dances movement category, performed in section 10 of *Trackers*. It occurs about 9 minutes and 35 seconds into the dance. At that time, Chris Komar is centre stage and exits from the stage by performing this sequence. In CKExitStances, Cunningham devised a method of creating movement by selecting from existing stances in the LifeForms Menus, using chance operations. Figure 4.8 shows that Cunningham determined there would be fifteen stances, and then determined the

particular stance by selecting the menu number, and then the stance number within that menu using chance operations.

Number of Stances	Menu Number	Stance Number Within Menu
1	12	7
2	25	7
3	10	12
4	28	4
5	31	9
6	15	18
7	7	5
8	2	9
9	21	10
10	11	5
11	4	4
12	7	10
13	20	10
14	16	13
15	8	6

Figure 4.8. "CKExitStances" Chance Procedures

The fifteen stances which comprise the CKExitStances phrase danced by Chris Komar in *Trackers* are shown in Figure 4.9.



"CKExitStances from ***Trackers*** menu

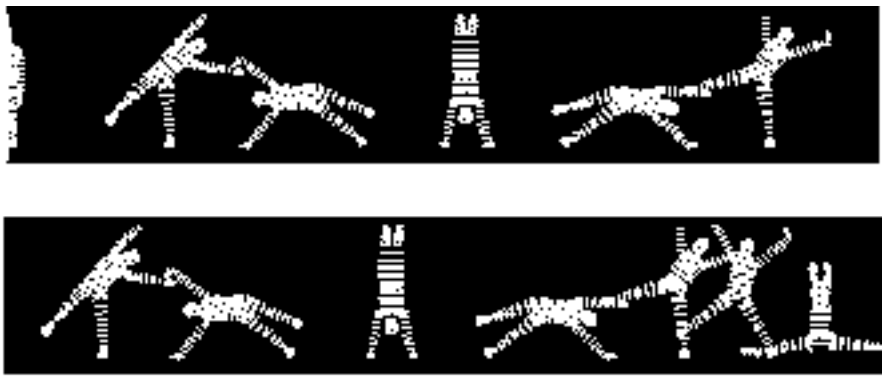
Figure 4.9. Existing Stances selected by Chance Procedures

The second method used by Cunningham to generate movement in LifeForms has been identified in Figure 4.7.2 as selecting existing sequences found through chance operations. An example of a sequence selected by this method is shown in Figure 4.10. The movement phrase is entitled "Cart2" and is a series of two cartwheels: the first version of this sequence was entered into LifeForms originally by the Computer Graphics lab computer programmer Markus Wakowski in order to test the sequence editor as it was being designed, programmed, and tested. Later, this sequence was modified by the author when illustrating the copy and paste feature of the Sequence Editor timeline to Cunningham in July 1990. This movement phrase is performed in *Trackers* by Jenifer Weaver, and belongs to the Compose movement category. The phrase "Cart2" is performed at about 11 minutes and 45 seconds into the dance.

One of the features of Cunningham's work is implementing the movement selected through chance procedures. He has said,

> In working out something, particularly using chance means with the LifeForms system, I try not to make any decision about whether I like it or not, or some idea like that, or even, whether it is possible, but rather, to look at it and see, oh, that could be possible under certain circumstances, and it is in that sense, the same as when I began to work with chance operations years ago.[30]

In the case of "Cart2", illustrated in Figure 4.10, it can be seen that after the first cartwheel the figure leans left before continuing the second cartwheel and then ends in the splits (legs apart on the floor).



Cartwheel Sequence in *Trackers* menu

Figure 4.10. Existing Sequence selected by Chance Procedures

In order to accomplish this in *Trackers,* Jenifer Weaver entered from downstage right, while a second dancer, Robert Swinston, ran from upstage centre to support her so that she would not fall over during the lean to the left; Robert then again supported her out of the splits, and

30 Merce Cunningham quoted in the BBC television series, *The Late Show: LifeForms and Cunningham*, broadcast June 1992.

both dancers continued moving to the left to exit. This is an example of Cunningham's ability to look at the phrase, as it was "found" in the LifeForms system, and then to see what circumstances would be necessary in order to execute it in a form that remained as close to its original representation as possible. The result of this way of working is an often unexpected and surprising juxtaposition of movement ideas that continually provide a mechanism for unforeseen and often startling, or in this case, even humorous relationships to unfold.

The third method Cunningham used for generating movement in LifeForms was to create sequences through learning to use the system (Fig 4.7.3).
For Cunningham, the learning process has been an ongoing one, not only in learning to use LifeForms, but also historically in continually searching for new ways of creating movement and understanding dance.

> I still do it because it (making dances) interests me. What's exciting is when I come across an idea that I'm unfamiliar with, or when I have a question to answer for myself. You have to find a way to do what you can do. It is difficult for all of us, but if it's something that interests you deeply, you will find a way.[31]

Cunningham's fervent interest is in finding new ways of understanding elements of movement, not in rehashing or reiterating what he has already done. In talking about the dances he has made with LifeForms he has said: "The common thread in these dances is that they are all different. That's what interests me. I am not interested in the idea of repeating something."[32] Cunningham learned to use LifeForms both during tutoring sessions (as outlined in section 4.3 above) and in time

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31 Thomas B. Harrison quoting Merce Cunningham in "Cunningham: Choreographer devises movements on a Computer", *Anchorage Daily News*, February 23, 1992.
32 Ibid.

spent with his own experimentation and review of system features. One important characteristic that exists in the way that Cunningham has used the LifeForms system is a certain lack of distinction between what he created as learning exercises for himself, and what he created for his dance pieces. Making dances for Cunningham is fundamentally about learning and questioning. It is therefore not surprising that much of the movement created in LifeForms has found its way into his dances. Cunningham has noted that even the earlier stance based version of LifeForms was used to generate certain shapes or stances that appeared in earlier works such as *Polarity* (1990). An example from this method of creating movement is show in the sequence "Leaper" from the *Trackers* menu, illustrated below in Figure 4.11. "Leaper" was constructed by Cunningham and the author as a tutorial exercise in learning how to cause the LifeForms figure to jump, and then change direction in space. The movement phrase "Leaper" is from the Compose movement category and is performed in section 1 of *Trackers*. It occurs at about one minute into the dance, and is performed by Helen Barrow, Robert Swinston, Carol Teitelbaum, and Jenifer Weaver.

"Leaper" sequence from ***Trackers*** menu

Figure 4.11. Sequence created learning to use LifeForms

The fourth method of generating movement identified in this study is the creation of new movement in LifeForms using chance operations (Fig. 4.7.4). Cunningham used chance to select which limb would be moved, how many limbs would be moved simultaneously, and what types of movement the body moved through. The Apsaras movement category contains movement created in this way. An example of the Apsaras movement category in performance can be seen at the beginning of *Trackers,* in Section 2 at approximately 1 minute and 30 seconds into the piece. At this point, Merce Cunningham and Jenifer Weaver are in the upstage right corner, and both support each other in performing the Apsaras 1 phrase (illustrated in Figure 4.12). First, Cunningham holds Jenifer Weaver while he turns her on the spot as she executes the phrase, and then Cunningham who is on the floor on his knees, remains there while performing the Apsaras 1 phrase while Jenifer Weaver then turns Cunningham around in a complete circle. Each dancer takes turns supporting the other while the supported dancer performs the Apsaras 1 phrase. This phrase is illustrated below in Figure 4.12.

Figure 4.12. Apsaras 1 timeline view

One of the details worth noting in the Apsaras 1 phrase is that the time relationship between the stances or shapes created is uneven or unequal. This produces movement which does not have a sense of metered

rhythm, but rather has an uneven rhythm which is an artifact of the length of the spaces inserted between the shapes produced by Cunningham. In other words, the time relationship was not a consciously selected variable, but was determined arbitrarily. It was this ability of LifeForms to allow an arbitrary time relationship to exist between specified physical shapes, rather than having to define any particular timing or meter, that appealed greatly to Cunningham. This was what Cunningham was alluding to when he said, "Working with LifeForms suggests possibilities of working with time and space that I had never thought of before"[33], and also when he said, "Things can happen that you think are impossible, but if you try them out, they lead you to something else. And it's all in space, not time, you're looking visually and putting things in space."[34] This is not to say that a choreographer couldn't define movement very specifically based on exact counts or points in time if she chose to do so; but it is not necessary to build movement that is specifically time based using LifeForms. Cunningham's method of creating movement in much of the work he did in *Trackers* reflects this approach that is not concerned with thinking about the specific timing while the movement is created. Once it has been created, however, the rhythms produced are often complex and polyphonic using different rhythms in different parts of the body. Cunningham always attempted to remain true to what was produced with his particular chosen method of creation. One of the striking observations of movement created without an effort to create specific timings, is that the outcome has an inherent rhythmic complexity which would be difficult to consciously create in a single iteration.

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33 Anne Pierce quoting Merce Cunningham, in "Cunningham at the Computer", *Dance/USA Journal*, Summer 1991, pp 14-15.

34 Jennifer Dunning quoting Merce Cunningham, in "Dance by the Light of the Tube" *New York Times Magazine Section*, March 1991.

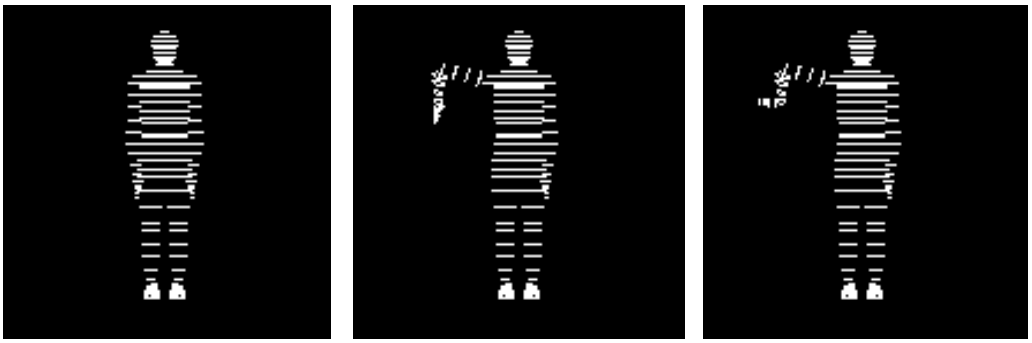
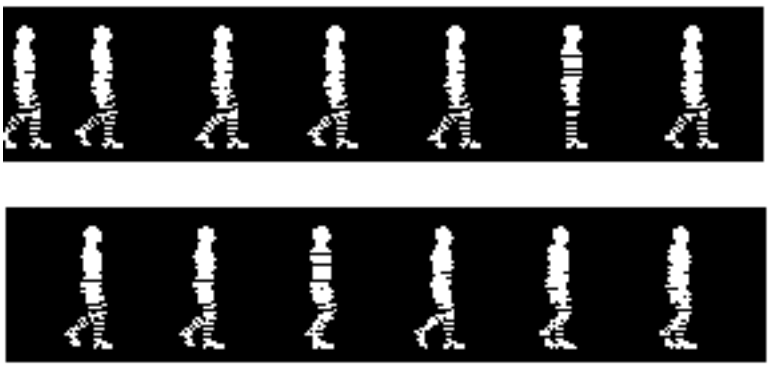


Figure 4.13. Apsaras 8 showing selection of limbs: shoulder, elbow, and hand

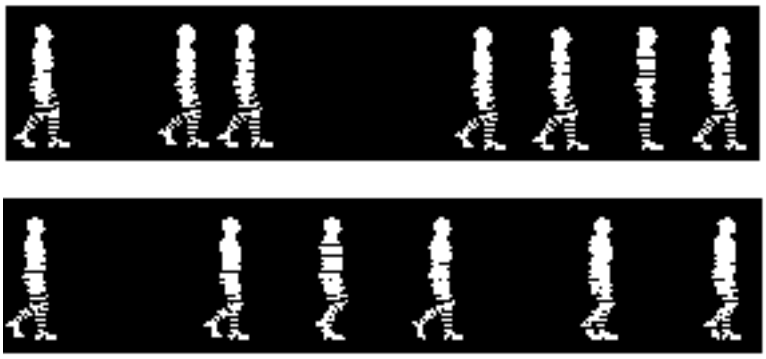
The last identified method of generating movement in LifeForms, was adding to or modifying existing locomotor patterns such as a simple walking pattern (using chance procedures). This method was used specifically for the *Walker* phrase, in the Trackers menu, which was performed in section 17 of *Trackers*, at approximately 16 minutes into the piece, first by Helen Barrow, and then joined by the dancers Kimberly Bartosik, Michael Cole, Emma Diamond, Emily Navar, Randall Sanderson, Robert Swinston, Robert Wood, and then finally Chris Komar. *Walker* was constructed in three separate iterations. During the first pass, Cunningham used a walking pattern which existed in the LifeForms menu, and began to alter the timing of the walking step pattern, by simply increasing or decreasing proportional timings between steps (see Figure 4.14). It is this ability to increase the spatial proportion between shapes in a direct visual way that leads Cunningham to say "instead of thinking in time, you're looking visually and putting things in space." [35] In this first iteration, the effect of increasing the spatial relationship between walking steps directly affected the timing of the steps causing a quirky, uneven and distinctively odd walking rhythm. During the second iteration, he added the arms without referring to any relationship between what was occurring in the legs. Again, this immediately created a complex polyrhythm in the body with legs moving irregularly, and then arms moving in their own irregular

35 T. Massari Mc Pherson quoting Merce Cunningham in *Mentor of Motion*, The Anchorage Times, January 23, 1992.

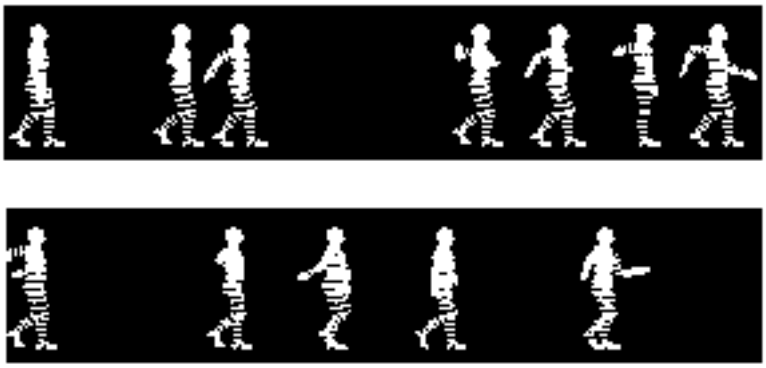
rhythmic pattern and shape. In the third iteration, Cunningham added the torso and head to the phrase, again without reference to what was occurring in the legs and the arms. The result of this procedure was a walking phrase which was highly idiosyncratic, and was reported by the dancers as very difficult to learn because of its sense of going against what the body naturally did when it walked. Again, it is striking to note that Cunningham created such an iconoclastic walking phrase by beginning with a regular and "normal" walk cycle which was originally placed in LifeForms to provide natural looking walks which are difficult to animate or generate with a simple keyframing approach. It is this tendency of Cunningham's to look at both the movement that existed in LifeForms and the operational features of the LifeForms system, and then find new and fresh ways of combining them rather than to try out what LifeForms was "supposed to do". It is an approach which looks beyond the defined boundaries, and continually attempts to break the standard rules which are rendered arbitrary when viewed from this perspective. Cunningham, who calls himself a practical person, is able to create specifically with what exists while simultaneously rethinking the very material with which he is working.



Iteration 1. Create walking step rhythm



Iteration 2. Create walking rhythm pattern by inserting space between each walk frame



Iteration 3. Create arm movements

Figure 4.14. Excerpts from the stages of creating the Walker phrase

Cunningham has commented, "My point about working with LifeForms is not to complain about what it can't do, but to look and see what it can do."[36]

36 Jody Leader quoting Merce Cunningham, in "Cunningham's computer-assisted dance comes to UCLA", the *LA Daily News*, May 9, 1991.

4.5 Use of Stage and Timeline View in creating *Trackers*

The previous description has explained how Cunningham created specific movement phrases within the LifeForms sequence editor. Although most of Cunningham's exploration with *Trackers* focused on the creation of movement sequences in the sequence editor, Cunningham has also worked at structuring sequences for multiple dancers using the stage and timeline views. In the case of *Trackers,* this took the form of visually working out spatial ideas for what he terms the dance's space grid. The space grid is worked out using chance procedures to determine the start position and timing and then usually rehearsed in the studio with the dancers. LifeForms enabled Cunningham to begin to explore how to put together various elements and work out spatial relationships before trying them out on the dancers. Since *Trackers* was Cunningham's first major work created using LifeForms, his work with these elements of the LifeForms system was still in the formative stages, and so these windows were used less frequently than the sequence editor in the creation of the dance.

Chapter 5 Epilogue: From *Trackers* Onward

"And, if you would understand what I am...,know this: all I have said I have uttered playfully, and I was by no means ashamed thereby: I danced."
Jesus, from the Acts of John[1]

"In one way or another what we thought we couldn't do was altogether possible, if only we didn't get the mind in the way.[2] *"*
Merce Cunningham

Cunningham has shared his vision of the possibility of choreographing with the computer, through his creation of dance with LifeForms. His work with LifeForms, was first publicly acknowledged with the making of *Trackers,* but *Trackers* was neither the beginning nor the end of his exploration with computer choreography. Through the dances he has made, Cunningham has amplified the understanding that choreographers can work with computer technology to extend possibilities in creating dance. Cunningham continues to be a mentor and inspiration to generations of dancers and choreographers. The increase in public awareness that has resulted directly from Cunningham's use of the computer has infused and penetrated current thought while it has simultaneously changed the face of dance.

When Cunningham initially began his work with LifeForms on the computer in December 1989, public response to this new exploration was to treat it with curiosity, but still somewhat skeptically. As Merce's experience and ability to use the software has grown, so has his experimentation with the system in creating dance. In the few short years since Cunningham has been using the computer, the response to this prospect has moved

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1 This quote is hanging on the wall in Merce Cunningham's computer room

2 Cunningham, Merce (1985) *The Dancer and the Dance*: *conversations with Jacqueline Lesschaeve,* Marion Boyars Publishers, New York, London, 1985.

forward with renewed interest, acceptance, and a willingness to explore the possibilities that could result from this intersection of disciplines.

The dance *Trackers* is an example of an ongoing process of exploration and discovery in Merce Cunningham's work with LifeForms and use of computer technology. *Trackers* was Cunningham's first major work in which a significant portion of the movement was created using LifeForms. But even before *Trackers*, Cunningham had used an earlier version of LifeForms to begin to explore the creation of single movement positions in the dance *Polarity*, which premiered in March 1990, three months after LifeForms was initially installed in Cunningham's back room. Since choreographing *Trackers*, Cunningham has created seven new dances with the assistance of LifeForms. In a period of less than two years, this creative output is prolific by any standard. (A list of Cunningham's work with LifeForms is shown in Figure 5.1, below). Cunningham's most significant achievement is not only an abundance in terms of the sheer number of dances he has created during that time period, but also an abundance in the distinctive quality of the work, and the pervasive impact his dances and his ideas have had on the world.

Cunningham's ideas are most remarkably felt through the dances he creates. Yet he has also had a tremendous influence through his verbal statements about making dances. His ability to articulate his work with dance and the computer has captured the public's imagination. As a result, Cunningham has been the primary force in the increase of public awareness that has grown around the field of computers and dance.

Dance	Premiere Date	Premiere Location
Polarity	20 March 1990	New York City City Center Theatre
Trackers	19 March 1991	New York City City Center Theatre
Beach Birds	20 June 1991	Zurich Theatre 11
LooseStrife	10 September 1991	Paris Theatre de la Ville
Change of Address	20 June 1992	London Royalty Theatre
Beach Birds for Camera	15 November 1992	Paris Paris Opera
Enter	17 November 1992	Paris Paris Opera
DoubleToss	26 February 1993	Minneapolis University of Minnesota

Figure 5.1. Cunningham Choreography Produced with LifeForms

Dance reviewers and critics write about his new work, describing how they imagine he could be using the computer to create dance:

> Cunningham's choreography for all three new dances (Beach Birds, Loosestrife, Change of Address) is super-charged with invention. The unusual falls and lifts may have been inspired by his work with the LifeForms computer program.... In *Change of Address* six dancers fall to the floor, legs pretzelled, and lie there tipped at odd angles. I imagine him pressing keys and coming up with some-thing that leaves the dancer with no leg to stand on.[3]

[3] Deborah Jowitt *Wildfire,* The Village Voice, April 7, 1992

It is clear from the results of Cunningham's work with LifeForms, that dancers have been enlivened with new ways of working, and that the creative process of making dance has been enriched by the use of the computer. Cunningham's capacity, not only to envision possibilities, but also to concretely materialize those possibilities through his work in dance, has raised public consciousness in a way that perhaps no other single figure in the world of dance or of computer technology could accomplish. In April 1992, Joan Acocella, dance critic for the Financial Times, wrote:

> The most striking characteristic of (Cunningham's) work, aside from its formal beauty, is its objectivity. No dancing on the American stage today is freer of sentimental pretension.... And, by a familiar paradox, this objectivity gives (the dancers) a huge subjective force.... The two new works, *Change of Address* and *Beach Birds*, were both marked by a rather strange mix of greater literalism and greater obscurity than one is used to seeing.... In 1990 Cunningham started using a computer as an aid in composing his dances. These two opposing developments may account for the oddly literal and oddly counterliteral quality of the new works. Thesis, antithesis.[4]

Another example is presented below in a review of a recent dance by Cunningham called *Enter*, premiered at the Paris Opera in November, 1992.

> *Enter* is the brainchild of Cunningham's obsession with modern computer technology.... Cunningham dissects the human body with a computer mouse, breaking down the simplest gesture into composite parts.... The title *Enter* is no accident. It was inspired by what Cunningham called `the most important button' on the keyboard.... Theatergoers and Cunningham admirers loved it. So did the critics, who hailed the hour-long creation as his finest achievement: `all of his contributions to modern dance are so masterful, so glorious that *Enter* is the culmination and crowning of his life's work' [5]

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[4] Joan Acocella, *Merce Cunningham Dance Company*, Financial Times, April 28, 1992

[5] Marilyn August, *High-Tech Inspires Choreographer Cunningham at 73*, Associated Press Writers, Paris, October 1992

This is due in part to Cunningham's attitude of looking beyond the preconceptions that limit our ability to attempt unlikely combinations of movement, or of movement tools. This viewpoint has been a part of Cunningham's work in dance for over fifty years. As Cunningham has said, "In one way or another what we thought we couldn't do was altogether possible, if only we didn't get the mind in the way."[6]

Throughout all of the public dissemination of the possibilities of using a computer in the creative process of making dance, in previews, reviews, and articles about Cunningham's work with LifeForms, journalists have used titles such as: "Dancing with a Mouse", "High-Tech Inspires Choreographer Cunningham at 73", "Cunningham at the Computer", "Dance by the Light of the Tube", "Cunningham: Choreographer Devises Movement on a Computer", "Modern Dance Pioneer Merce Cunningham Discusses Purity of Dance in the Computer Age", "Cunningham's Computer-Assisted Dance Comes to UCLA", "Quantum Leaps", and, "He Who Wields the Mouse". Journalism written about Cunningham since the making of *Trackers* deals almost exclusively with his use of the computer and how it has affected the making of dance.

As a result of this growing public acceptance, many universities, dance companies, and educational institutions in Canada, the United States, and even Europe, Australia, and the East, have indicated an interest in learning about or using LifeForms, and have even begun to address computers and dance as a viable area of study by including it in their dance curriculum.

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6 Cunningham, Merce (1985) *The Dancer and the Dance*: *conversations with Jacqueline Lesschaeve,* Marion Boyars Publishers, New York, London, 1985, p 60.

The public interest in Life Forms has also inspired people to find their own connections in terms of the possibilities that computers offer dance. For example, people have recognized that linking LifeForms to movement notation systems would combine the creative and the archival uses of computer technology.

> Cunningham believes that computer animation programs could be invaluable in recording dance. Deirdre Myles, who is training to become certified in dance notation, concurs, "I'm hopeful that (LifeForms) is going to be helpful for notators in working up what the scores say before you actually get into the studio", she said, "It's really hard to tell how things should look, and is difficult when you have lots of people to manipulate. It should be easier on a computer screen. [7]

Also many people, including Cunningham himself, have recognized the potential of a tool such as LifeForms in teaching movement technique. A dance student can look at the movement many times, at different tempos, from different viewing angles, in three dimensions, and can even stop it at any point, or even view it backwards. In relation to LifeForms use as a teaching tool, Cunningham has said:

> It could, for example, show a movement in the air, so totally in detail, a student could really see what happens[8]

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7 Marilyn August, *High-Tech Inspires Choreographer Cunningham at 73*, Associated Press Writers, Paris, October 1992.

8 *Dancing With A Mouse,* Los Angeles Times, May 25, 1991.

The work of exploring the uses of computer technology in dance is less than thirty years old, still young, even by human standards. What Cunningham's work with dance and computer technology has shown is that not only does the technology grow in response to the choreographers that use it, but that the choreographic process also grows, is enlarged and even altered by its use. The design and creative process is symbiotic, and both the design of LifeForms, and the design of the dances created with LifeForms affect one another deeply[9].

5.1 Future Directions

Cunningham has paved the way for others to explore LifeForms as a choreographic tool, and has done so by continuing his quest to understand and create movement beyond the limitations of imagination. Future directions include further study of the compositional process both with Cunningham and other choreographers, incorporation of higher level compositional procedures into the LifeForms interface, further definition of movement dynamic qualities displayed on the computer through work with Laban's Effort/Shape analysis, and research into exploring the use of human gestural input through three dimensional movement capture systems. As Cunningham has said:

> You have to find a way to do what you can do. It is difficult for all of us, but if it's something that interests you deeply, you will find a way. [10]

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[9] Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", juried paper to appear in the *InterChi Proceedings*, InterChi Conference, Amsterdam, April 1993.

[10] Thomas B. Harrison quoting Merce Cunningham in *Cunningham: Choreographer devises movements on a computer*" Anchorage Daily News, Sunday Feb 23 1992.

BIBLIOGRAPHY

Computers and Movement

Badler, N. I., J. O'Rourke, S. W. Smoliar and L. Weber (1978). "The Simulation of Human Movement by Computer", Project Report No. 14, University of Pennsylvania, September 1978.

Barenholtz, J., Z. Wolofsky, I. Ganapathy, T.W. Calvert and P. O'Hara (1977). "Computer Interpretation of Dance Notation", *Computing in the Humanities*, August, 1977, pp. 235-240.

Bradford, J. and P. Cote-Laurence (1991), "Animate Tokens, Their Design and Application", *Leonardo*, Vol 24 No 5, 1991, pp 557-562.

Brightman, P. (1984), "Making Dances with Algorithms: Towards a Theory of Choreography, based on the Use of Computer Programs and Laban Concepts", M.A. Thesis, Columbia University, 1984.

Brown, M. and S.W. Smoliar (1976). "A Graphics Editor for Labanotation", *Computer Graphics*, Vol. 10, No.2, Summer 1976, pp. 60-65.

Bruderlin, A., Calvert, T., Schiphorst, T., Welman, C., "The Creative Process of Human Figure Animation from Keyframing to Procedural Control", Poster session, *PreCarn Conference*, Montreal, Sept, 1992.

Bruderlin, A., Schiphorst, T., Calvert. T. "The Animation of Human Movement: How Visual Can We Get", *Human Figure Animation: Aproaches and Applications*, Siggraph Course Notes number 8, Siggraph 1990, pp245-260.

Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., Welman, C., "The Evolution of an Interface for Choreographers", InterChi proceedings, InterChi Conference, Amsterdam, April 1993.

Calvert, T., Welman, C., Gaudet, S., Schiphorst, T., Lee, C., "Composition of Multiple Figure Sequences for Dance and Animation", Visual Computer Vol 7 Springer-Verlag, 1991, pp 114-121.

Calvert, T.W., C. Lee, S. Gaudet and C. Welman (1987). "Compose: A System for the Interactive Composition of Dance", SFU Graphics Research Group Working Paper WP87-1, September 1987.

Calvert, T.W. (1986). "Toward a Language For Human Movement", *Computers and the Humanities*, Vol 20, No. 1, Spring 1986, pp. 35-43.

Calvert, T.W., J. Chapman and A. Patla (1982). "Aspects of the Kinematic Simulation of Human Movement", *IEEE Computer Graphics and Applications*, Vol 2, November 1982, pp. 41-50.

Calvert, T.W., J. Landis and J. Chapman (1979). "Notation of Dance with Computer Assistance", *New Directions in Dance*, D.T. Taplin ed., Pergamon Press, Toronto, pp. 169-178.

"Dance: A Future With Computers", *Dance Theatre Journal*, Vol. 1, No. 3, August 1983.

Herbison-Evans, D., B.G. McNair and N. Neilands (1980), "Computer Assisted Choreography Teaching", 3rd Australian Computing Conference, May 1980.

Herbison-Evans, D. (1988) "Dance, Video, Notation and Computers", *Leonardo,* Vol. 21, No. 1, 1988, pp. 45-50.

Hutchinson, A. (1967). "A Reply", *Dance Magazine*, January 1967.

Hutchinson Guest, A. (1981). "Promises of Modern Technology", *Dance Notation*, 1981.

Lansdown, J., *Computer Choreography and Video*, in *Computing in the Humanities*, Lusignan, S., and North, J.S., editors. Proc Third Int. Conf. on Computing in the Humanities, Waterlo, Ontario, Canada, August, 1977, pp 241-252.

Lansdown, J., (1978), "The Computer in choreography." *IEEE Computer* Vol 11, No 8, August 1978, pp 19-30.

Lasseter, J. (1987), "Principles of Traditional Animation Applied to 3D Computer Animation", 3-D Character Animation By Computer, Course Notes No.5, Siggraph 1987.

McNair, B.G., D. Herbison-Evans and N. Neilands (1980). "Computer Assisted Choreography Teaching", Proceedings of the 11th Australian Colleges of Advanced Education Computing Conference, May 1980.

McGovern, T. (1987), "The Use of Live-Action Footage As A Tool for the Animator", 3-D Character Animation By Computer, Course Notes No. 5, Siggraph 1987.

Melina, R. (1989). "Keynote Address", UNESCO Seminar: Creativity and the Computer, UQAM, Montreal, May 1989.

Metesky, G. (1982). "Providing a Grammatical Context for Motion Representation", 1982.

Noll, M. (1967), "Choreography and Computers", *Dance Magazine*, January 1967.

Officer, J.M. (1976). "Computerization of Human Movement - A Tool for Movement Analysis", *Proceedings: The International Congress of Physical Activity Sciences*, Quebec City, July 1976.

Ridsdale, G. (1984). "The Director's Apprentice: An Intelligent Story-Board", PHD Thesis Proposal, Simon Fraser Univeristy, Fall 1984.

Patla, A.E., W.E. Eickmeir and R. Ryman (1984). "The Use of Computerized Movement Notation System (COMONS) to Record the Kinematics of Human Ambulation", 1984.

Politis, G. (1987). "A Computer Graphics Interpreter for Benesh Notation", PHD Thesis, University of Sydney, March 1987.

Ryman, R., J.C. Beatty, K.S. Booth and B. Singh (1983). "A Computerized Editor for Benesh Movement Notation", *CORD Dance Research Journal,* 1983.

Ryman, R., A.E. Patla and T.W. Calvert (1983). "Adaptation of Labanotation for Clinical Analysis of the Kinematics of Human Gait", 1983.

Savage, G.J. and J.M. Officer (1977). "CHOREO: An Interactive Model for Choreography", *Proceedings: Fifth Man-Machine Communication Conference*, Calgary, Alberta, Academic Press, Inc. (London) Limited, pp. 233-249, May 1977.

Schiphorst, T., T. Calvert, C. Lee., C. Welman and S. Gaudet, "Tools for Interacting with the Creative Process of Composition", *Proceeding CHI'90*, Seattle, April 1990, pp. 167-174.

Singh, B., J.C. Beatty, K.S. Booth and R. Ryman (1982). "A Graphics Editor for Benesh Movement Notation" *CS-82-41*, Computer Graphics Laboratory, University of Waterloo, December 1982.

Smoliar, S.W. and L. Weber (1977). "Using the Computer for a Semantic Representation of Labanotation", *Computing and the Humanitites*, S. Lusignan and J.S. North eds., University of Waterloo Press, Waterloo, Ont., 1977, pp 253-261.

Smoliar, S.W. and W. Tracton (1978). "A Lexical Analysis of Labanotation With An Associated Data Structure", *Proceedings ACM Annual Conference*, Vol. 2, 1978, pp. 727-730.

Weber, L., Smoliar, S.W., Badler, N. I., (1978) "An Architechture for the Simulation for Human Movement", *Proceedings of ACM National Conference Proceedings,* 1978, pp. 737-745.

Sveinson, L. (1977). "The Computer as an Artistic Tool", *International Journal of Man-Machine Studies*, 10, Academic Press Inc., (London) Limited, 1978, pp 251-262.

Thomas, F. (1987), "The Future of Character Animation", 3-D Character Animation By Computer, Course Notes No.5, Siggraph 1987.

Venable, Lucy, "Archives of the Dance (13): LabanWriter - There Had To Be A Better Way" *Dance Research,* The Society for Dance Research, Vol., IX, Number 2, Autumn 1991, Oxford University Press, pp 76-87.

Weber, L., S.W. Smoliar and N.I. Badler (1978). "An Architecture for the Simulation of Human Movement", *Proceedings ACM Annual Conference,* Vol. 2, 1978, pp 737-745.

Welman, C., Calvert, T. (1992), "Inverse Kinematics through Quaternion Differential Manipulation" Department of Computing Science, Simon Fraser University, Technical Report, 1992.

Wolofsky, Z., (1974) *Computer Interpretation of Selected Labanotation Commands.* M.Sc. thesis, Department of Kinesiology, Simon Fraser University, April 1974.

Ungvary, T., S. Waters and P. Rajka (1992) "NUNTIUS: A Computer System for the Interactive Composition and Analysis of Music and Dance" *Leonardo,* 1992, Vol. 25, No. 1, pp 59-68.

Zelinger, J. (1976). "Directions for a Semiotics of Dance", Goldsmiths College, University of London, 1976.

Zelinger, J. (1979). "Semiotics and Theatre Dance", *New Directions in Dance,* D.T. Taplin ed., Pergamon Press, Toronto, June 1979, pp. 39-50.

Dance Analysis and Choreography

Bartinieff, I., M. Davis, and F. Paulay (1970). *Four Adaptations of Effort Theory in Research and Teaching*, Dance Notation Bureau, New York, 1970.

Blom, A.L. and L.T. Chaplin (1982). *The Intimate Act of Choreography*, University of Pittsburgh Press, 1982.

Cunningham, Merce (1955) "The Impermanent Art", *7 Arts*, No. 3, Colorado, 1955.

Cunningham, Merce (1968) *Changes: Notes on Choreography*, (edited by Frances Starr), New York, Something Else Press, 1968.

Cunningham, Merce (1985) *The Dancer and the Dance*: *conversations with Jacqueline Lesschaeve,* Marion Boyars Publishers, New York, London, 1985.

Davis, M. (1970). "Effort-Shape Analysis of Movement: An Evaluation of its Logic and Consitency and its Systematic Use in Research", in *Four Adaptations of Effort Theory in Research and Teaching*, Dance Notation Bureau, New York, 1970.

Dell, C. (1977), *A Primer for Movement Description using Effort-Shape and Supplementary Concepts*, Dance Notation Bureau Press, New York, 1977.

Foster, S. L. (1986). *Reading Dancing*, University of California Press, 1986.

Hanna, J.L., (1987). *To Dance is Human*, The University of Chicago Press, Chicago, 1987.

Hayes, E.R., (1981). *Dance Composition and Production*, Dance Horizons, New York, 1981.

Louis, M., (1980), *Inside Dance*, St. Martin's Press, New York, 1980.

Massine, L., *Massine on Choreography*, Faber & Faber, London, 1976.

Laban, R. and F.C. Lawrence (1947) *Effort*, MacDonald & Evans Limited, 1974.

Sheets, M. (1966). *The Phenomenology of Dance*, The University of Wisconsin Press, 1966.

Design and Compositional Process

Akin, O. (1978). "How Do Architects Design?", *Artificial Intelligence and Pattern Recognition in Computer Aided Design*, Latombe, ed., IFIP.

Branchi, W. (1983), "The State of Anxiety", *Computer music Journal*, Vol 7, No.1., 1983.

Buxton, W., "A Composer's Introduction to Computer Music", *Interface*, Vol.6, No. 2, 1977.

Chadabe, J. (1984). "Interactive Composing: An Overview", *Computer Music Journal*, Vol. 8, No. 1, 1984.

Clynes, M. (1978). *Sentics*. New York, Doubleday.

Dodge, C. and T. Jerse (1985). "Composition with Computers", *Computer Music*, Schirmer, 1985, pp. 265-321.

Ghiselin, B., ed. (1952). *The Creative Process*, University of California Press, 1952.

Glaser, B., and Strauss, A., (1967). *The Discovery of Grounded Theory*, Aldine - Atherton, Chicago, 1967.

Johnson-Laird, P.N., *Mental Models*, Harvard University Press, Cambridge Massachusetts, 1983.

Kneller, G. F. (1965). *The Art And Science of Creativity*, Holt, Rinehart, and Winston, Inc., New York, 1965.

Koenig, G. M., *PROJECT ONE, Electronic Music Reports*. Amsterdam: Swets & Zeitlinger, B. V., 1977.

Koenig, G.M. (1977). *My Experiences with Programmed Music, Faire*, Vol. 4, No. 5, G.M.E.B., 1977.

Koenig, G.M. (1980). *Composition Processes, Computer Music*, M.Battier & B. Truax, eds., Canadian Commission for Unesco, Ottawa, 1980.

Koestler, A. (1964). *The Act of Creation*, MacMillan, New York (1964).

Laske, O., (1989), "Composition Theory: An Enrichment of Music Theory", *Interface,* Vol. 18(1-2) pp. 45-59.

Laske, O., (1990), "Toward an Epistemiology of Composition", I*nterface,* Vol. 20 pp. 235-246.

Laske, O., (1990), "The Computer as the Artist's Alter Ego", *Leonardo,* Vol. 23(1) pp. 43-56.

Norman, D.A. (1988). *The Psychology of Everyday Things*, Basic Books, Inc., NewYork, 1988.

Oxman, R. and J.S.Gero (1988). "Designing by Prototype Refinement in Architecture".

Pagels, H.R. (1989). *The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity*, Bantam Books, New York, (1989).

Pylyshyn, Z. (1989). "The Design Process: Lecture Notes".

Shore, H., (1986). "Beyond TRON: The Technological Challenge to the Arts", *Art and Reality A Casebook of Concern*, Talonbooks, Vancouver, October 1986.

Simon, H. A., (1981). *The Sciences of the Artificial*, The MIT Press, Cambridge, Massechusetts, 1981.

Truax, B. and J. Barenholtz (1977). "Models of Interactive Computer Composition", *Computing in the Humanitites*, S.Lusignan and J.S. North eds., University of Waterloo Press, Waterloo, Ont.

Truax, B. (1976). "A Communicational Approach to Computer Sound Programs", *Journal of Music Theory*, Vol 20, No. 2, 1976, pp. 209-220.

Truax, B. (1980). "The Inverse Relation Between Generality and Strength in Computer Music Programes", *Interface*, Vol 9, No.1, 1980.

Truax, B. (1985). "The PODX System: Interactive Compositional Software for the DMX-1000", *Computer Music Journal*, Vol 9, No. 1, 1985.

Truax, B. (1986). "Computer music Language Design and the Composing Process", *The Language of Electroacoustic Music*, S.Emmerson, ed.,, The Macmillan Press, London, 1986.

Truax, B. (1992). "Composing with Time-Shifted Environmental Sound", *Leonardo Music Journal*, 1992, pp. 149-167.

Waldron, M. J. (1987). "Modeling of the Design Process", *Intelligend CAD I*, Proceedings, of the IFIP TC 5/WG 5.2 Workshop on Intelligent CAD, Boston, MA, 6-8 October, 1987, Elsevier Science Publishing Company, New York (1989).

Wiggen, K. (1969). "The Musical Backgound of Computer Music", *Fylkingen International Bulletin*, No. 2, 1969.

Other

Clark, Ronald, W., *EINSTEIN The Life and Times*, World Publishing Company, 1971,

Laing, R.D. (1982). *The Voice of Experience*, Penguin Books, New York, 1982.

Sheldrake, R.A. (1988). *The Presence of the Past: Morphic Resonance and the Habits of Nature*, Times Books, New York, 1988.

Thompson, W.A., (1981). *The Time Falling Bodies Take To Light*, St. Martin's Press, New York, 1981.

Weizenbaum, J. (1976). *Computer Power and Human Reason*, W.H. Freeman and Company, 1976.

Appendix I

This appendix chronologically outlines the history of the LifeForms work that occurred between the author and Merce Cunningham, in Cunningham's studio in New York City. Listed are dates and a brief description of events, from the initial meeting and installation through to software upgrades, tutoring, working and exploratory sessions between Cunningham and the author.

Date	Description
05-08 Aug89	initial meeting with Merce Cunningham, Michael Bloom (Director of Education and Media for the Cunningham Foundation), and Dr. Tom Calvert to discuss upcoming installation dates and procedure for installation.
29 Nov89 – 07 Dec89	initial installation of SGI personal Iris 4D/20; operating system installation, and LifeForms installation. Tutoring begins with Stance based version of LifeForms, then called Compose.
14 - 16 Dec89	re-installation of LifeForms to remedy some bugs identified in first visit, followed by a continuation of the tutoring sessions with Stance based version of LifeForms.

Date	Description
12 - 17 May90	tutoring session with Stance based version of LifeForms based on Cunningham's work in progress; installation of preliminary Sequence Editor version of LifeForms; preliminary viewing of Sequence Editor based version of LifeForms by Cunningham and initial discussion and suggestions.
05 - 21 Ju190	installation of new Sequence Editor version of LifeForms including timeline with keyframe shapes; tutoring sessions with new system begins and continues for two and 1/2 weeks; creation and editing of LifeForms manual and tutorial guide to assist Cunningham.
19 - 25 Aug90	tutoring session with new Sequence Editor version of LifeForms continues for one week.
05 - 12 Jan91	tutoring session with Sequence Editor version of LifeForms continues specifically to answer questions relating to the creation of the new dance *Trackers*; Cunningham begins to work with LifeForms to create *Trackers,* while dancers are on a break.
16 - 20 Mar91	Cunningham Dance Company's spring performance season at the New York City Center Theater; premier of *Trackers*; CNN interview with Cunningham and the author.

Date	Description
25 - 30 Sep91	re-installation of LifeForms to reduce a number of bugs; tutoring sessions with Cunningham; new version with inverse kinematics wasn't ready to install: installed bug fixes for stage and timeline views. Author talks to Cunningham about the making of *Trackers.*
28 Mar92 – 06 Apr92	Cunningham Dance Company's spring performance season March 17 - 29 at the New York City Center Theater; new SGI Operating System Installation (3.3.2); convert all Cunningham's sequences and dances to new file formats for new LifeForms interface; install new LifeForms with test version of inverse kinematics; tutorial sessions with Cunningham for one week. Author talks to Cunningham once again about the making of *Trackers*.
14 – 15 Apr92	BBC interview for *The Late Show* with Cunningham, Schiphorst and LifeForms.
30 May – 08 Jun92	installation of new version of LifeForms which includes inverse kinematics; tutorial sessions with Cunningham; realization that faster machine is necessary for latest LifeForms.
05 – 10 Sep92	working sessions with Cunningham with inverse kinematic version of LifeForms.