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Expressive Trajectories

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Abstract

This paper presents Expressive Trajectories, *a project for Interactive Digital Art and Contemporary Dance. The project is composed of X-Motion, a real-time interactive system for live performances; and Choreographisms, an interface abstraction for graphical interpretation of motion-paths. This framework is demonstrated through an experiment based on a choreography of the artist Analivia Cordeiro for Unsquare Dance.*

Categories and Subject Descriptors (according to ACM CCS): I.3.8 [Computer Graphics]: Applications

1. Introduction

In recent years, the use of multimedia resources, such as live projection and dynamic lighting, has been increasingly exploited in music shows, dance presentations and art performances. However, up to now, these powerful visual sources have been applied mostly as an additional element to the set background, thus transforming it into a visually dynamic stage.

The above context motivated us to develop a multidisciplinary project that aims to combine techniques from Computer Graphics, Vision and Animation with applications in Contemporary Dance, Stage Design and Art. Our goal in this project is to push forward the state-of-the-art by calling into the scene real-time interaction and vision techniques. In this way, by integrating motion capture with procedural graphics and live displays, we expand the creative possibilities enabling graphical elements to be used, not as a mere passive set element, but primarily as an active one – a virtual agent capable of interacting with other actors in the scene under the guidance of the director-choreographer.

For that goal, we created the X–Motion system which enables the design of a virtual dynamic stage that is linked to the dance. The system uses movements of dancers as an input for the generation of graphisms that are projected on the set in real-time. Through the system, the choreographer directs not only the dancers' movements, but also graphical elements that are projected into the set, which becomes dynamic and interactive. Thus, these graphisms act as virtual dancers, establishing an interaction and dialogue with real dancers mediated by the choreographer. They can be modified by interactions with the dancers, instigating changes to the dancers' movements as well.

The system captures the motion of markers on the dancers' body to generate trajectories that are represented as curves parametrized in time. Authoring is based on graphical interpretation of movement, thus establishing an association of motion-paths with visual forms. These motion-paths are coupled with procedural methods which transform them into (re)active shapes. Expressive visual elements are programmed by the director-choregrapher using an abstraction that we call *choregraphisms*. This interface defines the syntactic and semantic graphical rules to be applied to motion paths during a live performance.

An experiment to evaluate the project was conducted with a renowned dancer/choreographer Analivia Cordeiro. She is a pioneer on dance-technology in Brazil and also a specialist on the Laban method. She made use of the system to develop an artistic work called *Unsquare Dance*.

The rest of the paper is structured as follows. In Section 2 we describe the X-Motion system and its architecture. In Section 3 we discuss the concepts used for graphics interpretation in the interface Choreographism. In Section 4 we show some results of the performance "Unsquare Dance". Finally, in Section 5 we conclude with final remarks and hints of future directions.

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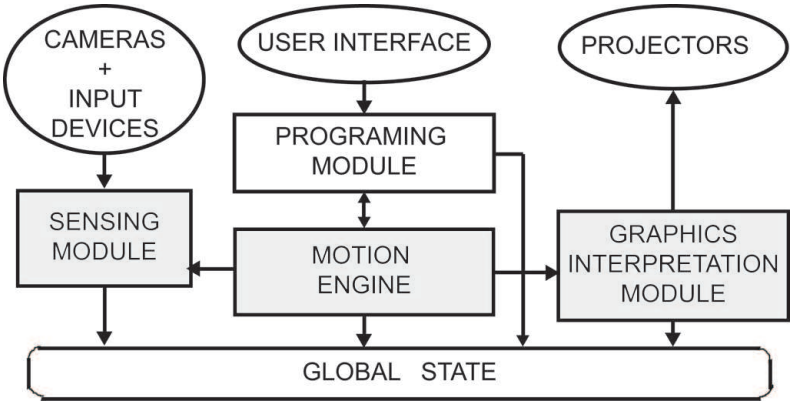

Figure 1: *X-Motion System Architecture.*

2. The X-Motion System

The X-Motion system analyzes a video stream of a dancer's performance and calculates the time-dependent positions of markers placed at the dancer's body. This data is then used as input to procedural rules that drive the interaction and the graphics output to be projected in real-time on a background screen.

The system architecture is composed of four modules: the *sensing module* which captures and analyzes the data coming from input devices; the *programming module* which manages the procedural library; the *motion engine* module which controls the interactive global state; and the *graphics interpreter* module which renders the results. An overview of the X-Motion System's architecture with its components is shown in Figure 1.

The system implements a finite state machine where a state is defined by a set of formal attributes that determines the appearance and behavior of the generated graphisms. Real-time interaction sets the machine in motion, scheduling procedural evolutions: i.e., changes through time, and possibilities of state alterations with transitions between them.

2.1. Sensing Module

The sensing module is responsible for real-time data input into the system. It performs primarily motion capture from the dancers and also acquisition of secondary signals from other devices.

The performer movements are captured using an infrared camera and retro-reflective markers that are attached to points on the performer's body.

First, the raw video is processed to extract the position of markers. This is done by subtracting the background from the captured frame and by thresholding the resulting image and computing the the center of mass of white blobs in the processed frame. See Figure 2.

input frame background processed frame

Figure 2: *Capturing Markers.*

Second, these markers are tracked through time using Kalman filtering to obtain point trajectories. Finally, bicubic spline interpolation method is used to define time-dependent curves. The system calculates attributes of these motion paths, such as velocity, acceleration, etc. Figure 3 depicts a diagram of the sensing module.

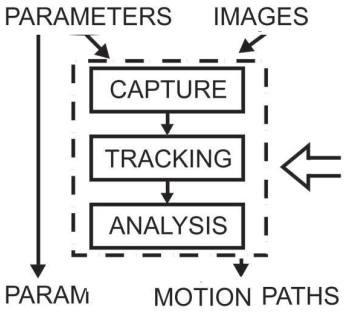

Figure 3: *Sensing Module.*

2.2. Motion Engine

The motion engine is the core of the system. It embodies a Finite State Machine that controls the real-time interaction and the global state. The engine is composed by a scheduler, an event processor and a state transition manager.

The scheduler implements the system's clock and activates all the other modules. It keeps track of the sequence of tasks to be executed by the system in real time.

The Finite State Machine (FSM) is defined by states and transitions between these states. Each state is characterized by a drawing behavior associated with motion paths (i.e. we can define a state which draws a circle at several locations along the path, and we could define for this state that the circle radius will vary with the path curvature).

Transitions will let the system change from one state to another. To define a transition we need to set the source and target state as well as the event that will trigger the transition. Events could be of different types: curve events, keyboard, mouse, midi, etc... The system analyzes the possible transitions for the current state and when a transition event occurs the system changes the drawing behavior.

A diagram of the Motion Engine is shown in the bottom part of Figure 4.

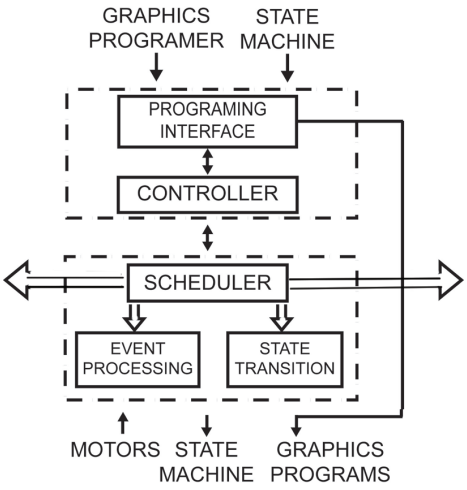

Figure 4: *Motion Engine and Programming Module.*

The programming module is the main interface of the system with the choreographer. It

2.3. Graphics Interpretation Module

3. Choreographisms

When defining a state, the choreographer is in fact programming the way the dancer can interact with the graphisms. The dancer, on the other hand, also controls the system through state changes. Triggering of a new state may be linked to variables such as motion path parameters, clock time, procedural animation objects (motors, oscillators, etc.), or even randomness.

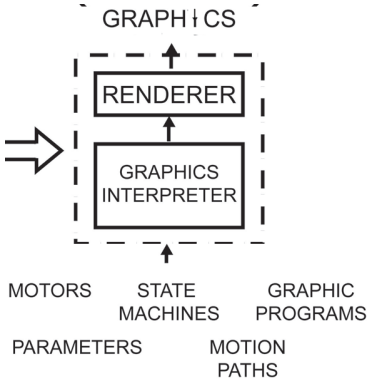

Figure 5: *Graphics Interpretation Module.*

4. The Experiment

Unsquare Dance was an experiment to evaluate the Expressive Trajectories project. This experiment was realized during December of 2007 at IMPA and included a series of dance performances based on a choreography of the artist Analivia Cordeiro. The title of the work comes from the music "Unsquare Dance" by Dave Brubeck. The piece consists of a live performance by Analivia in a dynamic stage made by projected computer graphics elements.

The whole experience was recorded in a series of videos with different graphic interpretations.

4.1. Unsquare Dance Manifesto: *by Analivia Cordeiro*

– How did this work appear: motion language broads any spatial change of the body, from delicate gestures to expansive, exalted ones, which cause strong impression. These spatial changes, apparently invisible, are captured through the eyes as ways to its capacity of visual persistence. This interpretation isn't new, since it comes from Ancient Times: the Greek defined dance as drawing in the space.

The exhibition of a movement trajectory is secular: male private dances, made with fire torchs, describe circles in the air, like, for example, the Polinese dance called Sivanofaoti []. The study of the movement by its trajectory is more recent: it starts with photographic recording of light moving in the dark. With the advent of computers, the capturing technology improved, and it made possible various analysis in time and space. There is a large body of research in this area, and in author's specific case, it dates back to the project *Nota-Anna* [].

The choreography for "Unsquare Dance" was born from observations of author Analivia Cordeiro, which originated from her practical–theoretical studies of human motion seen through electronic media. This line of investigation points to the need of giving texture to time curves described by

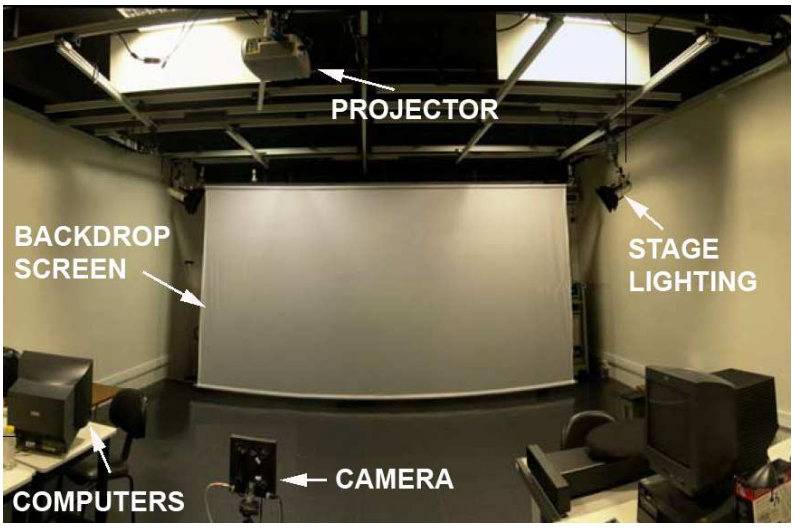

Figure 6: *Stage.*

motion paths in the computer. Such texture could give visual meaning to the musculature/weight relation.

The X-Motion system brought to life this dance piece. A characteristic of the software is to create different visualizations for the movement varying parameters such as: color, line types, stroke weight, and other effects that can be manipulated in real-time. The system gives infinite textures to lines, to be imaginated and defined by the artist, transmitting expression.

While the performer executes the movement, the choreographer interprets the motion giving it an artistic expression. Thus, the same performance can generate many visual results depending of the visual interpretation that creates active shapes with it. Therefore, X-Motion is foremost an aestetic instrument. Unsquare dance was born from these principles.

The lines and shapes that the Unsquare Dance choreography produces are not abstract, they result from the body motion in real-time. They stimulate thinking about motion, an act made possible by the "sixth sense" of human beings. The cinestesic, the one that tells us where each joint is located in our body and in space in each instant in time.

In this context, question can be posed: *would the spectator that watches a performance of Unsquare Dance be able to see the lines which describe the movement without the visual help of the computer?* Maybe not yet. Our eyes are not trained to look in such a way to someone that is moving. We pay attention in a person, to his/her expression, clothes and colors. But, who is conscious of the paths that each part of a moving body describe in space? Very few. Currently, these trajectories say little to the layman, however in the future they will tell a lot. This is the way to motion education in the future.

The motion capture of human joints and its trajectories in space induces a new kind of performance (be it in contemporary dance, sports, fights etc..). A novel way to learn, practice and create movements. This leads to a new look about performance, showing its essence, because it reveals pure motion, independently of physical aspects of the person moving, and at the same time, it characterizes very clearly the way each person moves.

This record of motion introduces with property, the performance in the digital world, but respecting the organicity of our body. The virtues and acrobatics, in the future, will be able to describe perfectly the plasticity of circles, straight lines and elaborate shapes. For this the body joints should be free and perfectly coordinated within the unity of the body. Which is a big challenge!

In general, the motion education is undergoing deep changes since the beginning of the twentieth century, seeking, particularly in the contemporary dance, to overcome the rigidity of the classical ballet. A lot has been done. Many techniques appeared with the purpose to reconquer the organicity of the natural motion of human beings. But, an effective instrument for motion evaluation that has surpassed the rules of ballet dos not exist yet.

An instrument for describing the execution of any movement of the body in space and time can point to flaws and locate them with precision in the specific body joint. This can lead to a new vision of movement.

The choreography Unsquare Dance is composed by natural movements, which are based on the passive release that uses the impulse of the springs generated by the musculature / force relation of gravity, maintaining the consciousness of the joints "open". It didn't look for references in ballet move-

ments, modern dance or contemporary dance. The goal was to show the anthropormorphic of the generated trajectories, that can be easily observed on the rhythm, on the line's drawing and on the "organic" geometry generated by the movement of the markers placed on body joints.

The expression of the movement is exactly located on the relationship between the mathematical form of a line and its execution by the body: *How round is a circle?* In which instant of its practice does it curve? There is the expression of movement. Individual expression: if another dancer performs the same dance, the trajectory is going to be similar, but not equal. The difference is the expression.

In the same manner if two choreographers, using the X-Motion system, create visual effects for the same dance, the results would be diverse. Considering the dual of creators performer / choreographer, the performance of the body imprints (i.e. stamps, marks) the final work. It is a new body-art, placed between the electronic environment – instead of ink over canvas as a tradicional form of body-art.

Why body-art? First because without a body it doesn't exist, it is the essence. Second of all what can be seen is a trail made by the body; the impression of the body; and not the own body. Third, is the unit performer / choreographer that generates the work. Directly. The result is function of body performance. Infinite art pieces can be created. Everything depends on how many performers and choreographers are acting.

One characteristic is significant: the possibilities offered by the X-Motion system suggest an imaginative flexibility for the choreographer (as well as for the performer), because they allow a creation of visual effects in a direct, simple way. It activates imagination and genuine creativity, "creativity from the start", it means, who uses the system defines which, when and how the visual elements will be depicted. It opens a true new universe.

5. Conclusions

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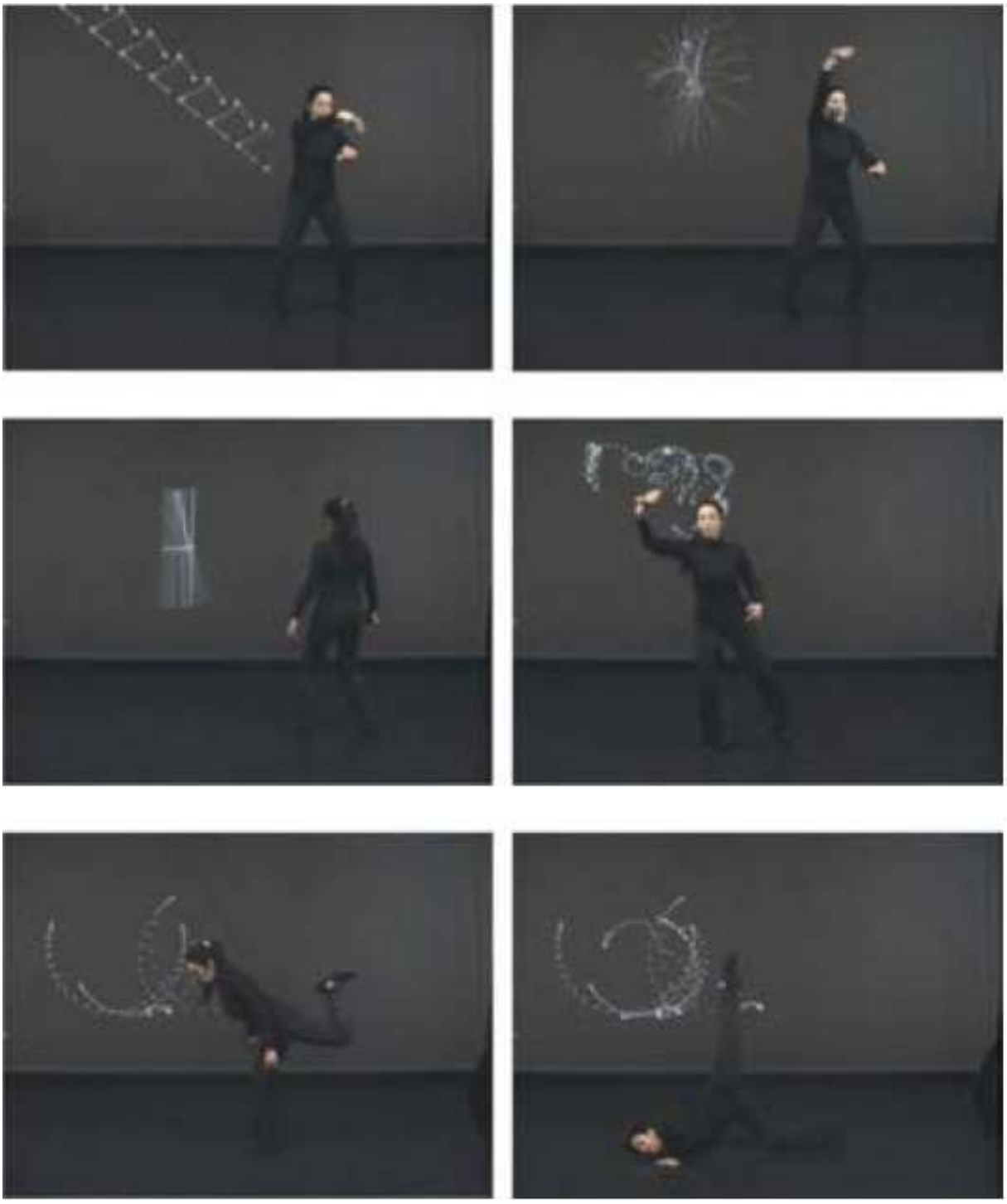

Figure 7: *Dance Performance.*

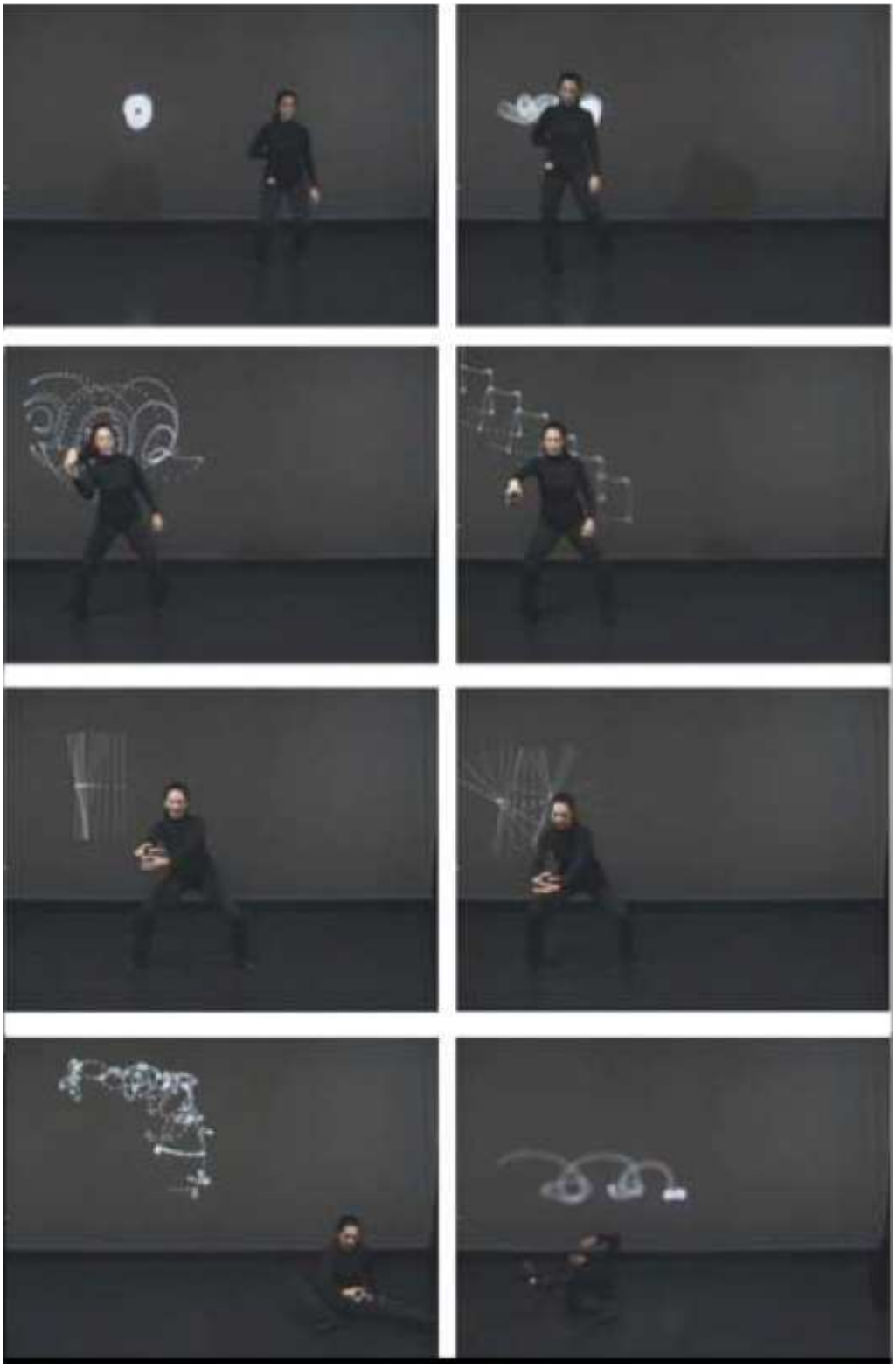

Figure 8: *Dance Performance.*