CHOREO: AN INTERACTIVE COMPUTER MODEL FOR CHOREOGRAPHY

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Abstract

Dance notation is the symbolic representation of three-dimensional movement and has been recognized for its value in recording and analyzing choreography. Accurate notating depends on the subjective judgement of the notator and building a dance score or reading it back is time-consuming.

An interactive computer programme, called CHOREO, is an attempt to aid in these problems by its use as both an aid for teaching notation and also as a means of providing visual simulation of an existing score. A VT-15 graphics display with a function box and acoustic pen provide the interactive computing facilities. The programme operates on a PDP-15 with 80K memory. The programme consists of three parts: 1) an input package allowing interaction via function box and acoustic pen to build a notation score with visual feedback on the CRT: 2) an interpretation package which translates the score into mathematical language; and 3) an output package which provides display of a stick figure model and replay facility for simulation of human movement.

CHOREO: MODÈLE INFORMATIQUE INTERACTIF POUR LA CHORÉGRAPHIE

Résumé

La notation de la danse, qui est la représentation symbolique du mouvement tridimensionnel, se révèle très utile pour l'écriture et l'analyse des chorégraphies, Une notation précise dépend du jugement subjectif du notateur et il faut consacrer beaucoup de temps à l'écriture d'une partition de danse et à sa relecture.

On a mis au point un programme informatique interactif, appelé CHOREO, afin d'aider à la solution de ces problèmes; le programme sert aussi bien a l'enseignement de la notation qu'à la simulation visuelle d'une partition existante. Une unité d'affichage graphique VT-15, avec clavier de fonctions et stylo à action acoustique, permet le calcul interactif. Le programme, qui fonctionne sur un PDP-15 avec mémoire de 80K, comporte trois parties: 1) un programme-produit d'entrée assurant une interaction par l'intermédiaire du clavier de fonctions et du stylo à action acoustique, permettant la notation d'une partition avec réponse visuelle sur l'écran cathodique; 2) un programme-produit d'interprétation qui traduit la partition en langage mathématique; et 3) un programme-produit de sortie permettant l'affichage de croquis des danseurs et les reprises pour la simulation du mouvement humain.

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INTRODUCTION

The subject of dance literacy has become an issue of great interest and concern to those persons in the profession who realize its tremendous importance.

Until the twentieth century, dance had no adequate means of recording its masterpieces. Even the steps, on which dancing and ballets were based, could only be indicated by drawings of static positions and the movement had to be verbally described. Moreover, these descriptions assumed a knowledge within a framework of reference which was changing with fashion and social evolution.

The severity of this difficulty can be likened to an inability of music composers to write down their compositions until this century. In other words, our knowledge of Bach or Beethoven would be only as accurate as each teacher's memory of a composition and his ability to play it for his student. As well, a student, wishing to stay with current musical taste and perhaps not caring for historical integrity, might perform the work to suit his own virtuostic strengths, and then later in his life, pass the work to his own students. How much of Bach would remain by now, to be analyzed and reinterpreted afresh, is impossible to estimate.

Film would seem to be the obvious answer to the dance world's dilemma. However, a ballet on film is an interpretation of the choreographer's intent as is the recording of a symphony, and learning a ballet from a film is as difficult as seventy musicians learning a symphony from a recording.

There are now notation methods which enable the choreographer to record dance in an analogous manner to that of writing music. Unfortunately they are all complicated and demand as much time and effort to master as the learning of another language. But the notation methods do adequately solve the problem of translating three-dimensional movement to two-dimensional symbols.

Labanotation [1] is probably the most detailed and accurate notation method so far and it is now being used extensively in North America. However, no matter how accurate the Laban symbols are, the symbols are chosen and recorded by a notator who makes a subjective estimate of the placement of each body part in space. The notation, then, is only as accurate as the eye-estimate of the notator.

Modern technology would seem to have a valuable role to play in support of the newly developed notation. Computer graphics has been initiated as a tool for simulating human movement via dance notation concepts. There are two projects in Canada which are exploring the problems and possible uses of computer graphics in this area. Calvert [2] of Simon Fraser University is interested in applications for Kinesiology, while the project being developed at the University of Waterloo is concerned with the following:

1. Improving eye-estimation of the location of body parts for purposes of writing dance notation.
2. Reproduction of a notation score in visual form on the computer. (This would be valuable as a record of a work of art in dance and also a fast method of settling future copyright claims). [3, 4]

These goals were not apparent when the project at Waterloo was initiated. The Department of Systems Design had already designed a computer graphics package called FILMIT [6], which enabled linked models to be manipulated in three dimensions. One of the models was a human figure. The Dance department was approached to explore the model's possible use for dancers. At first it was thought that the figure could be used for experiments in choreography (designing a dance). Although the goals have now been altered, it was then 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. Fortunately, the highly organized nature of the notation systems were amenable to the methods of interactive package that allowed the dancers to communicate with the computer in their own language.

The first interactive system, which is called CHOREO, was based on the Leonide Massine method of notation. This notation method was chosen because of a recognizable correspondence between the notation and the mathematical methods of the computer model. The present system called CHOREO-L, is based on the more popular Labanotation system. Both CHOREO and CHOREO-L are now discussed in the following sections.

CHOREO

The central idea of a dance notation method is quite straightforward: key body position are specified at instants of time, where time runs in a beat pattern not unlike that of music. In other words, as long as dancers know start positions, end positions and the time duration of the movements, they can easily interpolate for the intermediate positions, so that smooth flowing motion is the final result. This concept is certainly not foreign to those familiar with computer animation methods. The start and end positions and duration of movement is the information supplied by the symbols in the dance score. It is this information then that has to be presented to the computer model in an orderly fashion.

a) Interactive Input: Since each symbol in any notation system, as well as the Massine method, carries with it a verbal description (hence the language of dance), which has at its roots a simple Cartesian coordinate system, it was felt that the first means of interaction could quite readily be established through CRT presented menu cards rather than the notation symbols themselves (see Fig. 1).

Any body position of the graphical model can be specified by selecting the required body parts in turn (see Fig. 3), selecting the type of movement for the body part (see Fig. 4) and finally selecting the degree of the movement (there are only a small number of these). Each selection from the menu cards is made by a two-row, five column function box, where the buttons have a one-to-one correspondence with the menu items. Many key body positions, with beat duration values, which is the basis of a dance, constitute the input data to the computer.

b) Computer Simulation of the Dance: The graphical model of the dancer is presently composed of fifteen body parts where each part is of a simple appearance (see Fig. 5). The model is a tree linked structure and its topology can be easily described by a parent-son relationship. Since each body part is assigned its own local coordinate system, any body part can be consistently attached to its parent body part once the proper coordinate value in the parent coordinate system is given. The graphical model can be placed in various body positions, its a mathematical sense, by specifying three angular rotations of all local coordinate frames (hence the body parts) with respect to the parent frames. Since the limbs are described with respect to their own local axis system, the shape or appearance of the limb is completely independent of the overall operation of the model.

The input data, which contains the key positions of all body parts can be readily converted to mathematical information. This is accomplished by converting the given body part position to both a vector direction (orientation) and a rotation (or roll) about the axis of orientation. Since there are only small number of body part orientations a look-up table of corresponding vector directions facilitates the above mentioned conversion. The simulation of the dance is essentially obtained by calculating a number of intermediate body positions (frames) between the key body positions, where any body position is the result of the individual body parts. The number of intermediate or interpolated body positions is a function of the duration (that is, the given number of beats) of the movement, hence different velocities can be specified for different movements. In addition, the real time duration of a standard beat can be interactively supplied for purposes of synchronizing the visual simulation with a musical score.

c) Computer Graphics Output: As each frame of the simulation is calculated, a visual display is provided on the CRT, while at the same time the associated display file is saved on disk, (the calculation time for each frame is in the order of one second). A real time simulation of the dance can readily be obtained by a replay feature which recalls and displays the frames at 1/24 of a second - the speed of a standard motion picture projector. An interface is also available for computer actuation of a single frame 16mm. Bolex camera for purposes of making a film of the choreography.

CHOREO-L

At the time of writing this paper, the CHOREO system is being altered to allow for the use of the Labanotation method (see Fig. 2). As mentioned earlier, this new system is called CHOREO-L. There are two primary differences between CHOREO, (which is based on the Massine notation system) and CHOREO-L: firstly, in CHOREO-L, the choreographer now describes the dance to the computer by actually selecting and organizing the symbols of the Labanotation method (recall that in CHOREO a verbal description of the symbols was required); and secondly, individual body parts can be instructed to start and end movements at different beat values (in the Massine system, the limb positions are simultaneously specified). Both differences introduce the need for greater computational sophistication.

a) Interactive Input: In CHOREO-L, the choreographer describes the dance to the computer by selecting the appropriate body part and its spatial position symbol from a general menu. The general menu is a graphical overlay on an accoustic tablet and the selection of the symbols is made by the associated accoustic pen. As the score is built a visual record is displayed on the CRT for purposes of verification, while at the same time, a record of the score is saved in an organized fashion in the computer.

b) Simulation and Output of the Dance: In order to calculate the body position of each frame, the same mathematical procedure is used in the CHOREO-L system as in the CHOREO system; that is, each body part is described by a vector direction and a roll angle. However, since the movement of each body part now starts and ends at its own key frame times (rather than at a common time value), a somewhat more extensive storage and checking procedure is required in the program in order to calculate the individual body part positions for each frame of the simulation.

   In addition, the CHOREO-L system ensures that the graphical model appears to be in static balance at each instant of time. This has been accomplished by the combination of assigning representative weights to each body part and judicious adjustments of the body position to ensure a balanced posture.

   The computer graphics output procedures of CHOREO-L are identical to those of CHOREO.

COMPUTER HARDWARE

The computer hardware used in this research consists of a PDP-15 with 80K words of memory and a VT-15 graphics display.

FUTURE DEVELOPMENTS

The results to date have been encouraging, primarily because the system has been accepted by both students of dance and professional dancers. Students of notation methods have found the computer graphics approach to be useful as a tutor, while the professionals have found the methods of interaction easy to learn and use. However, much more work is required to bring the system to the point of full application. For example, at present, CHOREO does not handle motional type commands (walking, jumping, etc.). More, body joints need to be made available, and more body parts need to be added. Specifically, the thorax should be subdivided into an upper and lower part and a shoulder girdle should be designed. These additions would increase the suppleness of the model and help provide for a greater degree of expressiveness.

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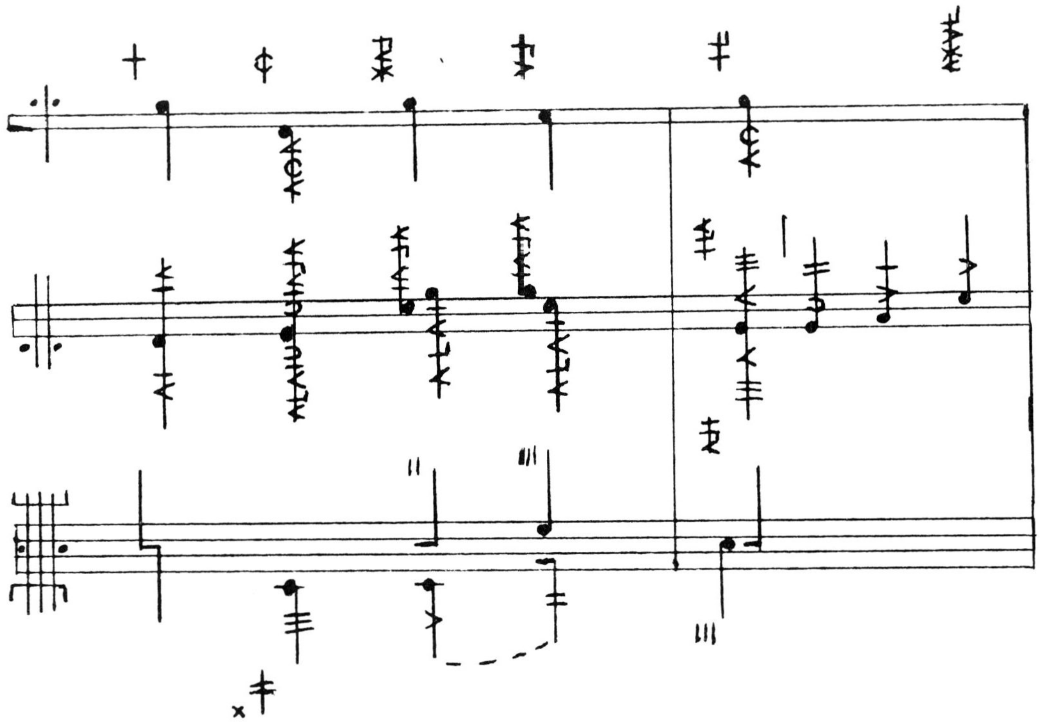

Figure 1

A Sample of the Massine Notation Method

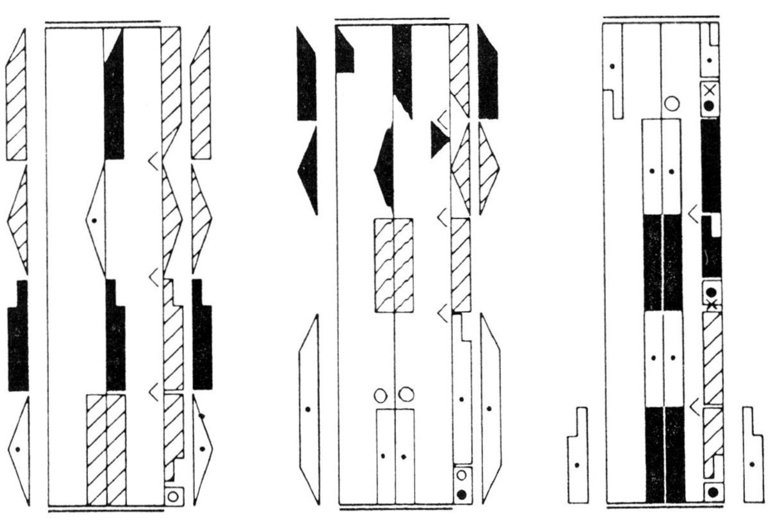

Figure 2

A Sample of Labanotation

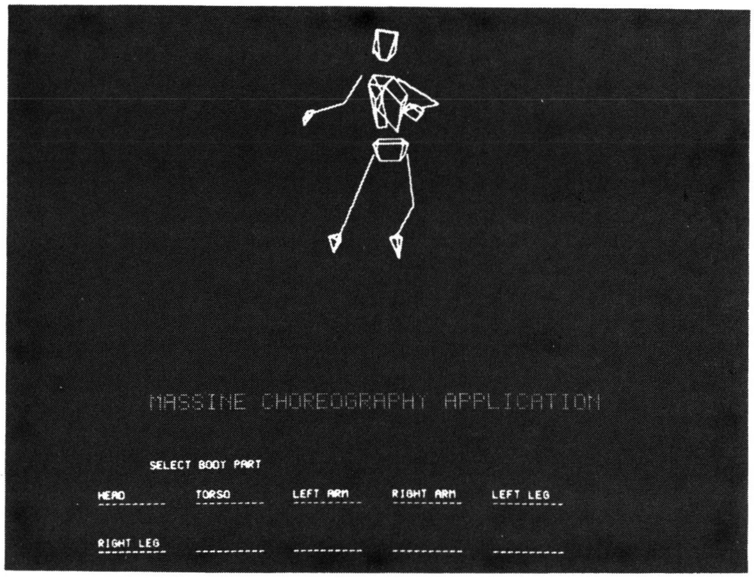

Figure 3

Body Part Menu

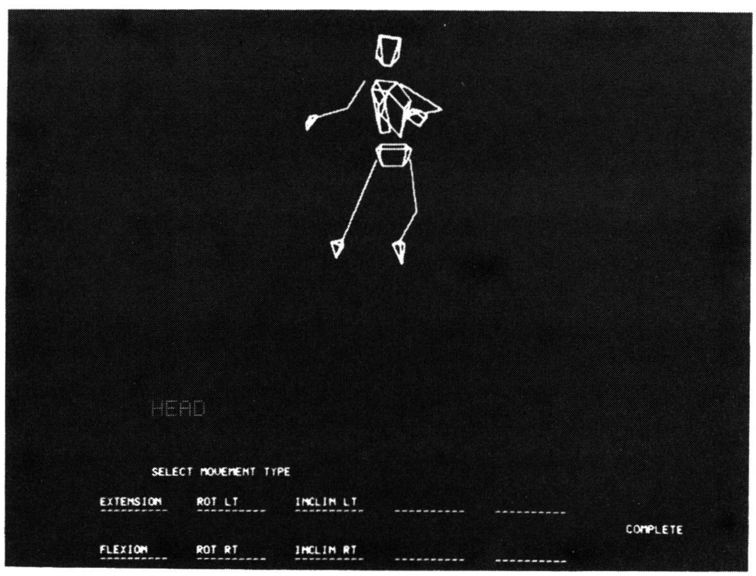

Figure 4

Movement Type Menu

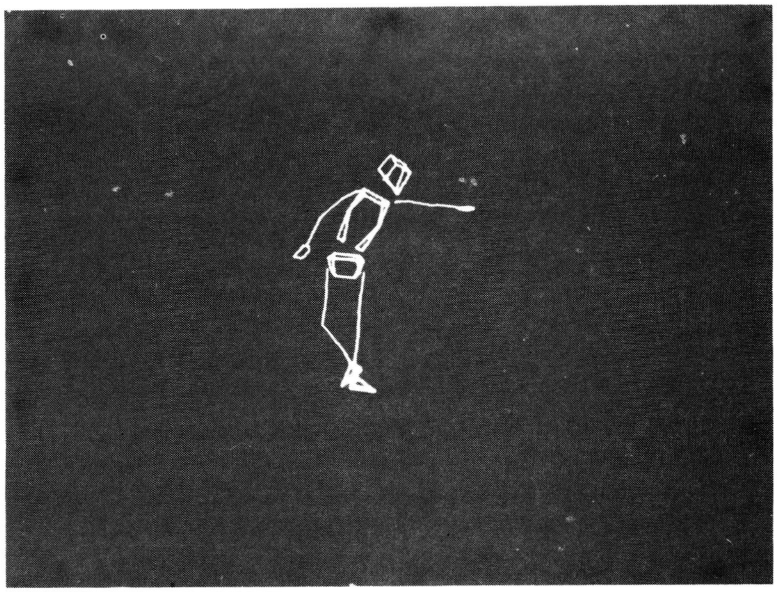

Figure 5

A Single Frame from a Dance Sequence