COMPUTER GRAPHICS SIMULATION OF BODY MOVEMENT LANGUAGE

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ABSTRACT

Labanotation is widely known symbolic language for recording and describing human movement. Through the use of interactive computer graphics a Laban score can be described to the computer and a simulation of the movement viewed on a CRT in terms of a simple computer graphics model of a human form. The Laban score is entered by means of an acoustical tablet with visual feedback of the score appearing on a CRT. The score is stored in table form from which the movement simulation is driven. As the table is interpreted, each body part moves asynchronously using techniques of key-frame animation. The system has been used in areas of dance and spatial layout.

SIMULATION INFOGRAPHIQUE DU LANGAGE POUR DESCRIPTION DES MOUVEMENTS DU CORPS

RÉSUMÉ

La notation de danse "Labanotation" est un langage symbolique très connu servant à enregistrer et à décrire les mouvements du corps humain. On introduit dans un ordinateur par l'entremise d'un organe d'infographie conversationnelle une partition de mouvement Laban, dont la simulation grâce à une représentation infographique simple d'une posture du corps est observable sur un écran cathodique. Cette partition est introduite au moyen d'une tablette graphique et elle est vérifiée visuellement sur l'écran où elle est reproduit. Elle est emmagasinée dans l'ordinateur dans une sorte de tableau à partir duquel est commandée la simulation du mouvement. Au fur et à mesure de l'interprétation de ce tableau, chaque partie du corps est déplacée de façon asynchrone en faisant appel à des techniques d'animation d'images maitresses. Ce système est employé dans l'étude de la dance et de la posture spatiale.

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Introduction

In the past half dozen years, research into the simulation of human body movement using body movement languages and computer graphics has commenced at a number of centres through-out the world [1,2,3,4]. The concept is quite simple: describe the body movement to the computer through interactive graphics techniques based on one of a number of body movement languages and then observe a simulation of the movement through a computer graphics model of a human, on a CRT. To date, the primary area of application of such systems has been dance, but engineering, kinesiology and psychology have shown some interest.

The main reason for the interest of such systems in dance is simply the need of the dance world to enhance dance literacy. More specifically, until the twentieth century, dance had no adequate means of recording its masterpieces. But with the advent of notation systems, the translation of dance into symbolic form became possible and dances could be recorded and preserved, bringing to dance a literacy that music has enjoyed for hundreds of years. Dance's interest in computer graphics systems that give a simulation from a notated score can be succinctly expressed in the two following statements:

i) to improve eye-estimation of body positions while learning to write notation, and

ii) to provide a visual simulation of an already notated score.

There are three notation systems, or body movement languages, that have been used in the above referenced computer graphics systems and these are: Labanotation [5], Benesh notation [6] and Massine notation [7]. Each of the notation systems has a number of common features: they all use a stave (similar to music), the shape of the symbols describes the type of movement, the position of the symbol in the stave defines the body part and time runs along the stave. An example of Labanotion and the associated body position is shown in Fig. 1. Each of the notation systems has a unique feature: Labanotion contains a great level of accuracy and can be used to record almost any kind of human movement, Benesh notation contains simplicity with reasonable accuracy and is most suitable for dance, Massine notation is structured for analyzing the harmony of movement sequences. All three systems are suitable for describing "gestural" movements (arm waving, etc.) but are found wanting for describing "motional" movements (walking, jumping, etc.) because parameters which give the character of a walk or jump are just too numerous to fully define.

The original work in the area of simulating human body movement at Waterloo was directed towards dance [8], and was based upon the Massine system of notation: the results of this work are described in Reference

[9]. Because of the dance world's intense interest in Labanotation in North America it was decided in 1977 to create a system that used Labanotation as the input to the computer graphics system. It was also felt at the time that Labanotation would be the most useful system to use for engineering applications - mainly because of its accuracy and flexibility.

This paper describes the system based on Labanotation and discusses, in order, the following sections: Labanotation (briefly), the interactive input of a Laban score to the computer, the method of data storage, interpretation and simulation of the Laban score, an example and comments.

Labanotation (kinetography Laban)

The main symbols which comprise Labanotation are shown in Fig. 2. The figure shows how the shape of the symbol indicates a pointing direction of a body part where the direction is perpendicular to the longitudinal axis of the parent of the body part. The third dimension-height is indicated by the shading of the symbol. Placement of the symbol in the columns of the stave determines which part it represents. The score is written from the bottom of the stave upwards, and the length of the symbol represents time duration. The rotation and flexion (bending at elbow, for example) symbols are not shown in Fig. 2. As an example, Fig. 1 shows how Laban symbols combine to describe a body position. Fig. 3 shows an example of a movement sequence written in Labanotation. The notation is interpreted by moving a body part into the position described by the symbols, such that the position is reached at the time beat on which the top of the symbol aligns. All body parts are described asynchronously and all separate body part positions combine at any instant in time to give the overall body position. The operation of the computer graphics system that simulates the movement inherent in the notation is given in the following sections.

System Overview

The Engineering computer graphics system at Waterloo comprises a Digital Equipment PPP-15 computer with a VT-15 refresh type graphical display. An accoustic tablet is available for interactively describing the movement. The simulation of the movement is provided for by a graphical model of a human composed of 15 body parts where each body part is of a simple appearance: this is shown in Fig. 1. The details of the graphical model are given in Reference [9].

Interactively Describing a Movement

The user describes the movement to the computer by selecting the appropriate body parts and their spatial position symbols from a general menu as shown in Fig. 4. The general menu is a graphical overlay on an accoustical tablet, and the selection of the symbols is made by the associated accoustic pen. As the movement is described, the corresponding score of Laban symbols is displayed on the CRT for purposes of visual verification. In addition, the information contained in the symbols is stored as a record in the data base.

A standard graphical form for each symbol is available and this form may be stretched or compressed in order to depict the proper time duration of the associated movement. The level of the body part is indicated on the CRT by the intesity of the shading rather than by the convention shown in Fig. 2. The data base consists of a sequence of records which take the following form:

column	support	direction	level	flexion	rotation	end time	start time

Once the movement has been described and a simulation is asked for, the records are ordered according to starting time. This makes the records appear as a pop-up stack to the interpretation section.

Simulation of the Movement

Each record in the stack contains the starting time, the time duration and the final position of the body part relative to its parent of attachment. Each body part moves asynchronously to each other with the common denominator being a software clock which begins to tick at a user-set rate until the entire movement is over. The body part is positioned in terms of three angular rotations about its point of attachment. The angles at any time instant after the starting time are obtained by adding angular increments (in order) to the start position angles. Actual positions are established each time with respect to a normal position to avoid accumulation errors. The movement proceeds as the record stack is read, but the stack needs to be read only when one of two conditions is met and these are: 1) when a particular body part movement has ended, and 2) when the start time in the waiting record matches the clock time. Once the movement of a body part starts, the movement continues until the end time matches the clock time; movement increments are then set to zero. The time duration is used to allot from the total movement the fraction of movement permitted at each clock tick. These intermediate positions or frames provide for fluid, or animated like motion of the model. The topology of the graphical model and the mathematical sequence of events which gets all the body parts oriented properly is described in Reference [9].

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.

Example

A simple example of Labanotation input and graphical simulation output is shown in Fig. 5. Starting from the bottom of the notation the arms are instructed to abduct to a horizontal position and then return (Fig. 5-b), and then the legs, in sequence, are instructed to abduct and return (Fig. 5-c).

Comments and Future Developments

The results of the simulation of body movement from Labanotation have not been particularly encouraging to date. Only a small percentage of the original work based on Massine notation could be used in the present work and this meant considerable time consuming software development, so that the extent of the Laban system in actual operation is quite meagre. The majority of the work went into the interactive input section, where the symbols are selected and displayed in accordance with the Labanotation procedures.

There has been no serious investigation into incorporating motional commands (walking, jumps, etc.) - perhaps the most important area of human movement - since the structure of Labanotation leaves too much to interpretation and this in turn makes an algorithmic approach difficult. Recent work by Calvert [11], has attempted to combine Labanotation for gestural commands with their own high level language for motional commands. Some progress has been made with this idea. Moreover, kinesiologists at Waterloo have questioned the accuracy of Labanotation and indicated that the original Massine input style [9], with the added capability of defining specific angles, would be more useful. This would appear to apply to engineering type applications as well.

The present system will be useful for students learning Labanotation; however, the amount of effort required to bring the system to the point where it can be used for practical simulation exercises is more than the authors are willing to invest. Any future work will be oriented towards simulating motional commands and this implies the design of a new movement description language, or system, which does not rely on one of the notation systems, but does include the use of the computer from the earliest stages of conceptualization.

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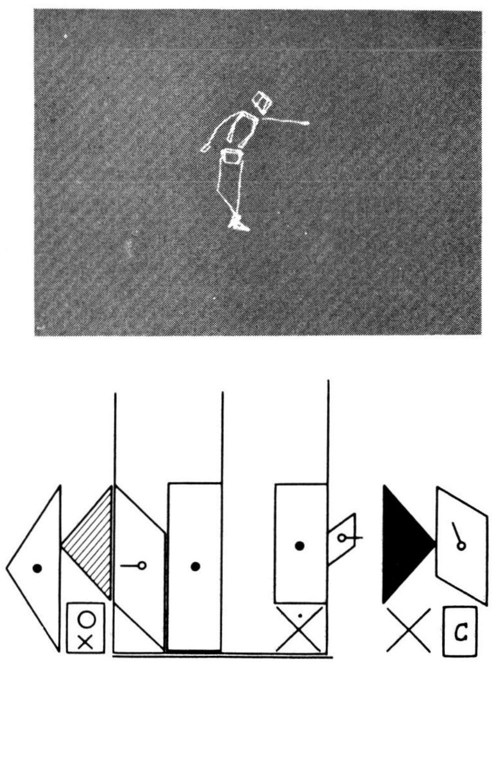


Fig. 1: Description of a body position using Labanotation

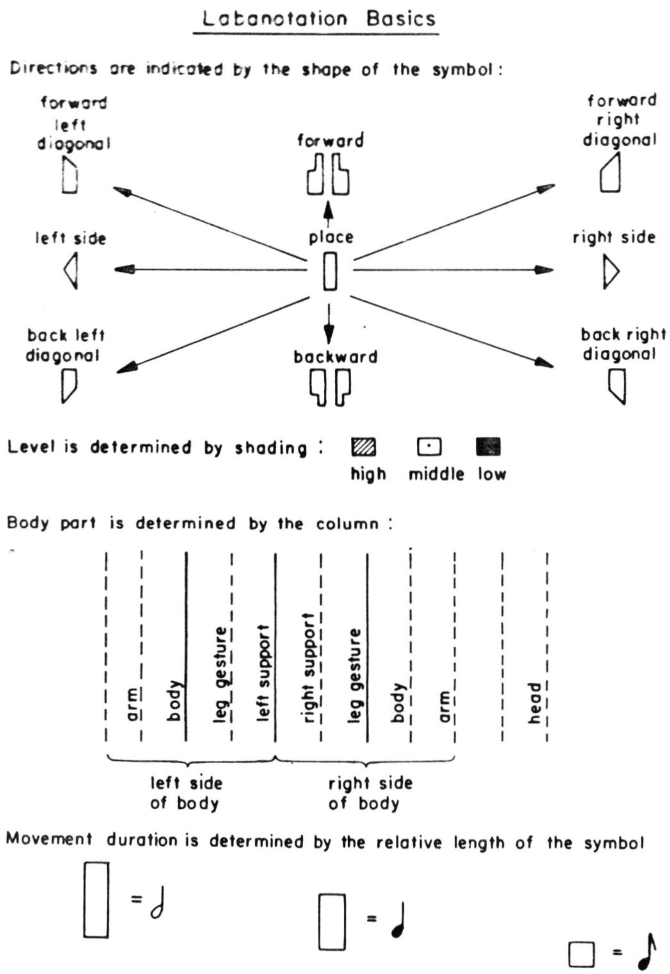


Fig. 2: Labanotation: basic symbols

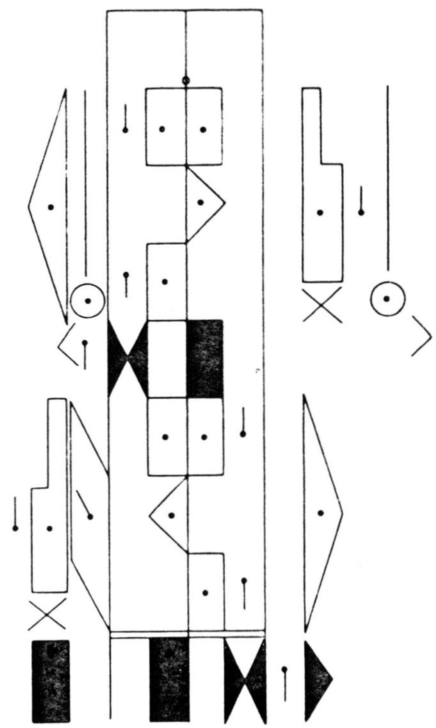


Fig. 3: A movement sequence in Labanotation

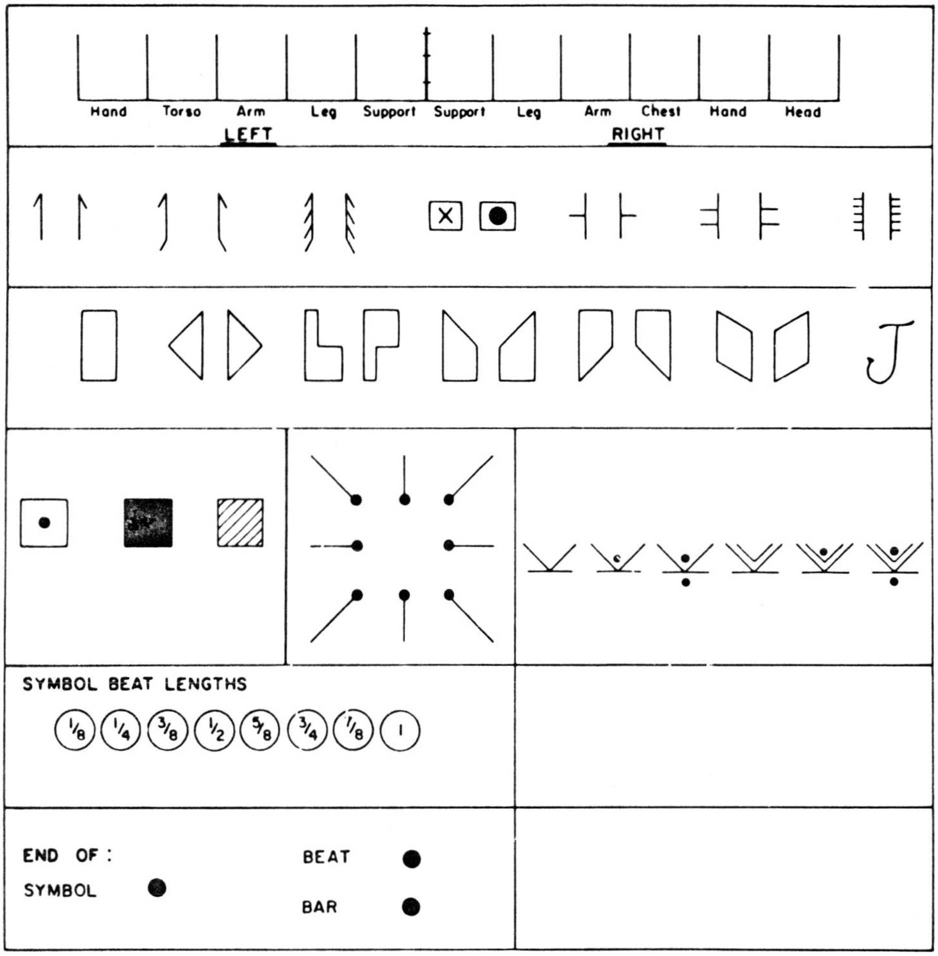
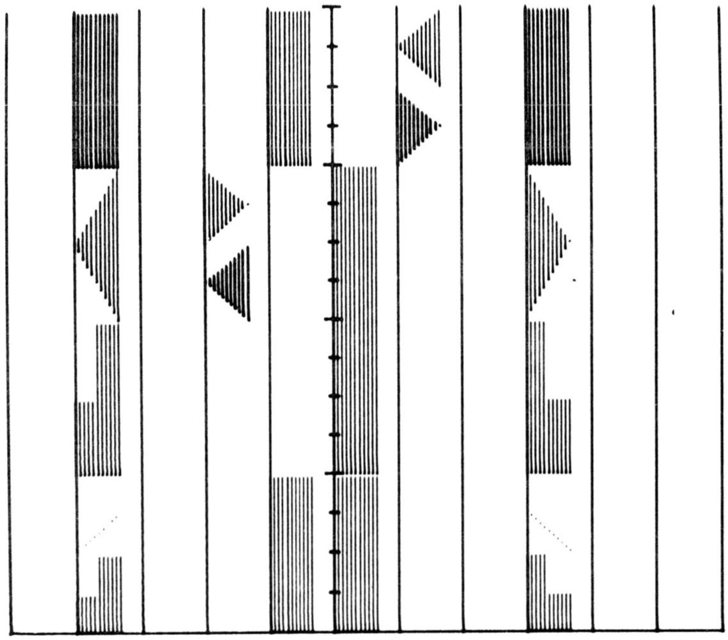


Fig. 4: The Labanotation menu which is used with the accoustic tablet



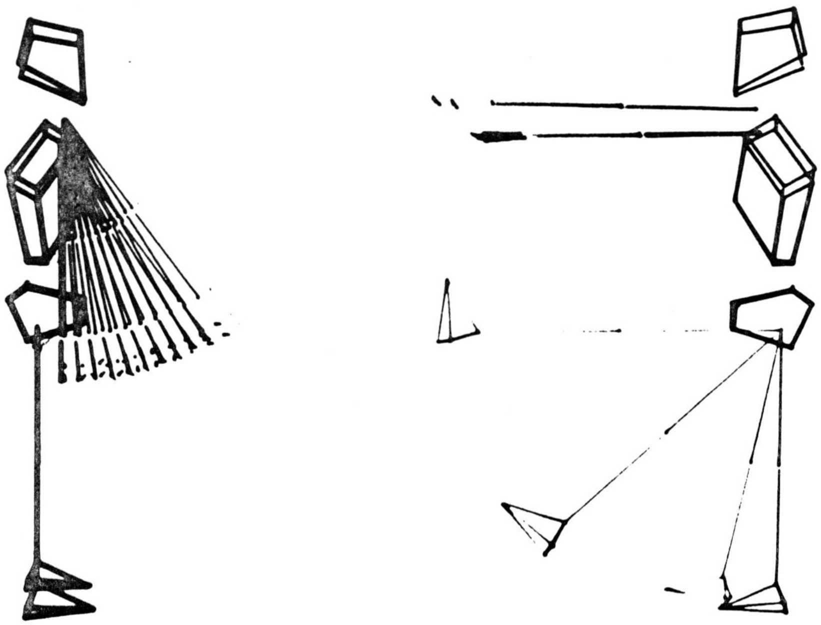


Fig. 5: A simulation of Labanotation: (a) the score (b) the arm movement (c) the leg movement.