VOLUME III | NR. 1 | JANUARY 1970 Reprint

COMPUTER STUDIES

in the Humanities and Verbal Behavior

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EDITORIAL ADDRESS

Computer Studies in the Humanities and Verbal Behavior is sponsored by the University of Kansas. Manuscripts: Sally Y. Sedelow, Department of Computer Science, University of Kansas, Lawrence, Kansas 66044, U.S.A. General correspondence: FLOYD R. HOROWITZ, Department of English, University of Kansas, Lawrence, Kansas, U.S.A.

Computer Studies in the Humanities and Verbal Behavior appears quarterly in issues of approximately sixty pages. Four issues constitute a volume. The subscription price is $ 10.00/*f* 36.00 per year per volume; single issues cost $ 3.00/*f* 10.50. Back issues as well as subscriptions and single issues can be ordered from every bookseller or subscription agency, or directly from Mouton & Co., P.O. Box 1132, The Hague, The Netherlands.

Computer Choreography: An Experiment on the Interaction Between Dance and the Computer

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This paper describes an experiment carried out at Pennsylvania State University where a computer program for defining the position of dancers on the stage was developed by the authors. It also describes the way in which the results were put on stage.

INTRODUCTION

The idea of developing a computer program to compose choreography was first conceived towards the middle of 1965 when one of the authors became acquainted with the work done by David Caplin in the mid-fifties on the use of computers to compose piano sonatas, based on the rules for composition specified by Mozart in the eighteenth century. During the next two years the idea was discussed with several scientists, artists, dancers and choreographers, in Latin America, Europe and the United States. By mid 1967 the objectives and the general structure of the program were defined and the programming began in October of the same year, when both authors decided to join efforts under the sponsorship of the Theatre Arts Department of the Pennsylvania State University and in particular Mr. Robert Reifsneider, Professor of Dance at that institution.

Three months later a group of students, gathered in a dance workshop, began to work on the results obtained. By the end of March 1968 the results were put on stage at the Playhouse Theatre of Pennsylvania State University.

To our knowledge there have been two previous attempts to use computers in composing choreography. The most elaborate of these[1] is that of Dr. Michael Noll of Bell Telephone Company. He made use of a screen to display the spacial and arm movements of a group of dancers on stage. Furthermore, he pointed out the possibilities of using a computer combined with the use of tapes and films in order to help the choreographer to design and record particular sequences of movement. In a comment on Dr. Noll's article, Mrs. Ann Hutchinson mentioned that a previous attempt had been done at the University of Pittsburgh where a sequence of movements for one dancer was generated using a computer program. These patterns of movement generated by the computer were subsequently tried by some students of Mrs. Hutchinson in London. Of more importance were the comments she made about the limited scope the application of computers has for choreography, mainly due to notational difficulties in specifying efficiently and unambiguously the movements of a dancer.

The project described in this paper was carried out independently, and until the programming stage we had no knowledge of these two previous attempts. One difference between our work and those efforts previously reported consisted of our being concerned with putting on stage the results. During the development of the project the interaction between the dancers, the choreographer and the computer program was our main object of concern.

The first objective of the project was to show to the dancers and choreographers on the one side and to the computer scientists on the other that no matter how sophisticated, detailed and "perfect" a computer program for composing choreography could become, it could never replace the choreographer. In other words, there is always going to be a need for a choreographer, i.e., an artist, and that the threat of a computer takeover in the arts (if we may extrapolate from dance) is absolute nonsense. Perhaps so stated this objective seems trivial. However, if we were to give a sample of the reactions of dancers and artists to whom the idea of a computer composing choreography was communicated, it would be clear at once that these fears exist in their minds and that they are very real to them (perhaps due to their ignorance of what a computer can or cannot do). This objective had also the aim of cooling the enthusiasm of some computer scientists who

* Now at the Management Science Center of the University of Pennsylvania and the Hybrid Computer Laboratory of Pennsylvania State University, respectively.

[1] Michael A. Noll, "Choreography and Computers", *Dance Magazine*, January, 1967.

think only in terms of shifting registers and of binary arithmetic and for whom artistic genius is just a more complicated kind of program.

The second objective was perhaps more relevant. This was to show choreographers that eventually they could profit a great deal by using a computer and that a set of computer programs could help them to devise dances more effectively. In this sense the objective was to show the feasibility of such an undertaking rather than to produce the actual programs from which the choreographers and dancers could extract ideas and use as a working tool.

DEVELOPMENT OF THE CONCEPTS INVOLVED IN DESIGNING A COMPUTER PROGRAM TO COMPOSE CHOREOGRAPHY

The first task was to define what the computer program was supposed to do. In particular, which type of movements it was supposed to manipulate and how to code them and handle them with the computer. Additional tasks included how to interpret the results and finally and most importantly, how they could be translated into movements by the choreographer and subsequently be put on stage.

One of the authors has been interested in dance for a major portion of his life, and having some knowledge of computer programming, he knew the relative difficulty of programming detailed individual movements. In addition, many discussions with scientists and dancers were considered. As a result, it was decided that only a limited set of movements could be programmed in the first set of computer programs if the constraints on money, time, and feasible staging were to be satisfied simultaneously. We feel, however, that the selection of a limited set of movements for programming did not impair the possibility of achieving the second objective, namely to show in principle the feasibility of using computers to help choreographers.

The movements chosen for programming were the relative position or spacial movements of dancers on the stage. The determination of individual movements at a specific location was left to the dancers and the choreographer. The program would only decide where each dancer was supposed to be at a particular moment in time. It was also decided that the computer program should be able to specify how many dancers would start the dance and, in the eventuality that the number of dancers on stage would vary during the dance, which dancers were supposed to leave (or enter) and from which positions.

Some other considerations were also taken in account but they were not introduced in the programs described here. These were the possibility of forming groups of dancers and the possibility of deciding whether symmetry was desired or not when determining spacial movements on the stage.

The first consideration when devising the program to determine spacial movements was to decide how the space on the stage was to be divided. We opted for using a network of hexagons to define areas on the stage floor such that at any moment in time a particular dancer would be assigned to one of these hexagons. We used what is technically called an "hexagonal grid system". The reason for choosing the partition of the stage floor was that any movement from the center of one hexagon to the center of any adjacent one involves the same distance to be traveled and hence (in theory) the same amount of displacement effort is involved in moving in any direction (this does not happen with a network made of squares or rectangles for instance). The hexagons were arranged as shown in Figure 1.

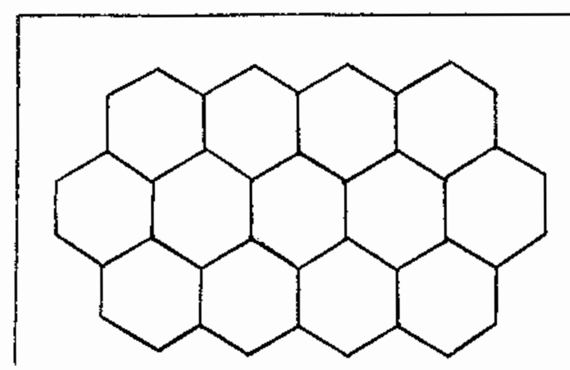

Fig. 1. Partition of the Stage Floor

The particular restrictions built into the program whose results were put on stage were:

1. In one transition a dancer could remain in the same hexagon or move only to the adjacent ones. This prevents the dancers from jumping from one end of the stage to the other in one transition.

2. Dancers could leave or enter the stage only from the side hexagons.

3. The program would handle as many as 12 dancers and any number of dancers between 1 and 12.

4. The program would define the positions of all dancers on stage for any number of musical measures or independent time segments.

Within this set of restrictions the program operates by defining the position of every dancer at a particular moment in time. Once this is done, the dancer moves to the next measure or moment in time and continues in this way until the prescribed number of measures is completed. For each dancer at each moment of time the program chooses a random number which represents his position on the stage (one of the hexagons) and compares it with his previous position. If the transition complies with the restrictions above, the movement for that dancer is decided. If not, a new random number is generated until one representing a hexagon which satisfies the restrictions is selected. The procedure is essentially the same for a dancer entering, leaving or moving on stage.

Note that there is no restriction on the number of dancers that might be assigned to the same hexagon at the same moment in time. This is the way in which the computer program generated groups of dancers.

The process of selecting the position of each dancer on stage is analogous to a first order Markov process, e.g., the position of a dancer at any moment in time is dependent only on the immediately preceding one. However, the program is built in such a way that it is possible to extend it to take into consideration more than just the immediately preceding position when deciding on the dancer's next move. Pierce[2] has discussed this subject with respect to a program devised for composing music. He concludes that, from the aesthetic point of view, very little is added by taking into consideration more than just the immediately preceding position when determining the dancer's next move.

One modification which was introduced later permitted a dancer to remain at the same hexagon for any number of measures between three and ten, and the length of his stay was also determined at random. The reasons for introducing this modification will become apparent later.

The version of the computer program consists of one main routine and six subroutines. It was set for six dancers and for 107 measures. It was left to the computer to decide the initial number and position of the dancers, the times of changes in the number of dancers on stage and the number of dancers introduced or removed at each change. All these decisions were made in addition to defining the relative position of the dancers on stage at each measure.

The output of the program consists of a series of scores. One score for the choreographer shows the movement of each dancer at each moment in time, and six more (one for each dancer) show the individual scores for the dancers.

A sample output for one dancer would look like this:

DANCER NO. 3

TIME	POSITION
1	6
2	6
3	6
4	7
5	7
6	7
7	7
8	7
9	2
10	2
11	2
12	2
.	.
.	.
.	.

Fig. 2

This output would be interpreted as follows: during the first three measures dancer number 3 would be in position (hexagon) no. 6, then he would move to hexagon 7 and remain there from the 4th up until the 8th measure, then he would move to hexagon 2 for four measures and so on.

These are the most important characteristics of the program used, most of the minor programming details are fairly standard and are not worth mentioning.

HOW THE RESULTS WERE PUT ON STAGE

As mentioned before, by the time the computer programs were being written, the organization of a dance workshop for the winter term at Pennsylvania State University, was under way. Of the twelve dancers involved only two had previous experience, and most of them belonged to the Theatre Arts department. Professor Reifsneider acted as coordinator and advisor to the workshop, whose main objective was to put on stage original choreographies by the students participating in it. It was decided that one of the dances to be presented by the group would be choreographed using the computer program described above.

One of the problems involved with putting the computer choreography on stage was that of selecting the music. Professor Reifsneider solved this problem by choosing a piece of music from one of Vivaldi's violin concertos, which had 107 four by four measures, each measure lasting exactly for a second. Therefore, the program was set to determine the position of the dancers at 107 different moments in time, according to the rules already described. It was rather interesting to observe the effect of matching in a dance one of the earlier forms of

[2] J. R. Pierce, *Symbols, Signals and Noise* (Harper Torchbooks, 1961), pp. 260-262.

music, baroque music, with a choreography devised by using one of the most advanced instruments of our time. It almost seemed anachronistic, but the resulting overall effect was enhanced by selecting this particular type of music. Probably with modern electronic music or even music composed by a computer the effect on the dancers, the choreographer and ultimately the audience would not have been the same.

The participants in the workshop received with enthusiasm and curiosity the idea of putting a computer choreography on stage. Most of them had only a dim idea of what a computer could or could not do and several explanations of the program, the objectives of the project and the way we envisaged it on stage were required. They associated immediately the idea of computer choreography with rigid and forced movements of their arms and with mechanical displacements on stage. One of the most difficult things for them to realize was that an interaction between the computer, the choreographer and the dancers was possible and that they could have the freedom to select their own individual movements (with the supervision and help of the choreographer) within the frame of the spacial movements determined by the computer. Professor Reifsneider acted as the choreographer with one of the authors as his assistant.

The first scores generated by the program were brought to the dancers and they were asked to memorize the series of movements on the stage floor. These scores were distributed among the dancers at random, three for the male dancers and the other three for the female dancers. As it turned out, the first score distributed was generated by a version of the program which did not allow any dancer to stay for more than one measure at each position on stage. In order words, spacial movements were generated at each measure. The net result was pandemonium on stage. Each dancer was too busy moving from one location to another (the hexagons were depicted on the stage floor) and did not have time to do any other type of movement or to interact with the other dancers. After trying two or three scores generated by this version of the program it was decided that it needed to be modified, allowing each dancer to remain in the same position for at least three measures. Otherwise the dance would degenerate in a frenzy of movement which would confuse everyone, including the dancers.

The modification was introduced, and a new set of scores was generated using the program. Once again the dancers were asked to memorize their sequence of movements, and the results were tried again, first without music and later introducing it. The resulting movements were interesting and had some sense of aesthetic quality in them, but as long as each dancer was supposed to decide on his own individual movements, a general impression of disorder prevailed throughout the dance. This is where the choreographer intervened. He decided that the general mood of the dance was to be slow, ceremonious and mannered, that at least in two or three of the dance sequences all the dancers were supposed to do the same type of individual movements. He suggested and vetoed some types of individual movements in order to maintain the overall harmony of the dance.

Within these restrictions and the ones imposed by the computer generated scores, the dancers still had ample opportunity to exercise their ingenuity in the selection and interpretation of their movements. They decided to turn the dance into a humoristic love satire. The net result was a curious mixture of computer generated movements, baroque music, slow movements, humor and wittiness, which produced an extremely amusing and interesting dance. It was a complete success when performed in front of the audience, up to the point that it was decided to make it a permanent feature of the winter dance workshop.

It is of interest to mention some of the reactions of the dancers during the rehearsals. The particular score put on stage started with two dancers. After a few measures it added the other four and at the 15th measure disposed of one of the dancers, who never returned again. The dancers could not believe that the computer had made these decisions by generating random numbers. They all thought that WE (the authors) had instructed the computer to do so; the idea of a computer deciding on its own was alien to their minds. The dancer who was supposed to leave the stage at the 15th measure was midly bitter about it and thought that WE had decided that he would have to leave.

Looking at the future, let us imagine that the programs described here have been developed further. Taking the case of spacial movements for the moment, think what the choreographer would be able to do if he had a computer terminal with a visual screen (as the one described by Dr. Noll) and that he wants to explore some ideas for using five dancers on stage, during five minutes, and with some other restrictions imagined by him. By typing a few instructions on the keyboard, the computer could be directed to generate an infinite number of dances which satisfy the restrictions specified by the choreographer, who can observe a few on the visual screen and then decide to take some of the patterns, discard others, and amalgamate different portions of dances. All the patterns would be submitted to him by means of the visual screen. It is still HIS decision whether to use any of the results and if so how to use them.

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