Baroque Dance Animation with Virtual Dancers

Maresa Bertolo, Paolo Maninetti, Daniele Marini

Dipartimento di Scienze dell'Informazione, Università degli Studi, Milano, Italy

maresa@iol.it, marini@dsi.unimi.it

Abstract

Our approach to computer simulation of the human movement is based on a high level description of the grammar of the movement and on the combination of basic movements acquired using motion capture systems. The combinatory techniques inspired by the ancient notation system of the Baroque Dance can lead to achieve complex tasks like synchronisation with the music tempo and rhythm in a simple way.

The first phase of our project was the study of the human morphology and possible movements in the Baroque Dance, then we built an anthropomorphic 3D model which articulated structure makes it able to dance. Then we studied the major Baroque Dances, to identify their syntactic structure suitable for a hierarchical decomposition of a complete choreography. Third, we encoded the elementary movements by using a motion capture system with a professional human dancer, building two libraries of simple and complex movements, to be used for the control of the motion of the 3D articulated figure in two dinstict cases: for real-time generated dances and for rendering-based generated dances. Synchronisation with the music tempo and rhythm has also been solved, thanks to the rule that each musical measure corresponds to a complex step, or a word in our metaphor.We implemented two kind of interactive web tools to be used by the choreographer in order to define a choreography for the virtual dancer.

The result is an easy to use animation system, settled as an educational application.

Keywords: cultural heritage, education, virtual environments, simulation.

1. Introduction

The study of the movement of the human figure and its computerised animation are basic themes for the development of computer animation systems. Many relevant research results had their focus on the low level description of human movements. Our approach starts from a high level analysis of the human body motion and models classes of motion in terms of a *grammar of movement*: a complex motion can be seen as the composition of simpler movements. By adopting a motion capture technique we can easily describe elementary motions in terms of joint position and rotations.

During the centuries, dance was the object of many studies; the research for the development of a method for a symbolic notation of the movements is surely a very important one and can now bring to a formal description and synthesis thanks to computer based techniques.

The Baroque Dance is a very formal body language, that follows rigid composition rules. In the language metaphor, we can see a choreography as a series of sentences, each sentence being composed of phrases which are complex dance steps, in turn composed of simple elementary steps (words of the dance vocabulary). The original contribution of the choreographer consists therefore of the creation of the *sentences*, that give life to a nice or a bad dance.

2. Background

The use of computer systems and computer graphics to explore and synthesise dance or human body movement dates back to 1964[1]; the first proposal of motion capture of simple movements to create a vocabulary for dance synthesis was in 1966, but the necessary technology at that time was not yet available.

The major breakthrough to this field came when interactive computer graphics became available [2, 3, 4]. The idea of capturing the movements of a human professional is today a very common approach to control a virtual actor for film and TV production.

An inspiration to the approach that we have adopted comes from the work by Tom Calvert, who discusses a methodology which starts from a simple kinematics description and increases accuracy by adopting a variety of techniques. In our opinion any dance or movement notation can be very complex, and our experience shows that focusing on a well defined and restricted field, a notation system can be fruitfully adopted to describe a sequence of body movements and to provide a computer system of the necessary information to synthesise the cinematic representation.

3 The Feuillet Notation

The Baroque Dance was chosen as our case study for its high degree of formalisation. At the court of the French King, Luis XIV, dance was an important aspect of life; it was regulated by two different kinds of rules: technical and social. A social rule, in every dance hall a side of the room was reserved to the *Presence* (the King and his court); dancers couldn't give their back to the Presence. A technical rule, each composed steps must be executed in the time of a single music beat. All baroque dances share a limited set of basic steps; the choreographer chooses the steps for the dance, following both the personal taste and the rules for the step sequences and for the dance path.

In this context, R. A. Feuillet[5] published in 1701 his essay on dance notation, changing all the movement representation techniques, previously made through long and ambiguous descriptions[6]. The graphic representation of the movements is complete and very simple. The dance and the dancers are represented as they are seen from above, by circles and lines. During the dance, the dancer follows a path which is represented by a straight line; the steps are drawn along this line, and special symbols are drawn on the step arc to specify if the dancer should raise, jump or made other dance variation.
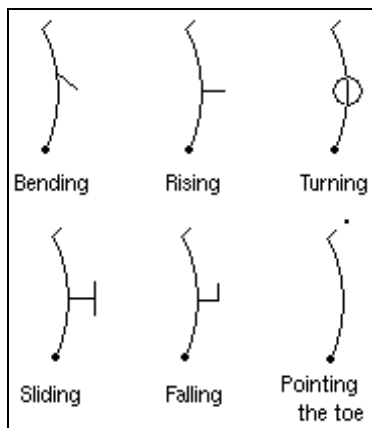

Figure 2: *Some example of Feuillet Notation*

4 Syntactic analysis and creation of Baroque Dance choreographies

We implemented an integrated animation system that allows to build Baroque Dance choreographies through a natural language input, a simple list made of step names. A program produces a more detailed list (where direction, the supporting foot at the step start and other data are added), which is the input for the program that creates the dance.

In order to create this system, we made a previous rigid syntactic analysis of the Baroque Dance rules, strictly connected with the dance structure. Our translation software uses this rules to establish the correctness of input steps.

Some rules of the Baroque Dance formal grammar:
Dance := Menuet | Courante | Allemande
Menuet := Pas de menuet a deux temps | Pas de menuet a trois temps
Courante := Pas de Courante | Pas balancé |... | Pas de rigaudon
Allemande := Pas balancé | ... | Pas de rigaudon

5. The archive of primitive steps and the virtual dancer construction

Using a motion capture optical system (ELITE[7] a TV image processor, which acquires the position in space of reflecting hemispherical markers, thanks to optical infra-red methods) we collected a computational description for each dance step.

Being the Baroque Dance based on soft, often slow and quite simple movements, a little set of control points is enough to describe the movement.
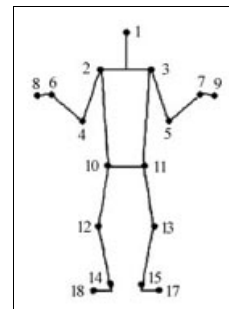

Figure 3: *The markers distribution*

During performer's movements, the system acquired the position of each marker, building a numerical description of the whole step. These data (after a correction of inaccuracy and missing data, typical of optical motion capture systems) were used to build the archive of the dance steps. A program was written to merge the steps sequences in a fluid unique dance, with an algorithm based on linear interpolation of movements data.

We built an anthropomorphic 3D model to execute the dance movements previously captured. We were interested in a formal coding of the dance, and not in an excessive thoroughness and realism in the model movements. Thus, our model is a simple painter dummy, to minimise computational and visualization time and to give maximum visibility to the body movements

The description of each step is provided by giving the position of each control point on the dancer body, at each acquired time. These data are used to guide the virtual dancer movements during the

execution of a dance with an animation software. Two complete choreographies, created by Maestra Federica Calvino Prina, on a Haendel's Minuet and the Lully's Bourrée d'Achille, were defined with this system and rendered on the videotape *Virtual Feuillet*[8].

This method allows us to build high quality dance animations, unfortunately not in real time. In order to make the whole system available through the net and to execute dances in real time, we translated both the model and the step description into Virtual Reality Modeling Language (VRML). The new data are relative to position and rotation in space of the parts of the dummy's body, using the pelvis as the root of the whole model. To complete the movement between extreme positions we used interpolators, and a *timer* sets the animation speed.

We use the MIDI format for the musical accompaniment, in cause of the simpleness of time informations extrapolations, very difficult to obtain from different kind of audio storage formats.

Given the list of steps and the music, chosen by the choreographer, the dance is generated by a program, which uses interpolators in order to build the dance and to synchronise it with the music (studying its agogic course)

6. Interfaces

Both the dance generator for videotapes and the real-time one need an interface, in order to allow choreographers and other users to build their own Baroque Dances. Interfaces are to be platform-independent, we implemented them using Java, JavaScript and CGI scripts; they are included in the Baroque Dance Project web site:
http://escher.usr.dsi.unimi.it/~danza.

6.1 Interface for videotape dances generation

This interface allows the user to build dance description which have to be renderised and translated in videotapes. It is an interactive two-steps applet Java, where the user is asked for the dance type, the starting dance direction and the starting foot in the first phase and for the steps list in the second. When a choreography is established, it can be saved in a simple text file and used as the input description data for the dance generation.

6.2 Interface for real-time dances generation

For this interface we used JavaScript and CGI. The data generated by the user are sent via Internet to a program, resident on our server, which elaborates them and sends back the VRML animation.

Due to the internet browsers different technologies, we have two differen kinds of this interface: a textual editor and a graphical one. Both of them allow us to choose one from some MIDI files for

the dance, the starting foot, the dance direction and the dance steps.

The textual editor is an HTML form, the graphical editor uses JavaScript 1.2. Its interface is a whole-screen browser window, which gives the available steps (with their names, their Feuillet Notation and a button to see a short VRML step's preview). The generated dance path and Feuillet Notation is shown in the right part of the window.

The *dance.wrl* file, result of the data processing, beside as be executed in real time on the user's computer, can be saved and added to a VRML environment.

If the choreographer wants a dance executed by more than one dancer, s/he simply has to use the system for each of the dancers, and then add all the resulting VRML files in the same whole dance.

7. Conclusions and future treatments

Coming dance data from motion capture, the steps archives contains only an instance of each Baroque Dance step. Thus, each instance of a single step during the dance is equal to all the others, and two or more virtual dancers dance in a very identical way, giving an unhuman quality to the whole dance. A possible solution to this situation should be to add a *movement noise* to the dancer's movements. A noise that could simply come from a *movement noise generator* (something like a perturbation curve generator), or that could be related to emotions, in order to give more life to the dancers. In this way, we could have shy, enthusiastic, sure, angry dancers.

Thinking to perform the created Baroque Dance on a virtual set, it could be possible to potentiate the graphical editor, giving to the choreographers a map of the stage. Thus, they could think the dance related to the stage spaces and the set objects occupation.

The study of a formal code for human movements was possible thanks to the formal structure of Baroque Dance. A similar structure may be found in others fields of human activity, in the dance or in sports disciplines.

It should be interesting to study other kind of dances, and to produce an archives of ancient folk dances, both to study human movements and record human dance heritage.

The creation of a library of the movements allows us to build a sequence of actions permitted by the discipline rules, in a completely automatic way. This is an interesting possibility not only for the study of the movements itself, but also for distributed educational applications. It makes it possible to learn, teach and study activity of other cultures or other environments.

References

1. J. Beaman, *Computer choreography* in *Anthology of impulse*, Dance Horizons, New York 1969, pp. 62-4

2. T. Calvert, *Composition of Realistic Animation Sequences for Multipe Human Figures*, in: N.I. Badler et alt., Making them Move, Morgan Kauffman Pub., San Mateo, 1991, pp. 35-50.

3. T.W. Calvert, J. Chapman, A. Tatla, *The Integration of Subjective and Objective Data in the Animation of Human Movement*, Computer Graphics, 14, 3, 1980

4. T.W.Calvert, C. Welman, S. Gaudet, C. Lee, *Composition of multiple figure sequences for dance and animation*, in R.A. Earnshaw, B. Wyvill (EDS), Procedure of CG International 89, Springer-Verlag

5. R. A. Feuillet, *Choreographie ou L'art de Décrire la Dance, par caracteres, figures et signes demonstratifs*, II ed., Paris, 1701.

6. A. Hutchinson Guest, *Dance notation - The process of recording movement on paper*, Dance Books, London, 1984.

7. Ferrigno, Pedotti, *ELITE: a digital dedicated hardware system for movement analyssis via real-time TV signal processing*, IEEE Transaction On Biomedical Engineering, 1985

8. M. Bertolo, M. Marini, M. Nasella, *Virtual Feuillet*, videotape, Università Statale degli Studi di Milano and Mediacube srl, 1996

9. W. Hilton, *Dance of Court & Theatre, The French Noble Style 1690-1725*, Dance Book Ltd., London, 1981

10. M. Little, N. Jenne, *Dance and the Music of J.S. Bach*, Indiana University Press, Bloomington, 1991

11. J. Tikker Harlow, *A musician introduction to Baroque Dance*, Dissertation of the Music School, University of Oregon, 1993

12. M.F. Cohen, B. Bodenheimer, B. Guenter, C. Rose, *Efficient Generation of Motion Transition using Spacetime Constraints*, SIGGRAPH 1996

13. A. Witkin, Z. Popovic, *Motion Warping*, SIGGRAPH 1995