Description and Reproduction of Stylized Traditional Dance Body Motion
by Using Labanotation

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Abstract --- We have long been conducting research on the description and reproduction of body motion based on Labanotation, and developed a system called LabanEditor. Labanotation uses a symbolic description and it is said that the notation can even describe motions of the fine each finger of a dancer. However, since, in this case, the resulting score staff will become extremely complicated, only the basic description has usually been used. On the other hand, there are styles of motion particular to traditional dances, and if we restrict ourselves to handling these dances, the basic notation scheme is insufficient to describe these motions. Based on the above, we investigated a method of describing and reproducing CG animation of highly-stylized traditional Noh plays using plain Labanotation. This has been realized by preparing motion template files which represent specific motions in Noh plays. We can handle any stylized dance motions other than Noh by preparing separate motion template files. In addition, we made improvements in the functionality of LabanEditor as follows: importing VRML models of stages, background sceneries and characters for dancers which correspond to the various types of dance, and controlling the quality of movements. The evaluation showed that both the system and the method satisfied our initial requirements.

Keywords: Labanotation, LabanEditor, 3D character animation, Noh, dance notation, choreography, traditional dance

1 Introduction

Labanotation [1] is a graphical notation scheme for describing human body movement that has been widely accepted for the purpose of recording human movements in the fields of choreography and dance education, mainly in Western countries. It is said that by using the full set of Labanotation graphical schematics, i.e., symbols and signs, almost all of our body movements can be described including even delicate finger motions and rotational movements of small rotating angle.

A stylized traditional dance has uniqueness in itself which reflects history, culture, emotion expression, place, etc. In the case of Noh, a type of Japanese performing arts, its movements are unique. For example, the basic standing position of Noh is with the torso ‘slightly tilted’ forward, with the back being lengthened. The arms curve downward and the knees are ‘slightly flexed’. When walking, the performer moves by sliding his/her feet forward, pivoting them up and down via the heel, while keeping the abovementioned standing pose.

When recording and representing artistic, traditional dance body motions, it is important to have capabilities for handling these very characteristic body movements, and these can probably be handled with the full set of Labanotation. However, the resulting notation would become extremely complicated, to the point where it would be difficult to comprehend what...
that movement is. This is a question of the power of the description provided by Labanotation from a practical point of view, and we face the difficult problem of how to realize a method of describing detailed features and nuance of artistic, traditional dance movements while suppressing the complexity in the notation score.

To date, several graphics applications have been developed for preparing Labanotation scores and generating body motion so as to make Labanotation popular in the dance community. However none of these have yet solved the abovementioned problem.

We have been working on a system named LabanEditor [2]. It includes the functionalities of both inputting/editing Labanotation score and displaying character animation so that beginners who are not familiar with Labanotation can study its description using a trial-and-error approach.

In this paper, we aim at description and reproduction of body motion of stylized traditional dances by using fundamental elements of Labanotation while maintaining the quality of CG character animation. We propose and implement a dynamic motion template technique enabling users to note stylized traditional dances and reproduce it in 3D CG animation from a Labanotation score. In order to evaluate our proposed method, we tried to represent animation of body movement of Noh dance.

Our system will be beneficial to the following groups of people:

1) Learners of Labanotation basics: after studying Labanotation basics with textbooks, learners can confirm the actual body motion by using character animation generated from the score.
2) Dance researchers and dancers who want to use Labanotation in dance education/research: the system provides them a trial-and-error based learning method so that they can make their works more effective.
3) Choreographers: the cycle of description of movement and successive confirmation of motion makes the choreographing process more effective.
4) Masters who are teaching traditional dance such as Noh: they can explain and teach special body movements included in traditional performing arts like Noh.
5) Novice dancers who want to experience traditional dance like Noh: they can continuously study body motions via the notation-animation cycle made possible by our system.

6) Choreographers, Noh players, scriptwriters of a new Noh play: they can use the system as a presentation tool for their idea about the choreography of the performance.

Our purpose is not in precise recording of dance body movement which is required when thinking of digital archiving for intangible cultural properties. Rather, we think a great deal of notating movements in symbolic representation by using well known Labanotation, which actually is not accurate enough to record the delicate movements. However symbolic representation has an advantage that it enables us to record the movement roughly and to make comparison easily among various dances.

The organization of this paper is divided into six sections. Section 2 briefly describes the method of notating human body motion by Labanotation. Section 3 describes related works on the computer use of Labanotation. Section 4 introduces the internal structure of LabanEditor, the user interface and the MotionViewer for converting Labanotation to character animation. Section 5 demonstrates a case study of applying LabanEditor to traditional Japanese performing art, Noh. Section 6 contains the conclusions and our future work.

2 Labanotation

Labanotation is a graphical notation system for recording human body movements invented by Rudolf von Laban, an Austro-Hungarian dancer and choreographer, in the 1920’s.

Figure 1 (a) is an example of Labanotation scores corresponding to dance motion. A Labanotation score is drawn in the form of vertical staff where each column corresponds to a body part. Figure 1 (b) shows the basic arrangement of columns in the staff. The horizontal dimension of the staff represents the parts of the body, and the vertical dimension represents time. The center line of the staff represents the center of the body: Columns on the right represent the right side of the body, and columns on the left, the left side of the body.

Symbols are placed in the columns of the staff. The vertical length of a symbol shows the duration of the movement, from its beginning to its end.
DanceForms [4-5] is a character animation software intended to be used among dancers and choreographers who are not familiar with PC animation software. It uses an independent notation scheme that is not compatible with Labanotation.

LabanWriter [6] was developed at the Department of dance at the Ohio State University. It is currently the most widely used Labanotation editor. The current version of LabanWriter can only run on Macintosh computers, and the system is only for preparing Labanotation scores and recording them in digital form. It does not provide a function for displaying character animations corresponding to the notation. The latest version of LabanWriter can handle about 700 Labanotation symbols.

There have been several attempts to generate CG animation from Labanotation. The CG animation generator transforms Labanotation scores, which were prepared with LabanWriter, to the animation via the commercial software LifeForms [7]. However, LifeForms can only support the fundamental symbols of Labanotation.

LabanDancer [8] is a LabanWriter scores to 3D animation translation tool. Like LifeForms, LabanDancer does not have any functions for preparing Labanotation scores and supports only a limited number of symbols.

LabanXML [9] was developed by Nakamura and Hachimura in 2006. The XML concept was brought to LabanEditor for interchangeability of the notation data. Labanotation scores can be formatted and generated by using XSLT (eXtensible Style Sheet Language Transformation) and SVG (Scalable Vector Graphic) both developed by W3C.

Yasumuro et al. [10] proposed a method to create and edit character animation using a motion description scheme similar to Labanotation. Users can input motions of a character by specifying a combination of words, referred to as "word set", which corresponds to a Labanotation direction symbol and contains information about body part, start time, duration and direction of motion. The system translates the word sets into body motions, but does not deal with Labanotation graphical score and symbols directly.

Shun Zhang et al. [11] introduced a notation-based motion choreography system called LabanChoreographer. Their objective is to perform data retrieval in order to find the most similar motions from a motion capture database for choreographing. They are using Labanotation as an index tool for retrieval. Character
animation is produced from motion capture data but not from the notation.

Since the above-mentioned Labanotation applications are separately designed and developed, there are no applications which can both create Labanotation scores and produce 3D CG character animation. For example, LabanWriter is able to input and edit the scores only, and LabanDancer is used only for displaying the movements.

4 LabanEditor

LabanEditor is an interactive graphical editor for editing Labanotation scores and displaying the 3D CG character animation associated with scores [2]. LabanEditor integrates the following functionalities. Firstly, the 3D CG animation from a Labanotation score is shown directly after a user prepares a Labanotation score. Secondly, LabanEditor can import/export the data format, LabanXML, which is an XML representation of Labanotation scores.

LabanEditor consists of two major software components. The main component is for preparing Labanotation score and the second, called MotionViewer is for displaying the 3D character animation.

We added the following new features to LabanEditor:
1) A dynamic template technique enabling users to notate movements and reproducing them in 3D CG animation using the fundamental description of Labanotation.
2) MotionViewer for displaying the 3D CG character animation with VRML importable characters and backgrounds,
3) A motion control module to manipulate the motion expression among key-frames in order to make the animation more natural.

VRML model is selected in our implementation because VRML is a standard 3D modeling language with interchangeability to other models. There are many well-known 3D modeling software that can export 3D objects in the VRML format, such as 3ds Max, Maya, and Lightwave, etc. Not only VRML sufficiently fulfills our requirements for modeling both characters and environments, but also Java, Java3D and VRML are well suited each other.

4.1 Internal Structure of LabanEditor

The internal structure of LabanEditor is shown in Figure 3. The LabanEditor has been implemented with Java language. LabanEditor can receive three kinds of input. The first is the LND file format [2], which is the internal representation of Labanotation. The LND will be discussed in section 4.3. The Second is LabanXML, also used for interchanging Labanotation data in various ways such as via the internet. The third kind of input method is for the user to input Labanotation directly and interactively through the WYSIWYG user interface shown in Figure 4.

4.2 User Interface

The LabanEditor user interface is designed as a WYSIWYG editor for Labanotation as shown in Figure 4. Users are able to input and edit the score and then display the CG animation immediately, which makes it possible to interactively confirm the movements. As shown in Figure 4, the score is written by placing graphical symbols in the Labanotation canvas area.

When inputting, the user firstly specifies the type of symbol, and then indicates the column position and the length of the symbol where the symbol has to be placed in the staff. The symbols can be move to other position in
the staff by using drag & drop or can be deleted. Figure 5 shows the Labanotation symbols that can be input into the current version of LabanEditor.

Figure 6 shows a 3D CG animation display window. Users can zoom in/out and change the viewpoint of the 3D scene on all three axes by using a mouse. The playback control panel at the bottom of the display window allows users to operate an animation display with the following functions: play, pause, jump to the beginning, skip a frame forward, jump to the end, and skip a frame backward, respectively.

While replaying the Labanotation score, we can observe the animation as well as the red horizontal line cursor, moving upward as the animation progresses, as shown in Figure 6.

4.3 Conversion of Labanotation Scores to CG Animation

In our LabanEditor system, Labanotation scores can be represented as a simple format called LND [2], which uses alphanumeric characters to represent basic symbols. In order to create a 3D character animation, we have to convert LND into animation data. The format of LND representation is shown in Figure 7. The lines that begin with “#” indicate the fundamental parameters of Labanotation. The movement of a body part is specified in the line followed by a command “direction”, which corresponds to the Labanotation direction symbols.

![Labanotation symbols](image1)

**Fig.5** Labanotation symbols and signs

![Labanotation symbols](image2)

**Fig.5** Dialog boxes for Labanotation symbols and signs

![CG animation display window](image3)

**Fig.6** CG animation display window
4.4 Dynamic template technique

As explained earlier, Labanotation can describe any human body movement including even finger motion [1], but when doing so, the resulting score becomes extremely complicated.

On the contrary, because of the rough resolution of body parts' directions, similar but distinct poses are sometimes defined with the same symbol. For example, the symbol in Figure 11 illustrates that a performer rotates his/her right shoulder at a low level but at slightly different angles. These two different poses are presented with the same Labanotation symbol in the fundamental level of description.

To solve this problem, we invented the method of dynamic templates in order to represent very specific movements using a fundamental subset of Labanotation symbols only. We can represent these characteristic motions by changing the template files dynamically during a display process, while using very fundamental symbols.

![Dynamic template](image)

Fig. 11 Different poses expressed with a same direction symbol
(a) Inputted scores
(b) Two different poses corresponding to (a)

The dynamic template method exchange templates dynamically depending on the motion to be described at the specified moment.

Figure 12 (a) shows the interface of the editing template file. The editing window can be activated by double clicking on a Labanotation symbol. For example, suppose the symbol in the Labanotation score, indicated by the red colour in Figure 12 (a), was selected by a user, subsequently, the user can directly edit the joint angles on a template editing panel as shown in Figure 12 (a).

Alternatively, the graphically editable template, which is activated by clicking the 'Animate' button in Figure 12 (a), enables the user to edit the template by adjusting the slide bars to adjust joint angles and observing the resulting pose as shown in Figure 12 (b). When completing their task, users can save the template with the 'save' button.
During the animation production process, the Labanotation symbols, in format of LND, are mapped to the key-frame poses indicated by the current template.

4.5 MotionViewer

MotionViewer is a sub-system for displaying 3D CG animation in correspondence to its score. The MotionViewer was implemented using Java3D.

The framework of the MotionViewer, as shown in Figure 15, consists of four modules:
1) Virtual Environments: a stage and background import module is used to import a VRML model into the Java3D environment.
2) Animation character: the VRML-compatible CG human character can be imported.
3) Motion interpolation: the motion is interpolated from one key-frame to the next key-frame.
4) Motion expression controller: this is a function used to control changes of the position and joint angle between two consecutive key frames.

Figure 16 shows examples of characters and environments in MotionViewer.

(a) (b)

The motion expression control module controls the animation of a character model from one key-frame to
the next key-frame. Motions between two consecutive key-frames can be generated by a simple linear interpolation in a movement with constant speed. In LabanEditor, we implemented a module for controlling the motion by applying a non-linear interpolation in order to create natural movement. Eq. (1) is applied for controlling the animation acceleration,

\[ f(t) = \frac{1}{1 + e^{s(t-t_c)}} - \min \right) / (\max - \min) \quad (1) \]

where \( f(t) \) is an interpolated position or joint angle at time \( t \) and a normalized time scaled from 0.0 to 1.0, respectively. \( s \) determines the slope of the curve, and \( t_c \) determines the time at the center of a movement. Parameters \( \min \) and \( \max \) are used to linearly scale \( f(t) \) to the range 0 to 1.

\[
\begin{align*}
\min &= \frac{1}{1 + e^{s(t-t_c)}} \\
\max &= \frac{1}{1 + e^{-s(1-t_c)}}
\end{align*} \quad (2) (3)
\]

Eq. (1) is used to control the animation of the translation of the body, and angles at joints, where the parameters can be adjusted independently. Figure 17 shows the user interface of motion control.

5 Use of LabanEditor for Noh plays

Noh is the most famous and characteristic Japanese traditional performing arts in the stylized form of a musical dance-drama.

A ‘Shimai’ is a kind of performances in Noh often played as a short informal performance extracted from the whole play. The Shimai is performed with vocal music, and the actor wears simple costumes of crested Kimono and Hakama (Japanese trousers). Shimai is composed of several stylized forms of motion, or ‘Kata’, each of which has unique motion characteristics and its own name. In the Kanze School, more than 50 typical Kata motions have been used.

A body movement in Noh plays is highly stylized and is not the same as ordinary human movement. For instance, the Noh performer performs walking by sliding a foot forward, pivoting it up and down at the heel. Therefore, the direction symbols used for moving forward, for example, in Labanotation must be interpreted differently when we handle Noh plays and generate body motion from it.

This has been realized by preparing motion template files which are editable to represent specific motions in that particular performance.

Some examples of Kata movement in Noh play are as follows:
(a) “Sashi-komi” is the movement of putting forward the right hand holding a fan while stepping forward.
(b) “Hiraki” is opening both arms while taking a step backward.
(c) “Hidari-byoshi” is a stamping motion with the left foot.

We represented 11 movements found in some typical ‘Shimai’ and composed of basic Kata shown in Figure 18 with Labanotation. The template files of Noh Kata were designed in consultation with a Noh player.

![Fig.17 Motion expression controller user interface.](image)

**Fig.17** Motion expression controller user interface.

![Fig.18 Description of basic Noh movement in form of Labanotation created from LabanEditor.](image)

**Fig.18** Labanotationによる能の基本動作「形」の記述例

Snapshots of Noh Kata are shown in Figure 19. Figure 19 (a) and (b) show the reproduced animation of Noh Kata from Labanotation score using the Noh templates and standard templates, respectively. In Figure 19 (c) the animation generated from motion capture data is given in order to show the actual Kata movement. We can recognize that Figure 19 (a) shows the movement almost same as Figure 19 (c).
6 Conclusions and Future Work

In this paper we proposed a new method of description and reproduction of stylized traditional dances such as Noh plays with Labanotation. A new version of LabanEditor, LabanEditor, successfully describes and reproduces Noh motions by using the dynamic template method.

We have achieved three major improvements. First, our approach shows that we can describe Noh plays with the fundamental description of Labanotation, with a limited number of symbols by using the dynamic template method. Second, we made it possible to freely interchange both character models and background such as a Noh stage. Finally, we implemented non-linear interpolation of motion expression. When using the proposed approach, the resulting motion expression looks natural.

Our future work involves Labanotation functionality and character animation as follows:

- Extensions for handling many extensive symbols of Labanotation are required.
- Human physical constraints, for example, a range of joint angles, a simple dynamics on, for example, the height of jumping and body balance, etc., must be considered in MotionViewer in order to make the movement more natural.
- A system for managing the revision and ownership of template files is necessary.
- The treatment of the interference between body parts and the environment must be implemented.
- The number of Noh Kata which can be handled in LabanEditor must be increased.
- Applications of the method to other stylized traditional dances and evaluation are necessary.

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1 LabanEditor is the LabanEditor version 3, which is the successor to LabanEditor2 [9] and LabanEditor [2], respectively.
expressions.

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