Description and Reproduction of Noh Body Motion by Using Labanotation

Worawat Choensawat
School of Science and Engineering
Ritsumeikan University

Sachie Takahashi
School of Letters
Ritsumeikan University

Minako Nakamura
Graduate School of Humanities and Sciences
Ochanomizu University

Kozaburo Hachimura
School of Science and Engineering
Ritsumeikan University

Labanotation uses a symbolic description for describing human body movement and it is said that the notation can describe even motions of each finger of a dancer. However, since the resulting score will become extremely complicated, the fundamental description has been usually used. On the other hand, there are styles of motion peculiar to the traditional dances, and if we restrict ourselves to handling a specific class of dance, we can describe these motion with the basic notation scheme. Based on the aforementioned, we investigated a method of describing and reproducing CG animation of Noh play with plain Labanotation. We proposed a method of dynamic template which allows users to refine the pose of Labanotation symbol and reproduce them in 3D CG animation. The evaluation showed that the system and the method had satisfied our initial requirements.

1. Introduction

A stylized traditional dance has uniqueness in itself which reflects history, culture, emotion expression, place, etc. For instance, Noh play, a Japanese traditional performing art, its movement is highly stylized and unique. For example, in walking movement, the performer moves by sliding his/her feet forward, pivoting them up and down via the heel, while keeping the fundamental standing pose. Some gestures of Noh play have specific meaning while others serve as an abstract aesthetic expression which expresses the emotions of the main actor.

The capabilities for handling these very characteristic body movements are the core of our research problem. These can probably be handled with the full set of Labanotation [1]. However, the resulting notation would become extremely complicated and only a few people are able to interpret it. 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.

As for this writing, several graphics applications have been developed for preparing Labanotation scores [2-3] and generating body movement [4-7]. However none of these have yet solved the abovementioned problem and all of the above mentioned applications are separately designed and developed, there are no applications which can both create Labanotation scores and produce 3D CG character animation.

We have been working on a system named LabanEditor [8-9]. 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 a dynamic motion template technique enabling users to notate stylized traditional dances and reproduce it in 3D CG animation from a Labanotation score. We also implemented the proposed technique in LabanEditor. In order to evaluate our proposed method, we tried to represent animation of body movement of Noh dance.

There are several groups of users who can take advantage of our system on dance studying as well as dance performance. The following will give a scenario of six use cases:

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

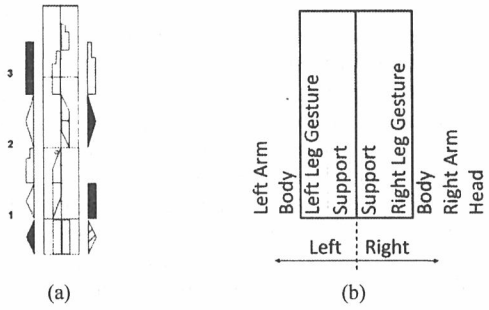
study body motions via the notation-animation cycle made possible by our system.

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.

2. Labanotation

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.

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.



(a) (b)

Figure 1: Labanotation scores
(a) Example of Labanotation scores.
(b) Columns of Labanotation representing body parts

Figure 2 shows the structure of direction symbols. The shape of symbol represents the direction of horizontal motion. A shade of direction sign shows the level of a movement, which is defined as follows: low, middle, and high, respectively. The motion of each body part is expressed by a sequence of symbols placed in the corresponding column.

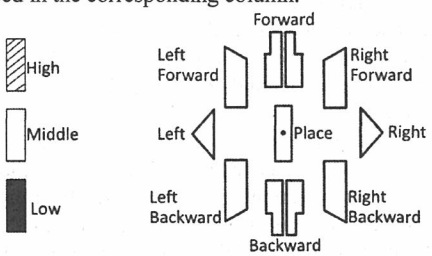


Figure 2: Direction symbols

3. LabanEditor

LabanEditor [8] is an interactive graphical tool for editing Labanotation scores and displaying the 3D CG character animation corresponding to the score.

We added the new features to LabanEditor as follow:

1. A dynamic template technique enabling users to notate characteristic poses and reproducing it in 3D CG animation using fundamental description of Labnotation.
2. A motion control module for manipulating the motion expression in between key-frames in order to make the animation more natural.

3.1. User Interface

With LabanEditor, users are able to input and edit the score and then display the CG animation immediately, which makes possible to interactively confirm the movements. Users can zoom in/out and change the viewpoint of the 3D scene on all three axes.

While replaying the Labanotation score, users can observe the animation as well as a red horizontal line cursor, moving upward corresponding to the animation progresses, as shown in Figure 3.

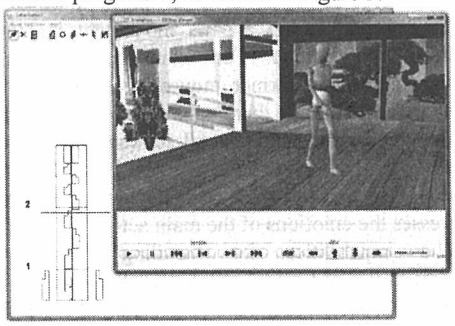


Figure3: Labanotation editing window and CG animation display window

3.2. From Labanotation score to CG animation

In LabanEditor system, Labanotation scores can be represented as a simple data format called LND [8], which uses alphanumeric characters to represent basic symbols as shown in Figure 4. The line beginning with "#" described the fundamental parameter of the Labanotation score. The movement of a body part is specified by the line followed by a command "direction", which corresponds to the Labanotation direction symbols.

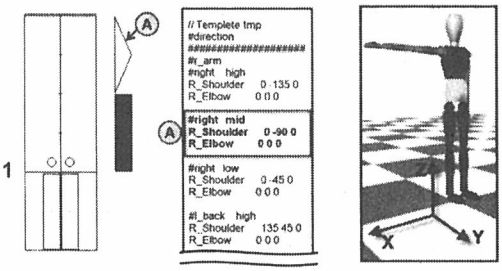
LND describes a pose of the body at each timing just like key-frame body posture for animation, so that we can produce motion of a body part by simply applying interpolation between start and end key-frame poses.

```
#beat     4/4
#tempo    120
direction l_support     forward   mid     0.0     1.0
direction r_arm         forward   mid     0.0     6.0
direction r_support     forward   mid     1.0     2.0
direction l_support     forward   mid     2.0     3.0
direction r_support     forward   mid     3.0     4.0
direction l_support     forward   mid     4.0     5.0
```

Figure 4: Example of LND

Our system converts direction symbols into animation key-frames by using a template file for a mapping between the symbol and its corresponding pose of the body part. The template file describes the relationship between a direction symbol at the particular column and the rotation and translation of the corresponding joint.

Figure 5 shows a notation and a description in the template file, and the resulting pose. The symbol marked "A" in Figure 5 (a) is mapped to the description of the part marked "A" in the template file shown in Figure 5 (b), which indicates a target pose of the right arm achieved by rotating the right shoulder joint 90 degree counterclockwise around the y-axis from the standard pose.



(a) (b) (c)

Figure 5: Relationship between user input symbols and a template file
(a) User input symbol
(b) Part of a template file
(c) A target pose corresponding to the template in (b)

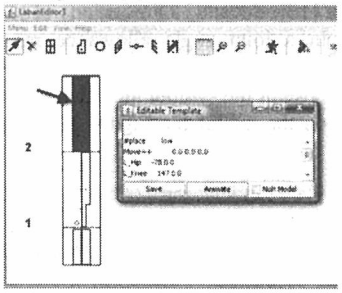
3.3. Dynamic template technique

As previously mentioned, the aim of our paper is to describe a stylized traditional dance with the basic notation scheme. Due to a rough resolution of fundamental elements of Labanotation, several similar poses could be defined with an identical basic symbol.

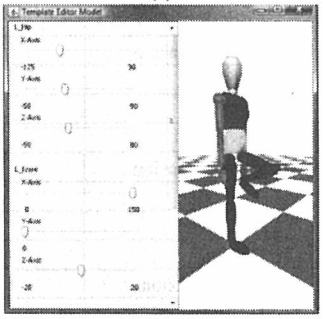
To solve this problem, we invented the method of dynamic templates in order to represent very specific movements using a fundamental subset of Labanotation symbols only. The dynamic template method exchange templates dynamically depending on the motion to be described at the specified moment.

Figure 6 (a) shows the interface of editing template file. Users can activate the editing window by double clicking on a Labanotation symbol. For example, suppose that the symbol in the Labanotation score, indicated by an arrow in Figure 6 (a), was selected by a user, then, the user can directly edit the joint angles on an editable template panel as shown in Figure 6(a).

Alternatively, the graphically editable template, which is activated by clicking the 'Animate' button in Figure 6 (a), enables the user to edit the template by adjusting the slide bars and observe the resulting pose as shown in Figure 6 (b)



(a)



(b)

Figure 6: Interface for editing a template.
(a) Template editing panel
(b) Graphical template editing panel

The information of template files are inserted into a LND file corresponding to the start time as shown in Figure 6. The command "#include" determines the template file used at a particular timing. As a result, in this case, the Labanotation score shown in figure 5(a) will be interpreted as the LND file shown in Figure 7.

```
#version 1
#beat     4/4
#tempo    100
#include                A.tmp
direction l_support     place   low     0.0     0.0
direction r_arm         place   low     0.0     0.0
direction r_support     back    mid     0.0     4.0
#include                B.tmp
direction r_support     place   low     4.0     8.0
rotation  l_support     place   low     4.0     8.0
```

Figure 7: Example of LND file using dynamic templates

The method of dynamic template can solve the abovementioned problem. However, by allowing a user to refine a pose of a symbol freely, the resulting pose may lead to one of the following problems:

1. The resulting pose could be a weird, unnatural, pose.
2. The resulting pose may not match the definition of direction symbol.

To solve these problems, we established two rules for the pose refinement. First, the positions of joint angles must be in a range shown in Table 1, which are the possible human being joint angles, where are defined in [10]. Second, the positions of joint angles must be in a joint angle allowance range of the direction symbol. Figure 8 shows that a user is able to refine the pose of the symbol indicated by an arrow in the score on the left of the Figure 8 only within the allowance range.

Table 1. Range of joint angle (Adapted from Luttgens & Hamilton, 1997)

Joint	Movement	Angle (degrees)
Elbow	Flexion	145
	Hyperextension	0
Shoulder	Flexion	180
	Hyperextension	80
	Abduction	180
	Adduction	50
Hip	Flexion	125
	Hyperextension	30
	Abduction	45
	Adduction	25
Knee	Flexion	150
Ankle	Plantar flexion	50
	Dorsiflexion	30

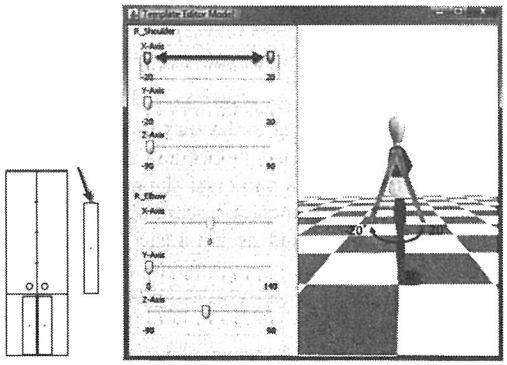


Figure 8: Example of joint angle allowance range of a symbol

The snapshots in Figure 9 are to compare the animation using dynamic template with one without using dynamic template. In this example, we used dynamic template technique on the last symbol in the Labanotation score indicated by the red colour. The end result shows that we are able describe a very characteristic body movement while suppressing the complexity in the score using dynamic template technique.

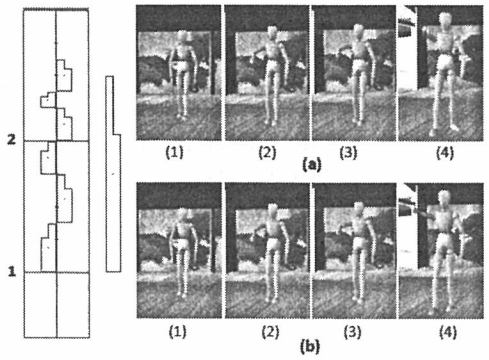


Figure 9: CG character animation using dynamic template

(a) CG character animation corresponding to the Labanotation score on the left using dynamic template.

(b) CG character animation corresponding to the Labanotation score on the left using single default template.

3.3. Motion Expression Control

When handling a very characteristic movement such as Noh, it is important to control the interpolation of joint speed change from one key-frame to the next key-frame according to a style of the body movement. We proposed the motion expression control module by applying the non-linear interpolation, cubic Bezier curve, in order to produce an animation with the natural movement.

$$f(t) = (1-t)^3 P_0 + 3(1-t)^2 t \times P_1 + 3(1-t)t^2 P_2 + t^3 P_3 \quad (1)$$

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. $P_0(0,0)$ and $P_3(1,1)$ is the start and end points, respectively while P_1 and P_2 are the control points which can be moved freely as shown in Figure 10.

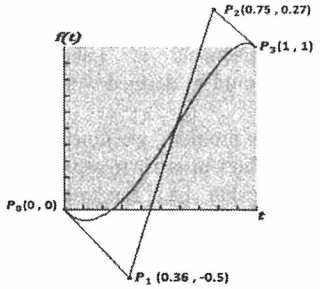


Figure 10: Motion expression controller user interface

Figure 11 shows two snapshots of the CG animation corresponding to the motion expression graphs on the left.

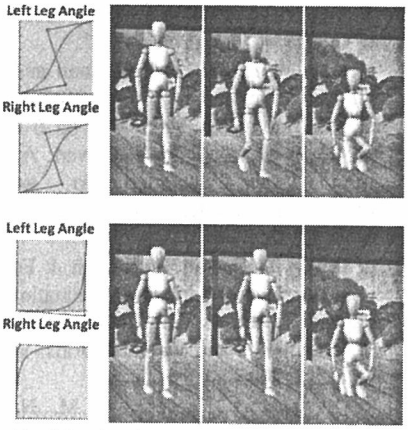


Figure 11: CG animation snapshots corresponding to the motion expression graphs

4. Use of LabanEditor for Noh plays

Noh is the classical characteristic Japanese traditional performing arts in the stylized form of a musical dance-drama. There are about 240 plays in the repertoire from five Noh schools [11].

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', putting together in a series.

Kata are the fundamental movement in Noh where each of which has unique motion characteristics and its own name. In the Kanze School, 55 typical Kata motions have been used.

Body motion in Noh plays is highly stylized and is not same as ordinary human body motion. 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.

(d) "Shitai" is the movement of taking one step backward and sitting on one knee.

We represented 11 motions found in some typical 'Shimai' and composed of basic Kata shown in Figure 12 with Labanotation. The template files of Noh Kata were designed in consultation with an experienced Noh player.

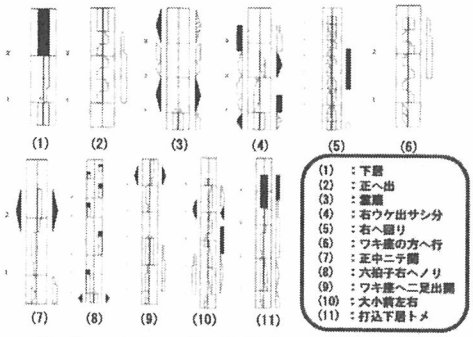


Figure 12: Description of basic Noh movement in form of Labanotation created from LabanEditor

Snapshots of Noh motion are shown in Figure 13. Figure 13 (a) and (b) show the reproduced animation of body motion from Labanotation score using the "Shitai" template and standard template, respectively.

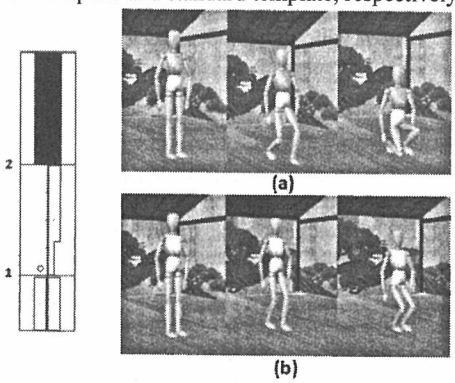


Figure 13: CG character animation of "Shitai"
(a) CG character animation corresponding to the Labanotation score on the left using a "Shitai" template.
(b) CG character animation corresponding to the Labanotation score on the left using standard template.

The evaluation of our method and its resulting representation was undertaken by two of our co-authors. The first person is an amateur, yet an advanced and well-trained Noh player with 15 years of experience. She has been trained by a professional Noh player in Kyoto. The second is a dance researcher who is a specialist of Labanotation teaching. She made an evaluation from the viewpoint of the application of Labanotation to Noh plays.

After the evaluation, we found that our method of the dynamic template technique is an efficient method of defining the movement of Noh. Template files which have been prepared can be shared among Noh players and researches etc.

5. 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. We implemented a new version of LabanEditor named LabanEditor3, which is the successor to LabanEditor2 [9] and LabanEditor [8], respectively. LabanEditor3 successfully describes and reproduces Noh motions by using the dynamic template method.

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.

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 simple dynamics on the height of jumping and body balance, etc., must be considered 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, such as a floor and stage properties, must be implemented.
- The number of Kata which can be handled in LabanEditor must be increased.
- Applications of the method to other stylized traditional dances and evaluation are necessary.

Acknowledgments

This work is supported in part by the Global COE (Center of Excellence) Program "Digital Humanities Center for Japanese Arts and Cultures" at Ritsumeikan University and the Grant-in-Aid for Scientific Research (B) No. 22300039, both from the Ministry of Education, Science, Sports and Culture.

References

[1] A. Hutchinson: Labanotation, Theatre Arts Books, 1977.

[2] M. D. Brown, S.W Smoliar: A Graphics Editor for Labanotation; Proceedings of the 3rd Annual Conference on Computer Graphics, Interactive Techniques and Image Processing, ACM Computer Graphics, Vol.10 (2) pp. 60-65, 1976.

[3] I. Fox: Documentation Technology for the 21st Century; World Dance 2000 Academic Conference, Papers and Abstracts, pp. 137–142, 2000.

[4] T. Calvert: Animating Dance; Proceedings of Graphics Interface 2007, pp 1-2, 2007.

[5] T. Calvert, L. Wilke, R. Ryman and I. Fox: Applications of Computers to Dance; IEEE Computer Graphics and Application, Vol. 25(2), pp. 6-12, 2005.

[6] M. Coyle, D. Maranan, T. Calvert: A Tool for Translating Dance Notation to Animation; Proceedings of Western Computer Graphics Symposium, 2002.

[7] L. Wilke, T. Calvert, R. Ryman, I. Fox: From dance notation to human animation: The LabanDancer Project: Motion Capture and Retrieval; Computer Animation and Virtual Worlds, Vol. 16(3-4), pp. 201-211, 2005.

[8] K. Kojima, K. Hachimura, M. Nakamura: LabanEditor: Graphical Editor for Dance Notation; Proceedings of IEEE 2002 International, Workshop on Robot and Human Interactive Communication, pp. 59-64, 2002.

[9] M. Nakamura, K. Hachimura: An XML Representation of Labanotation, LabanXML, and Its Implementation on the Notation Editor LabanEditor2; Review of the National Center for Digitization (Online Journal), Vol.9, pp. 47-51, 2006

[10] K. Luttgens, N. Hamilton: Kinesiology: Scientific Basis of Haman Motion, 9th Edition, 1997.

[11] B. Ortolani: The Japanese Theatre: From Shamanistic Ritual to Contemporary Pluralism, Princeton University Press, pp. 132, 1995.