Realistic Expression of Body Motion and Environment in LabanEditor

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(a) A female model in the checker dance floor environment
(b) A puppet model on Japanese traditional Noh stage

Figure 1: The virtual environments in MotionViewer

Abstract
The reproduction of dance body motion from Labanotation, one of dance notations, aims at realization of natural human movement in the changeable environment. Basically, the CG animation derived from the linear interpolation between a key frame and its adjacency frame. The linear interpolation does not express natural human movements; therefore, we propose a motion expression module by using a non-linear interpolation. A piecewise function and an exponential function are used to produce realistic human movement. The proposed functions can control body inertia in human movement. In this paper, we implemented the proposed interpolation functions in LabanEditor. We also developed the core of MotionViewer by Java 3D which the environment and CG models can be created by VRML language.

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1 Introduction
LabanEditor is an interactive graphical editor for writing and editing Labanotation scores. LabanEditor allows users to input/edit Labanotation scores and replay the animation of human body motion corresponding to the Labanotation score. The animation is displayed via 3D computer graphics in a MotionViewer.

It is widely acceptable that Labanotation is a useful tool for human movement recording, choreography and dance training [Kojima et al. 2002]. Although, the description of Labanotation is not accurate by comparison with motion capturing techniques, it is widely used in the field of dance. The Labanotation score plays a key role of choreographers, teachers, students, and performers.

The previous version of LabanEditor creates the CG animation derived from the linear interpolation between a key frame and its adjacency frame. The linear interpolation does not express natural human movements. Therefore, we propose a motion expression module by using a non-linear interpolation. A piecewise function and an exponential function are used to produce realistic human movement. The proposed functions can control body inertia in human movement.

We implemented the proposed non-linear functions in the MotionViewer and modified the MotionViewer to import VRML 3D models. The contributions of this paper are the following:

1. The motion expression module by using the non-linear interpolation between a key frame and its adjacent frame.
2. The human body and environments, as shown in Figure 1, such as stages and floors created by VRML language can be imported in the MotionViewer.

2 LabanEditor
LabanEditor consists of two major parts: The former part aims at preparing Labanotation scores. The latter, named MotionViewer, involves the reproduction of 3D computer animation. This paper focuses on the latter part different from all the previous versions: realistic expression of body motion and environment are new features. This new version of LabanEditor is called LabanEditor3.
Figure 2: User interface of LabanEditor3: (a) User interface for Labanotation scores preparation. (b) User interface of MotionViewer, where the movement of a character model is corresponding to Labanotation scores in (a).

Two types of the user interfaces are shown in Figure 2.

The first version of LabanEditor was developed by using Java applet and VRML [Kojima et al. 2002]; and the second version, LabanEditor2 [Nakamura and Hachimura 2006], implemented the Java3D-based MotionViewer. Due to VRML limitation, the MotionViewer of LabanEditor2 was re-written by using Java3D. The disadvantage of the Java3D-based MotionViewer is the difficulty in changing the 3D environments and the human character models. LabanEditor3 solved this problem by separating the design from coding by importing the VRML geometrical models into the MotionViewer.

3 MotionViewer

The framework of MotionViewer consists of the following modules:

1. 3D character models and stage format conversion is used to display the VRML model in Java3D.

2. Motion interpolation is a mathematic function used to derive movement data from key-frames. A key frame is a location of Labanotation symbols representing the beginning and ending of body motion.

3. Motion expression is a non-linear function to control the expression of movement in order to create natural movement.

Towards natural human movement, we implemented a module for controlling the motion by applying a non-linear interpolation in order to create natural movement. We applied Eq.(1) to controlling the animation acceleration.

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

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

\[
\min = \frac{1}{1 + e^{st_c}}
\]

\[
\max = \frac{1}{1 + e^{-s(1-t_c)}}
\]

Eq.(1) is used to control the animation of the following body parts, where the acceleration parameter as shown in Eq.(1) can be adjusted independently.

1. Body translation
2. Body joint angles: pelvis, rib, neck, and throat joint angle
3. Left arm joint angles: chest, shoulder, elbow, and wrist
4. Right arm joint angles: chest, shoulder, elbow, and wrist
5. Left leg joint angles: hip, knee, ankle, and foot
6. Right leg joint angles: hip, knee, ankle, and foot

In this paper, we consider the body inertia in human movement; e.g., it is difficult to suddenly stop fast moving at the correct position. For example, a dancer raises her right hand quickly as shown in Figure 3. The hand that continues moving further than the stop position results from the body inertia. We modified Eq.(1), which neglects the body inertia, by adding the over-shift functions before the stop/pause position. A new formula and its graph plotting when \(t = [0, 1]\) are shown in Eq.(4) and Figure 4.

\[
g(t) = \begin{cases} 
E q.(1) & ; 0 < t \leq t_c \text{ or } s < t \leq 1 \\
\frac{m(t-t_c)}{(t-r) + \text{overshift}} & ; t_c < t \leq r \\
\frac{m(t-t_c)}{t-r} + \text{overshift} & ; r < t \leq s 
\end{cases}
\]

The above formula is derived from the differentiation of Eq.(1). \(\text{overshift}\) is a user-defined parameter; i.e., the ratio of distance...
Figure 4: Graph of the proposed motion expression regarding the body inertia of human movement; the horizontal and vertical axes represent time and position, respectively. For example, this function controls the right arm angle as illustrated in Figure 3.

Figure 5: Regardless of the body inertia, the proposed exponential function as shown in Eq.(1) can be applied in the motion expression; e.g., adjusting two parameters, $t_c$ and $s$, produces the different motion expression between (a) and (b).

Exceeding the stop position. In this experiment, the overshift is set to 1.2. The other parameters are shown below:

\[
m = \frac{4s}{\max - \min} \quad (5)
\]
\[
p = \frac{0.5 - \min}{\max - \min} \quad (6)
\]
\[
r = \frac{1}{m} (\text{overshift} - p) + t_c \quad (7)
\]
\[
s = -\frac{2(Eq.\,(1) + \text{overshift})}{m} + r \quad (8)
\]

4 Conclusion

LabanEditor is a useful tool for (a) teachers and students in dance studies, (b) choreography, and (c) preserving traditional performing arts such as Noh dance. The merit of this work is the realistic expression of body motion; and the changeable environments of 3D character and stage models. The evaluation of this work is a remaining part that the reproduced animations by using our proposed motion expression will be reviewed by the experts. This will be in the future work.

References
