An Approach for Generating Labanotation from Motion Capture Data

Jirawat Chomputawat*, Worawat Choensawat* and Don Isarakorn†

*School of Science and Technology, Bangkok University
Rama IV road, Klong-Toey, Bangkok 10110 Thailand
Email: jirawat.chom@bulive.net, worawat.c@bu.ac.th
†Department of Instrumentation and Control Engineering, Faculty of Engineering
King Mongkut's Institute of Technology Ladkrabang
Email: kidon@kmitl.ac.th

***Abstract*— In Western dance communities, Labanotation is one of the most well known dance notations. Labanotation uses a symbolic description for describing the human body movement. This paper presents a tool for generating Labanotation score from motion capture data. A graphical user interface (GUI) for semi-automatically converting motion capture data to Labanotation scores is designed to reduce an ambiguous of key-frames selection and symbol definition. The GUI allows the user easily to define some of the symbols definition according to the dance motion. In addition, user can make the selection of their desirable motion key-frames to produce a quality Labanotation score.**

I. Introduction

Recently, the digital recording and archiving of intangible cultural assets, such as the classical dance and theatrical arts has been an important research topic [1], [2]. As referring to music, most of the musical composers prefer recording their compositions into music score rather than playing them into an audio recording. The same is true for dance notation that a dance notation represents the choreographer's intention, just as a music notation represents the composer's intention.

Labanotation is one of the most common movement notation systems. It is widely acceptable that Labanotation is a useful tool for human movement recording, choreography and dance training [3]. Dance notation does not record the exact movements of any particular person; but it does record the essential ideas of a movement, so that any particular person might interpret and perform those ideas again. Moreover symbolic representation has an advantage that it enables us to record the movement roughly and to make comparison easily among various dances. However, writing down the notation by observing the dance movement is a difficult task which required patience and skill.

With the advances in technology, motion capture systems provide the most precisely recording data that we are able to accurately measure body motions. The motion capture data measure temporal changes in three-dimensional position of body parts that are rigid and articulated by joints to record and investigate human body motion. Therefore, we implemented an application for assisting choreographer to record the dance movement into Labanotation score from motion capture data. The application aims at providing the user an interactive aspect that enables the user to create the notations in an immediate and responsive way.

The process for converting Labanotation score from motion capture data can be divided into four steps: 1) acquiring data, 2) selecting key-frames, 3) encoding posture, and 4) generating Labanotation data (LND) [4]. LND is an internal representation of Labanotation score by the system called LabanEditor [4], [5]. In the experiment, we used Microsoft Kinect as the motion capture system. After the converting to LND, we compared the motion acquisition from the Kinect with the animation produced from LabanEditor. Promising results have been obtained using the proposed method.

II. Labanotation and Labanotation Data

A. 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. A Labanotation score is written in the form of vertical staff where each column corresponds to a body part. Fig 1(a) is an example of Labanotation scores corresponding to dance motion. Fig 1(b) shows the basic arrangement of columns in the staff where each column represents the part of the body. 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.

Each Labanotation symbol defines a movement detail. The shape of the symbols depicts the direction of the movement. Shading within a symbol shows the level of a movement, i.e. vertical direction of movement (low, middle, and high), as shown in Fig 2. Symbols are placed in the columns of the staff which reflect part of the body to move. The vertical length of a symbol shows the duration of the movement, from its beginning to its end. Please refers to [3] for more detail about Labanotation.

B. Labanotation Data

Labanotation scores can be represented as a simple format called Labanotation Data (LND), which uses alphanumeric

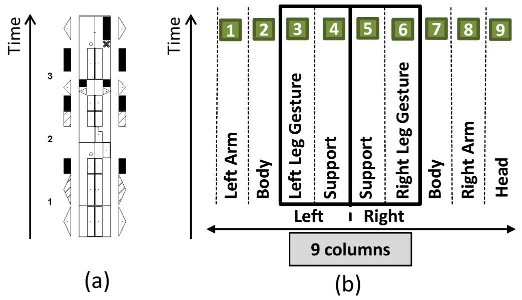

Fig. 1. Labanotation score: (a) Example of a Labanotation score, (b) Columns of Labanotation representing body parts.

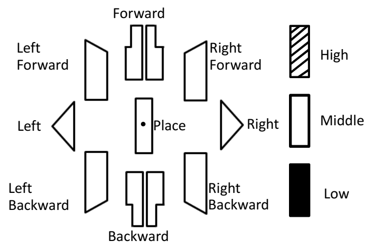

Fig. 2. Labanotation symbols

characters to represent basic symbols. LND describes a pose of the body at each timing just like key-frame body postures for animation, so that we can produce motion of a body part by simply applying interpolation between start and end key-frame poses. A key-frame pose of a body part at a time corresponding to an end of a symbol is defined by a Labanotation symbol. Fig 3 illustrates how a Labanotation score is convert to LND structure. 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.

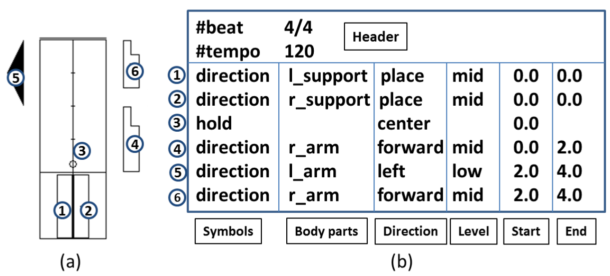

Fig. 3. Relationship between Labanotation score and LND; (a) example of Labanotation score and (b) the LND representation of Labanotation score in (a).

III. Proposed System

A. System Overview

This paper presents an interactive graphic system for converting of motion capture data to the LND format. The overall framework of the system is shown in Fig 4.

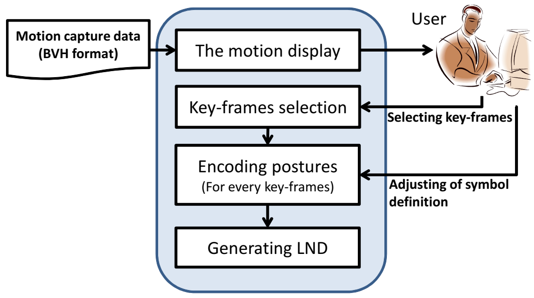

Fig. 4. System overview

B. Data Acquisition

The most commonly used formats of motion capture data are C3D, TRC, ASF/AMC and BVH. The ASF/AMC and BVH formats store hierarchical skeleton data, while the C3D and TRC format store 3D coordinates system. In this paper, motion capture data in the BVH format is used. The BVH format provide skeleton hierarchy information in addition to the motion data. For capturing full human body motion, 24-60 joints are commonly used. For our method, we selected only the important joint as shown in Fig 5.

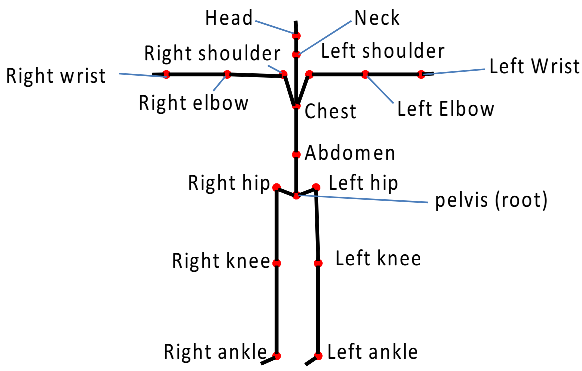

Fig. 5. Human body model

C. Key-frames selection

Recall from Fig 4 that a LND conversion consists of a motion capture file together with some symbols definition and suitable key-frames selection. Previously several researches proposed key-frame extraction techniques from motion capture data [6], [7]. However, those techniques are focusing on the compression of the motion capture data which are not practical for our purpose. Hachimura and Nakamura [8] introduced the method of key-frame selection using the threshold for magnitude of joint speed. However, for some kinds of dance, using a fixed threshold value for key-frame selection may not be appropriate.

Therefore, we developed an interactive GUI for the key-frame selection. While displaying the motion capture file, the user can interactively select the suitable key-frames. Fig 6 shows the main user interface for the key-frame selection where the motion capture file is displayed in three points of

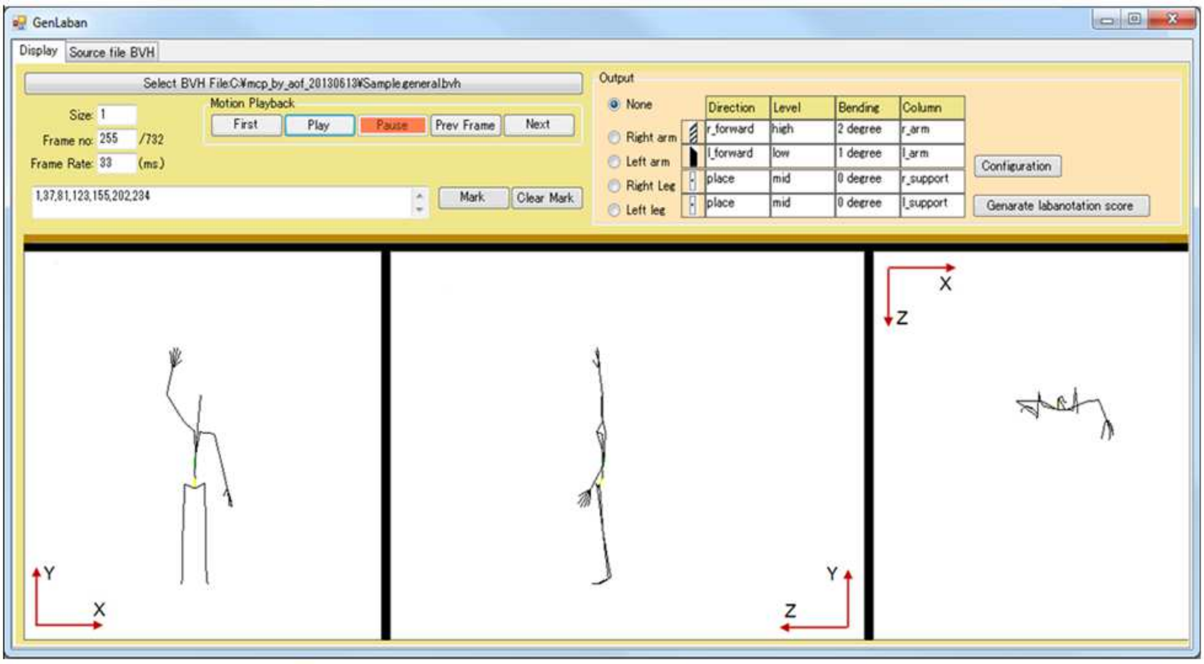

Fig. 6. Interactive graphical user interface.

view as following; 1) X-Y axis (front view), 2) Y-Z axis (side view), and 3) X-Z axis (top view). The user can easily mark the key-frame and then generate the LND file from the marked key-frames.

D. Posture Encoding

In order to analyze the movement direction of each body parts, firstly a vector indicating the facing direction of the performer must be determined. We used the normal vector of a triangular plane through "right shoulder", "left shoulder" and "chest" as the facing vector as shown in Fig 7(a). After the facing vector is determined, then the facing vector will be mapped into the standard cross of axes [9] which is the system of reference most commonly in use. In the standard cross of axes, the vertical axis (line of gravity) remains constant and the forward direction in the horizontal axis is the modified facing vector that lies at right angle to the vertical axis as shown in Fig 7(b).

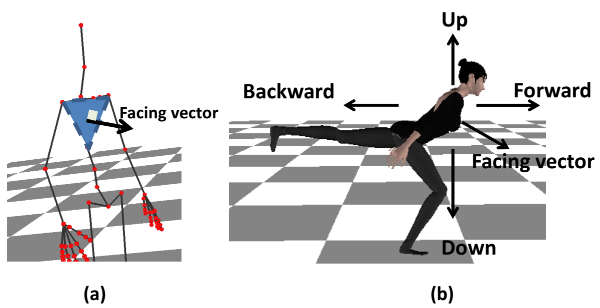

Fig. 7. Facing direction; (a) A normal vector that indicates the facing direction, and (b) The standard cross of axis

1) Defining the motion direction: After the forward direction is determined, the next step is to define the body posture of each selected key-frame to Labanotation symbols. We adopted the technique of quantization of the motion direction that proposed in [8]. The motion direction is determined using direction from parent joint to child joint which can be divided into 27 quantized spaces. The 27 spaces consist of nine horizontal directions and three vertical levels as shown in Fig 8.

For the motion direction of arms, we used shoulder as the parent joint and wrist as the child joint. In similar manner, for legs, hip and ankle joints are used as the parent joint and the child joint, respectively.

Note that we will consider the horizontal distance between a parent joint and its child joint for *place*. If the distance is less than the predefined threshold, the child joint will considered as *place*; otherwise, it must be classified into 8 directions as shown in Fig 8(a).

2) Bending Analysis: In addition to the direction symbols, six signs are used to specify the bending of the body part as shown in Fig 9. Let arms be an example. The bending degree of the left arm is calculated by considering three joints: left shoulder(S), left elbow(E), and left wrist(W). We, then, form two vectors: $\vec{ES}$ and $\vec{EW}$. The formula for the blending degree(θ) is written as follows:

$$\theta = \arccos\left(\frac{\vec{ES}\cdot\vec{EW}}{|\vec{ES}||\vec{EW}|}\right) \tag{1}$$

3) Duration Determination: In Labanotation, the duration of the motion is described by the length the symbol. The

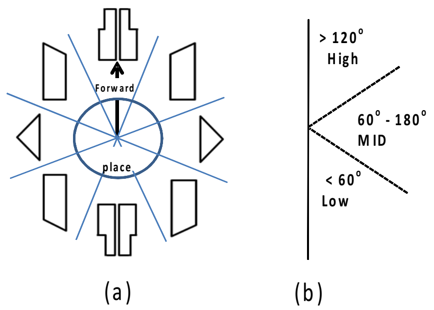

Fig. 8. Quantization of direction; a) horizontal direction associated with facing vector, and b) vertical direction according to the standard cross of axis.

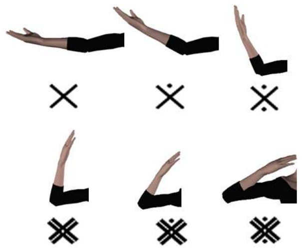

Fig. 9. Example of arm bending and its associate sign.

duration of the motion is the time between the previous key-frame and the current key-frame. Therefore, the length of the symbol can be calculated. We used the standard four beats per measure (bar) with 120 beats per minute (2 seconds per measure).

IV. System Evaluation

In the experiment, we use a Microsoft Kinect device as the motion capturing system. Kinect has a depth sensor that provides the full-body 3D motion capture capability. Fig 10 shows the use of Kinect for capturing the full-body motion. After capturing the motion, the set of key frames is manually selected as shown in Fig 11, and the LND file is generated from those key frames.

The system called 'LabanEditor' is then used to display the body animation of the generated LND file. LabanEditor has capabilities to read a LND file, display/edit Labanotation score, and display the 3D CG animation from the score. The Labanotation score in Fig 12 is generated from the LND file using LabanEditor. Fig 13 shows the snapshots of the CG animation of the Labanotation score in Fig 12.

V. Conclusion and Future Work

This paper shows the approach and introduces the tool for assisting choreographers to create the Labanotation score from motion capture data. The result demonstrates that the method and the quality of the produced Labanotation score are effective and usable. Because the rough resolution of Labanotation, different users may have different judgement of the symbol definition. The proposed tool provides a configuration panel

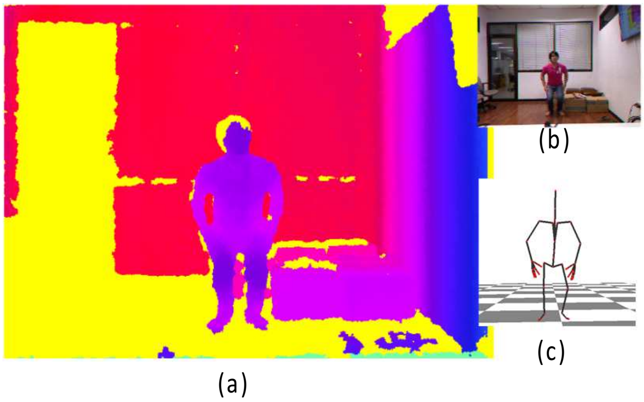

Fig. 10. Full-body 3D motion capture using Kinect; (a) The depth sensor, (b) Motion capture performed by Mr. Jirawat Chomputawat, and (c) Displaying of BVH model using the acquired 3-D information from (b).

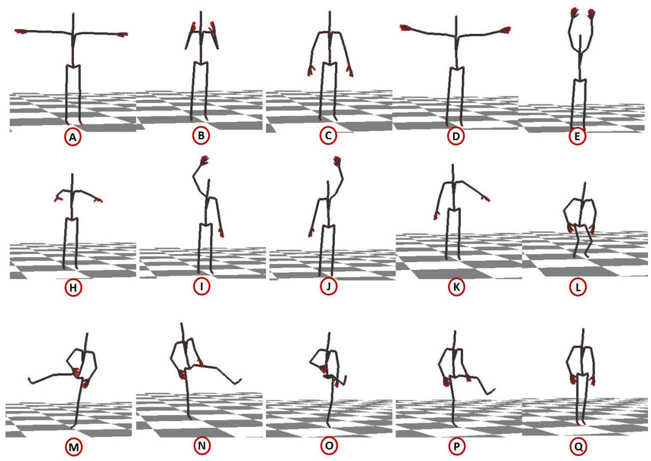

Fig. 11. The capturing motion.

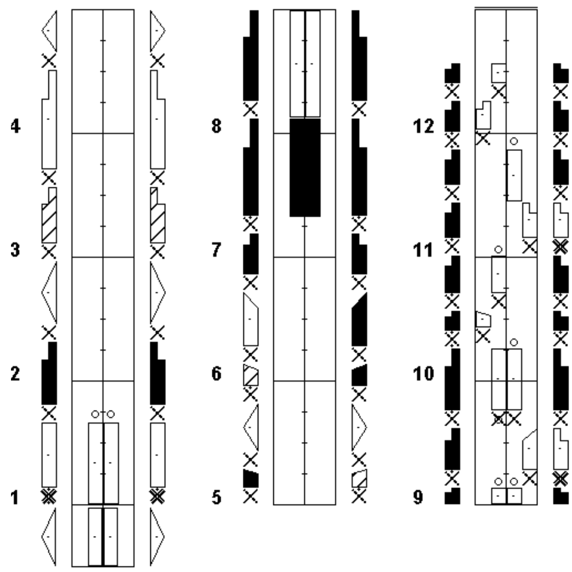

Fig. 12. Resulting Labanotation score

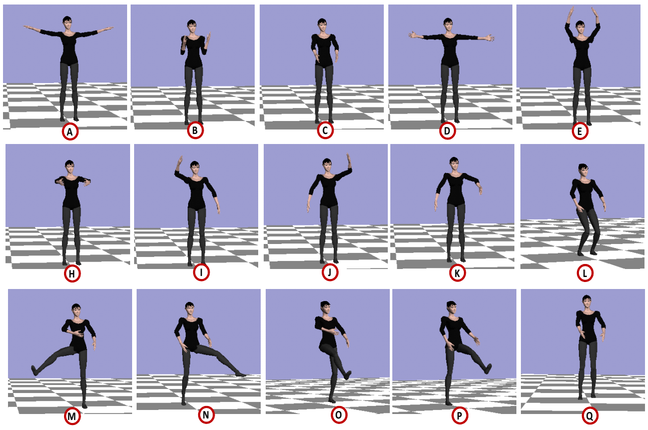

Fig. 13. Snapshots of 3D animation generated from the score in Fig 12.

for the user to define the symbol setting such as thresholds of bending degrees, motion directions, and vertical levels.

Since this work is in the beginning stage of the project, only basic motion and some fundamental Labanotation symbols can be handled. More complex motion such as turning and twisting will be further investigated.

REFERENCES

[1] K. Hachimura. Digital archiving of dance by using motion-capture technology. *New Directions in Digital Humanities for Japanese Arts and Cultures (A. Kawashima et al. eds)*, pages 167–181, 2009.

[2] K. Hachimura. Digital archiving of dancing. *Review of the National Center for Digitization (Online Journal)*, 8:51–66, 2006.

[3] A. Hutchinson Guest. *Labanotation*. New York: Routledge, Chapman & Hall, 1977.

[4] K. Kojima, K. Hachimura, and M. Nakamura. Labaneditor: Graphical editor for dance notation. In *Robot and Human Interactive Communication, 2002. Proceedings. 11th IEEE International Workshop on*, pages 59–64. IEEE, 2002.

[5] W. Choensawat, S. Takahashi, M. Nakamura, W. Choi, and K. Hachimura. Description and reproduction of stylized traditional dance body motion by using labanotation. *Transactions of the Virtual Reality Society of Japan*, 15(3), 2010.

[6] E. Bulut and T. Capin. Key frame extraction from motion capture data by curve saliency. In *Proceedings of 20th Annual Conference on Computer Animation and Social Agents, Belgium*, 2007.

[7] I.S. Lim and D. Thalmann. Key-posture extraction out of human motion data. In *Engineering in Medicine and Biology Society, 2001. Proceedings of the 23rd Annual International Conference of the IEEE*, volume 2, pages 1167–1169. IEEE, 2001.

[8] K. Hachimura and M. Nakamura. Method of generating coded description of human body motion from motion-captured data. In *Robot and Human Interactive Communication, 2001. Proceedings. 10th IEEE International Workshop on*, pages 122 –127, 2001.

[9] Ann Hutchinson Guest. *Labanotation: the system of analyzing and recording movement*. Routledge, 2013.