

DEVELOPMENT OF MULTIMEDIA TEACHING MATERIAL FOR LABANOTATION

by

Minako Nakamura & Kozaburo Hachimura

0. Abstract

By using a motion capture system we can measure and record human body motion of intangible cultural properties like ballet, dance or other performing arts. Because the measurement accuracy of the system is high, volume of the data is usually very large. Compact and abstracted description of the motion is also required. We developed a method to generate coded description from motion-captured data. Labanotation score is produced from the coded description, and it can be readily used in choreography and dance education. This compact coded description of the motion may also be used as an index for motion-captured data stored in the database.

1. Introduction

Today, motion capture systems have been used for measuring human body motion in the fields of CG-animation and movie production[1]. The system can also be applied to recording and archiving intangible cultural properties like dance and other performing arts. We can obtain accurate 3-dimensional position data of human body motion. Because volume of the data is very large, a compact coded description is also required from the viewpoint of both data compression and an intelligent coding for the data transmission. This paper describes a method to generate coded data which corresponds to Labanotation from those obtained by motion capture systems, and to develop multimedia teaching materials for Labanotation.

Computer technology has been introduced for preparing and editing Labanotation score for some time. One of the oldest ones is in [2]. Today, the software LabanWriter[3] has been widely used by dance performers and researchers, and LED[4] has also been developed and used in Unix environment. We have also developed a Labanotation editor named Laban Editor[5], which will be described later in this paper, and it was proved useful for choreography and dance education[6].

2. Generating LND from Motion Data

2.1 Labanotation and LND

We have developed an internal coded representation LND (LabaNotation Data), which was designed with reference to the structure of Labanotation. Figure 1 shows the format of LND representation. Lines followed by # are for specifying fundamental parameters of

Labanotation, and lines followed by // are comments. The directional motion of a body part is specified by a line followed by a command *direction*, which corresponds to the Labanotation direction symbol. The body part is specified in the second field, which is followed by the fields about direction, level, time of start and end of the movement.

2.2 The Outline of Generating LND from Motion Data

The overall processing steps of generating LND from motion data are as follows.

- Step1: Extraction of motion segments
- Step2: Quantization of motion direction
- Step3: Generation of tentative LND
- Step4: Integration of LND
- Step5: Quantization of duration

Here, we use the structure of the body as shown in Figure 2.

The motion corresponding to each column of the Labanotation is decided based on the combination of a *parent joint* and a *child joint*. A parent joint is a proximal joint which is considered to be a reference point for the movement of a distal child joint. For instance, when we focus on Right Arm (r arm) column of the Labanotation, RShoulder and RWrist would be a parent joint and a child joint respectively. Position of each child joint is represented in reference to the corresponding parent joint.

2.3 Extraction of motion segments

The motion data of an object joint is divided into several segments. This is done by extracting periods, in which the body part does not move. Namely, the period in which the magnitude of the speed of a joint is lower than a small threshold value is detected and taken as a resting period.

By eliminating the resting periods from the motion data we can segment motion data into several sections which are in motion. Each section extracted this way is called a *motion segment*.

An example of the result of extracting motion segments from the motion data of Right Arm is shown in Figure 3. In the figure a graph of magnitude of speed is presented, and the start and the end of segments are indicated by dots. In this case the threshold for magnitude of speed is set to 10mm/frame.

2.4 Generation of LND

In each motion segment a joint will exhibit various motions. The motion of a joint in a motion segment is next detected by analyzing the change of orientation of the joint, and is

represented by LND convention. The process consists of two steps: quantization of motion direction and detection of achievement points of the motion.

2.4.1 Quantization of the motion direction

In Labanotation, the horizontal direction of movement is represented by 9 orientations (including *place*) and vertical directions by 3 orientations. Therefore, we divide the space into 27 3-dimensional sectors placing the parent joint at the origin of the space, and decide the sector where the child joint exists. Thus the direction of the child joint is represented by 27 quantized orientations. This process is called a quantization of motion direction.

As shown in Figure 4(a), if the horizontal distance between a parent joint and a child joint is below a threshold value, child joint is said to be in place. Otherwise, the horizontal direction of a child joint is quantized into 8 directions as shown in Figure 4(b). The direction of vertical motion is quantized into 3 directions i.e., *high middle* and *low* according to the position of a child joint in reference to the parent joint.

2.4.2 Detection of points of achievement for the motion

Because the quantization of the direction of a child joint is carried out in each frame independently, a sequence of one direction would last as long as the joint exists in the corresponding sector. We call a sequence of frame data in the same direction a *run* (Figure 5).

The size, i.e., length, of Labanotation symbol written in the staff is determined by the duration of the motion. The symbol may be placed in the corresponding column of the staff, the start of the symbol being aligned to the start of a run. However, the end of the run does not necessarily correspond to the end of a symbol. We have to determine the appropriate frame corresponding to the achievement of the motion in each run.

We define a *key orientation* for each Labanotation symbol, and when the direction of the child joint approaches the key orientation in the run we think that the motion has been achieved at this point. Namely, as shown in Figure 5 we extract a frame in which the direction of child joint approaches most closely to the key orientation. We decide that this frame corresponds to the end of the Labanotation symbol.

2.5 Integration of LND

By the process described in the previous section, every motion segment is represented by its successive LND lines and consequently a series of many small Labanotation symbols will be produced. The LND expression determined so far is tentative and a part of it may be redundant. Therefore, we check this tentative LND in accordance with the customary convention of Labanotation.

A tentative LND will be converted into well-formed LND by applying rewriting rules, i.e. rules for deleting and unifying LND lines. Figure 6 shows an example of rewriting rules. Namely, a file of tentative LND is scanned, and if the sequence of LND lines like Figure6 is found, then the tentative LND lines corresponding to the lines preceded with a character "D "in the rule will be deleted.

By the process described above, the LND units which are found to be redundant are deleted and merged into their neighboring units as shown in Figure6. This process is repeated until the lines of LND that meet the conditions given in the rewriting rules are exhausted.

2.6 Quantization of duration

In the final step, the duration of each LND generated by the processing is adjusted. An unit of time in LND is defined as time between bars divided by an appropriate positive integer. Thus, the duration of the symbol is adjusted so as to become the multiple of the unit time. This process is called a *quantization of duration*

3. Applications for Teaching Labanotation

3.1 Laban Editor

The LND obtained can be displayed and printed as a Labanotation score by the system called LabanEditor, which has been developed by the author 's group [5]. Figure 7 shows a screen image of the LabanEditor. When LND is read in, the corresponding

Labanotation is displayed. The LabanEditor is able not only to edit, display and print Labanotation scores, but also to output a VRML-based .le corresponding to the LND. We can reproduce the motion of human body by a 3D CG model on Web browsers by using a VRML plug-in and a Java applet program which has been developed to control the display of the motion.

As was previously mentioned, several Labanotation graphical editors have been developed so far [2,3,4]. However, the advantages of our LabanEditor to these predecessors are as follows: It is portable because it has been developed as a Java application program, and it is able to display the motion in 3D on the Web browsers by using a VRML plug-in and a Java applet program.

3.2 Multimedia Teaching Tool for Dance and Labanotation

We have also developed the multimedia tool for preparing teaching materials for dance education based on the motion capture data. The nature of dance or human movement is three-dimensional. Labanotation, which analyzes the human movement to the temporal and spatial elements, is abstraction of the human movement. Learning Labanotation cultivates not only an ability of decomposition of the movement through writing but also an ability

of reconstruction of it through reading notation. Training these abilities is important for dance education.

Figure 8 shows an example of screen display. The tool displays motion data by a 3D stick figure CG model. It also displays the MPEG video which was taken while motion capturing. Labanotation score representing dancer's movements is also displayed, which is produced from LND data. They can be displayed synchronously, a linear moving cursor being displayed on the Labanotation score. This tool makes it possible for learners to understand interactively both deconstruction and reconstruction of the movement.

4. SMIL and its application to Choreography and Dance education

SMIL (Synchronized Multimedia Integration Language) is a mark-up language developed by W3C and integrates multimedia objects and synchronizes these objects. Using SMIL, Labanotation, VRML based CG animation, and Video can be integrated and synchronized. In this integration a dance is divided into motives. Each motif of Labanotation, VRML, and Video are synchronized. A motif is an atomic unit of synchronization.

It is necessary in dance education to understand human movements in each body part and reproduce them rather than to see dance itself. The movement of each body part emphasized by CG animation plays an important part in dance education, because it is a more abstract expression of dance than the videotaped images are. Moreover, Labanotation, the most abstract expression of dance, gives students a deeper understanding of dance.

This study is to integrate and synchronize these three different media and make it possible to reproduce these media at the same time or in order. In the process of teaching dance, Labanotation can be a tool for the teaching of the concept of choreography or a work and analysis of dance (grammar of dance movement). The addition of the video and 3D animation makes the teaching easier and more precise.

Figure 9 is the SMIL sample document. Like HTML, SMIL document consists of HEAD and BODY elements. META elements describe meta information like author or title. LAYOUT element defines regions of each media to present on the screen. BODY element defines time line of presentation including sequential and parallel presentation of the media objects. Figure 10 is the sample of integrating the Video of Japanese folk dance and its Labanotation score.

In the existing conditions, however, the SMIL approach can't be put to practical use immediately, but this could be placed as the fundamental study in the domain of the dance study, in which we are sure to make positive use of the motion capture system.

5. Conclusions

Labanotation is not well known to Japanese dance educators; only a few can teach it. If the motion capturing data can be converted into those of the LabanEditor, that will make the automatic notation of physical movement possible and it will also become the efficient way to teach Labanotation.

We were able to convert successfully the body motion data into Labanotation-based coded representation. Up to now, however, the method takes into account only the horizontal and vertical motion of a child joint. We are now trying to handle twisting motion about proximal joint.

We are now making multimedia-teaching materials of dance based on an arranged curriculum. In the near future we will be able to use them in dance classes and check them up.

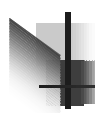
Acknowledgments: The authors are very grateful to Mr. Toshiro Matsumoto for his effort devoted in the development of the system. This research was partially supported by the Grant-in-Aid for University and Society Collaboration from the Ministry of Education, Science, Sports and Culture and the grant from Matsushita Audio Visual Education Foundation.

REFERENCES

- [1] R.Maiocchi; 3D character animation using motion capture, in Interactive Computer Animation, N.M. Tahlmann and D. Tahlmann eds, PrenticeHall, pp. 10-39,1996
- [2] M.D. Brown and S.W. Smoliar; A Graphics Editor for Labanotation, Computer Graphics, Vol.10, No. 2, pp. 60-65,1976
- [3] <http://dance.ohio-state.edu/research/LabanWriter>
- [4] F. Edward, Hunt, G. Politis and D. Herbison Evans; The design of LED: An X-Windows Mini-Editor for Labanotation, <http://linus.socs.uts.edu.au/~don/led/led.design.html>
- [5] Y. Yoshida, Y. Matsuoka and K. Hachimura; Processing of Human Body Movement based on Labanotation -LabanReader and LabanEditor-, IPSJ SIG-CH, Vol.98, No.51, pp.61-68, 1998 (in Japanese)
- [6] M. Nakamura and K. Hachimura; Labanotation and New Technology: Application of Hypermedia to Choreography and Dance Education, Proc. WorldDance2000, pp.131-135, 2000

ILLUSTRATIONS

Figure 1



LND

```

//Notated by T.Matsumoto
#speed 80
#rhythm 4/4
#unit_per_line 5
#unit_total 10

#unit 0
direction l_support place mid
direction r_support palce mid
direction l_arm left mid
direction r_arm right mid
space l_arm small 1
space r_arm small 1

#unit1
direction r_support forward mid 0.0 1.0
direction l_support forward mid 1.0 2.0
direction r_support forward mid 2.0 3.0
hold r_support 3.0 4.0

#unit2
direction l_support forward mid 0.0 1.0
direction r_support forward mid 1.0 2.0
direction l_support forward mid 2.0 3.0
hold l_support 3.0 4.0
                    
```

Figure 2

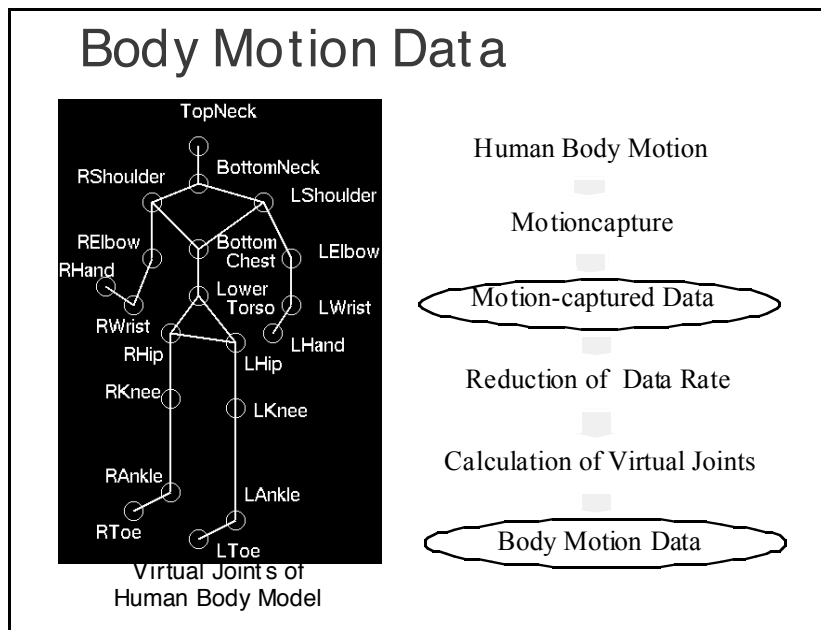


Figure 3

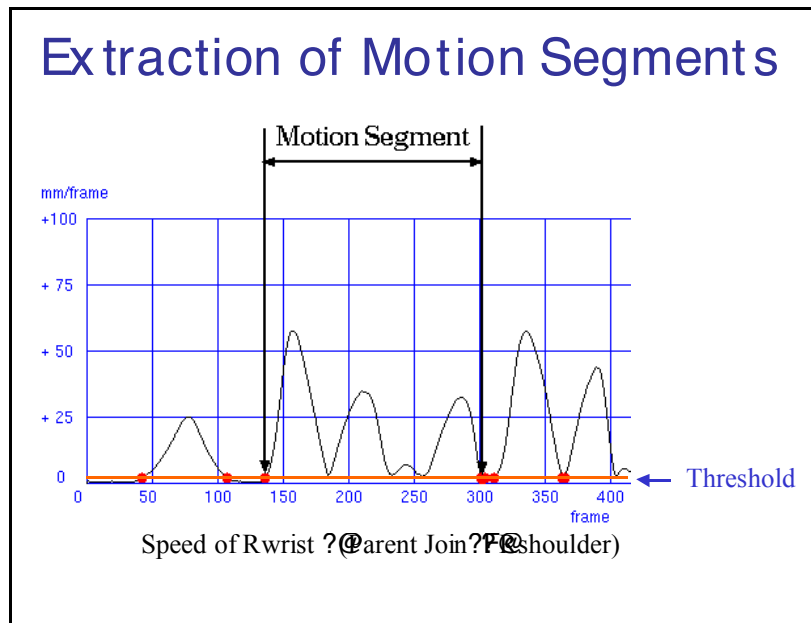


Figure 4

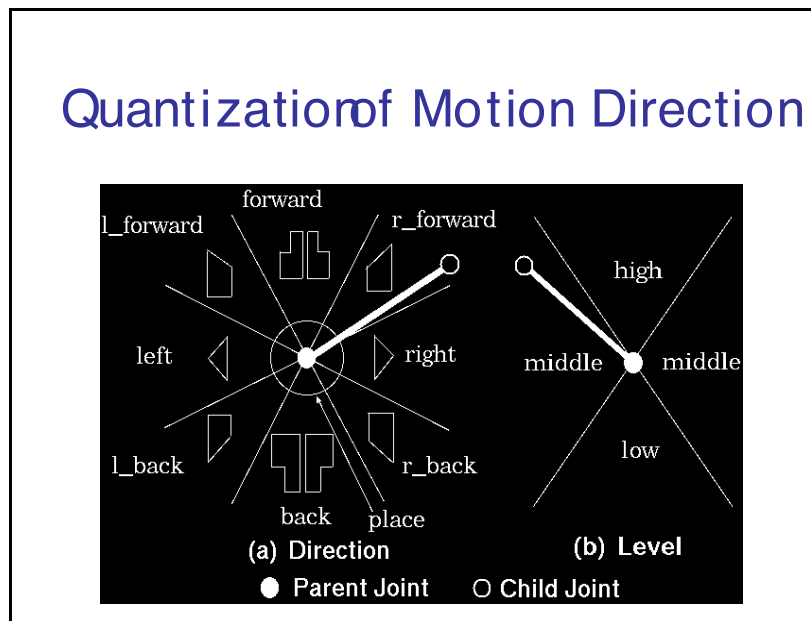


Figure 5

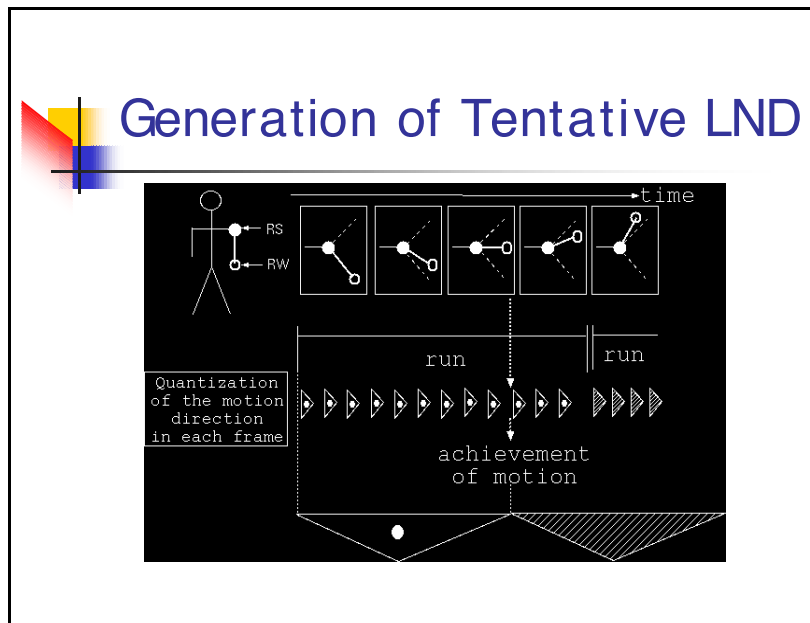


Figure 6

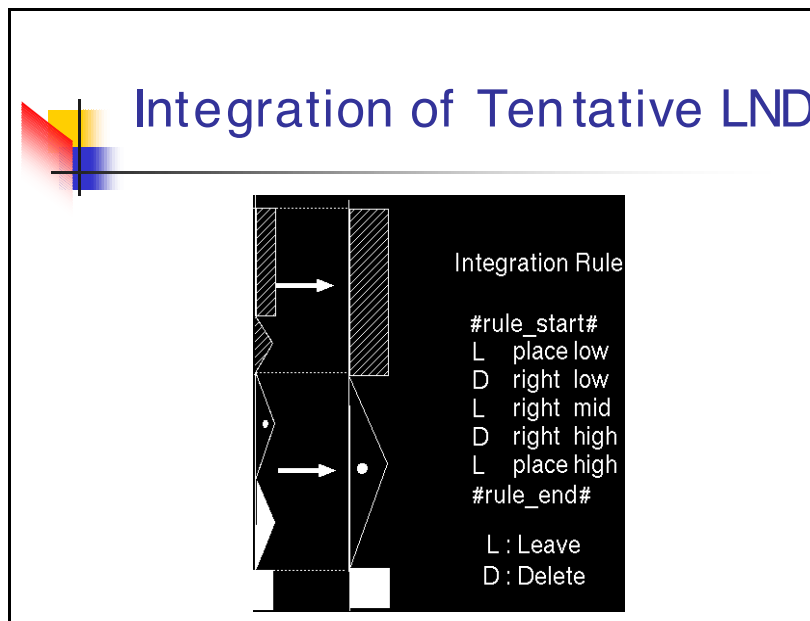


Figure 7

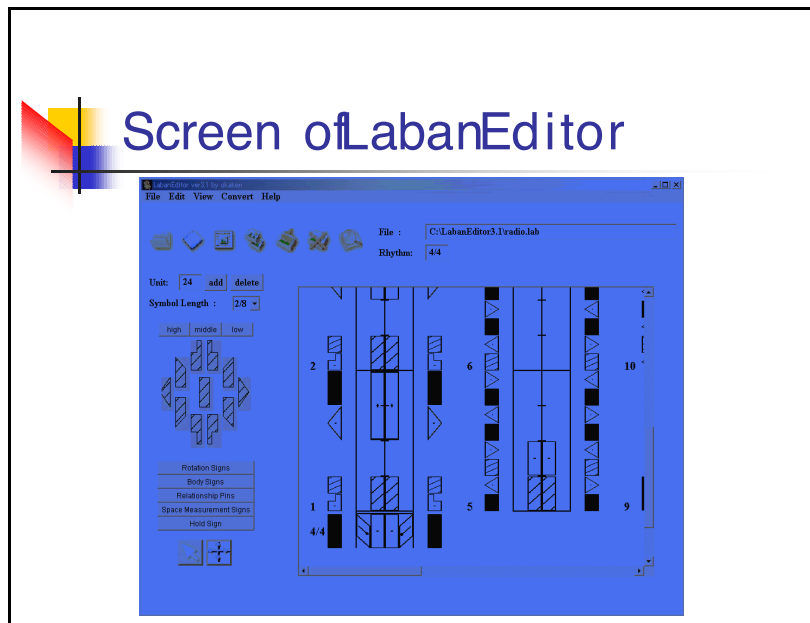


Figure 8

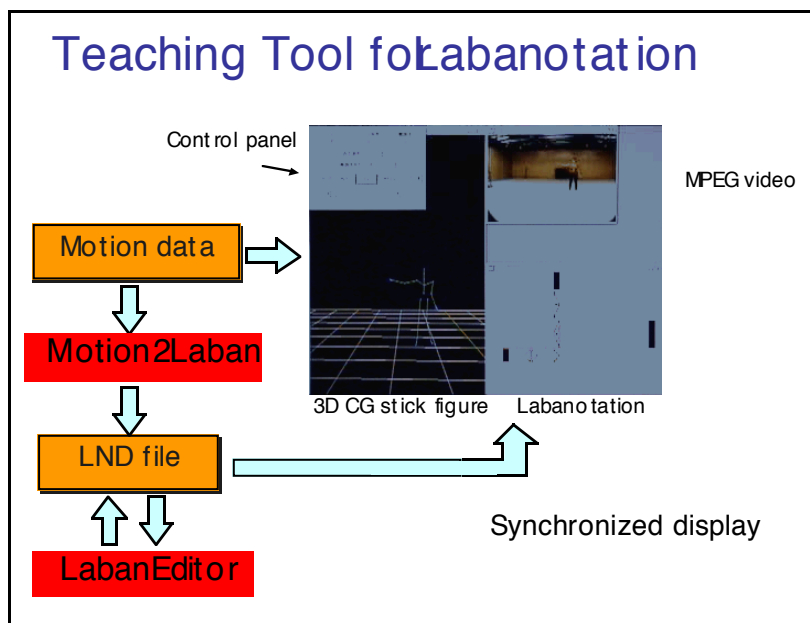



Figure 9



SMIL document sample

```
<smil>
  <head>
    <meta name="author" content="Minako Makamura"/>
    <meta name="title" content="Laban and dance"/>
    <layout>
      <root-layout height="240" width="705"/>
      <region id="takatsuzu_Region" left="0" top="0"
        height="240" width="352" z-index="0"/>
      <region id="notation_Region" left="0" top="0" height="240" width="352"
        z-index="0"/>
      <region id="takatsuzul_Region" left="353" top="0" height="240"
        width="352" z-index="0"/>
    </layout>
  </head>
  <body>
    <seq>
      <video id="takatsuzu" src="media/takatsuzu.rm"
        region="takatsuzu_Region" system-bitrate="307200"/>
      <par>
        <video id="notation" src="media/notation.rm" region="notation_Region"
          system-bitrate="307200"/>
        <video id="takatsuzul" src="media/takatsuzu.rm"
          region="takatsuzul_Region" system-bitrate="307200"/>
      </par>
    </seq>
  </body>
</smil>
```

Figure 10

