Multi-Level Segmentation of Dance Motion by Piecewise Regression

Takeshi Miura† Kazutaka Mitobe† Takaaki Kaiga†† Takashi Yukawa‡ Toshiyuki Taniguchi† Hideo Tamamoto† Noboru Yoshimura†
†Akita University ††Warabi-za Co., Ltd. ‡North Asia University

1. Introduction

It has been recognized that a technique to divide a raw motion-capture data stream of a dance into segments on the time axis is needed [Sonoda 2008]. In particular, the extraction of the higher-level information such as the hierarchical segmentation-structure is a subject of growing interest at the present time. In this study, the authors attempt to develop a method to segment dance motion in a multi-level style, namely in a hierarchical fashion.

2. Multi-Level Segmentation of Dance Motion

A human-body model with skeletal structure is used in this study. Body motions are described using the exponential maps of the joint angles. The components of the exponential map correspond to the respective joint movements as shown in Figure 1.

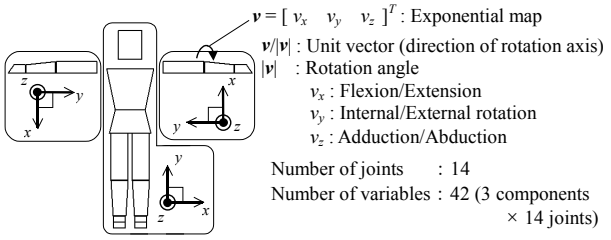

Figure 1: Model of a human body.

There are two types of levels in the segmentation of dance motion: the physical level and the semantic level [Sonoda 2008]. On the physical level, moments at each of which the change of the aspect of movement occurs are selected as the division points. Such moments can be extracted by searching the local-minimum /maximum points in the time-series data of the exponential map as shown in Figure 2.

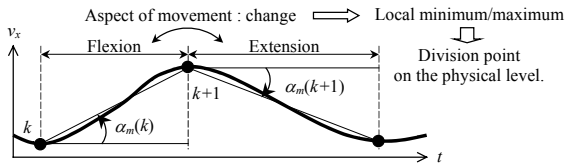

Figure 2: Change of the aspect of movement.

It is well known that searching the local-minimum/maximum points by detecting the sign change of the differential coefficient of raw time-series data is too sensitive to small fluctuations. The technique of piecewise linear regression [McGee 1970] is used to guarantee the robustness against the fluctuations; the influence of them is absorbed in the regression process. The number of division points is determined by maximizing the following formula:

$$V_1 = \frac{1}{K-1}\sum_{k=1}^{K-1}\sum_{m=1}^{42} |\,\alpha_m(k+1) - \alpha_m(k)\,| \qquad (1)$$

where $\alpha_m(k)$ is the slope for the mth variable at the kth division point, derived as shown in Figure 2, and K is the number of division points (the first frame is added), respectively. The parameter adjustment frequently required in the extraction of the local minimum/maximum is not needed in the above procedure.

†miura@ipc.akita-u.ac.jp, ††kaiga@warabi.or.jp, ‡yukawa@nau.ac.jp

The stillness of the body is evaluated in the semantic-level segmentation since the completion of each motion in a dance is recognized by the stillness [Preston 1963]. The physical-level division points each of which gives the local minimum of the following formula are selected as those on the first semantic level:

$$s(k) = \sum_{m=1}^{42} |\,\alpha_m(k-1)\,| \qquad (2)$$

Division points on the higher semantic levels are selected in the same way, namely by extracting the local minimums at each level.

3. Result

Figure 3 shows an example of the multi-level segmentation of dance motion. The motion-data stream was acquired in the performance of the Japanese folk dance *Ondo* of *Nishimonai Bon Odori* by a motion capture system with magnetic sensors.

The obtained physical level consists of 35 segments. At the first semantic level, most of the division points agree with those in Ref. [Shigeizumi 1981] which shows the division of the whole motion of *Ondo* into the unit gestures. The structure of the second semantic level indicates the relationship between the motion and the musical accompaniment [NFDFJ 2007].

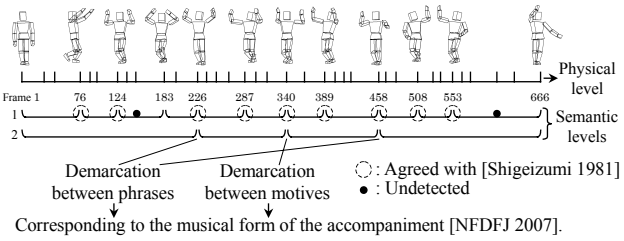

Figure 3: Multi-level segmentation (Japanese folk dance *Nishimonai Bon Odori*, *Ondo*).

4. Conclusion

The above result shows that the present method is effective in the multi-level segmentation. It should also be noted that the present method is applicable to any dance without adjustment.

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