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A choreographic authoring system for character dance animation reflecting a user's preference

- Supplemental Materials -

Ryo Kakitsuka[†1] , Kosetsu Tsukuda[2], Satoru Fukayama[2], Naoya Iwamoto[1], Masataka Goto[‡2] and Shigeo Morishima[§3]

[1]Waseda University, Japan [2]AIST, Japan [3]Waseda Research Institute for Science and Engineering, Japan

1. A Choreographic Authoring System

Fig.1 shows the overview of the system. First, the user assigns a preferred motion to any part in the music (Fig.1, ①). Dance motions that correspond to other parts in the music are synthesized automatically so that dance motions are connected naturally (Fig.1, ②). Secondly, the user selects parts he/she want to fix or change in a sequence of dance (Fig.1, ③). The part the user wants to change replaces for other motion preferred by the user from motion database (Fig.1, ④). Dance motions that correspond to other parts in the music are updated automatically again (Fig.1, ⑤). Finally, a new sequence of dance considering the user's preference is composed by repeating the steps.
In this paper, we focus on two issues: (1) how can we enable a user to easily search for his/her favorite motion? and (2) how can we automatically synthesize a sequence of dance? Our approaches to these problems are described below. Motion segments in the database are provided by segmenting existing dance motions into every 4 counts.

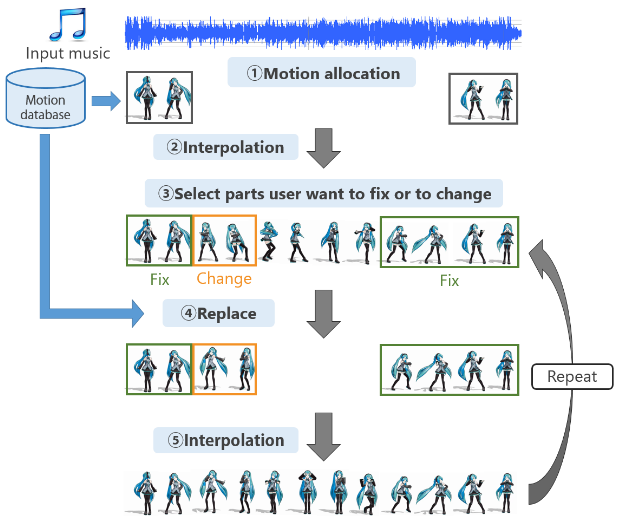

Figure 1: *Overview of the System*

1.1. Dance Search System

It is difficult to judge whether a dance motion is good or not without previewing a dance motion in conjunction with a corresponding musical piece for most users. In our system, the user can see sequence candidates on a screen and simply choose the preferred one (Fig.2). The user can also re-retrieve motion data using relevance feedback proposed by [Roc71]. During early phases of feedback, our system expands the variety of candidates. It gradually converges as the number of re-retrieval increases. We utilize the diversification framework proposed by [DHC*11] to select candidates in simultaneous consideration of a candidate's relevance to corresponding music part and to motions already selected. The $n+1$-th motion segment is given by

$$m_{n+1} = \underset{m \in R \setminus S_n}{\operatorname{argmax}} \{\rho \cdot rel(q,m) + (1-\rho) \cdot \Phi(m, S_n, L_l)\}. \quad (1)$$

ρ is the parameter that controls the tradeoff between $rel(q,m)$ and $\Phi(m,S_n,L_l)$. $rel(q,m)$ represents the relation between the candidate motion segment m and the corresponding music part q. We use RMS mean of each musical bar as the music feature and use motion intensity (defined by Eq.2) mean of each motion segment as the motion feature. We define the motion intensity W as the linear sum of approximated instantaneous speed calculated from the position of the joints:

$$W(f) = \sum_i \alpha_i \cdot \|\dot{x}_i\| \quad (2)$$

where α_i is a regularization parameter for the i-th joint. These regularization parameters depend on which parts we recognize as important for dance expression. $\Phi(m,S_n,L_l)$ controls the variety of candidates. We define $\Phi(m,S_n,L_l)$ as follows:

$$\begin{aligned}\Phi(m,S_n,L_l) =& \tau \cdot \min\{D(m,m_i)|m_i \in S_n\} \\ &+ (1-\tau) \cdot \max\{Sim(m,m_j)|m_j \in L_l\}\end{aligned} \quad (3)$$

where S_n is the set of motion segments already posted by the system and L_l is the set of motion segments the user liked. $D(m,m_i)$ and $Sim(m,m_i)$ represent the dissimilarity and the similarity be-

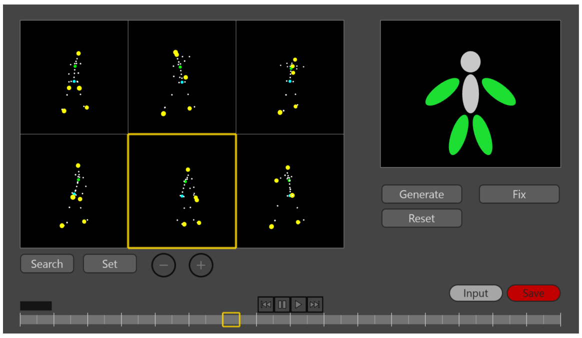

Figure 2: *Example of interactive sequence selection. Six different image sequence candidates are previewed and the lower-center candidate is chosen by a user.*

tween m and m_i, respectively. $D(m, m_i)$ and $Sim(m, m_i)$ are calculated by using the method proposed by [WLP*14]. As the number of re-retrieval is increased, τ is decreased. Thereby, the variety of candidates is contracted.

1.2. Automatic Synthesis of a Dance Sequence

Our system automatically synthesizes a sequence of dance matched to input music, with the constraint condition that the motions selected by the user are fixed. Therefor, the user can focus on the parts that the user has a strong preference for in the input music.
First, our system assigns motions from motion database to other parts considering connectivity of motion segments and acquires the best matched motion segment sequence. The rhythm of candidate dance motion segments is synchronized to that of input music by resizing of motion segments. Evaluation function S_{seg} analyzes connectivity of motion segments. The motion segment sequence that minimizes the sum of S_{seg}^{-1} is obtained by using Dijkstra's algorithm (Fig.3).
In the evaluation function S_{seg}, we utilize the connectivity analysis of motion segments proposed by [SNI06]. We consider both the posture similarity S_{pose} and movement similarity S_{move}. Posture similarity S_{pose} between the i^A-th frame of the motion segment A and the j^B-th frame of the motion segment B is defined as the angular similarity of the link direction vectors:

$$S_{pose}(i^A, j^B) = \sum_l \beta_l (h(v_l(i^A)) \cdot h(v_l(j^B))) \tag{4}$$

where β_l is a regularization factor for the l-th link. Through h, an input vector a is converted to the unit vector $a/|a|$. Movement similarity S_{move} is calculated as follows:

$$\begin{aligned} S_{move}(i^A, j^B) = \sum_l \beta_l \cdot g[h(v_l(j^B) - v_l(i^A)) \cdot h(\dot{v}_l(i^A))] \\ \cdot g[h(v_l(j^B) - v_l(i^A)) \cdot h(\dot{v}_l(j^B))] \end{aligned} \tag{5}$$

where $g[x] = x$ if $x > 0$, and $g[x] = 0$ otherwise. Here $\dot{v}$ is calculated from the candidate motion segment. Thus, connectivity of motion segments S_{seg} is given by $S_{seg} = S_{pose} + S_{move}$.
Finally, the resulting motion sequence is acquired by connecting the motion segment sequence using cubic interpolation.

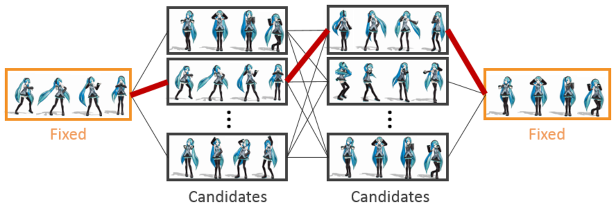

Figure 3: *Automatic Synthesis of a Dance Sequence*

2. Result and Conclusion

We defined the diversity of candidates as the mean of the dissimilarities between each pair of six sequence candedates $(\frac{1}{15}\sum_{i=1}^{5}\sum_{j=i+1}^{6} D(m_i, m_j))$. Fig.4 presents the relationship between the diversity of candidates and the number of feedback. As expected, the variety of candidates gradually converges as the number of feedback iteration is increased. However, the diversity of candidates starts increasing after the number of feedback is 3. This is because the motion segments selected previously as sequence candidates are neglected. The resulting dance animation by using our system is in the supplemental movie. It was found from the result that our system can automatically synthesize a sequence of dance by analyzing the connectivity of the motion segments. We can create a new dance performance for character animation considering a user's preference by this system. As for future works, a closer evaluation of usability of our system is necessary for our purpose.

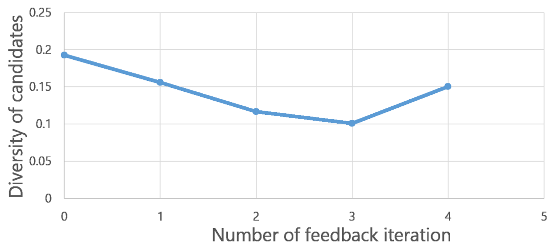

Figure 4: *Diversity of the candidates*

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References

[DHC*11] Dou Z., Hu S., Chen K., Song R., Wen J.-R.: Multi-dimensional search result diversification. In *Proc. of WSDM* (2011), ACM, pp. 475–484. 1

[Roc71] Rocchio J. J.: Relevance feedback in information retrieval. 1

[SNI06] Shiratori T., Nakazawa A., Ikeuchi K.: Dancing-to-music character animation. In *Computer Graphics Forum* (2006), vol. 25, Wiley Online Library, pp. 449–458. 2

[WLP*14] Wang P., Lau R. W., Pan Z., Wang J., Song H.: An eigen-based motion retrieval method for real-time animation. *Computers & Graphics 38* (2014), pp. 255–267. 2