Synchronized Partial-body Motion Graphs

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Abstract

Motion graphs are regarded as a promising technique for interactive applications. However, the graphs are generated based on the distance metric of whole body, which produce a limit set of possible transitions. In this paper, we present an automatic method to construct a new data structure that specifies transitions and correlations between partial-body motions, called Synchronized Partial-body Motion Graphs (SPbMGs). We exploit the similarity between lower-body motions to create synchronization conditions with upper-body motions. Under these conditions, we generate all possible transitions between partial-body motions. The proposed graph representation not only maximizes the reusability of motion data, but also increases the connectivity of motion graphs while retaining the quality of motion.

1 Introduction

Standard motion graphs (SMGs) are generated based on distance matrix that defines the similarity between two motions [Lee et al. 2002; Kovar et al. 2002]. Recently, Zhao and Safonova [2008] interpolated several motions to find extra transitions in-between motions, named well-connected motion graphs (WcMGs). Their results showed that the WcMGs generated smoother transitions than the SMGs. Wang and Bodenheimer [2008] studied the optimal length for a transition between motions. However, all of the above works compare motions in whole body sense, which neglect the local comparison of partial motions. For example, when we compare two motions that have similar lower body motions but dissimilar upper body motions, possible transitions are not obvious (see Figure 1(a) and Figure 1(d)).

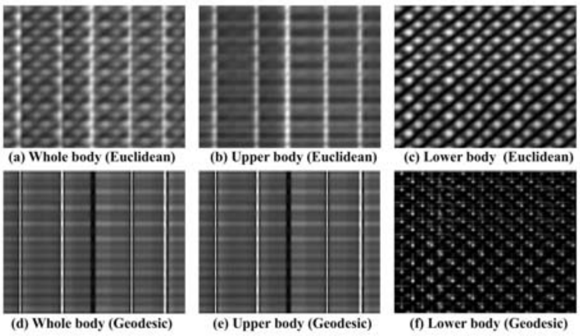

Figure 1: Comparisons of six different distance matrices between a walking motion (vertical) and a walking motion with five punches (horizontal). The darker value corresponds to a higher similarity and the brighter value represents a lower similarity. (a)-(c) Correspond to distance matrices in considering whole body, upper body and lower body using Euclidean distance. (d)-(f) Correspond to distance matrices in considering whole body, upper body and lower body using Geodesic distance.

Previous partial-body motion synthesis approaches [Heck et al. 2006; Jang et al. 2008] focus on synthesizing different parts of body motions, however; we lack a data structure to represent the transitions and the correlations between the partial-body motions.

In this paper, we present an automatic method to construct a rich connectivity motion graph by synchronizing and concatenating partial-body motions. We first adopt the method from Heck et al. [2006] to split the human figure into two parts. Then we attempt to compare the partial motions individually. Our results show that the transitions between lower body motions are significantly increased with a lower user-specified threshold under both of the distance metrics (Euclidean and Geodesic) as shown in Figure 1. By this observation, we can construct a motion graph which describes how the partial-body motions are transited and synchronized. We discuss the method of generating the graph in details next section.

2 Synchronized Partial-body Motion Graphs

Our new data structure defines two categories of edges that connect partial-body motion clips, *Transition edges* and *Synchronization edges*. Transition edges are the connection between two partial bodies of the same type. When the partial bodies are not in the same type, transition is not allowed. Synchronization edges are the linkage between two partial bodies of the different types. When the partial bodies are in the same type, the edges will not exist. By using these two types of edges, we connect the partial-body motions to create SPbMGs.

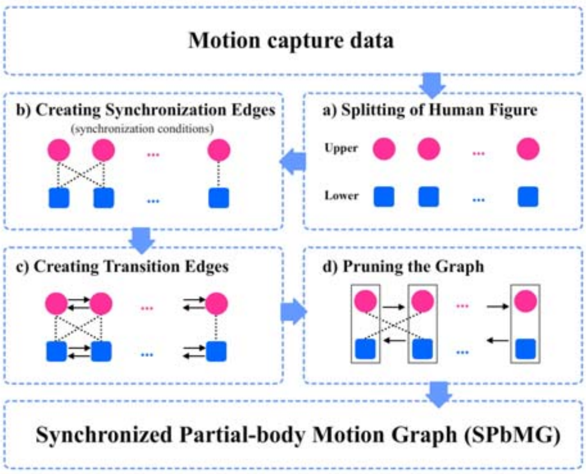

Figure 2: Overview of generating SPbMG. The circle in the figure denotes the upper body motion clip, and the square represents the lower body motion clip.

Figure 2 shows an overview of our approach. We first split the motion capture data into two categories: upper body motions and lower body motions. Then, we create the synchronization edges to correlate two partial bodies. We define that any two upper body motions can be *swapped* when their corresponding lower body motions are sufficient similar under the temporal and spatial

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conditions. The temporal condition is to check whether dynamic time warping (DTW) curve exists or not; the spatial condition is to find the synthesized orientation such that the distance between two lower-body motions is minimized. [Heck et al. 2006]. After we have a set of synchronized partial-body motions, we find all possible transitions based on the similarity of motions by computing the distance matrix. Finally, all transitions in the motion graph are evaluated for validity, and those invalid ones are removed. We define a valid transition as follows: A transition exists between two partial-body motions if and only if the current synchronized partial-body motion has a transition to the next partial-body motion that synchronizes with the target transition partial-body motion.

3 Experiment Results

We examine the extent to which the SPbMGs are capable of generating transitions with a lower threshold than SMGs. All the motion examples were measured on a 2.4GHz Intel Xeon(R) computer with 3 GB main memory and a Quadro FX 1800 graphics accelerator. We analyze two set of motion data which are captured by our motion capture system sampled at 60Hz. The first set of motion data is a walking motion with two punches of 5 seconds and a normal walking motion of 5 seconds. The second set of motion is a walking motion with five punches of 15 seconds and a normal walking motion of 15 seconds.

To analyze the connectivity of the graphs, we use the approach similar to that Zhao and Safonova [2008] that measures the size of the Strongly Connected Component (SCC) with respect to the size of the original motion data set. By using SCC, we can analyze how well the nodes are connected with each other in the graphs. We compare our proposed graph structure with SMG. Figure 3 shows the transition coverage for both SPbMG and SMG at various threshold values. For SPbMG, we compute the average number of transitions of upper body and lower body. The value in each cell in the table is normalized from zero to one. When the value is closer to one, it has a richer connectivity at the specified threshold value. The results show that SPbMGs produce richer transitions at lower threshold than SMGs in both set of motion data. SPbMGs have over than 90% transitions when the threshold value is about 1.4, while SMGs have more than 90% transitions when the threshold value is about 2.4.

Motion dataset A			Motion dataset B		
Threshold	**SPbMG**	**SMG**	**Threshold**	**SPbMG**	**SMG**
0.2	0.17	0	0.2	0.16	0
0.5	0.34	0	0.5	0.36	0
1	0.64	0.1	1	0.71	0.16
1.5	**0.92**	0.51	1.5	**0.95**	0.62
2	0.95	0.77	2	0.96	0.83
3	0.99	**0.94**	3	0.99	**0.96**
5	1	1	5	1	1

Figure 3: The comparison of transition coverage of SPbMG and SMG. The bold value in the cell represents the transition coverage is just over than 90% under the specified threshold.

To demonstrate the applicability of SPbMG, we create several animation examples for visually evaluation. The result shows that SPbMG has a faster transition than SMG. The examples are shown in the accompany video.

4 Discussion

In this paper, we introduced an automatic method to construct a motion graph that represents all possible transitions and correlations between two partial-body motions, named Synchronized Partial-body Motion Graph (SPbMG). The representation of SPbMG increases the reusability of motion data to create a long stream of motion for interactive applications.

Since our graph structures are relied on the motion data to construct, we do not guarantee the synthesized partial-body motions are physically correct. We suggest employing the center of mass (CoM) of human to validate the balance of the synthesized motion such as in [Jang et al. 2008]. Another limitation is that the data requirements for constructing a SPbMG are unknown. Thus, one of the potential future works is to remove the redundant motion data to construct a minimum size motion graph [Zhao et al. 2009].

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