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Shape Interpolation via Multiple Curves

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Abstract

We present a method that interpolates new shapes between a given pair of source and target shapes. To this end, we utilize a database of related shapes that is used to replace the direct transition from the source to the target by a composition of small transitions. This so-called data-driven interpolation scheme proved useful as long as the database is sufficiently large. We advance this idea one step further by processing the database shapes part by part, which in turn enables realistic interpolations with relatively small databases. We obtain promising preliminary results and point out potential improvements that we intend to address in our future work.

1. Introduction

Interpolating new content between the given source and target content is a fundamental problem in both computer graphics and computer vision with a myriad of applications. The content in our context is the set of 3D shapes discretized in the form of mesh structures with vertices, edges, and faces. In this domain, we can consider key frame animation and mesh generation as two samples from a large range of applications.

The traditional way of attacking this problem is to interpolate each corresponding vertex pair through the connecting line or another primitive [Ale02], or corresponding triangle pair in an as rigid as possible way [ACOL00, HAWG08]. In an effort to reduce artifacts such as volume loss and self-intersection, a different line of works replaces the absolute geometric coordinates with differential [Ale03] and rotation-invariant [LSLCO05] coordinates.

A more stable and natural solution to the 3D shape interpolation problem brings in the idea of using more shapes from the family of the input shape pair. These shapes are supposed to act as helper intermediate nodes that connect the source shape to the target shape. In scenarios where the source is extrinsically quite different from the semantically similar target, e.g., two different poses of the same actor, it makes a lot of sense to hop through the extrinscally similar intermediates instead of performing one big jump. To formalize this thought which first appeared in [SRIC01] as example-based interpolation, Gao et al. [GLHH13] build a complete graph with shapes as graph nodes and dissimilarity amounts as graph edge weights. They then perform a shortest path search on this graph which effectively lists the desired intermediate shapes. They improve on the results by updating their interpolation scheme between the consecutive intermediate shapes [GCLX16]. Regardless of the path creation and the consecutive interpolation methods, this line of work requires a significantly large database to be able to find convenient intermediates for a plausible end result. Note that, such path-based data-driven methods are adapted to other computer graphics problems as well [NBCW*11, SY14].

2. Method

The main idea of our method is to exploit the given database as much as possible, hence small-size database would not be a problem for us and large-size database would provide more opportunities for an even more realistic interpolation. Our method is based on the following observation: two shapes that are not globally similar can still provide similar rigid parts. Hence, with a significantly less number of database shapes, we can perform realistic shape interpolation as long as the part-by-part interpolation over different paths are merged in a consistent manner.

We propose a parametric curve framework based on multiple Bézier curves for the consistent merging of the parts. The idea is to unify multiple part interpolations over different intermediate shape paths through the same time parameter. To make this work, each path of intermediate shapes is represented as a Bézier curve and the same time parameter controls the movement over each curve. Hence, at time, for instance, 0.5, we get the halfway positions of all different parts which brings consistency. In order to merge these different parts of the same time, we merely fix one reference part and move the others to their corresponding positions.

Prior to the merging step, we create the shortest paths of intermediate shapes for each part, which requires the quantification of the dissimilarities between each shape part. To this effect, we add up the Euclidean distances between the corresponding vertices. This simple similarity measure works as long as the shapes are in the correct orientation, which we assume. Another assumption of this work is the predefined one-to-one correspondences, which could be

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automated [KLF11, SY13]. We finally note that the simple and fast linear interpolation is performed between the consecutive intermediate shapes suggested by the Dijkstra's shortest path algorithm on our weighted complete graph.

3. Results and Discussion

We obtain the preliminary results of our method on the *Dancer* database that is a set of 27 reconstructed poses of a dancing human actress [VBMP08]. We demonstrate two promising results in Figure 1, each in comparison with the basic linear interpolation between the source and the target shape. The volume loss artifact observed in the arms of our competition is not observed in our results. The timing of our method demands 229 milliseconds (ms) of one-time preprocessing for the weighting of all edges. Recall that we have 7 parts and 27 models. We can then respond to each query in 90 ms of path computation time followed by 16 ms of Bézier-based interpolation time. We prefer not to segment *Dancer* limbs further as they move without bending throughout the database. The manual segmentation shown in the top of Figure 1 is propagated instantly to the entire database using the available one-to-one correspondences of the fixed-connectivity models.

Our preliminary results verify that the proposed part-based data-driven shape interpolation framework is promising and its simplicity enables simpler future work extensions. There is, however, still plenty of room for improvement on the current short work. In particular, we will address the following issues in our extension work: improvements on the graph creation and path creation processes as well as on the merging process. We will also perform a thorough evaluation by utilizing more databases and competitor methods.

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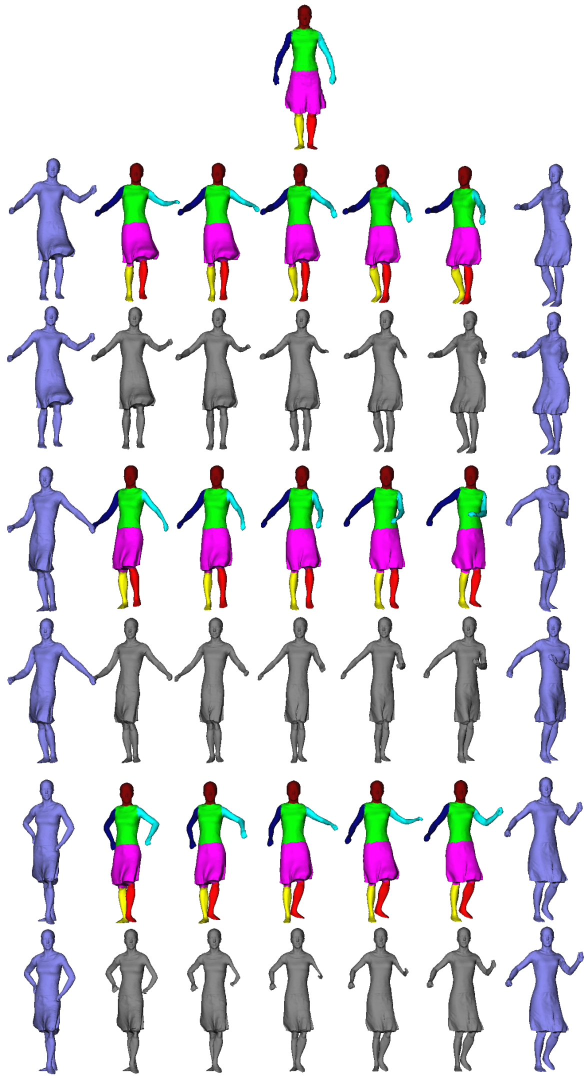

Figure 1: *Representative model of the* Dancer *with its parts highlighted (row 1). Our results (rows 2, 4, and 6) in comparison with the corresponding linear interpolation results (rows 3, 5 and 7).*

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