Boneless motion reconstruction

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1 Introduction

With the improvement and declining costs of motion capture (Mocap) technology, modern computer graphics increasingly uses it as a major source of data for character animation. Mocap data provides trajectories for character animation by tracing the motion of a set of markers on moving subjects. Standard techniques for motion data reconstruction from such data require global knowledge of the model structure, such as a skeleton. Skeletons are difficult and quite time consuming to construct. We introduce the first, to our knowledge, automated technique that can realistically reconstruct character animation based on Mocap data alone (Figure 1(b)).

2 Algorithm

Given a mesh model and Mocap data, the sole input required from the user is a correspondence between markers in the Mocap data and vertices on the model (Figure 1(a)). The correspondence provides the positions for a subset of the model's vertices for each frame in the animation sequence. Our goal is to find the positions for the remaining vertices in a manner that best preserves the shape of the source model. Model editing addresses a similar problem where the surface of the model is modified in response to some control mechanism, preserving the shape of the surface as much as possible. Recent methods for model editing, e.g. [Yu et al. 2004], require both the positions of the control vertices and their orientations, which are not available in the Mocap data. We introduce a new method for motion reconstruction using an editing approach that does not require orientation information. Given the positions defined by the Mocap data for a subset of vertices we use a new local shape representation to compute the positions for the remaining vertices. Our geometry representation stores the position of each vertex, with respect to its neighbors in the mesh, using a local projection plane, similar to [Sheffer and Kraevoy 2004].

Given a mesh with vertices V and edges E the projection plane corresponding to the mesh vertex $v_i \in V$ is defined in terms of a normal n_i and an offset d_i from the origin. We define a projection plane normal as

$$n_i = \sum_{k=1}^{m} (v_{j_{k+1}} - l) \times (v_{j_k} - l) / \| \sum_{k=1}^{m} (v_{j_{k+1}} - l) \times (v_{j_k} - l) \| \quad (1)$$

where $v_{j_1}, \ldots, v_{j_m}$ are the neighbor vertices of v_i, and $l = \frac{1}{m} \sum_{(i,j)\in E} v_j$. In other words, we use an area averaged normal to a local Laplacian mesh as the normal of the projection plane. This enables us to achieve much better results in terms of stability and shape preservation compared to [Sheffer and Kraevoy 2004], where the normal estimate was based on the current position of v_i. The local representation of each vertex with respect to its neighbors consists of: a set of mean-value coordinates w_{ij}, describing the vertex position in the projection plane relative to its neighbors; and, an offset h_i, describing the vertex offset above the projection plane. Unlike [Sheffer and Kraevoy 2004], we use a normal formulation based solely on the neighbor vertex positions v_j. Therefore, we are able to obtain an explicit formula for reconstructing v_i

$$v_i = F_i(V) = \sum_{(i,j)\in E} w_{ij}(v_j - (d_i + v_j \cdot n_i)n_i) + h_i n_i, \quad (2)$$

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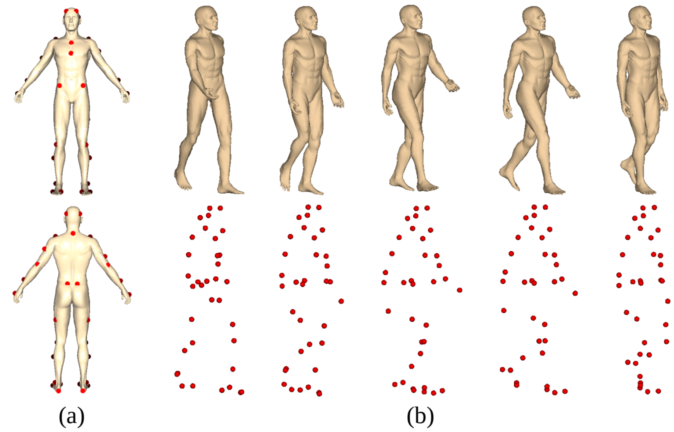

Figure 1: Reconstruction of fully realistic complex motion from Mocap data. (a) Marker placement on the surface of the model. (b) (top) Animation sequence. (bottom) Original Mocap data.

which leads to a closed form global reconstruction formulation

$$\arg\min_V G(V) = \frac{1}{2} \sum_{v_i \in V} (v_i - F_i(V))^2. \quad (3)$$

We solve this minimization problem using the Gauss-Newton method. To enable near real time performance, we incorporate a multiresolution structure into the reconstruction procedure, interleaving it with the numerical minimization. This approach makes the shape representation computation slightly more time consuming, but dramatically speeds up the reconstruction. The reconstruction takes less than a second for models of up to 100K faces. In case of Mocap data reconstruction the representation computation can be done once as a pre-processing step, while reconstruction is performed repeatedly. Therefore, the hierarchical approach is very suitable for our scenario.

3 Conclusion

We introduce a new, robust method for motion reconstruction from Mocap data based on a novel shape representation. Our representation captures the local shape properties of the model and is invariant under rigid transformations, allowing parts of the model to be bent or rotate during animation. In contrast to standard methods for motion reconstruction our technique does not require any additional global knowledge of the model structure such as skeleton. Given the input, our technique provides an effective tool for Mocap data reconstruction (Figure 1(b)).

References

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