Flexible Point Handles Metaphor for Character Deformation

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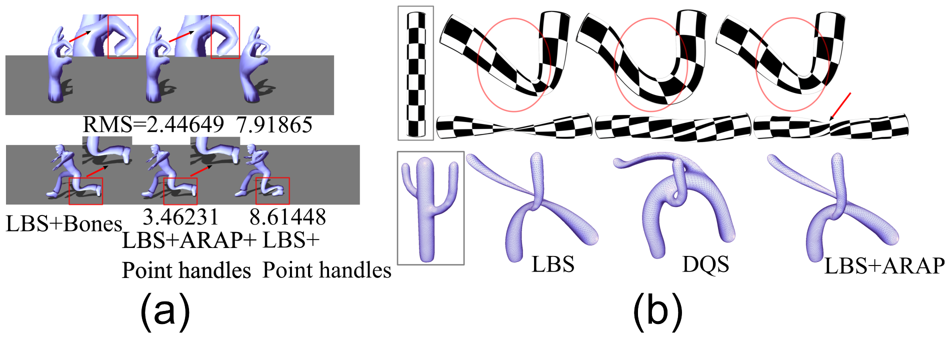

Figure 1: *(a) Our scheme is able to produce rigid bending. (b) Shape details are better preserved by our scheme w.r.t. LBS and DQS, thereby resulting in more natural poses.*

Abstract

Skinning using point handles has experimentally shown its effectiveness for stretching, twisting, and supple deformations [Jacobson et al. 2011] which are difficult to achieve using rigid bones. However, point handles are much less effective for limbs bending since their influence weights vary over the skin mesh. This poster presents an efficient scheme, which expands the space of deformations possible to the point handles by supporting rigid bending using a rigidity energy minimization framework. Thus, 3D points that are much easier to design while provide larger space of deformations than a skeleton can be used as alternative handles in character skinning.

CR Categories: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation;

Keywords: energy minimization, character skinning, point handles

1 Point handles metaphor

Given a model consisting of H point handles, a skin mesh S containing N vertices $\{v_1, ..., v_N\}$ and M triangles $\{t_1, ..., t_M\}$ at rest pose, each vertex v_i is bound to the handles by influence weights expressed as a vector $\mathbf{w}_i = (w_{i,1}, ..., w_{i,H})$. Given the transformations of point handles $(C_1^f, ..., C_H^f)$ at frame f, optimal deformation is computed by solving the minimization problem

$$\min \quad E_s(S^{'}) = \sum_{i=1}^{N} \sum_{j \in \mathcal{N}_1(v_i)} \omega_{i,j} \parallel (v_i^{'} - v_j^{'}) - R_i(v_i - v_j) \parallel^2$$

$$\text{s.t.} \quad v_k^{'} = v_k \sum_{j=1}^{H} w_{k,j} C_j^f, \quad k \in \mathcal{H},$$

where $\mathcal{H}$ is the set of indices of the proximal vertices, $\omega_{i,j}$ are per-edge cotangent weights between v_i, and each one-ring neighbor $v_j \in \mathcal{N}_1(v_i)$. R_i of vertex v_i is derived from the singular value decomposition (SVD) of the covariance matrix $S_i = \sum_{j \in \mathcal{N}_1(v_i)} (\omega_{i,j} e_{ij} e_{ij}^{'T}) = U_i \sum_i V_i^T$, and $R_i = V_i U_i^T$, where $e_{ij} = v_i - v_j$ and $e_{ij}^{'}$ is the edge after reconstruction. The minimization is achieved using the same solution explained in [Sorkine and Alexa 2007].

Results An error metric w.r.t. the ground truth (skeletal deformations) is formulated for quantitative evaluations. The lower the computed value is, the more rigidly the limbs are bent. The metric is calculated as

$$E_{RMS} = \frac{\sum_{f=1}^{F} \sum_{i=1}^{N} \parallel bv_i^f - pv_i^f \parallel^2}{\sqrt{3NF}},$$

where F denotes the number of frames, bv^f and pv^f are deformed vertices at frame f resulting from a method with bone weights and point weights, respectively. Our scheme is tested on a human model mainly consisting of rigid bending deformations, and the results shown in Fig. 1(a) demonstrate the outperformance. Closed-form blending techniques, such as Linear Blend Skinning (LBS) and Dual Quaternion Skinning (DQS), do not support shape-reserving property, but our scheme better maintains the shape locality, see Fig. 1(b).

References

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