Data Driven Cloth Animation (sap_0169)

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Figure 1: Frames of cloth animation: coarse motion is controlled by skeletal motion capture while fine-scale kinematics are synthesized using data from high-resolution cloth capture.

Introduction We present a new method for cloth animation based on data driven synthesis. In contrast to approaches that focus on physical simulation, we animate cloth by manipulating short sequences of existing cloth animation. While our source of data is cloth animation captured using video cameras ([White et al. 2007]), the method is equally applicable to simulation data. The approach has benefits in both cases: current cloth capture is limited because small tweaks to the data require filming an entirely new sequence. Likewise, simulation suffers from long computation times and complications such as tangling. In this sketch we create new animations by fitting cloth animation to human motion capture data, i.e., we drive the cloth with a skeleton.

Deforming the Cloth A basic operation in our method is coarse-scale deformation of a cloth mesh from the database to match a specified skeletal pose. Our underlying surface representation is the *deformation gradient* [Sumner and Popović 2004], which represents the rotation, scale, and skew components of the affine map between two triangles. In our framework, we always compute deformation gradients with respect to a rest pose. To reconstruct the cloth in a new position, we specify the positions of a small number of vertices (namely, those corresponding to joints in the skeleton) and then reconstruct the mesh from the deformation gradients. The advantage to this approach is that joint locations in the reconstruction are guaranteed to match the skeleton exactly. However, deformation gradients are not rotationally invariant and artifacts are visible when there are large rotations in the deformation.

Matching Cost When we deform motion from our cloth database to match skeletal animation, we must be careful of two things: (1) we don't want the deformation to be too large (to avoid extrapolation error) and (2) we don't want to destroy the realistic motion of the original cloth data. We therefore define a matching cost that is the sum of two terms: the l_2 distance between the joints in the skeletons and the l_2 distance between the joint velocities, computed in the reference frame of the parent limb.

Finding a Sequence Our animation is constructed from a (deformed) series of short segments of cloth motion from the database. We find the optimal set of sequences using dynamic programming. Our trellis has two costs: a unary cost between a frame of human motion capture and the cloth database, and a binary *transition* cost between frames of the database. Our state space is the size of the cloth database and both costs are computed using the matching cost described above. To encourage longer sequences, we force a zero transition cost between subsequent frames in the database and add a penalty to all other transitions. To encourage time alignment we use a smaller transition penalty for transitions that drop or duplicate a frame.

The result of dynamic programming is a path through the database, where blocks of the path are roughly contiguous blocks from the database. In practice, these blocks are typically about 20 frames long (in 24 fps data).

Resampling in Time Because our dynamic programming scheme allows frames to be duplicated or skipped, we need to resample the cloth meshes in time to produce smooth animations. Resampling consists of two steps: first, we temporally smooth the database frame indices defining our path, resulting in fractional indices. Second, we sample the database at these fractional values by interpolating between adjacent frames. Interpolation is performed by linearly interpolating the skeleton and then averaging the deformation gradients with appropriate weights.

Smoothing Transitions The cloth reconstructions produced in the previous step have obvious jumps between disjoint sequences. We smooth between sequences over a 5 frame window by averaging deformation gradients. This final step has the potential to smooth out fine details, but we have seen little evidence of this in practice.

Results and Conclusion We use a database of roughly 1500 frames of captured cloth pants to animate cloth on two different sequences of human motion capture data. Our cloth database lacks any walking motion, and as a result we see minor artifacts when producing walking and running motions. However, animation is realistic for other motions and (more importantly) kinematics are transferred appropriately at the fine scale. We believe that data-driven synthesis is a valuable tool for cloth animation – especially in dynamic contexts such as video games where extensive simulation may not be possible.

References

SUMNER, R., AND POPOVIĆ, J. 2004. Deformation transfer for triangle meshes. In *SIGGRAPH*.

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