Simplicial Interpolation for Animating the Hulk

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Figure 1: The Hulk in The Avengers. We used simplicial interpolation to improve animation quality.

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1. Introduction

Animating skin deformation of a character is a non-trivial task. Especially when the character is a very muscular and almost naked like the Hulk. To obtain realistic deformations, the bone structure, muscle, fat and skin layers need to be taken into account. Therefore animators often rely on multiple techniques to achieve satisfactory results. Enveloping, or skinning is a still very popular approach. Each point on the skin is deformed according to the joints that influence it. The Pose Space Deformer (PSD) [Lewis et al. 2000] was introduced to address some of the limitations of enveloping, such as lack of collapsing joints. The modeler can sculpt the desired deformation for some key poses. Each sculpted pose become a data point in a high dimensional space, defined by the degrees of freedom of the rig. Poses not corrected by the modeler are interpolated using Scattered Data Interpolation (SDI) technique. Lewis et. al. use Radial Basis Function (RBF) as the SDI method and emphasize the importance of smoothness in choosing this method.

A limitation of RBF, as a smooth SDI method is that the interpolating function tends to overshoot and ripple when interpolating data points. In PSD context, this artifact generates temporal pop artifacts as the character transitions from one pose to another. RBF is also becoming less numerically stable, as the number of interpolating points increases, and it either has global support or it is not guaranteed to interpolate the data points.
We rely on an existing blendshape system to model the skin's deformations. We use SDI to compute the weights fed into the blend shape system for a given pose. Our method has the following benefits: a) it does not introduce local extrema, overshoots or ripples; b) it has natural local support; c) efficient run-time and d) the method is conceptually simple to understand and predict its results by non-technical artists. In order to achieve these results we use an SDI method called Simplicial Interpolation.

2. Simplicial interpolation for animation

We front-load the modeling effort by correcting calisthenic poses, not tight to a particular animation sequence. This approach gives the animator a better preview of the final shape and results with fewer per frame corrections. For each calisthenic pose the modeler corrects the skin shape formation. Each sculpted pose is mapped to a point in high-dimensional space. The coordinates are determined by the joint angles at that pose. We only use the modified axes of each joint. In the resulting d-dimensional space, we construct a set of d-simplices (d+1 points each) using Delaunay algorithm implemented in qdelaunay [Barber et al. 1996]. In 2D this amounts to triangulating the input points. Typically each region such as hand, knees or shoulders has its own calisthenic session and an independent simplex structure. These structures are created during the modeling phase and are not modified during animation.
When the animator animates the rig and changes the joint values, it provides the current pose. The system then finds the simplex in which that pose resides. Next the system computes the barycentric coordinates to find the weights of each precomputed shape defining this simplex. These weights are fed into the blendshape animation system and are used to mix the sculpted shapes. Our system successfully handles cases such as extrapolation, fewer than d + 1 sculpted poses and degenerate simplices.

Discussion : The presented method transitions between poses in a predictable way, without popping. Hence improving the preview of the final shape for the animators and reducing the amount of per-frame corrections from the modelers. The method scales well with the number of poses. The main limitation is scalability with number of degrees of freedom (DOF). As the number of DOFs grows, the number of simplices substantially increases, making both pre-processing and animation more expensive. Still we used it with up to six DOFs per region and found it to be very beneficial for animating the Hulk.

References

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