Shape Analysis Driven Surface Correction

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Abstract

In this paper, we describe a technique called Shape Analysis Driven Surface Correction that introduces a new generalized way of storing and restituting surface corrections and automate their blending by using live surface shape analysis combined with Radial Basis Function (RBF) based interpolators.

1 Introduction

Animation of creature skin deformation is the most common and important application of free form deformation in computer graphics. Pose Space Deformation systems improve final deformations on mesh envelopes using interpolated blendshapes driven by input measurement used to compute the suitable blend factor. Weighting and balancing of these blend factors is commonly solved by scattered data interpolation algorithms.

These systems commonly require a heavy setup, need artist unfriendly parametrization and expensive creation of several intermediate sculpted shapes.

We present a generalized and efficient surface correction system that improves the final quality of animated meshes, increases artist productivity, and avoids most pitfalls of the aforementioned techniques.

The main concepts used in our technology are:

• Surface corrections driven by live surface shape analysis combined with RBF interpolators
• Robust vertices 3D displacements computation and restitution using multiple laplacian smoothed local surface spaces

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2 Live surface shape analysis combined with RBF interpolation

Our system drives shape corrections using the animated shape itself.

We developed a surface shape comparison algorithm to compute the differential factor between a reference shape (the state of the surface without correction for which we have an edited correction registered) and the current state of this surface in a random animation pose.

When a shape is deformed during the animation, our system evaluates its similarity factor with each reference shape in the correction database.

The similarity factor is a translation and rotation invariant point cloud comparison using both distance and angular metrics.
As our surface correction system relies on additive 3D displace-
ments, the similarity factor cannot be directly used to weight the 
corrections, thus for each shape correction these similarity factors 
are used as inputs of a RBF interpolation solver.

The parametrization of each RBF interpolator uses the two by two 
cross similarity factor between the reference shapes of each correc-
tion.

3 Vertex 3D displacement in multiple 
smoothed local surface spaces

Considering a vertex $V$ from an original surface, and $V'$ the 
corresponding one after an artist correction, we compute a delta in 
worldspace. For each vertex $V_i$ connected to a vertex $V$ by the edge 
umbrella, we compute a set of matrices $M_i$ using the smoothed nor-
mal of $V$ and the edge vector $V_i-V$. The smoothed normal of the 
vertex $V$ is computed as usual, but after a global iterative laplacian 
smoothing of the deformed mesh. World space delta of $V$ is then 
transformed and stored for each connected tangent matrix $M_i$. This 
set of deltas $D_i$ is called the local 3D displacement of the vertex $V$.

$$\vec{D}_i = (\vec{V}' - \vec{V}) \cdot M_i^{-1} \quad (1)$$

Restitution of one vertex correction is achieved by the following 
equations:

$$\vec{R} = \sum_{i=0}^{n} (\vec{D}_i \cdot M_i \cdot \frac{1}{n}) \quad (2)$$

$$\vec{V} = \vec{V}' + \frac{\vec{R}}{\|\vec{R}\|} \cdot\|D_0\| \quad (3)$$

Using multiple 3D displacements per vertex avoids the arbitrary 
choice of a surface tangent space orientation, and production usage 
proved that it gives better and more reliable results for the resti-
tution of correction’s deltas, even with heavily deformed or noisy meshes.

4 Results

Our tool has been used in two animated features The Little Prince 
and Mune : The Guardian of the Moon. It offered an efficient and 
quick process to achieve shape driven surface correction for body 
and facial rigs with minimal setup. This system was additionnaly 
used by the FX department for fast and efficient post cloth simula-
tion shape corrections.

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