# Refining Deformations with Poly Translation Frames on SubD Affectors

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## Abstract

We introduce an improved method that aids in the refinement of deformations around areas where hard edges are preferred over softer deformation results. Using information from the limit and cage of a subd affector surface, our method preserves the desired hard edges from the underlying pose affector model and allows for smooth deformations of folds along the edge extremities. This type of refinement is desirable for deformation areas within facial rigs such as animation of brow furrows where deeper, harder edges are desired to emphasise the extremity of the expression. The method supplements existing Skeletal Subspace Deformation (SSD) methods and addresses SSD's collapsing edge artifact issue.

**CR Categories:** I.3.3 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation

**Keywords:** deformation, wrinkles, ssd, animation

## 1 Introduction

In rigging facial deformations, multiple techniques are used within the facial rigs to achieve the desired deformation. At the base level, control joints are bound to the desired vertices of the deformation mesh. The deformations are then generated using various Skeletal Subspace Deformation (SSD) techniques [Weber 2000] on these affector joints. Additional control methods such as additional vertex blending [Kavan and Žára 2000], pose space interpolation [Lewis et al. 2000] and the use of subsequent affector control meshes are often used during or after the initial deformation to further reduce artifacts and refine the results.

We concentrate on improving deformation refinement through mesh affectors. More specifically, we desire better results for facial expression nuances such as deep brow furrows, cheek creases from large grins etc. where harder edges around the crease regions may be more favorable.

First, we review the basic concept behind the SSD method for those unfamiliar with them.

SSD techniques bind each vertex on the deformation mesh onto some reference joint. For any given attachment, a current affector frame, $F$, is computed that determines the transformation of the corresponding attachment to its final deformed position. For each vertex, $v$, of the deformation mesh the deformed vertex $v'$ can be calculated from the following equation:

$$v' = FA^{-1}v \tag{1}$$

where $A^{-1}$ refers to the reference affector's local space transformation matrix. The final deformed position is simply a transformation into the reference affector's local space and then a transformation back into world space via the updated affector frame, $F$.

## 2 Using Local Offsets

Instead of directly transforming the bound vertex $v$ on the deform mesh to the affector's local space and then back again, we take a different approach.

In our implementation, an offset, $\vec{v}$, local to the frame at the bound point on the affector is derived at bind time. This offset is used in our final deformation calculations. During deformation time, we maintain $\vec{v}$ between the attached mesh vertices and its bound position on the corresponding reference affector.

The final deformed vertex, $v'$, can be trivially calculated through a single transformation of the current affector frame with the local offset vector, $\vec{v}$ :

$$v' = F\vec{v} + x \tag{2}$$

In the above equation, we have split the transformation into its rotational and translational components for clarity. The $x$ variable denotes the bound point affector and defines the translation of the affector's current bound location for the given deformed vertex $v'$.

## 3 Refinment Through Mesh Affectors

It is common for riggers to use polygonal mesh bindings as a post process to better refine deformations after initial deformation via joint manipulation.

Extending the basic SSD method, vertices on a mesh to be deformed are bound to the surface of a reference affector mesh (typically to the closest face or faces), rather than to an affector joint. The indirect manipulation of the corresponding affectors will further deform the meshes.

However, as with traditional SSD methods that use bindings to joints, bindings to polygonal faces can also suffer from the same crunching artifact around areas of extreme discontinuities. See Figure 1 (a). These crunching artifacts are usually alleviated or improved through careful choice of multiple weighted attachments per deformation vertex.

## 4 Deformations Through SubD Affectors

We present here a more elegant solution that improves deformation results and eliminates the need for vertex blending strategies via use of multiple weighted attachments per deformation vertex.

Instead of basic polygonal meshes, we encourage the use of subdivision (i.e. subD) surfaces as mesh affectors. With this approach,

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we take advantage of the refined mesh structure on the subD's limit surface to reduce possible crunching artifacts around problem areas. Each attachment point is on the closest mesh face on the affector's limit surface. The resulting affector frame, $F$, used for the final deformed vertex calculation thus comes from the corresponding face information from that attached point.

As shown in Figure 1 (b), the enhanced curvature information on the limit surface of a subD produces smooth deformation folds on the deformation mesh akin to the subD limit surface's curvature.

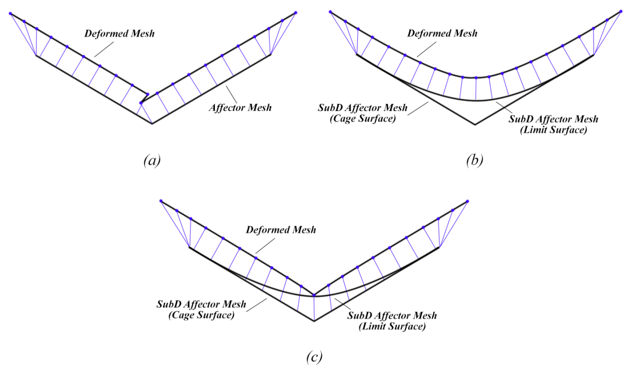


**Figure 1:** *Deformation results on different mesh bindings. (a) Crunching artifact from a direct binding to closest face on an affector mesh. (b) Using a subD affector and binding to its limit surface produces artifact free deformations. (c) Combination of using the affector frame at the limit surface and translational component on the cage surface produces artifact free hard edge deformations.*

## 5 SubD Poly Translation Frames

While the subD solution works well for alleviating the crunching problem, it is however not perfect. The resultant deformations produced by such an affector mesh can potentially be overly smooth. The result is the loss of essential hard edge information required around certain regions of interest. Further more, volume loss can also occur with subD affectors. A side effect of using the curvature information on the subD's limit surface.

To address the loss of volume and over smoothness issues, we introduce here, what we refer to as *"SubD Poly Translation Frames."* While the limit surface attachment can be too smooth and the cage attachment (which equates to attaching to a non subd surface) can be too course, *SubD Poly Translation Frames* give a middle ground solution that gives the best of both worlds.

*SubD Poly Translation Frames* separate the affector frame into 2 distinct components on different levels of the subD affector. The rotational property, $F$, of the affector frame is taken from the attached face on the subD limit surface. The translational component, $x$, of the frame however is placed on the subD's cage.

Applying to Equation 2, this mixed frame configuration allows for the smooth and flexible attachment placing of a subD surface without the resultant crunching artifact, while preserving volume and the hard edges present on the cage. See Figure 1 (c).

For vertex bindings we can now introduce frame type information on a per vertex attachment level. This gives us overall control on the resultant deformation around areas of interest. We may control how 'smooth' or how 'rough' a deformed area should be by defining which frame type should be used for the mesh vertex binding in question.

## 6 Conclusion

We have described a simple but yet robust solution to achieving smooth deformations of folds where the preservation of hard edges along the fold lines is desirable (e.g. deformation of intense brow furrows). Direct fine grain control of different mesh binding paradigms is achieved through the inclusion of frame types on a per vertex binding level.

To date, this method has been used on many facial rig setups in production characters with great success. Figure 2 illustrates a use example with the "Guy" character from the movie "The Croods". *Poly Translation Frames* were used around the jaw, cheek and lower neck regions of the character where stronger, more defined features were required.

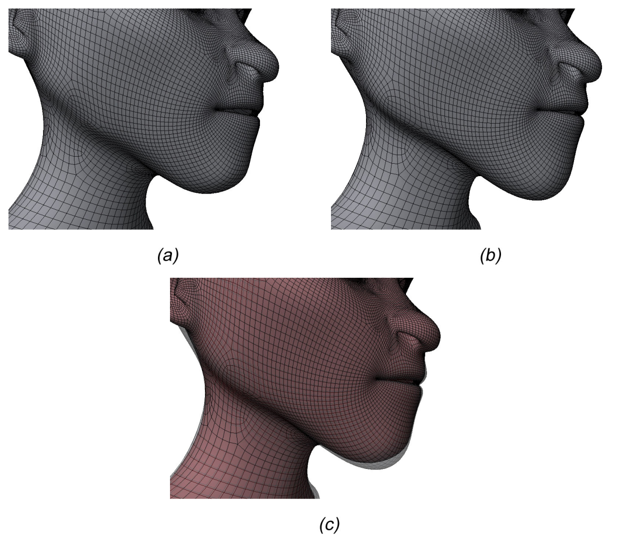


**Figure 2:** *Deformation refinement results on "Guy" character from the movie "The Croods" using Poly Translation Frames on subD mesh affectors. (a) SubD affector mesh used without Poly Translation Frames. Note the volume loss and softer areas around the jaw, cheek and lower neck regions. (b) Poly Translation Frames were applied around the jaw, cheek and lower neck regions. Note, how these areas are fuller, more defined looking. (c) Overlapped comparison.*

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