Practical Experiences with Pose Space Deformation

Gene S. Lee* Frank Hanner†
Walt Disney Animation Studios

1 Introduction

Pose Space Deformation (PSD) [Lewis et al. 2000] is a shape interpolation technique for animation. This method uses radial basis functions (RBFs) to perform per-vertex, multi-dimensional scattered-data interpolation. This formulation effectively interpolates a *driven* shape according to a set of *targets*, each at a particular *driver* value. In the case of correcting a pinched elbow, the skinned geometry is the driven, the targets are the sculpted adjustments, and the driver is the elbow joint. This paper presents some practical experience with PSD acquired while creating the film *BOLT*.

2 PSD Lessons

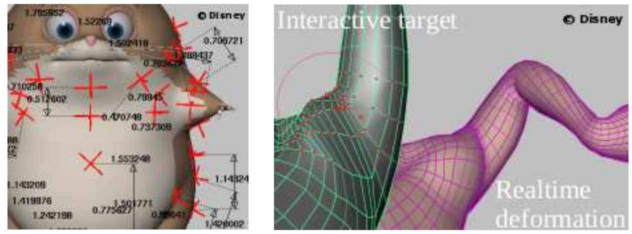
PSD proved an effective tool in *BOLT*'s modeling and animation pipeline. It supported a high level of art direction, and its use was varied to many domains, including cloth animation and facial rigging. Extensive experimentation and use resulted in the following practical lessons about PSD.

A. Non-conventional drivers and drivens work well also: PSD works well as a general interpolant — it is useful for interpolating many kinds of drivers and drivens. In *BOLT*, distance markers proved more effective than joints as drivers for deforming the shape of Rhino the hamster (see Figure 1a). In addition, UI manipulators served as drivers for facial animation. The values of the manipulators drove facial meta-controls, not the geometry directly.

B. Partitioning reduces complexity: Some deformations require intricate detail or high dimensional drivers. Handling these with a single PSD system is troublesome. The shoulder of a human, for instance, has a complex multidimensional configuration. Many targets are needed to properly cover the whole configuration space while deforming the shoulder aesthetically. A partitioning of a PSD system into several layers or parallel subsystems, each with its own drivers and drivens, can reduce complexity. For instance, one layer can be used to create broad modifications to a shape while the other adds refined detail. Or, one subsystem corrects the upper portion of a shape while the other corrects the lower. An added benefit to partitioning is that each layer and subsystem may be scaled and blended independently. The animators on *BOLT* often scaled subsystems for great effect.

C. Effective feedback reduces iterations: The work flow of PSD involves creating targets, setting RBF parameters, and tweaking the deformation until it is aesthetically pleasing. One way to tweak the deformation is to update the targets, either by replacement or modification. The latter approach can be performed interactively while the user scrubs corresponding drivers through the local region in pose space. By doing so, one receives immediate feedback while updating targets. In *BOLT*, precise deformations were achieved by simultaneously updating target shapes and scrubbing the rotation of joints (see Figure 1b).

*gene.s.lee@disneyanimation.com
†frank.hanner@disneyanimation.com



(a) *Distance Markers* (b) *Interactive Tweaking of Target*

Figure 1:

D. Alternative interpolants can be more effective: RBFs are a means to perform scattered-data interpolation, but not the only means. Hence, it is useful to augment PSD to apply other interpolants. For example, multidimensional linear interpolation, which strictly ramps from one value to the next, was used effectively on *BOLT*. This interpolant performed well on elbow and knees, and allows the user to clamp the last target pose such that it remains persistent at extreme joint rotations.

E. One coordinate frame is insufficient: PSD updates the value of a driven by either setting its absolute value or applying an offset to a base configuration. The latter approach is more efficient and the common practice when dealing with skeleton-driven characters. These kinds of offsets, which are geometric, must be defined with respect to a coordinate frame. With *BOLT*, numerous coordinate frames, such as ones based on skinning or vertex normals, were provided to enable PSD to work with many kinds of drivens, such as cloth or surfaces, derived from characters, that can not inherit pre-existing coordinate frames.

F. Users are capable of setting RBF parameters: Interpolation behavior with RBFs is not immediately intuitive, due to the highly mathematical nature of its parameters. To address this issue, one can either fix and hide parameter settings or educate users on the purpose and impact of each parameter. Experimentation with carefully crafted visualizations showed that the latter approach is feasible and useful. The visualizations offer users a greater understanding of how parameter settings effect PSD interpolation.

G. Supporting tools are critical: It takes time to apply PSD successfully, especially when applied to complex characters. For *BOLT*, it took approximately three weeks to apply PSD onto a major character. Therefore, numerous tools were developed to streamline the application of PSD to additional characters. These include tools to mirror or transfer targets, and those to replicate PSD with new drivers and drivens. When one character was complete, scripts simply used these tools to map deformations from one character to the next.

References

Lewis, J. P., Cordner, M., and Fong, N. 2000. Pose space deformation: A unified approach to shape interpolation and skeleton-driven deformation. In *Proceedings of ACM SIGGRAPH 2000*, ACM Press, ACM, 165–172.