2D and 3D Facial Correspondences via Photometric Alignment

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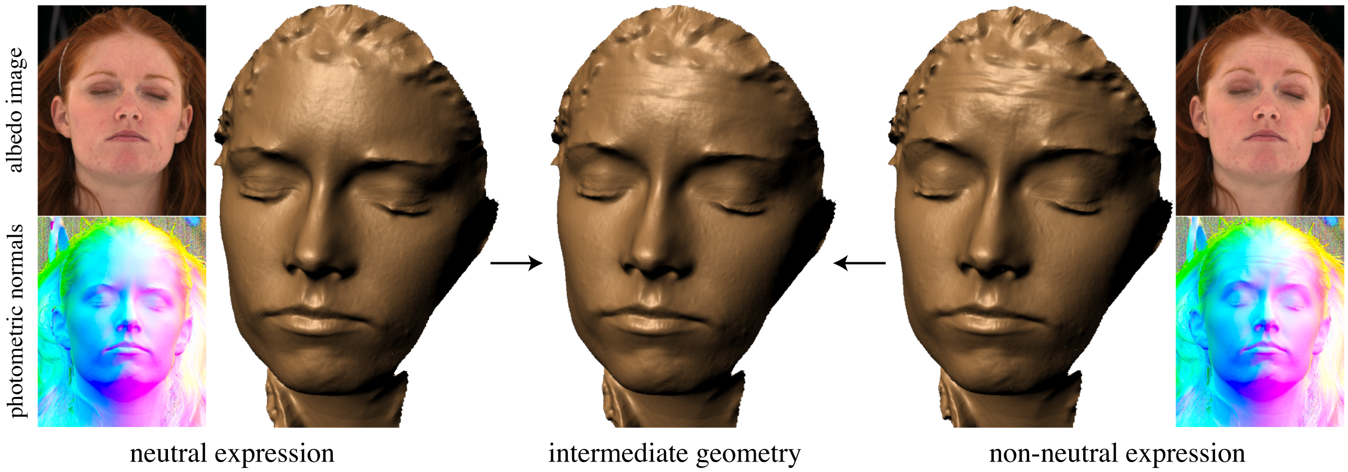

Figure 1: *Correspondences between 3D geometries: Facial expression geometries parameterized in a common 2D domain are blended to produce intermediate 3D geometries.*

1 Introduction

Capturing facial geometry that is high-resolution, yet easy to animate, remains a difficult challenge. While a single scanned geometry may be straightforward to animate smoothly, it may not always yield realistic fine scale detail when deformed into different facial expressions. Combining scans of multiple facial expressions, however, is only practical if geometrical correspondences between the different scanned expressions are available. Correspondences obtained based on locations of facial landmarks or of placed markers are often sparse, especially compared to fine-scale structures such as individual skin pores. The resulting misalignment of fine detail can introduce artifacts or blur out details we wish to preserve.

We obtain dense correspondences by computing optical flow on albedo images and photometric normal maps simultaneously, a process which we refer to here as "photometric alignment." We first compute 3D geometry for each facial expression by combining stereo correspondences with photometric normal information. We then compute short-range correspondences between a given expression and the neutral expression to produce a common UV parameterization for all expressions. This consistent parameterization enables blends between geometries which preserve fine detail while maintaining temporal coherence.

2 Method

Our setup consists of a sphere of LEDs and a stereo pair of cameras. For each facial expression we capture an albedo image as well as photographs under a set of spherical gradient illumination patterns, similar to those used by [Ma et al. 2007], for computing a photometric normal map. However, unlike [Ma et al. 2007] we do not use structured illumination patterns.

We compute coarse-scale 3D geometry using multi-view stereo. We perform optical flow measurement, constrained to epipolar lines, between the albedo images and normal maps of the two camera views. The disparity map obtained from the optical flow correspondences yields a coarse 3D geometry, on which we emboss photometric normals to produce high-resolution geometry. We represent this geometry as a 3D point cloud: a 3D coordinate for each 2D coordinate in the UV domain of the primary camera. This 2D to 3D map, together with the albedo and photometric normal map, share the same 2D UV parameterization.

We compute photometric alignment between a captured facial expression (albedo and photometric normals) and the captured neutral expression. We use the correspondences to warp the non-neutral maps in 2D to align with the neutral maps. This photometric alignment constitutes a reparameterization of the non-neutral geometry into the 2D UV domain of the neutral expression.

3 Results

The product of our method is a set of geometries—with associated albedos and normal maps—for which corresponding points on the 3D geometries of different facial expressions are located at a common 2D coordinate in the UV parameterization. This facilitates manipulations which combine information from multiple expressions, while coherently maintaining fine detail. Here we demonstrate such a manipulation: a morph between facial expressions by simply calculating a linear weighted blend of the 2D-parameterized geometries (Figure 1, Supplemental Video). In this case the blend weights are spatially uniform; but by introducing weight variation with location in the 2D domain, this becomes a starting point for more sophisticated blend shape applications.

References

MA, W.-C., HAWKINS, T., PEERS, P., CHABERT, C.-F., WEISS, M., AND DEBEVEC, P. 2007. Rapid acquisition of specular and diffuse normal maps from polarized spherical gradient illumination. In *Rendering Techniques*, 183–194.

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