

A High-Resolution Geometry Capture System for Facial Performance

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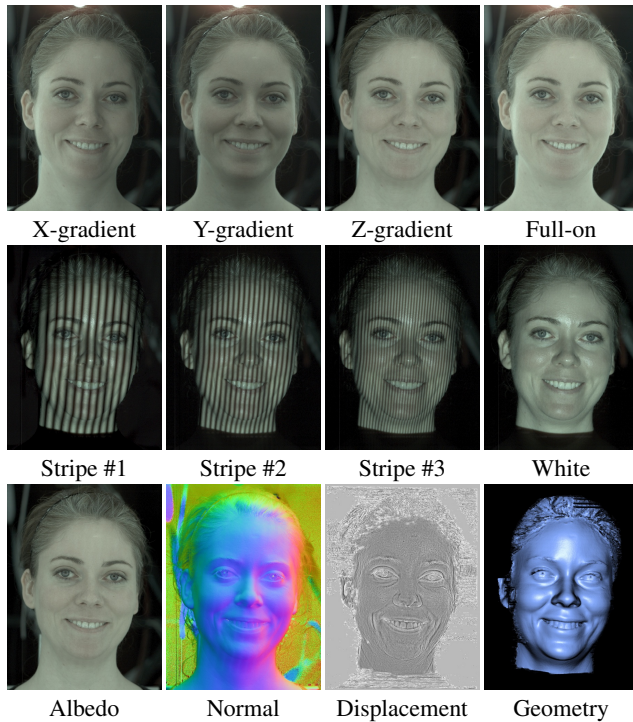


Figure 1: **Top**, images taken under spherical gradient illumination. **Middle**, A subset of the structured light pattern images of three different frequencies plus a full white pattern. The other three stripe patterns have the same frequencies but with a 90 degree phase shift. **Bottom**, Results for each scan: albedo texture, world-space normal map, displacement map, and a high-resolution mesh.

Introduction We developed a high-resolution, real-time facial performance capture system based on a spherical gradient photometric stereo technique [Ma et al. 2007] and multi-view stereo. We use four spherical gradient illumination patterns to estimate normal maps of subjects. A structured-light-assisted two-view stereo system is employed to acquire 3D positions of the subject. The captured stereo geometry is then enhanced using the gradient normals. This allows details such as dynamic wrinkles and fine-scale stretching and compression of skin pores to be captured in real-time.

Capture System Our real-time 3D capture system uses a combination of structured light and photometric stereo to obtain high-resolution face scans. The grayscale structured light patterns are output by a high-speed MULE (Multi Use Light Engine) DLP video projector from Fakespace Lab, running at 288 frames per second. To capture fine details of human skin, a stereo pair of Vision Research Phantom high-speed digital cameras synchronized to the projector and a similar spherical gradient illumination device as in [Ma et al. 2007] to capture 24 full measurements per second, each comprising 12 images.

We use six sinusoidal structured light patterns at varying scales and a full-on projector pattern. After each structured light sequence we generate four gradient illumination patterns and an additional diffuse tracking pattern with a spherical lighting apparatus. Because our gradient illumination patterns are captured at different points in time, we correct for subject motion as in [Wenger et al. 2005] using an optical flow algorithm. We compute this flow be-

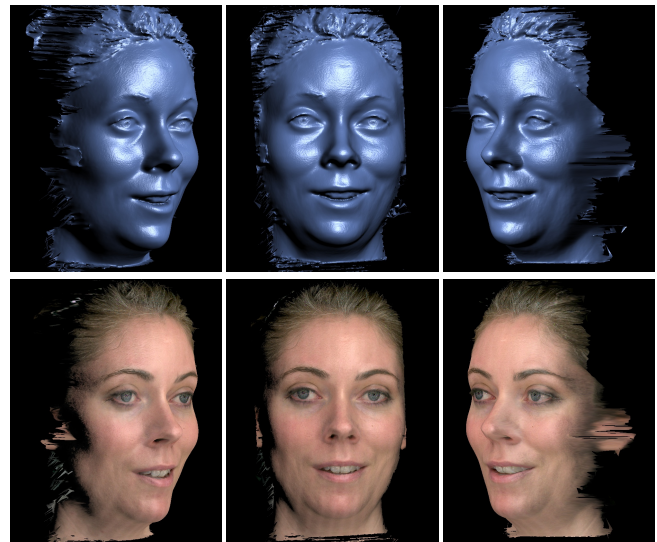


Figure 2: The acquired high-resolution geometry (top) and shadings by using the normal map and albedo texture with a simple Phong BRDF shader, from three different viewpoints.

tween the first gradient pattern and the tracking pattern, and then use this flow to warp the four gradient-lit images to the same point in time. This allows for accurate calculation of surface normals using ratios of the gradient-lit images.

Geometry Processing A dynamic programming algorithm is used to find camera-to-camera correspondences from the ratios of the sinusoidal structured light patterns to the full-on pattern. The stereo geometry is created by triangulating camera rays based on the correspondences. We compute photometric surface normals from the spherical gradient patterns, and then use the photometric normals to correct the stereo geometry by minimizing the difference between the geometry normals and corrected photometric normals. This step not only adds fine-scale details to the stereo geometry but also corrects the low frequency geometry noise that is difficult to get rid of by using mesh smoothing algorithms.

Results The two cameras capture data at a resolution of 2400×1800 (Bayer pattern). With a internal RAM storage of 12GB, the maximum recording time is around 5 seconds. The result of each scan contains a high resolution mesh that usually consists of 1M triangles, a smoothed medium resolution mesh, a color texture, a world-space normal map, and a displacement map represents the difference between the high resolution mesh and the smoothed mesh.

References

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- WENGER, A., GARDNER, A., TCHOU, C., UNGER, J., HAWKINS, T., AND DEBEVEC, P. 2005. Performance relighting and reflectance transformation with time-multiplexed illumination. *ACM Trans. Graph.* 24, 3, 756–764.