Measurement-Based Synthesis of Facial Microgeometry

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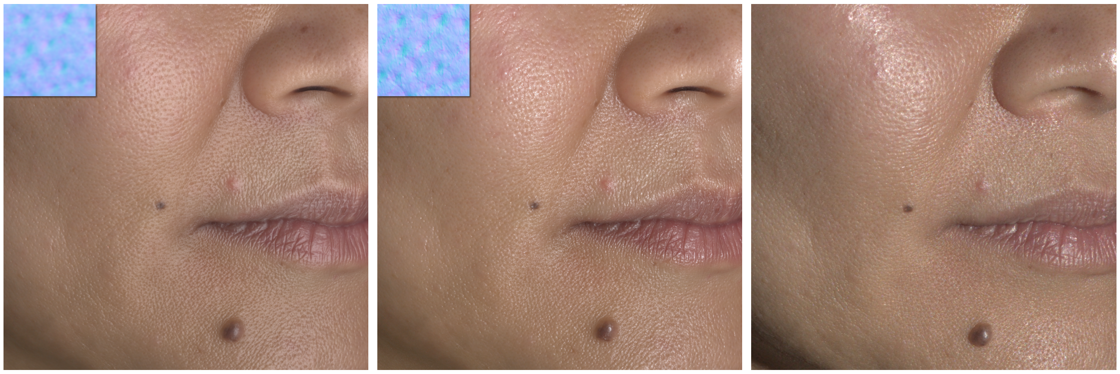


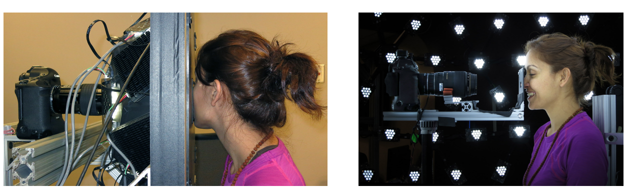
(a) Rendering from original facial scan (b) Rendering using synthesized microstructure (c) Comparison photograph

Figure 1: *(a) Scanned mesostructure with 4K displacement map. (b) Synthesized microstructure with 16K displacement map. (c) Real photograph under flash illumination.*

1 Introduction

Current scanning techniques record facial *mesostructure* with sub-millimeter precision showing pores, wrinkles, and creases. However, surface roughness continues to shape specular reflection at the level of *microstructure*: micron scale structures. Here, we present an approach to increase the resolution of mesostructure-level facial scans using microstructure examples digitized about the face. We digitize the skin patches using polarized gradient illumination and 10 μm resolution macro photography, and observe point-source reflectance measurements to characterize the specular reflectance lobe at this smaller scale. We then perform constrained texture synthesis to create appropriate surface microstructure per facial region, blending the regions to cover the whole entire face. We show that renderings of microstructure-augmented facial models preserve the original scanned mesostructure and exhibit surface reflections which are qualitatively more consistent with real photographs.

2 Recording Skin Microstructure

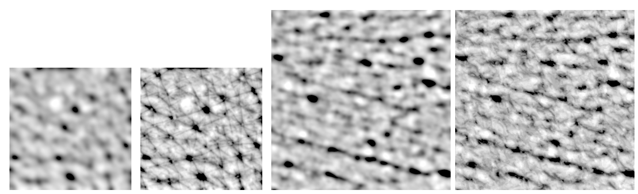


(a) (b)

Figure 2: *Microgeometry acquisition setups (a) Twelve-light hemisphere capturing a patch on the cheek. (b) LED Sphere with camera inside, capturing the nose tip.*

We record the microstructure of skin patches under polarized gradient illumination using either of two systems. For both, we stabilize the skin patch relative to the camera by placing the subject's skin against a 24mm $\times$ 16mm aperture in a thin metal plate. Our small capture system (Fig. 2(a)) is a 12-light dome, where each light can produce both linear polarization conditions. The difference between images acquired under parallel- and cross polarization isolate surface reflectance and attenuate the blur of subsurface scattering. For BRDF fitting, we additionally acquire a single-light polarization difference image. For smooth or oily skin patches, twelve light positions can yield separated specular highlights, biasing surface normal measurement. For higher angular resolution, we can alternately acquire microstructure with the macro camera and aperture frame inside the same 2.5m-diameter polarized LED sphere used for facial scanning (Fig. 2(b)).

3 Facial Microstructure Synthesis



A A' B B'

Figure 3: *We add microstructural detail to a scanned facial region B using the analogous relationship between an exemplar microstructure patch A′ and a blurred version of it A which matches the mesostructural detail of B.*

We segment the face into seperate regions (forehead, nose, temple, cheek, and chin) and use the surface mesostructure evident in the full facial scan to guide the texture synthesis process for each facial region. We then merge the synthesized facial regions into a full 16K map of the microstructure. To do this, we derive displacement maps of both surface meso- (A, B) and microstructure (A') from the measured specular normal maps (Fig. 1, inset) and then synthesize displacement maps with microstructure (B') for the entire face using constrained texture synthesis based on Image Analogies [Hertzmann et al. 2001]. Finally, we render with BRDFs measured during microgeometry acquisition; greater detail is provided in the supplemental technical report [Graham et al. 2012].

References

GRAHAM, P., TUNWATTANAPONG, B., BUSCH, J., YU, X., JONES, A., DEBEVEC, P., AND GHOSH, A. 2012. Measurement-based synthesis of facial microgeometry. Tech. Rep. ICT-TR-01-2012, USC-ICT.

HERTZMANN, A., JACOBS, C. E., OLIVER, N., CURLESS, B., AND SALESIN, D. H. 2001. Image analogies. In *Proceedings of the 28th annual conference on Computer graphics and interactive techniques*, ACM, New York, NY, USA, SIGGRAPH '01, 327–340.

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