Fast Rendering of Realistic Faces with Wavelength Dependent Normal Maps

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Introduction Due to complex nature of the facial reflectance, high end rendering techniques often require too much data or too much computation time to be suitable for production or real time rendering. In this work, we present a novel and efficient face rendering technique based on the use of wavelength dependent normal maps. Normal maps are typically used for the high frequency surface details they contain. Previous work showed that normal maps can be adjusted to include more complex effects such as ambient occlusion We extend this further and demonstrate that by using a separate normal map for each color channel it is possible to represent complex wavelength dependent material properties such as subsurface scattering. Our technique is easy to integrate into both real time and global illumination rendering frameworks. We demonstrate how to use these normal maps to produce photorealistic digital faces.

Data This work is based on data provided by a novel face scanning system [Ma et al. 2007]. The data are: a diffuse albedo map, a specular intensity map, wavelength dependent normal maps, a specular normal map, and a high resolution 3D model of the face.

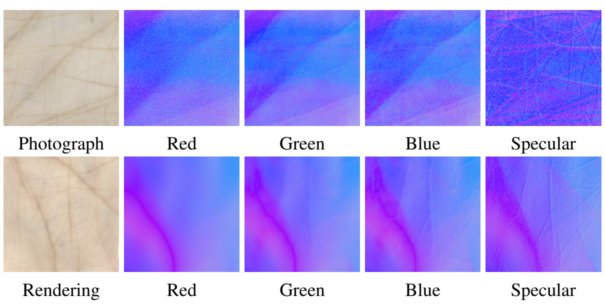

Figure 1: **Top**, comparison of the different normal maps from a patch of a hand with the true surface normals recovered from the specular channel. **Bottom**, wavelength normal maps recovered form subsurface scattering rendering of a hand model compared to the model surface normals (Note the pose and skin sample of row 1 & 2 are different)

Wavelength dependent normal maps Photometric stereo techniques infer surface normals from the luminance of an object captured under multiple lighting conditions. The specular component of an object's reflectance provides the most accurate information about object shape because the diffuse component is often affected with global illumination effects such as bounced light and subsurface scattering. Because light scatters differently for each color, performing photometric stereo on each color channel separately leads to wavelength dependent normal maps. The first row of Fig. 1 shows the normal maps of a patch of hand skin recovered from the red, green, blue channel of the reflectance's diffuse component, and the normal map recovered from reflectance's specular component. The red channel is smoother because red light diffuses more that others through the skin as shown in Fig. 1.

In our case we derive these normal maps using photometric stereo. If photographs are not available or if the subject is synthetic, it is also possible to produce wavelength dependent normal maps. Using subsurface scattering simulation one can produce high quality renderings of a synthetic face or other material under multiple illumination conditions suitable for photometric stereo. It is then possible to recover the normal maps from these images. The second row of Fig. 1 illustrates this point. These normal maps look like blurred versions of the surface normal map. This is due to the subsurface scattering model used for the rendering in which the diffusion term is dominant and the scattering parameters are uniform. The normal maps recovered from real photographs show much more spatial variation, for instance hair detail is present in all red, green and blue normal maps.

Our work has conceptual similarities with recent techniques that have been developed based on diffusion approximation over irradiance maps to simulate subsurface scattering [Borshukov and Lewis 2003]. Since the different normal maps present different degrees of smoothness it can be seen as a way to blur irradiance. The novelty in our approach is to leverage the inherent spatially varying and complex light transport effects present in the different normal maps.

Figure 2: Face rendered using the different normal maps **(left)** compared to simple normal mapping rendering **(middle)** and a subsurface scattering rendering **(right)**. Zoom in the picture to have a closer look to the face detail. The middle one appears chalky and lacks skin's characteristic translucency.

Rendering Although the normal maps recovered from photometric stereo are locally accurate, globally they suffer from drift due to ambient occlusion and indirect lighting. Rendering with them leads to artifacts caused by a mismatch between geometry's attached shadows and normal shading. We correct the normal maps by replacing their low frequency component by the one from the high resolution mesh as in [Nehab et al. 2005]. For rendering we use the diffuse albedo map and the normal maps corresponding to the RGB channels to shade each color of the diffuse component respectively. The specular component is shaded using either the geometric normals of a high resolution mesh or the normal map recovered from the specular channel. Our work demonstrates that rendering using these normal maps can yield convincing local subsurface scattering effects. This is entirely due to the separation between the specular and diffuse layers. The specular layer is representative of the "true" surface. Surface detail is only seen in regions with highlights. In regions where diffuse reflection is dominant, the skin looks smoother and using separate RGB normal maps better shows red light scattering into pores and crevasses. Fig. 2 shows faces rendered with global illumation and wavelength dependent normal maps, rendered global illumination and high resolution geometry only, and rendered with subsurface scattering as in [Jensen and Buhler 2002] (from left to right).

References

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