SPECULARITY REMOVAL FOR SHAPE FROM SHADING

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ABSTRACT

Specularly reflecting surfaces confuse traditional shape-from-shading algorithms because the variation in image intensity within a specularity does not directly relate to the cosine of the incident angle, as it would for a simple Lambertian reflector. To overcome this problem, color is introduced and a method of removing the specular component of the intensity variation is proposed based on a dichromatic model of surface reflection. Unlike Shafer's method for specularity removal, which is restricted to uniformly colored surface patches, our algorithm uses information from several differently colored regions. The specular component due to interface reflection does not change across the regions even though the diffuse component due to body reflection does. In color space, the regions project to planes and the color of the specular component is found as the common intersection of these planes. Once the color of the specular component is known, it is removed from the original image. The resulting image preserves the relative intensity of the diffuse component so it can then be successfully input to a traditional shape-from-shading algorithm.

KEYWORDS:
specularity, surface orientation, shape from shading, Dichromatic Model, color space, Lambertian, interface, body and ambient reflection.

1. Introduction

Intensity shading provides many cues about surface orientation. Obtaining shape from shading information, however, is difficult because the intrinsic scene characteristics are encoded in a single intensity value which may have resulted from an infinite number of combinations of illumination, orientation and reflectance. While the encoding is unique, the decoding is not.

Although the general shape-from-shading problem is ambiguous, it becomes solvable when various constraints about the geometry and photometry of the reflecting surface are exploited. Woodham solves the problem by assuming a priori knowledge of the reflectance map and constraints on the surface curvature [15] [16]. Horn and Brooks derived a numerical scheme [6] [2] for computing local surface orientation from the variation in image intensity. To render the problem solvable without relying on a priori supply of reflectance map, the domain was restricted to scenes containing only smooth surfaces of uniform Lambertian reflectance, illuminated by a single point source at great distance.

While their methods will calculate the shape of uniformly colored Lambertian reflectors, due to the complications in modeling specular reflection component [14] [3], they cannot handle scenes containing specularly reflecting surfaces. Unfortunately, the majority of surfaces are non-Lambertian so specular highlights need to be taken into account for a more generally applicable shape-from-shading algorithm. Babu et. al., in order to determine the orientation of non-Lambertian surfaces, exploit the uniformity in image irradiance along the iso-brightness contours from specular reflection [1]. Their method, however, is insufficient as it is limited to planar surfaces only.

A typical specularity appears on the plastic, multi-colored beach ball shown in Figure 1-1. Just as one would expect, a plot of intensity as a function of position along the indicated line shows a sharp peak within the specularity.

Our approach to the problem of shape from shading for non-Lambertian surfaces is first to calculate the specular component using an algorithm different, but derived, from Shafer's [11] [8] [7]. Once the specular component is known, it can be removed to obtain an image containing only diffuse components. With the specular component no longer confusing the intensity data, the traditional shape-from-shading methods once again become applicable to the recovery of surface shape. Figure 1-2 shows the resulting diffuse-component image calculated by our algorithm. The intensity through the specular region now varies as would be expected of a Lambertian reflector.

Both the diffuse and the specular components are combined in the image intensity variation. Since the