Qeios

Peer Review

Review of: "Acquisition of Spatially-Varying Reflectance and Surface Normals via Polarized Reflectance Fields"

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The paper presents a novel method for estimating spatially varying material properties through polarized light imaging combined with statistical analysis. The proposed approach demonstrates promising qualitative outcomes, supported by comprehensive ablation studies that systematically validate the effectiveness of each component in the framework.

The primary concern I have with the current paper is the lack of quantitative measures and (proper) references. For example, in Fig. 9, I don't know how the authors' analysis of "**closely** match" and "**accurately** captures" is defined. Are there any references (with the same environment map)? Are there any quantitative measures of the accuracy? Well, I see that "errors are measured as the L2-norm of the gradient vector upon solver convergence or reaching the maximum iterations," but it conceptually differs from the difference between the ground truth and the reconstruction results.

In other words, I would like to see whether the reconstructed textures are sufficient to recover the captured image under the **same** lighting conditions. At least, this is doable with synthetic examples, by recovering textures from a rendered image (so you know the ground truth of these textures) and comparing them. Without a proper reference or quantitative measure, I find it hard to judge how accurate it is.

The definition of visibility $\nu(\omega_i, \omega_o)$ needs clarifying. From my perspective, visibility is usually a concept related to two points instead of two directions. Why are diffuse and specular visibilities handled separately?

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Eq. 4 needs clarifying. In Eq. 4, the authors use R(ω_i, n), but in the next paragraph, they use R(ω_{ir}, n). I suppose the term surface reflection function is equivalent to the BSDF, but why is it independent of ω_o? Especially given that specular inter-reflection is mentioned later in the same paragraph. Additionally, I would suggest illustrating different direction vectors via a figure with arrows.

The iterative optimization process would benefit from a more detailed presentation. Specifically, it would be valuable to show: (1) the complete optimization process, including intermediate states and the gradient/difference (per iteration) of material parameters; (2) the impact of the number of optimization steps on the results; and (3) any cases where the optimization process diverged, along with the conditions that caused divergence. This additional information would provide a better understanding of the method's behavior and limitations.

Fig. 18: "Diffuse and specular normals are similar, but in multi-layered materials, they may differ slightly." I assume the left example is designed to demonstrate this phenomenon, but why is the bottom of the vase with black specular normals? I expect some discussion, but the figure is not even referenced in the paper.

The overexposure removal process raises several concerns regarding potential bias and accuracy: (1) The classification of overexposure requires clearer definition, particularly in distinguishing it from glints (some kinds of light transport, in particular, specular reflections of small light sources) as shown in Fig. 2. (2) The method's handling of intermediate roughness levels warrants investigation. While extreme roughness cases (perfect specular or diffuse) are addressed, the robustness of glossy materials with moderate roughness remains unclear. (3) The potential impact of this outlier removal approach on the overall accuracy and potential introduction of bias needs thorough evaluation, especially considering the method's application across different material properties.

Generally, I found the method novel and intriguing. However, considering the above issues in clarifications and validations, I believe this paper requires a major revision before publishing, thus my weak negative score. I would like to listen to other reviewers who are domain experts in this field.

Minor comments:

Table 2 is unnecessary in my opinion. After all, Eq. 27 can be easily derived analytically.

Fig. 15: sepcular -> specular

Eq. 14: it seems the \right command is missing

Algorithm 1: What's the value of epsilon and delta used in the experiments?

principle bsdf -> principled bsdf (?)

Declarations

Potential competing interests: No potential competing interests to declare.