Memorandum: Known Bug in the RADIANCE Photon Map

Roland Schregle, 05/2016

Symptom

During beta testing with DRC case studies in late January 2016, Daniel Ploerer discovered – purely by accident, after setting an excessively high specularity and low roughness – a very strong specular highlight (200kcd/m^2!) on a desktop in his cellular office model. This occurred for a particular timestamp in an annual simulation which was associated with a critical solar angle. **This highlight is missing in the current photon map release.**

Pmap

Classic

Cause

This results from the material coefficient callback passed to the ***direct()*** routine to evaluate shadow rays cast towards light sources. The callback in this case is ***dirnorm()*** (for “normal” materials using the Ward BRDF), which adds in the specular and diffuse BSDF component for the source direction. This is then factored in by ***direct()*** if the source is visible. This routine is agnostic to the receiver material and thus cannot arbitrate the overcounting.

In the photon map rendering, the shadow ray is terminated by the overcounting test in the ***badcomponent()*** macro because the ray was transferred through glass, and is therefore considered a caustic that is already included in the photon map. And because the caustic comprises only the diffusely reflected component on the desk; **the specular component, contributed by the same shadow ray, is killed too and thus absent**. This was confirmed by temporarily disabling the overcounting test in ***badcomponent()***, resulting in the specular highlight but also overcounting in the diffusely reflected component as a double caustic, as expected.

Remedy

As of 05/2016, there is no way to separate the diffuse and specular components within ***direct()***, as the material properties are unknown at this point. On the other hand, omitting the diffuse BRDF component in ***dirnorm()*** isn't possible either, as this would require knowing a priori whether the source is visible directly or via a transferred ray (e.g. through glass as in the test scene), with the latter requiring only the specular component to avoid overcounting the caustic.

Consequently, there is no straightforward bugfix, as we are severely constrained by RADIANCE's legacy architecture. This would require a significant reorganisation of the code, which could potentially introduce disastrous side effects. Correspondence with Greg Ward and discussions with Carsten Bauer yielded no immediate solution, either.

Reproducibility

This bug manifests itself consistently if the specular highlight is directly visible, i.e. at primary rays.

Impact on DRC Project

The bug does not directly invalidate the simulations conducted for the DRC project, as these primarily involve evaluating illuminance for daylight autonomy. Luminance maps for glare analysis would potentially be invalidated (underestimated), but these lie outside the scope of the DRC project.

Broader Impact

As the code has now been officially released as part of RADIANCE, this bug should be given high priority. We consider this a serious issue that needs to be resolved in consideration of its user base and RADIANCE's reputation as a validated lighting simulation tool.