# An Approximate Shading Model for Object Relighting
*Supplemental Material*

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## Easing and back extrusion

Since the object is not a real 3D model, we need to do *surface easing* and *back extrusion* to the model for each particular scene before rendering to avoid texture distortion and light leaking, respectively.

**Surface easing** The approximate shape model we construct from a fragment assumes an orthographic camera, and we associate each point $(x, y, h)$ a texture UV coordinate $(x, y)$. However, in the rendering system, the object is (likely) viewed by a perspective camera. This will cause texture distortion in the new image. Since we expect the focal point to be (a) far from the camera, and (b) largely frontal, a simple easing method avoids self-occlusion and restore the texture field. Write $p_m = (x, y, h)$ for a vertex on the model, $p_f = (x, y, 0)$ for the coordinate of the vertex in the image plane, $f$ for the focal point. We replace $p_m = (x, y, h)$ with $p_f + h * (f - p_f)/||(f - p_f)||$. Notice that if the camera is orthographic, there is no change in vertex position, and for cameras that are distant along the z-axis compared to the $x$ and $y$ axes, the shift is small.

**Back extrusion** The mesh object is constructed by lifting the mesh from a 2D plane to an estimated heightfield, leaving the back of the object empty. This causes skinny lateral shadows and may cause light leaking at the bottom (see Fig. 12 in the supplemental material). We extrude the back of the mesh to alleviate this problem. First, we flip the mesh along its contour plane, assuming the object is symmetric. We then allow users to manually select a distance to extrude the back of a mesh to ensure full contact of the object bottom with the supporting surface. The flipped and extruded back is eased in the camera direction to make sure it is invisible.


Figure 12. Back extrusion to avoid light leak. Left: Light leaking at the bottom of the lotus using a model without back extrusion. Middle: With back extrusion, we get a corrected shadow with no light leak. Right: Side view of the extruded model. The distance of extrusion is interpolated from the bottom to the top.

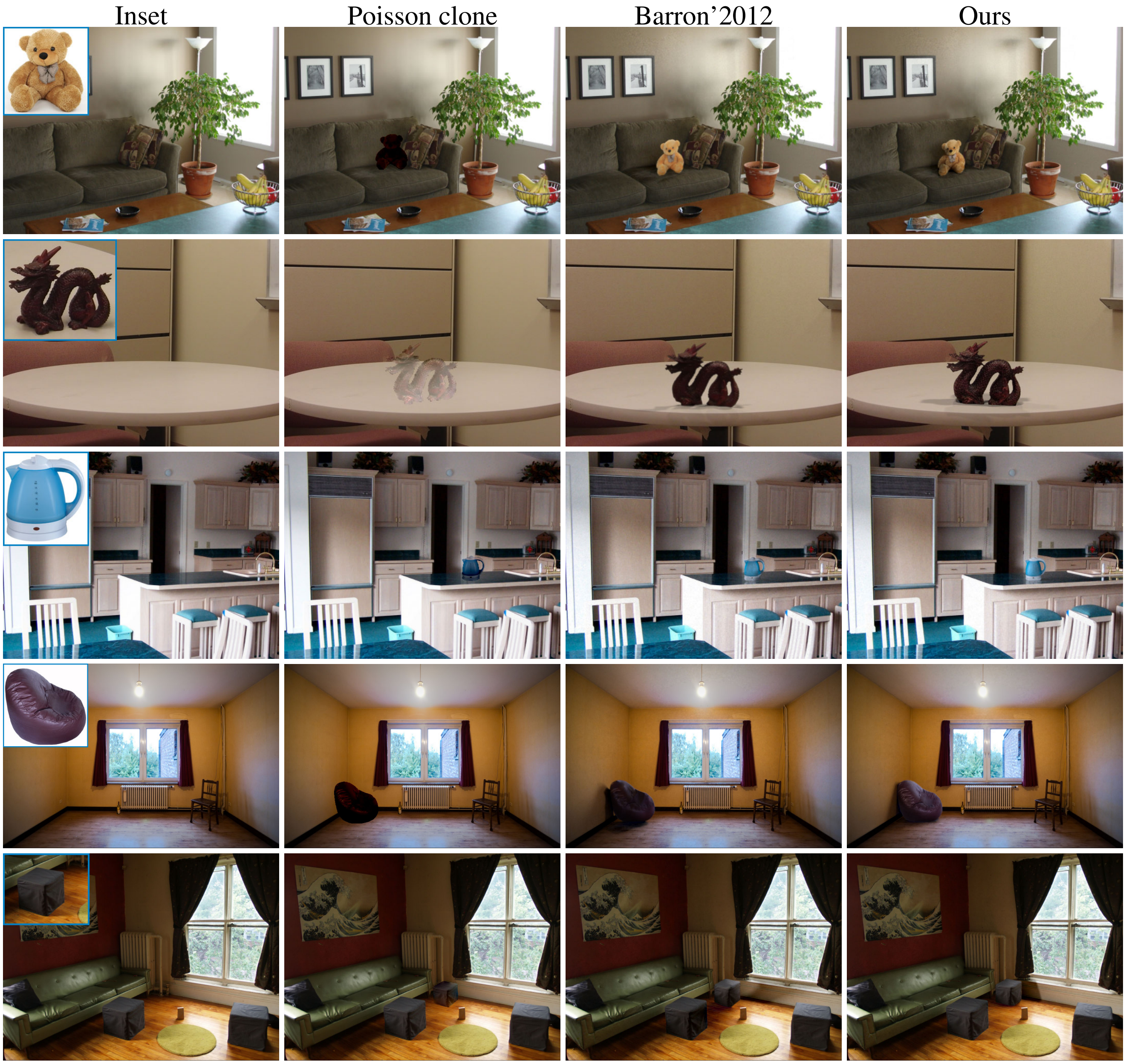


Figure 13. More relighting results. Column 2 shows results by Poisson editing [24].


Figure 14. Our relighting system adjusts the shading on the object for a variety of scenes with different illumination conditions. Detail composition simulates complex surface geometry and materials properties that is difficult to achieve by physically-based modeling.


Figure 15. Relighting objects into existing 3D graphics scenes. Lighting and shadowing of inserted objects appears consistent with the rest of the scene, and our method also captures complex reflection (front teapot), refraction (back teapot) and depth-of-field of effects (ostrich). *Modeling credit to: Jason Clarke (tea scene), "Carbonflux" (Sponza scene), and Doug Hammond (HDRI maps).*

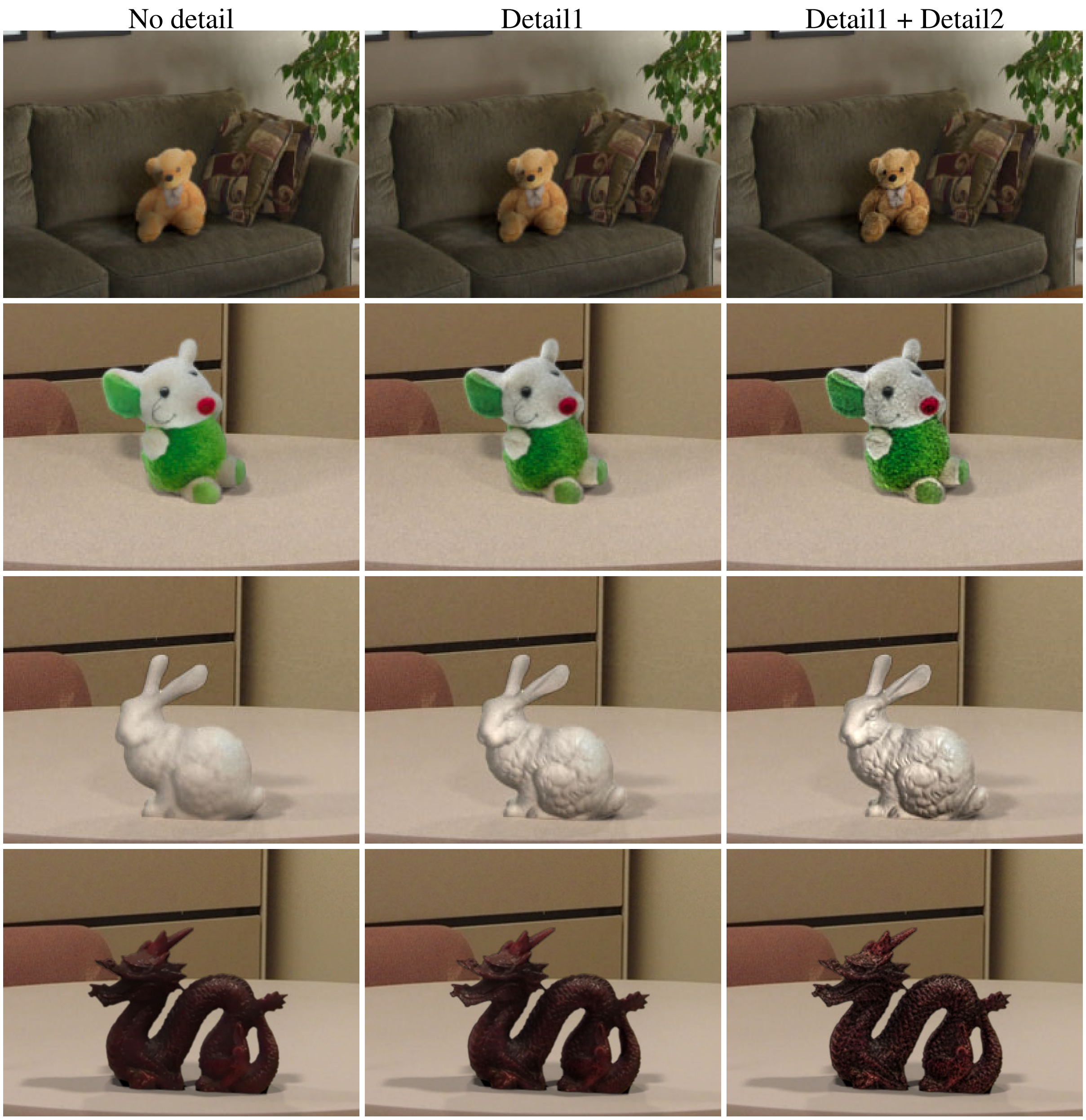


Figure 16. More detail composition results.

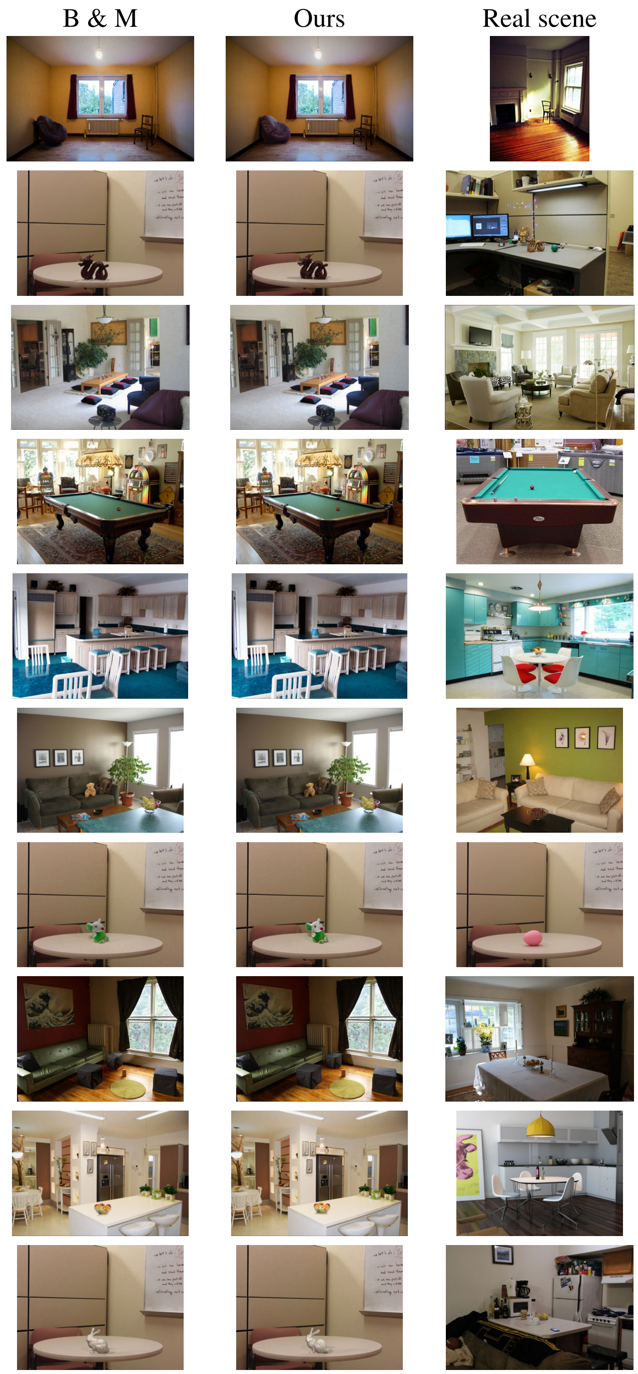


Figure 17. The 10 image examples in our user study. Column 1 is the result by Barron and Malik; Column 2 is by our method; Column 3 is the real scene corresponding to each insertion example. We would like to make the image set and collected user data publicly available.