Supplemental material: Additional performance evaluation

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Abstract

We provide further performance evaluation of our technique against scenes from the original work on iridescent scratches. The scenes benchmarked in the main body of our work are included without comment at the end of this supplemental material.

1 Multiple light evaluation of the environment lighting

Spherical light sources are very often used to approximate bright incandescent light bulbs and polygonal lights extend the same concept to generic light sources. Area light sources better approximate luminaires mirror reflected by highly specular surfaces, such as iridescent scratches, compared to point light based many lights approaches. To demonstrate the applicability of the techniques derived within the main body of our work we are going to provide a set of renderings of the dining table high quality scene from the original work by Wernel et al. Similar to the original work we pick a coherence area radius of $\sigma = 10\mu m$ which yields thinner scratches in practice. The scenes have approximately 200000 scratches split between the spoon and the fork, resulting in densely worn surfaces which better resemble reality. The result is a very faithful recreation of the scenes provided in the original work. To better understand the sources of error compared to the original model we prepared a table of assumptions (Table 2). The scenes as rendered by our framework use precomputed irradiance in light maps to approximate the global illumination and are tone mapped with the Reinhard operator similarly to the original work.

We split the results in two categories: images with 16 spectral bands (Figure 2a, 2b, 2c, 2d) and regular RGB (Figure 1a, 1b, 1c, 1d). The result of using more spectral bands is slightly more muted colors. Note that we do not consider scratches without anti-aliasing in this case as the smaller coherence area results in much greater subpixel detail. The performance impact is shown in Table 1. Adding more spectral bands does not result in integer increase of the rendering times as the computation of the response is the less expensive part of the evaluation. On the other hand, adding polygonal lights is quite expensive as it was shown in the main body of the work. The performance penalty of more polygons is close to linear. The slight deviation from linear dependence of the performance based on the number of polygons might be explained by scheduling effects on the GPU. However, this kind of detailed analysis would require an advanced profiling (simulation) software for the GPU which is not freely available at this point.

Modeling bright light passing through windows is overall justified as it can be seen by comparing Figure 1a and 1b. The same observation is valid for the multiple spectral bands renderings in Figure 2a and 2b. However, the step towards capturing even more windows in the scene as in Figure 1c and 2c may not result in a change for this particular view. This observation points towards possible future investigation of culling the light sources that are unlikely to contribute. Approximating parts of the environment, such as the walls in Figure 1d and 2d is less justified as it results in fairly uniform reflections that do not contribute significantly outside of the perfect mirror reflection. One possible topic of future investigation in this case is polygons with gradients to better match the environment.

We further validated our technique against one of the ground truth scenes in the original work by Werner et al. in Figure 7. Note that the scratches might appear slightly brighter in our renderings compared to the photographs as we are working with a pinhole camera that perfectly resolves them.

2 Evaluation at different zoom levels

We created an artificial benchmark within the main body of the work to outline the cost of having scratches lit by different light sources. Here, we provide the images without comment. Note that the coherence area radius is $\sigma = 60\mu m$ in this case as it makes the scratches visible even without anti-aliasing. We provide separate figures for sphere light sources with anti-aliasing enabled (Figure 3) and disabled (Figure 4). Similarly we provide the same figures for a light source made of a single triangle with anti-aliasing enabled (Figure 5) and disabled (Figure 6)

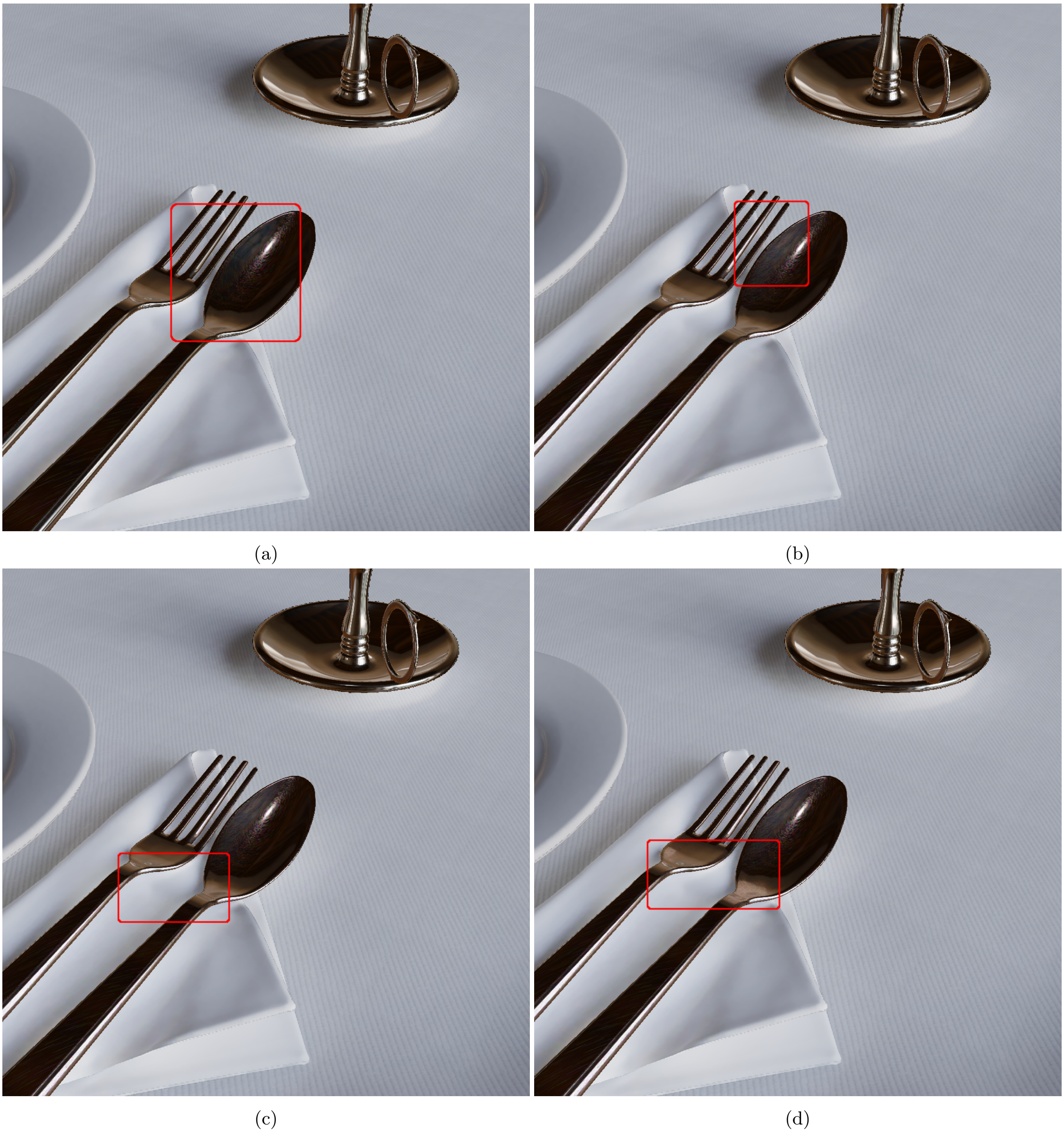
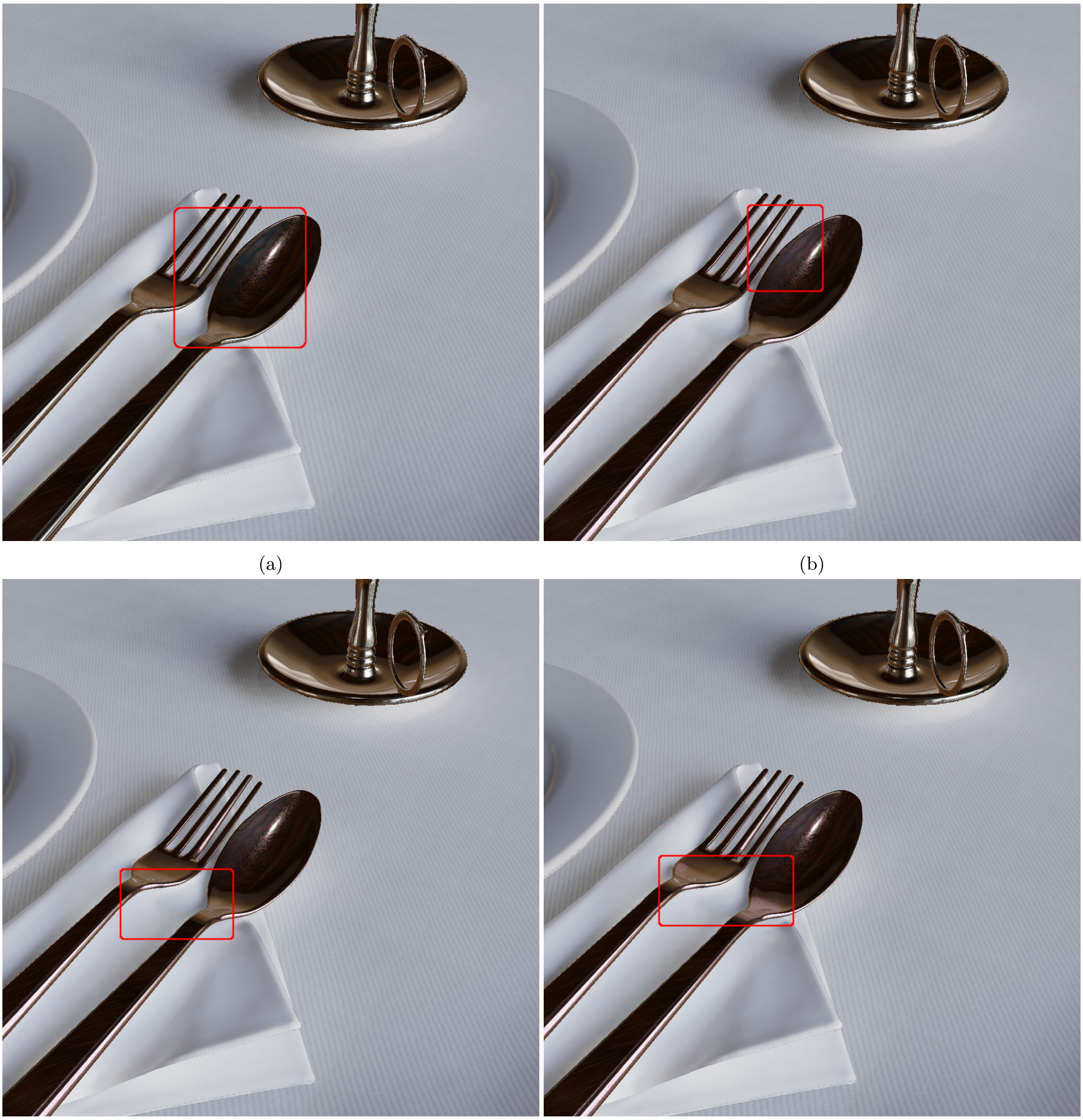


Figure 1: Images in RGB of increasing complexity: (a) no extra rectangles, (b) one rectangle approximating the window with the biggest solid angle, (c) approximating also the next big window, (d) adds the reflected wall. 200000 scratches spread equally between the spoon and the fork.



(a) (b) (c) (d)

Figure 2: Images with 16 spectral bands of increasing complexity: (a) no extra rectangles, (b) one rectangle approximating the window with the biggest solid angle, (c) approximating also the next big window, (d) adds the reflected wall. 200000 scratches spread equally between the spoon and the fork.

Light Polygons	RGB		16 Spectral Bands	
	Figure	Render Time	Figure	Render Time
None	Figure 1a	42ms	Figure 2a	58ms
2	Figure 1b	408ms	Figure 2b	753ms
4	Figure 1c	562ms	Figure 2c	995ms
6	Figure 1d	799ms	Figure 2d	1649ms

Table 1: Performance with different combinations of rectangles approximating key parts of the environment. Benchmark was performed on a laptop with NVIDIA GTX 970M GPU.

(a) (b) (c)

Figure 3: Sphere light source with 10000 scratches and anti-aliasing enabled at different zoom levels: (a) 0.5x, (b) 1x, (c) 2x.

(a) (b) (c)

Figure 4: Sphere light source with 10000 scratches and anti-aliasing disabled at different zoom levels: (a) 0.5x, (b) 1x, (c) 2x.

(a) (b) (c)

Figure 5: Triangle light source with 10000 scratches and anti-aliasing enabled at different zoom levels: (a) 0.5x, (b) 1x, (c) 2x.

(a) (b) (c)

Figure 6: Triangle light source with 10000 scratches and anti-aliasing disabled at different zoom levels: (a) 0.5x, (b) 1x, (c) 2x.

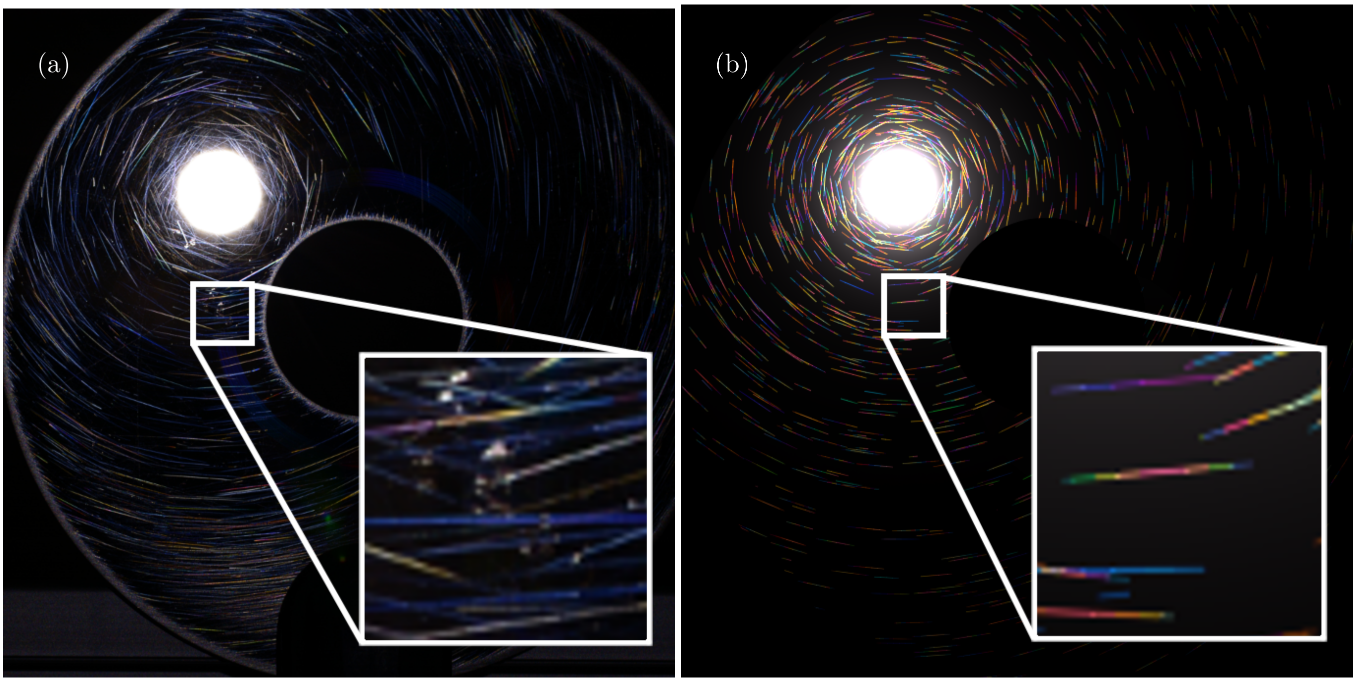


Figure 7: Comparison between (a) ground truth photo of a disc and (b) rendering with our sphere light approximation. Variation is achieved by splitting the scratches into multiple segments. The phenomenological connection with the ground truth is preserved by our approximation.

Table 2: Convenience list of the assumptions that are used by our model as well as a reference to its first introduction.

Assumption	**Usecase/Effect**	**Reference**
Small angle phase dependence	$(\mathcal{D}^{(m)} \propto \exp(i4\pi D^{(m)}/\lambda))$; Analytic area-light integration	Sec.3.1; Fig.3
Rectangular profiles only	Separation of angular and spatial terms	Sec.3.1
Scratches extend over coherence area	Separation of angular and spatial terms	Sec.3.1; Eq.9,10
No scratch-surface interaction (Incoherence)	Base reflectence decoupled from scratch reflectance	Sec.3.1; Eq.6
No scratch-scratch interaction (Incoherence)	Separate reflectance computation for each single scratch	Sec.3.1; Eq.7
Elliptic pixel footprint	-	Sec.3.2
Coherence area much smaller than:		
- Pixel footprint	Separation of integrals, limit-case solutions for $\lvert\eta_{\mathcal{P}}^{(m)}\rvert^2$, $\rho_{\mathcal{P}}$	Sec.3.1,3.2,3.3
- Projected light source	Separation of integrals over solid subtended by light source	Sec.3.4