

Hamiltonian Light Transport

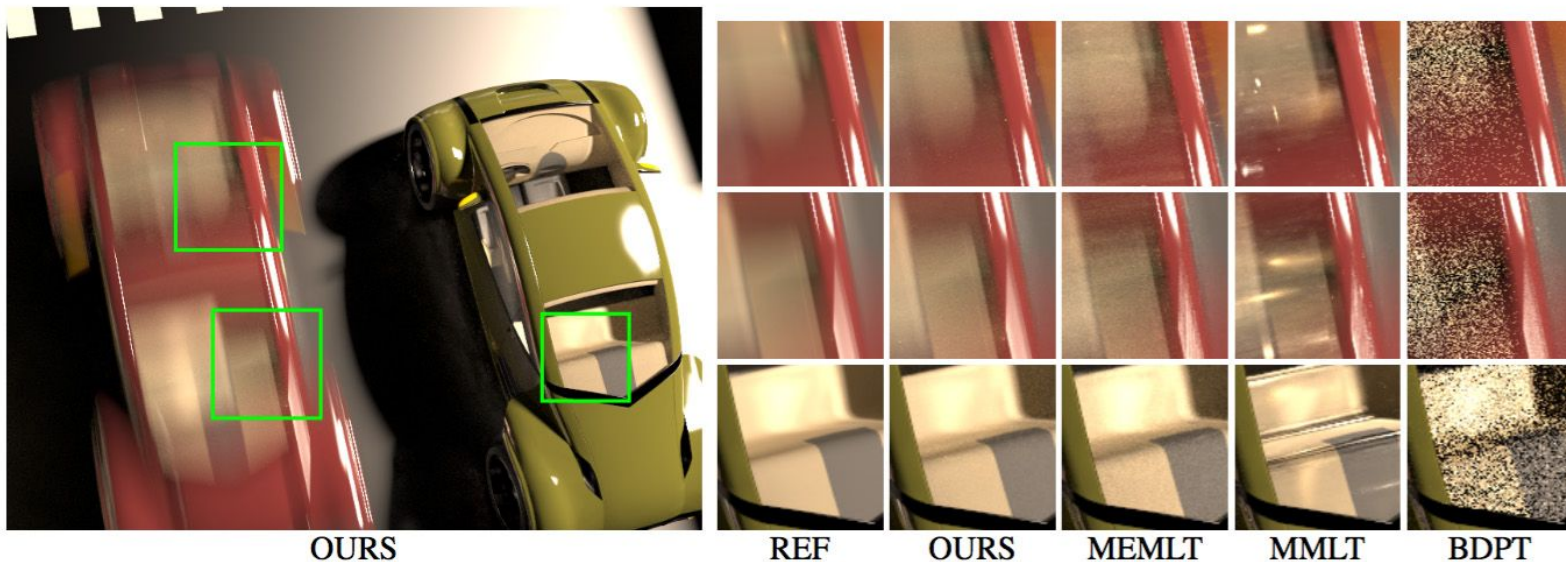
20193168 **Hyunsu Kim**

20193099 **Baekjun Kim**

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Anisotropic Gaussian Mutations for Metropolis Light Transport through Hessian-Hamiltonian Dynamics [T.-M. Li '15]



Anisotropic Gaussian Mutations for Metropolis Light Transport through Hessian-Hamiltonian Dynamics

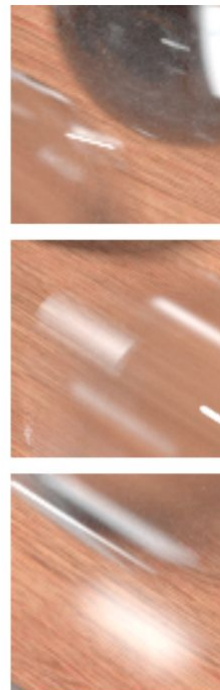
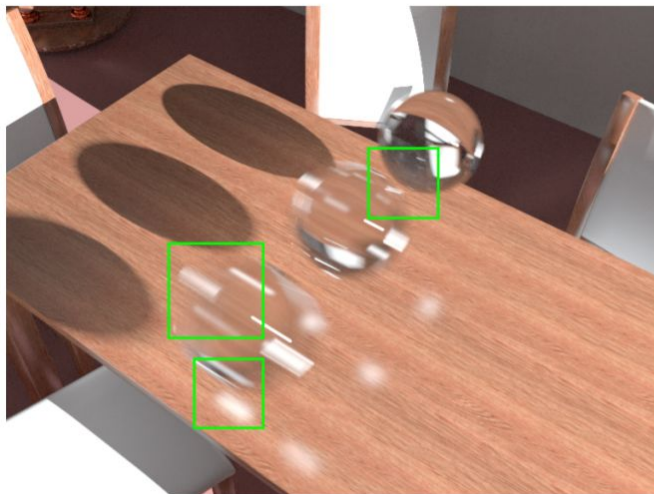
[T.-M. Li '15]

~~Metropolis sampling~~

**Hamiltonian Monte Carlo
(HMC) sampling**

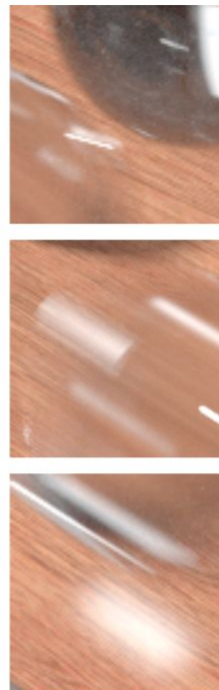
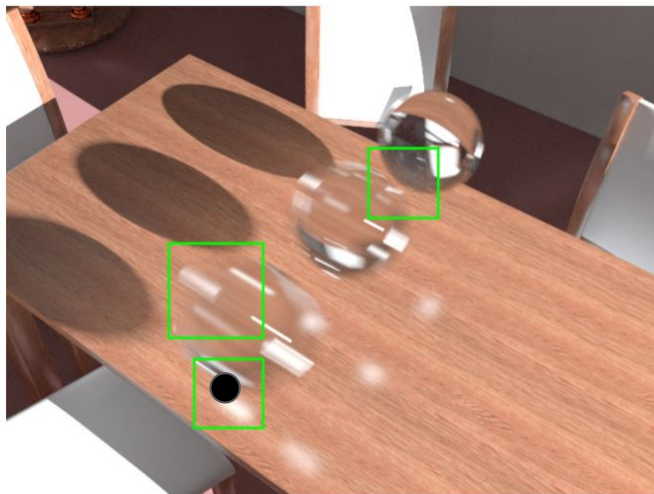
Problems of [T.-M. Li '15]

1. Hard to **globally** explore high-contribution regions in the scene.



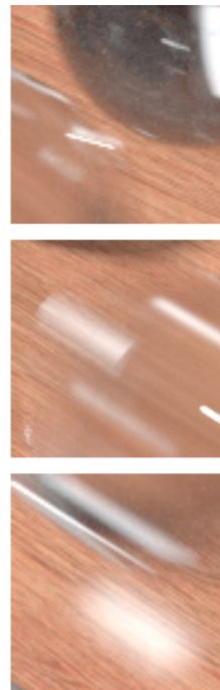
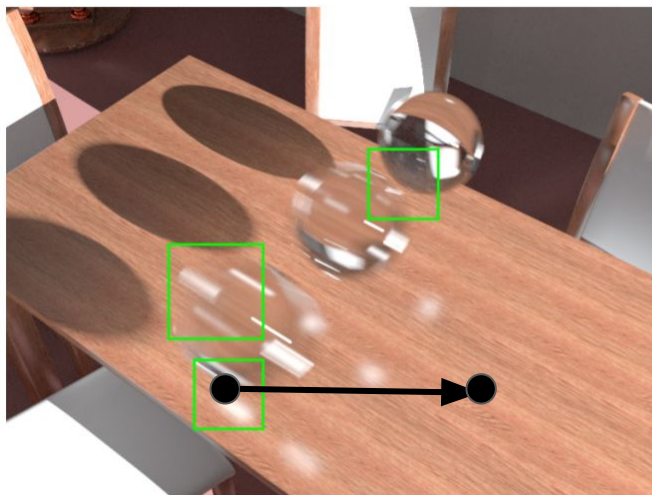
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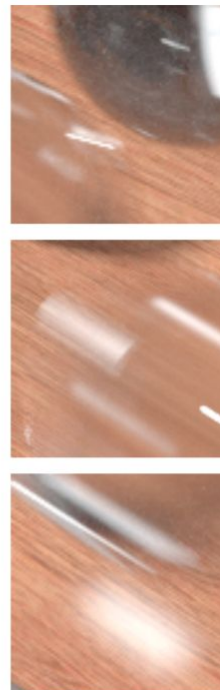
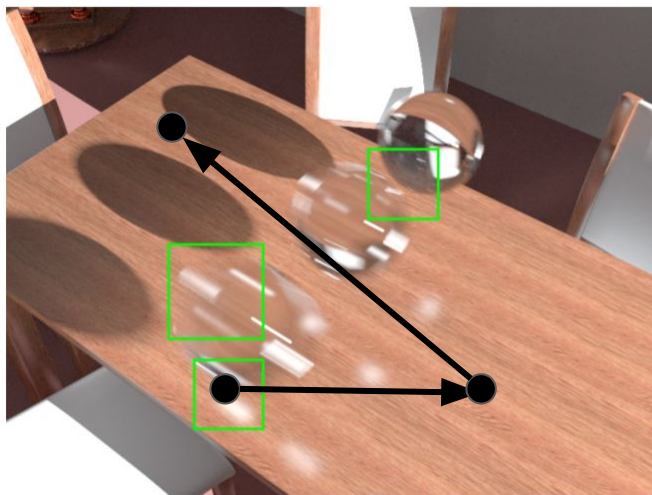
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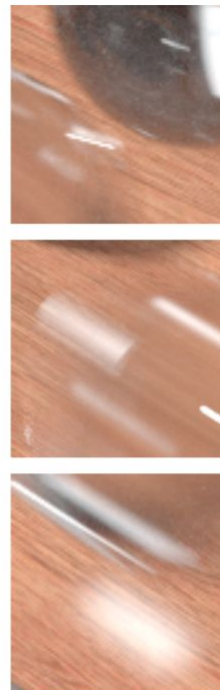
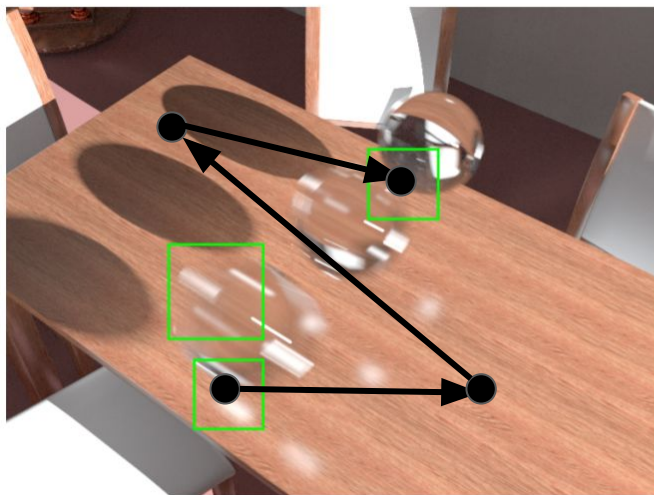
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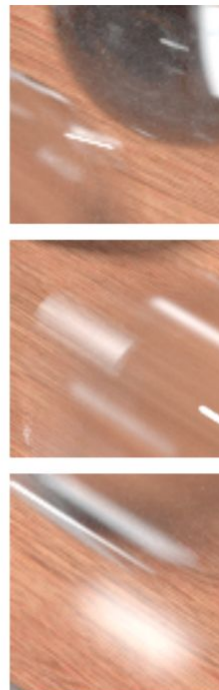
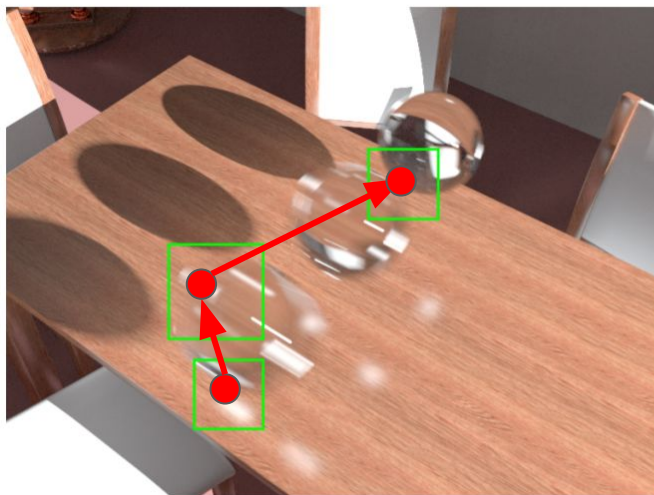
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Problems of [T.-M. Li '15]

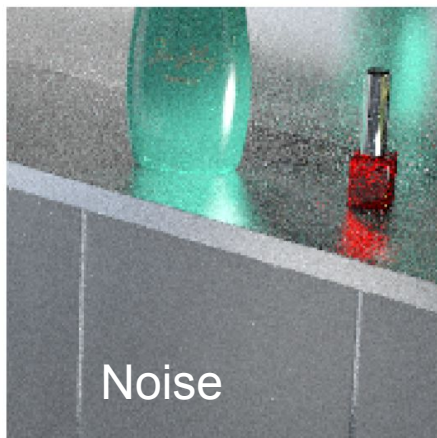
1. Hard to **globally** explore high-contribution regions in the scene.

Ideal case!



Problems of [T.-M. Li '15]

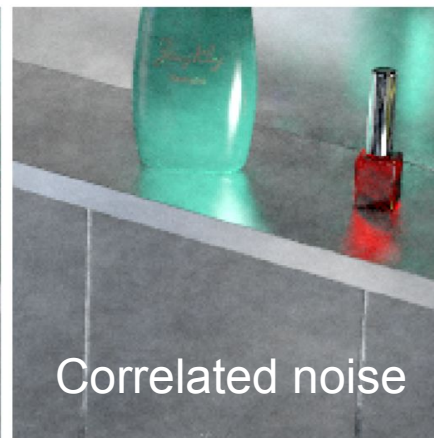
2. **User-specified** hyperparameter σ^2 adjusting the acceptance probability



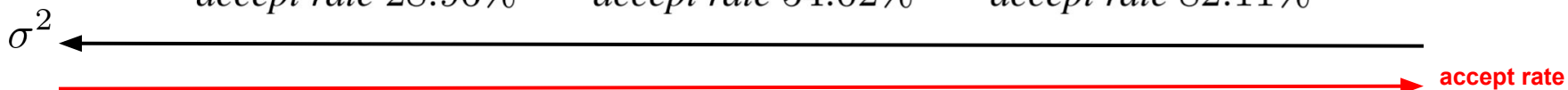
(a) $\sigma^2 = 0.028$
accept rate 28.96%



(b) $\sigma^2 = 0.007$
accept rate 54.02%



(c) $\sigma^2 = 0.001$
accept rate 82.11%

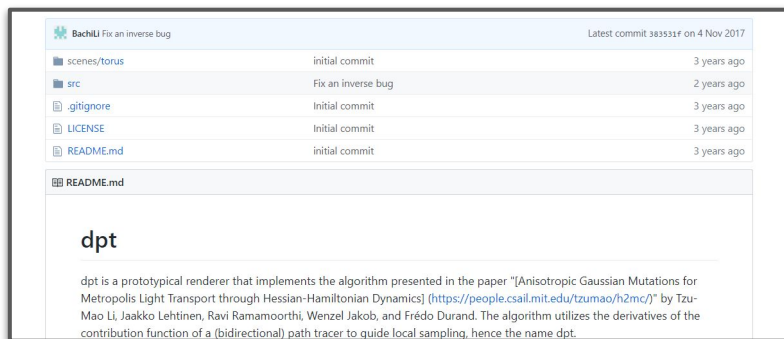


What we've done so far

1. Checked out the **source code** running correctly.
2. Found out a **clue** theoretically how can we explore globally.
3. **Compared** different choices of σ^2

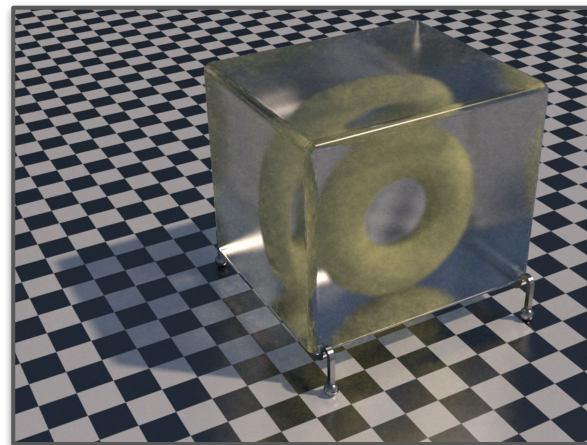
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The source codes



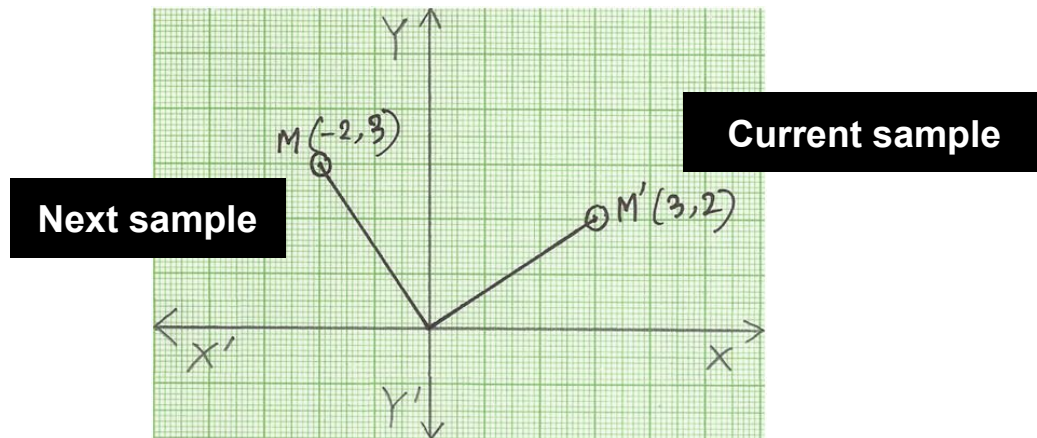
The screenshot shows a GitHub repository page for 'BachLI Fix an inverse bug'. The repository is located at 'scenes/torus'. The commit history shows an initial commit for 'scenes/torus' and 'src' 3 years ago, and initial commits for '.gitignore', 'LICENSE', and 'README.md' also 3 years ago. The 'README.md' file is open, showing the title 'dpt' and a description: 'dpt is a prototypical renderer that implements the algorithm presented in the paper "[Anisotropic Gaussian Mutations for Metropolis Light Transport through Hessian-Hamiltonian Dynamics]" (https://people.csail.mit.edu/tzumao/h2mc/) by Tzu-Mao Li, Jaakko Lehtinen, Ravi Ramamoorthi, Wenzel Jakob, and Frédo Durand. The algorithm utilizes the derivatives of the contribution function of a (bidirectional) path tracer to guide local sampling, hence the name dpt.'

An image we created



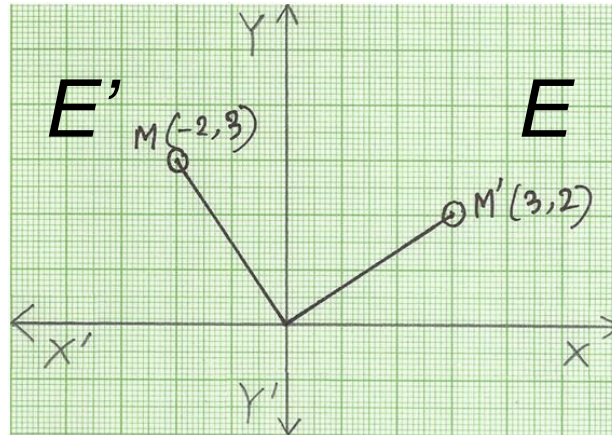
Found out a clue theoretically how can we explore globally

1. Hamiltonian Monte Carlo preserves **energy** defined by light transport function.
2. We found out **a new mutation** preserving the energy: **ROTATION**



Found out a clue theoretically how can we explore globally

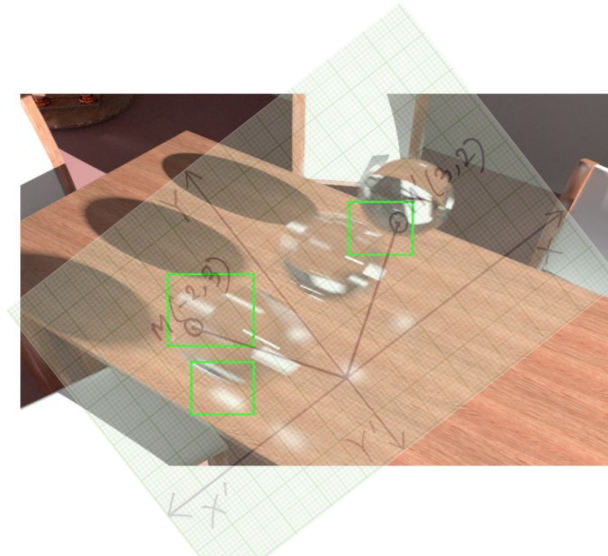
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$$E = E'$$

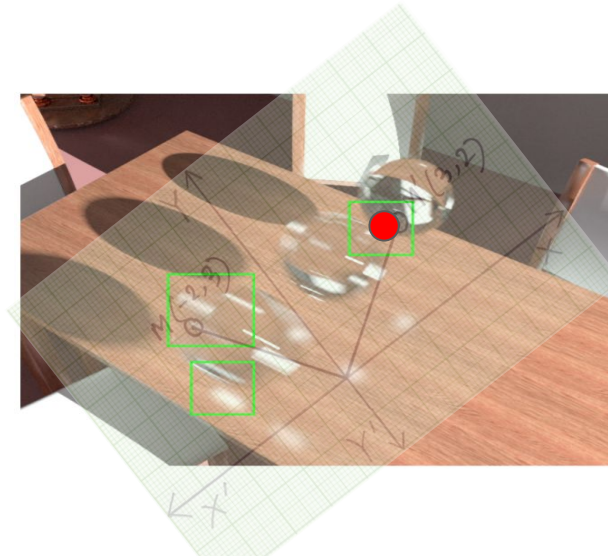
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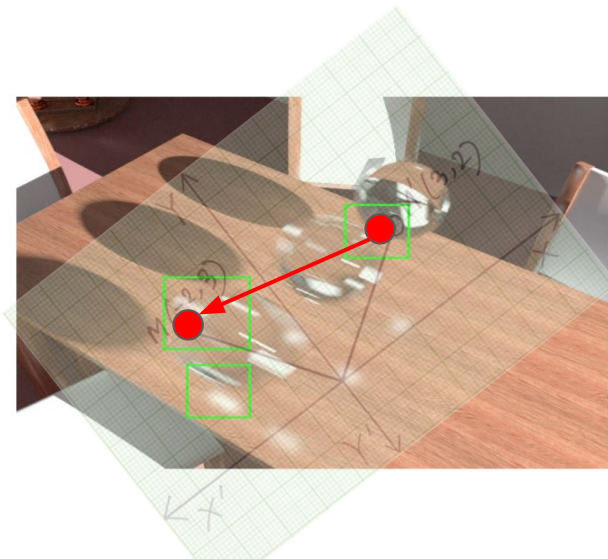
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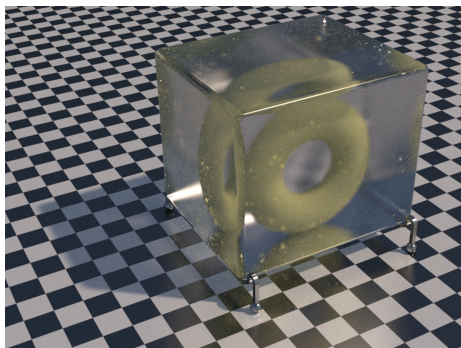
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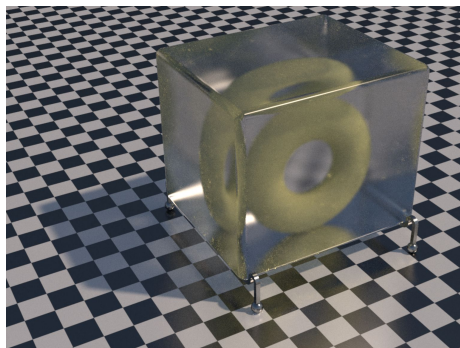
Compared different choices of σ^2

$$\sigma^2 = 0.01$$



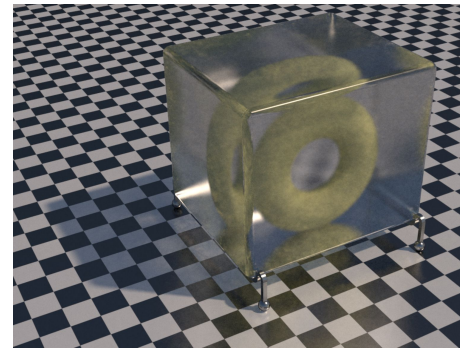
Elapsed time: 194.655secs
Large step acceptance rate: 0.085
Small step acceptance rate: **0.063**
Lens step acceptance rate: **0.106**
H2MC Small step acceptance rate: **0.385**
H2MC Lens step acceptance rate: **0.733**

$$\sigma^2 = 0.05$$



Elapsed time: 206.41secs
Large step acceptance rate: 0.086
Small step acceptance rate: **0.176**
Lens step acceptance rate: **0.226**
H2MC Small step acceptance rate: **0.477**
H2MC Lens step acceptance rate: **0.758**

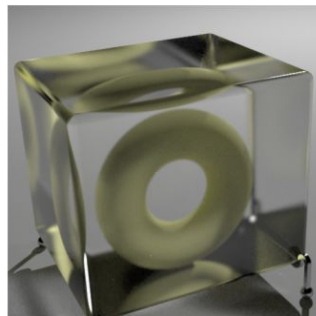
$$\sigma^2 = 0.001$$



Elapsed time: 198.928secs
Large step acceptance rate: 0.087
Small step acceptance rate: **0.626**
Lens step acceptance rate: **0.664**
H2MC Small step acceptance rate: **0.715**
H2MC Lens step acceptance rate: **0.802**

Difficulties

1. The source code includes **only one** rendering image.



2. In the paper, they modified the Hamiltonian Monte Carlo that does **not use the energy quantity**. → Can we still apply our mutation?

~~**E**~~

3. σ^2 is **hard** to be optimized mathematically.

$$\Sigma^* = \left(\Sigma^{-1} + \frac{1}{\sigma^2} \right)^{-1}$$

Future Plan

1. **Discuss** about how can we apply the theoretical mutation into the modified HMC algorithm.
2. **Discuss** about how can we optimize σ^2 by referring adaptive MCMC [Andrieu and Thoms 2008, Hachisuka and Jensen 2011]
3. **Apply** the improved algorithm.
4. **Evaluate** our development by comparing with this paper and the reference.