Hamiltonian Light Transport

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20193099 **Baekjun Kim**

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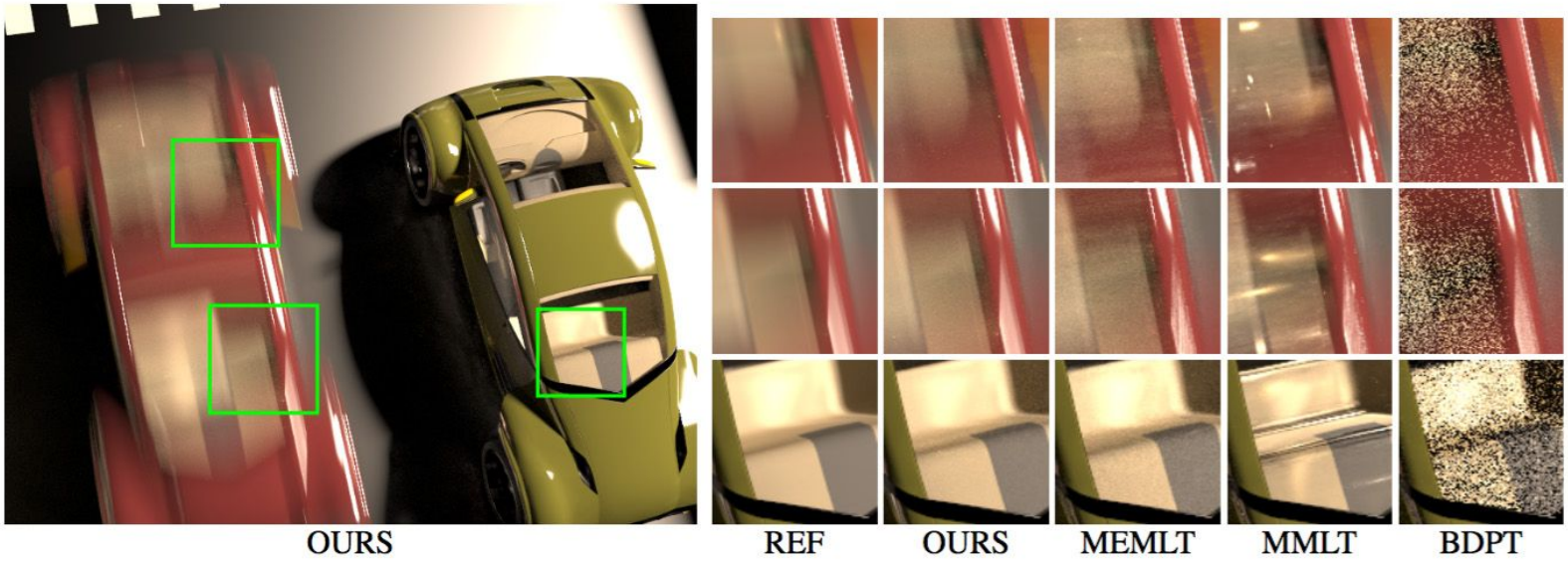
Anisotropic Gaussian Mutations for Metropolis Light Transport through Hessian-Hamiltonian Dynamics [T.-M. Li ‘15]

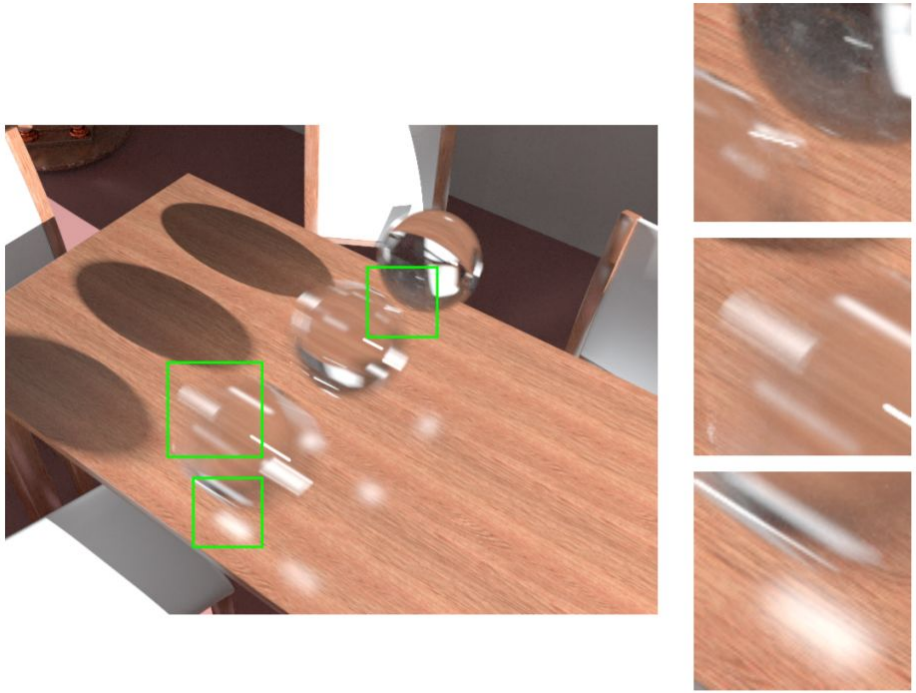


Anisotropic Gaussian Mutations for Metropolis Light Transport through Hessian-Hamiltonian Dynamics [T.-M. Li ‘15]

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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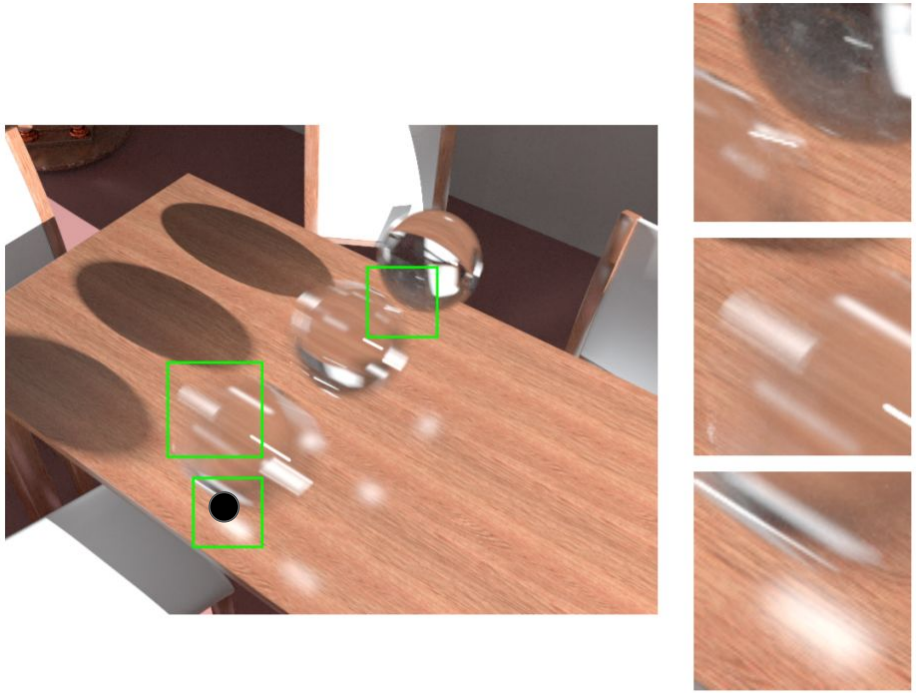

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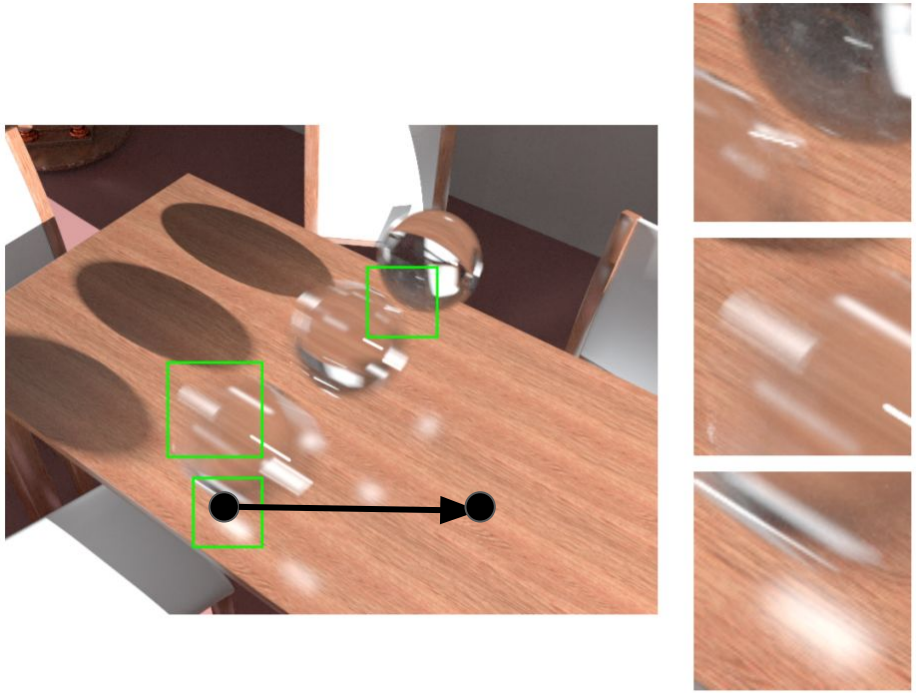

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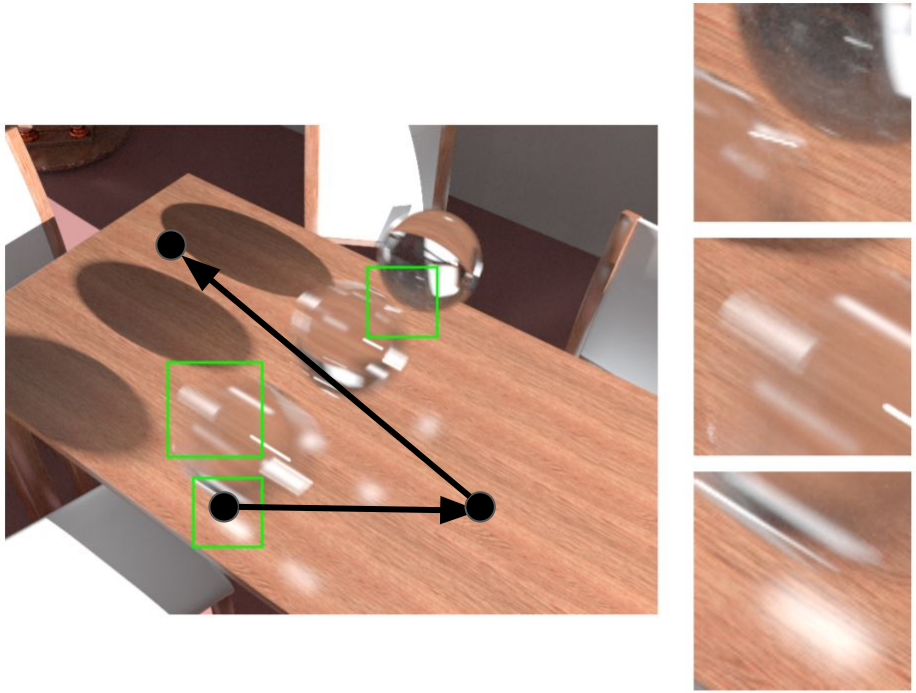

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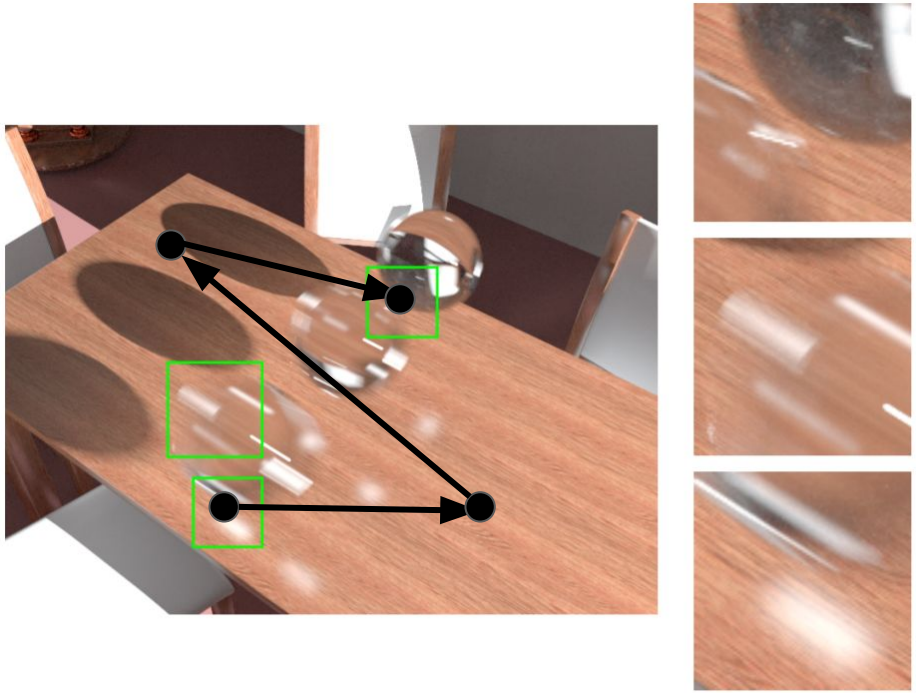
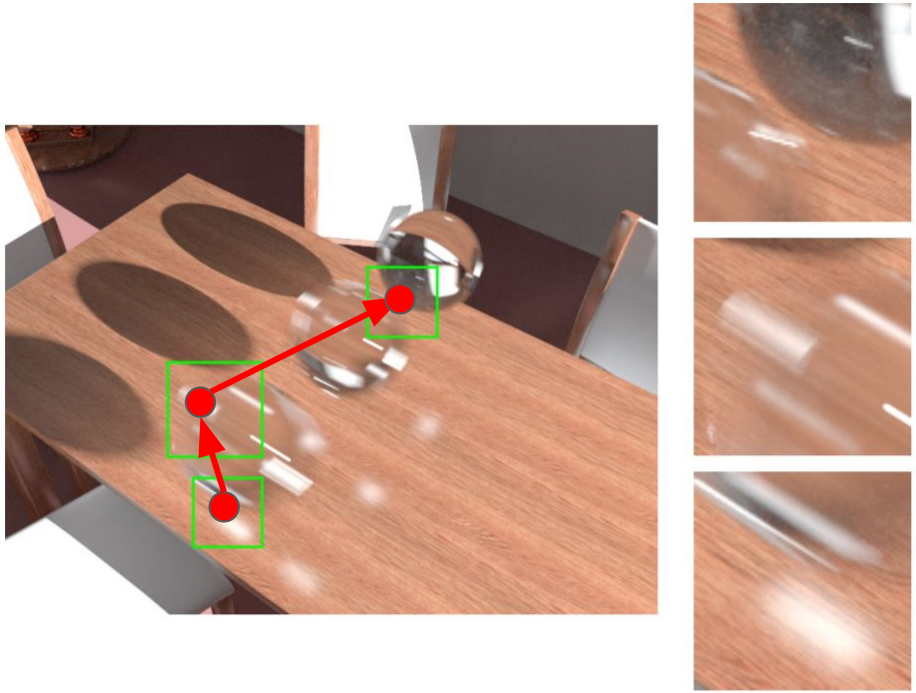


Problems of [T.-M. Li ‘15]

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%

σ^2 ←

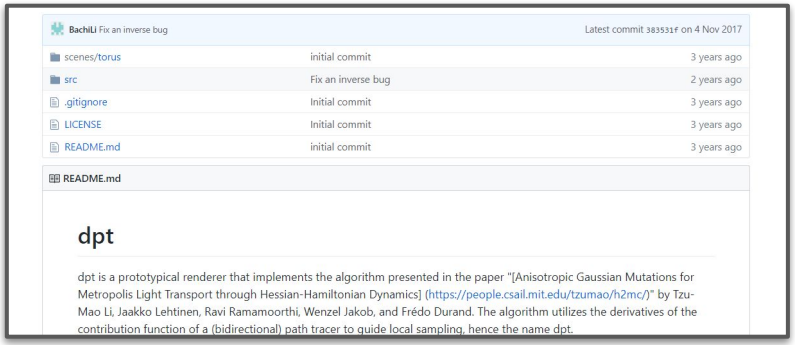
→ accept rate

What we've done so far

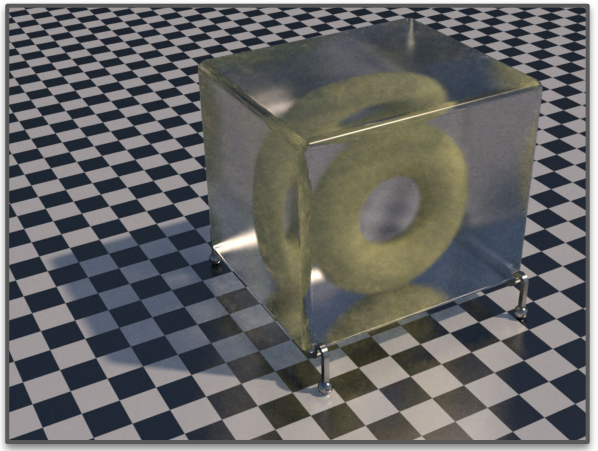
1. Checked out the **source code** running correctly.
2. Found out a **clue** theoretically how can we explore globally.
3. **Compared** different choices of σ^2

Checked out the source code running correctly

The source codes

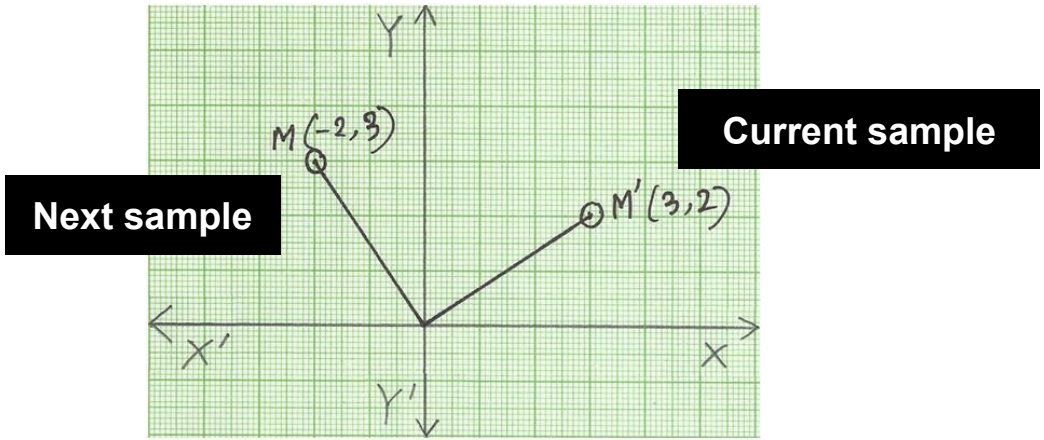


An image we created



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**



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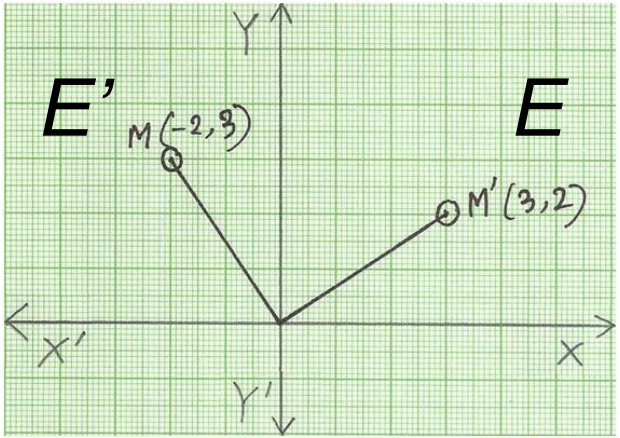

$E = E'$

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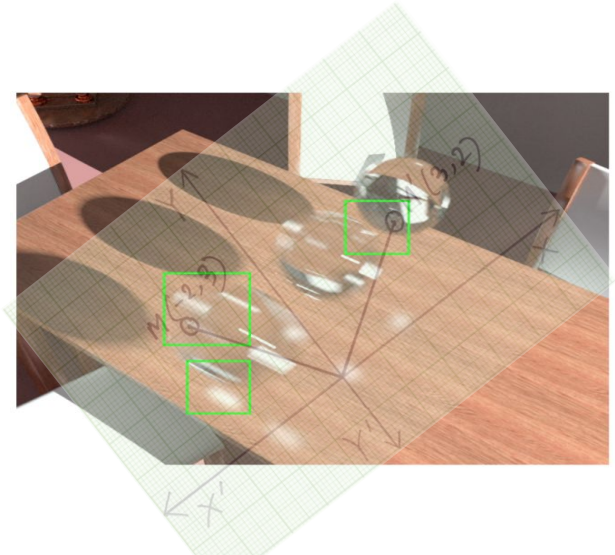

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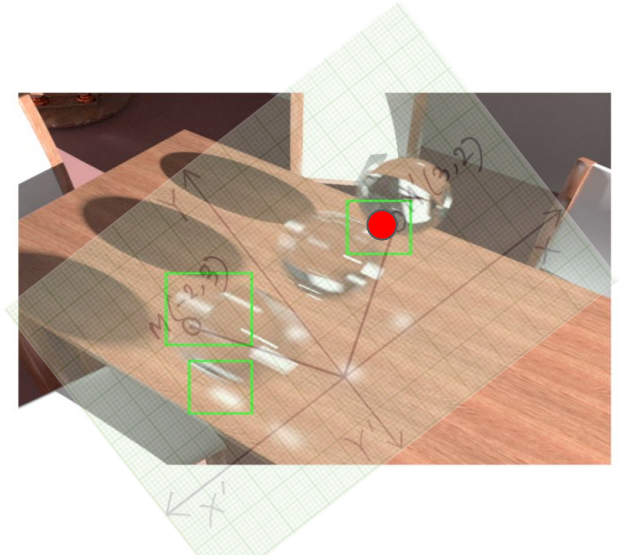

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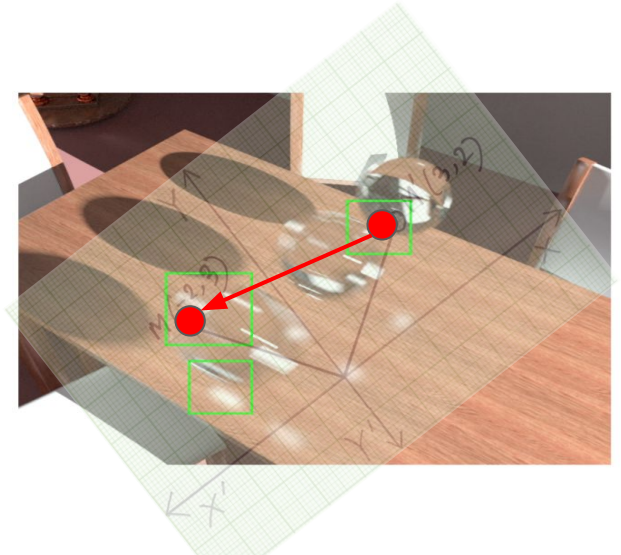
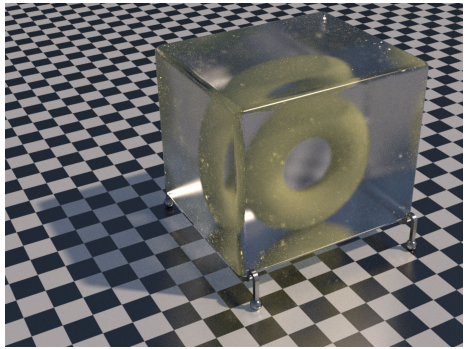


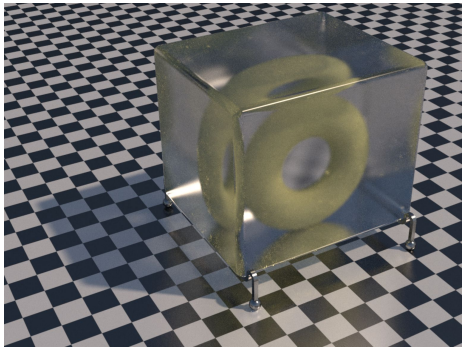
Compared different choices of σ^2

σ^2 = 0.01



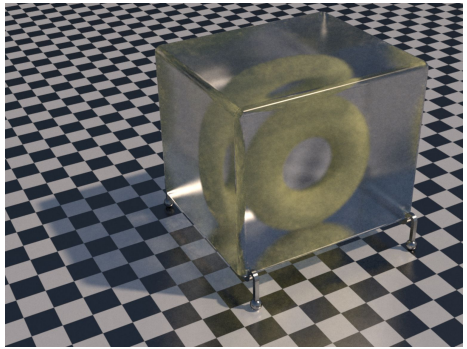
Elapsed time: **194.655secs**
Large step acceptance rate: **0.085**
Small step acceptance rate: **0.063**
Lens step acceptance rate: **0.106**
H2MC Small step acceptance rate: **0.385**
H2MC Lens step acceptance rate: **0.733**

σ^2 = 0.05



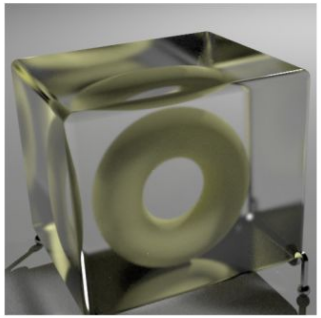
Elapsed time: **206.41secs**
Large step acceptance rate: **0.086**
Small step acceptance rate: **0.176**
Lens step acceptance rate: **0.226**
H2MC Small step acceptance rate: **0.477**
H2MC Lens step acceptance rate: **0.758**

σ^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.