Simulation of the multi-view imaging system with differentiable ray tracing

Maxime Vandegar, Michael Kagan

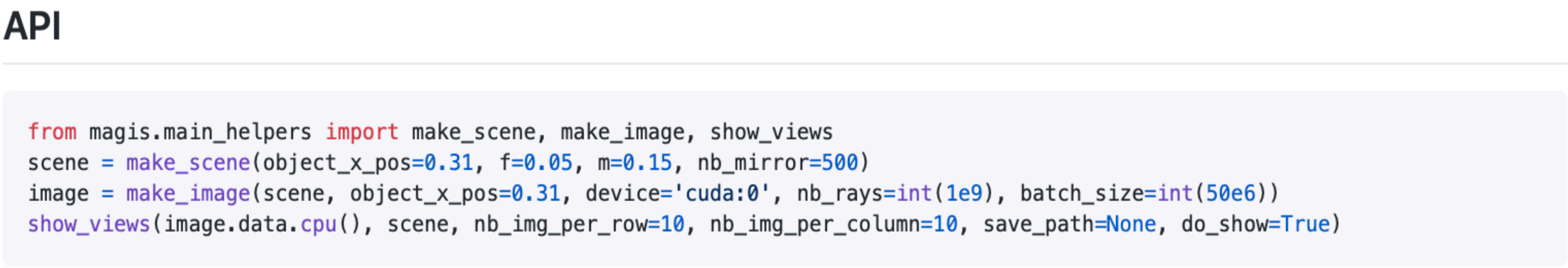
March 2021

U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Photon mapping (rays from cloud to sensor)

- A high-level API is available.



API

```
from magis.main_helpers import make_scene, make_image, show_views
scene = make_scene(object_x_pos=0.31, f=0.05, m=0.15, nb_mirror=500)
image = make_image(scene, object_x_pos=0.31, device='cuda:0', nb_rays=int(1e9), batch_size=int(50e6))
show_views(image.data.cpu(), scene, nb_img_per_row=10, nb_img_per_column=10, save_path=None, do_show=True)
```

- Generating an image takes ~10minutes on a single GPU.
  - Can be reduced to ~1minute with simple optimization.

- The code is stored on a private GitHub repository.
  - Shall we think about storing it elsewhere?

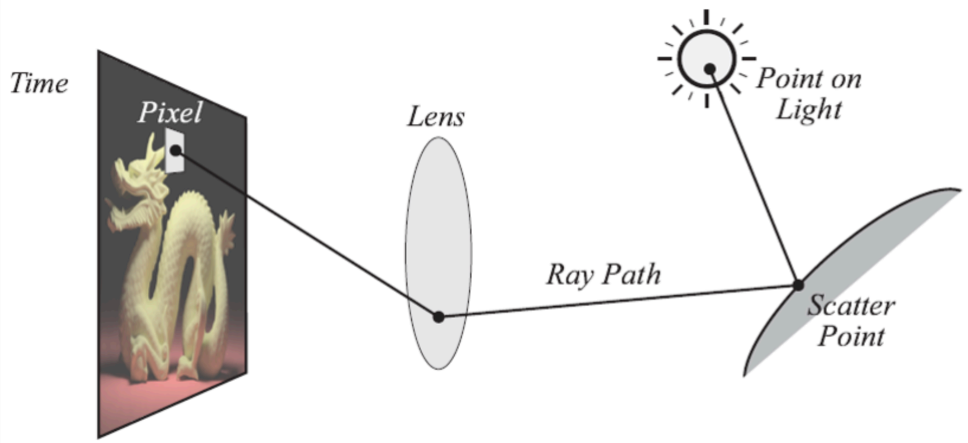
Photon mapping (rays from cloud to sensor)

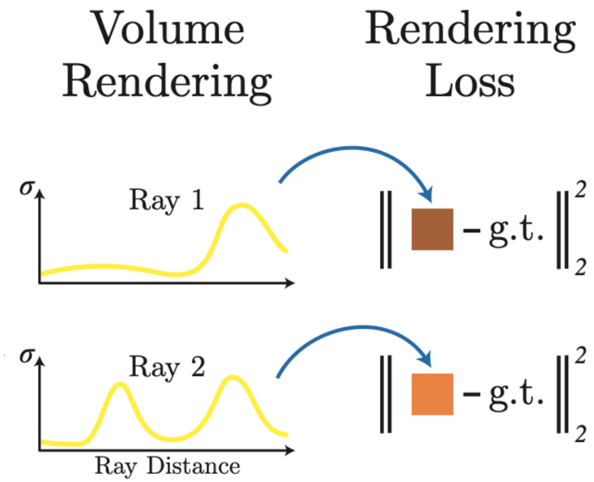
- ✅ Simulation & simulation-based inference.
  - Useful to simulate realistic images.
  - Can be used with simulation-based inference algorithms to learn $p(\phi|d)$.
  - Can be used to generate a dataset of pairs $\{\phi_i, d_i\}$.

- ❌ 3d reconstruction.
  - Some operations are not naturally differentiable.
    - E.g img[int(hit_position / pixel_size)] += 1.
  - $A(.)$ is a mapping from a batch of rays to an image.
    - Many rays are required for the image to be statistically significant → large memory footprint.

Ray marching (rays from sensor to cloud)

- Naturally differentiable.
- Allows to query the value of a single pixel.
- In general, more efficient.
  - Approach used in computer graphics.





Credits: ArXiv:2003.08934 & https://medium.com/suriya-d-murthy/building-your-very-own-path-tracer-from-scratch-c-4d9d3ce5fea4

Status & next steps

- Photon mapping:
  - Spacial-based optimization:
    - A first attempt at solving $||A(x) - b||^2$ did not work.
    - Many things can go wrong.
    - Dozens of diagnostics can be run.
    - → Putting aside, not a priority at the moment.
  - Density-based optimization:
    - Optimizing the ray luminosities is better defined in terms of gradients.
    - → Under progress.

- Ray marching:
    - → Under progress.