Space Carving and Neural Radiance Fields for 3D Segmentation

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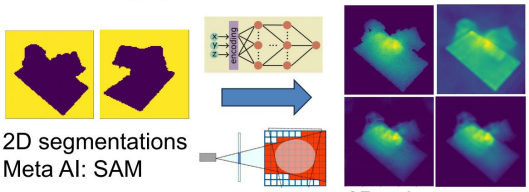
Motivation

- Aim: get 3D object segmentations (useful for robotics, graphics…)



2D segmentations
Meta AI: SAM

3D volume representations

Related Work

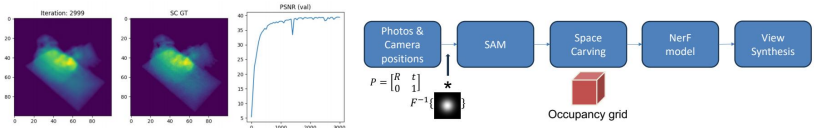
- Implicit volume representation by NeRFs
  - Gradient-based optimization (slow)
  - Compact representation
- Explicit volume representation by space carving (SC)
  - Iterative procedure, use 0-rays to carve out the shape (fast)
  - Memory intensive ($O(n^3)$)

References

[1] Kutulakos and Seitz, "A theory of shape by space carving," IEEE ICCV,1999.
[2] Mildenhall and Ben et al., "Nerf: Representing scenes as neural radiance fields for view synthesis," ACM, 2021.
[3] Kirillov, Alexander et al., "Segment anything," IEEE ICCV, 2023.

New Technique

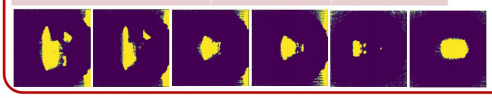
- Use SC to supervise NeRF (3D loss, less ill-posed problem)
- Use NeRF to represent the 3D object shape compactly



Experimental Results

	NeRF	SC	SC + NeRF
PSNR	14.49 dB	38.97 dB	39.38 dB
Memory	82,433	16,777,216	82,433
Runtime	12000 s	3.8 s	3300 s

Gaussian blur	SC	SC + NeRF
No blur	38.97 dB	39.38 dB
$\sigma = 0.5$	28.13 dB	28.37 dB
$\sigma = 0.75$	27.630 dB	27.999 dB
$\sigma = 0.9$	27.627 dB	27.997 dB
$\sigma = 1$	27.54 dB	27.96 dB



SC parameters vs. PSNR