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3D Scanning with NeRF for Movie Makers

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History

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- Phases of development
  - Multi-View Photogrammetry(or so-called structure-from-motion)
  - Hardware scanning with depth sensors
  - AI-based 3D scanning(e.g. NeRF)

Structure-from-Motion

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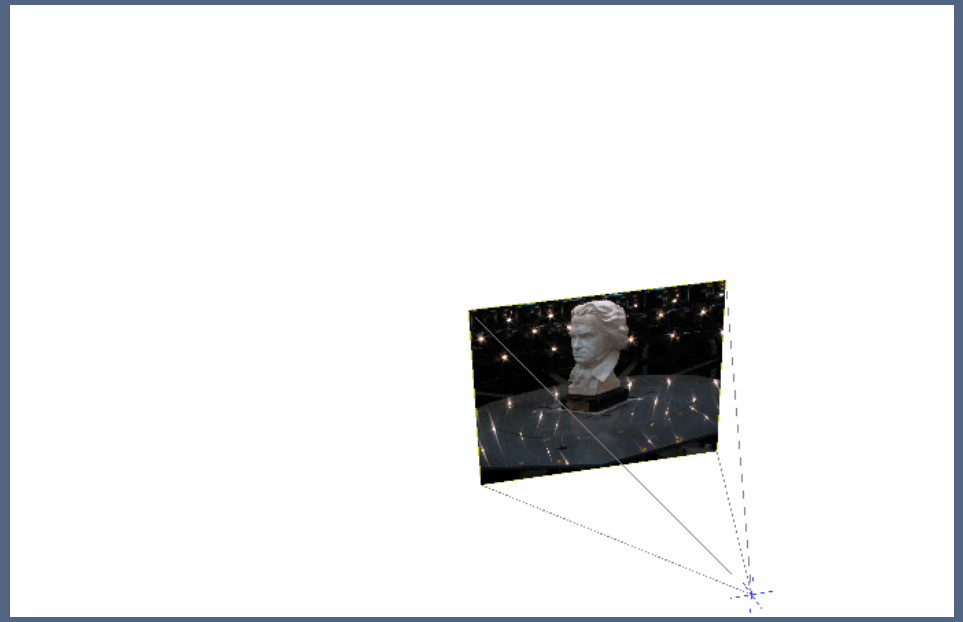
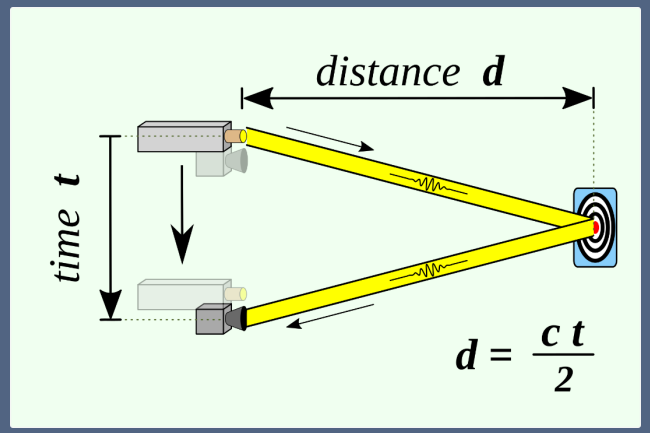
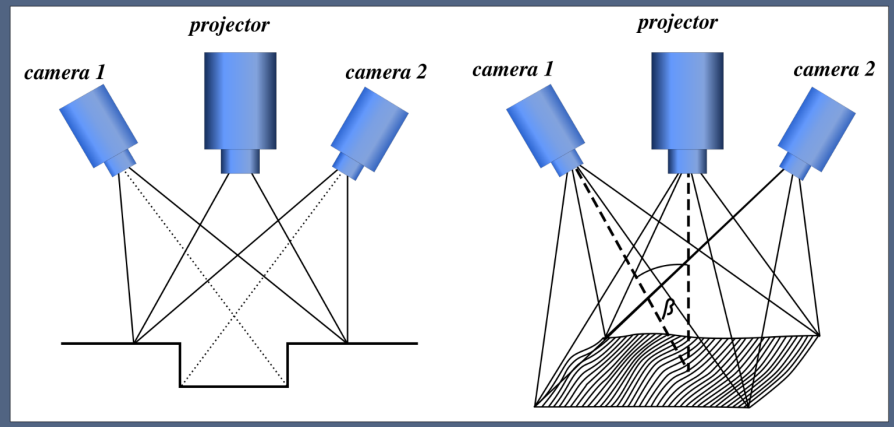


Source: https://cvg.cit.tum.de/research/image-based_3d_reconstruction/multiviewreconstruction

Depth Sensor Technology



Source: https://en.wikipedia.org/wiki/Lidar



Source: https://en.wikipedia.org/wiki/Structured-light_3D_scanner

AI-based Scanning

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"If traditional 3D representations like polygonal meshes are akin to vector images, NeRFs are like bitmap images: they densely capture the way light radiates from an object or within a scene,"

-David Luebke, NVIDIA

Source: https://blogs.nvidia.com/blog/2022/03/25/instant-nerf-research-3d-ai/

Why NeRF?

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- Relighting of the scene
- Fine details are captured
- Reflections can be handled correctly
- Transparency is handled correctly(e.g. glass surfaces)

How does NeRF work?

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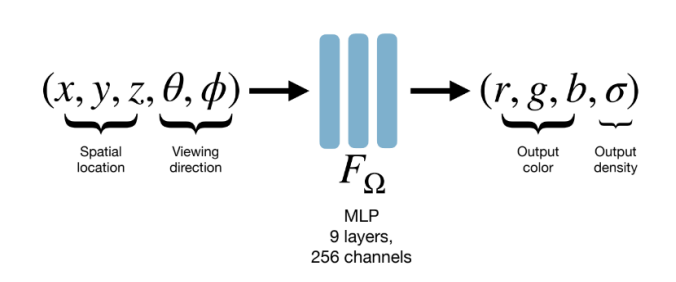
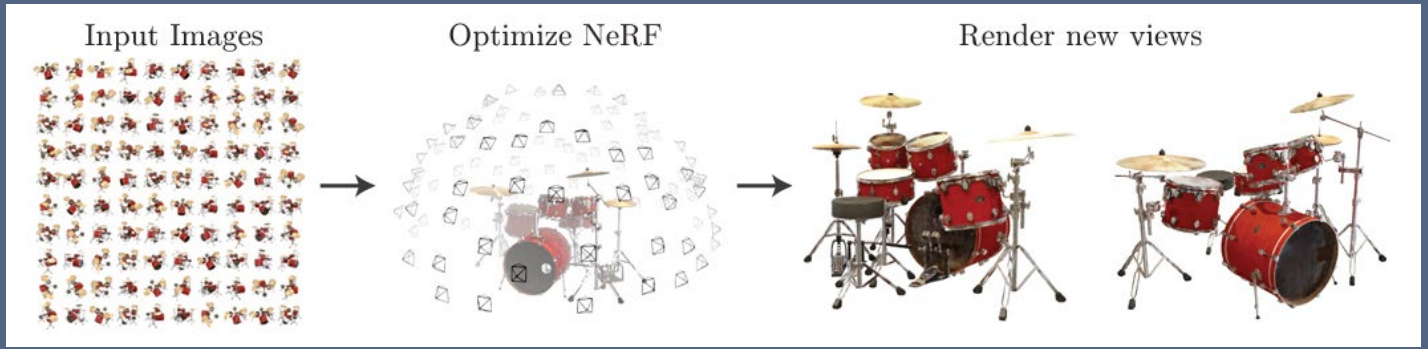
1. For each pixel, march camera rays through scene to gather a set of samples at (**x, d**) locations.
2. Use (**x, d**) points and viewing directions at each sample as input to produce output (c,σ) values (essentially rgbσ).
3. Construct an image using classical volume rendering techniques.

Source: https://towardsdatascience.com/its-nerf-from-nothing-build-a-vanilla-nerf-with-pytorch-7846e4c45666

"NeRFs are a volumetric representation encoded into a neural network. They are not 3D meshes and they are not voxels. **For each point in space the NeRF represents a view dependent radiance.** More concretely each point has a density which describes how transparent or opaque a point in space is. They also have a view dependent color that changes depending on the angle the point is viewed."



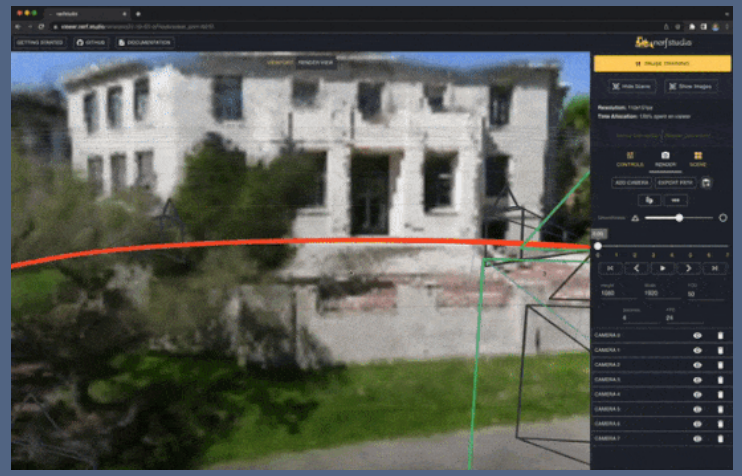


Source: https://arxiv.org/pdf/2003.08934.pdf

Tools

Instant Neural Graphics Primitives

nerfstudio



- “Nerfstudio provides a simple API that allows for a simplified end-to-end process of creating, training, and visualizing NeRFs”

Supported Methods

- **Nerfacto**: our de facto NeRF method combines modules focused on quality with modules focused on faster rendering. Nerfstudio easily lets us experiment with the best of both worlds!
- NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis
- Instant NGP: Instant Neural Graphics Primitives with a Multiresolution Hash Encoding
- Mipnerf: A Multiscale Representation for Anti-Aliasing Neural Radiance Fields
- NerfW: Neural Radiance Fields for Unconstrained Photo Collections
- Semantic NeRF: In-Place Scene Labelling and Understanding with Implicit Scene Representation

Installation

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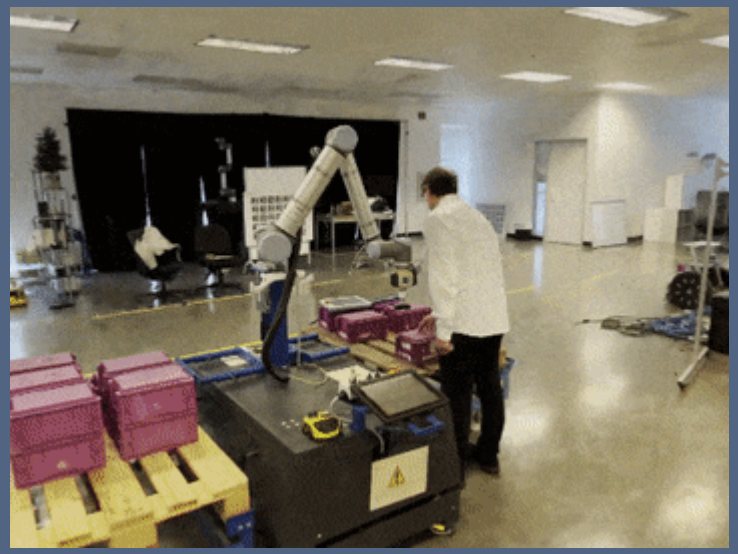
- Easier using a Docker image
- https://docs.nerf.studio/en/latest/quickstart/installation.html

Instant NeRF



- “In all tasks, our encoding and its efficient implementation provide clear benefits: rapid training, high quality, and simplicity”

Comparison of NeRF Methods

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- NeRF: default, slow training and inference times, not recommended(„For most tasks, using the original NeRF model is likely not a good choice and hence we provide implementations of various other NeRF related models…”)
- InstantNeRF: reduced computational complexity, faster training times
- mipNeRF: is better at representing fine details, more eligible for smaller objects to capture details
- NeRFW: better for complex environments, corrections to local illumination properties
- Nerfacto: new method of nerfstudio combining the methods above

How to get good results?

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If any of the following assumptions are broken, the reconstructions may fail completely or contain artifacts such as excess geometry.

- Camera poses are known
- Scene is static, objects do not move
- The scene appearance is constant (ie. exposure doesn't change)
- Dense input capture (Each point in the scene should be visible in multiple images)

Source: https://docs.nerf.studio/en/latest/nerfology/methods/nerf.html

Sample Result

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- Trained only for ***10 mins***
- Video: only 20 seconds

- Up until now, NeRF can be used for static scenes only...

NeRF for Dynamic Scenes

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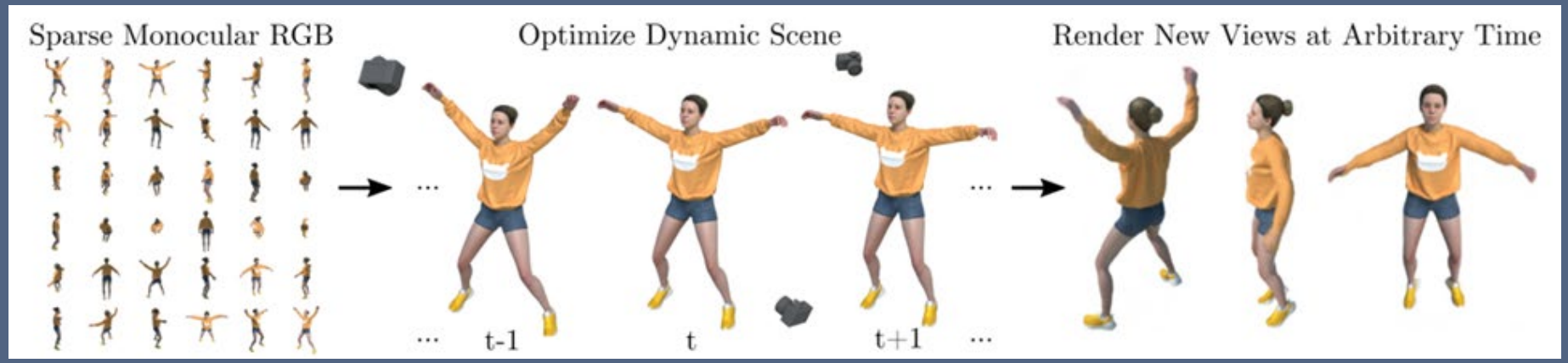
- We need to handle the time aspect correctly

D-NeRF


Sparse Monocular RGB
Optimize Dynamic Scene
Render New Views at Arbitrary Time
t-1
t
t+1

TiNeuVox

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