Twitter Thread by Jia-Bin Huang

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Neural Volume Rendering for Dynamic Scenes

NeRF has shown incredible view synthesis results, but it requires multi-view captures for STATIC scenes.

How can we achieve view synthesis for DYNAMIC scenes from a single video? Here is what I learned from several recent efforts.

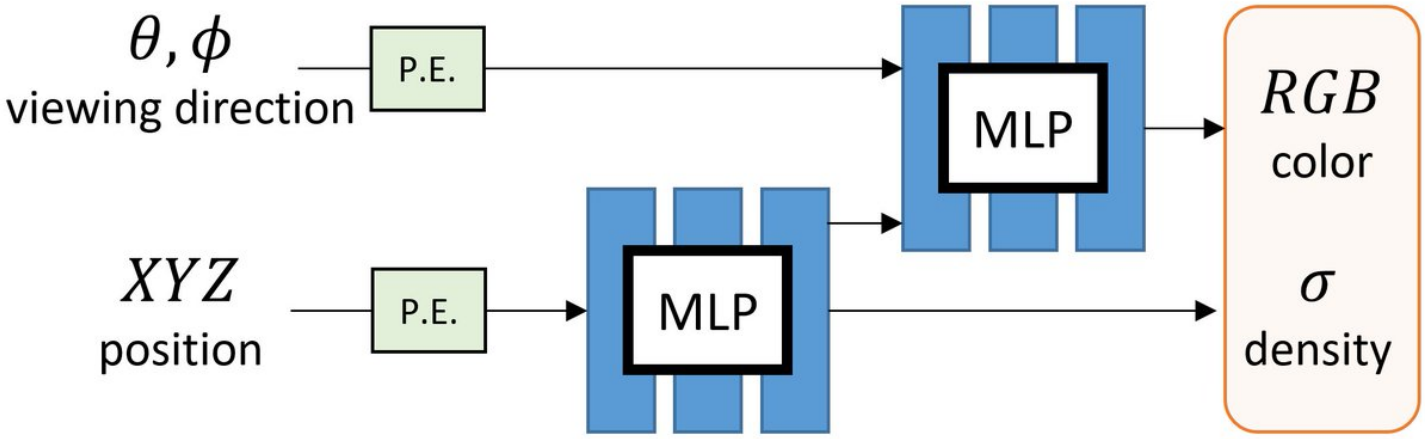
Instead of presenting Video-NeRF, Nerfie, NR-NeRF, D-NeRF, NeRFlow, NSFF (and many others!) as individual algorithms, here I try to view them from a unifying perspective and understand the pros/cons of various design choices.

Okay, here we go.

Background

NeRF represents the scene as a 5D continuous volumetric scene function that maps the spatial position and viewing direction to color and density. It then projects the colors/densities to form an image with volume rendering.

Volumetric + Implicit -> Awesome!



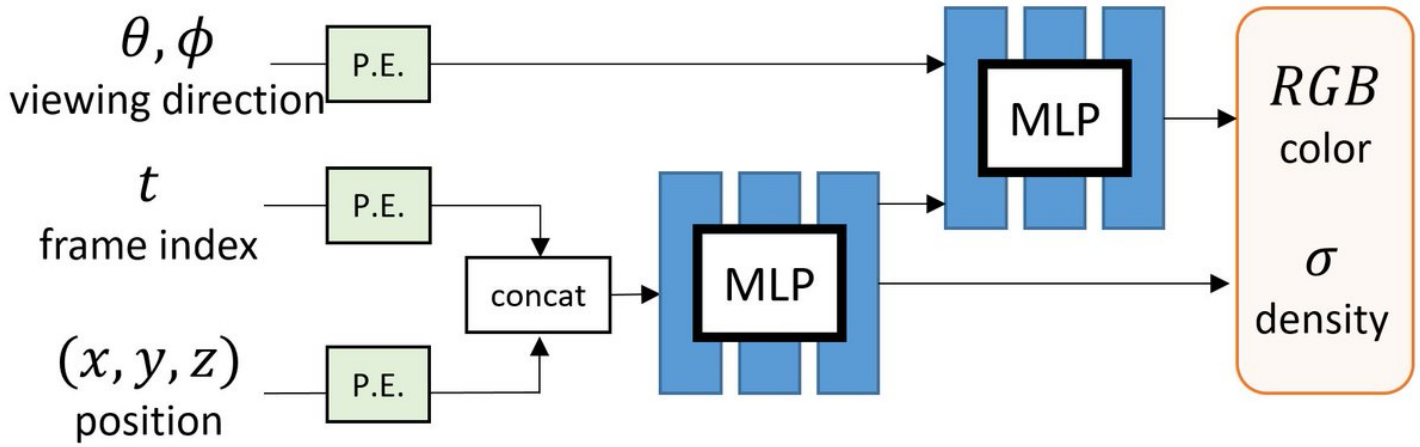
Model

Building on NeRF, one can extend it for handling dynamic scenes with two types of approaches.

A) 4D (or 6D with views) function.

One direct approach is to include TIME as an additional input to learn a DYNAMIC radiance field.

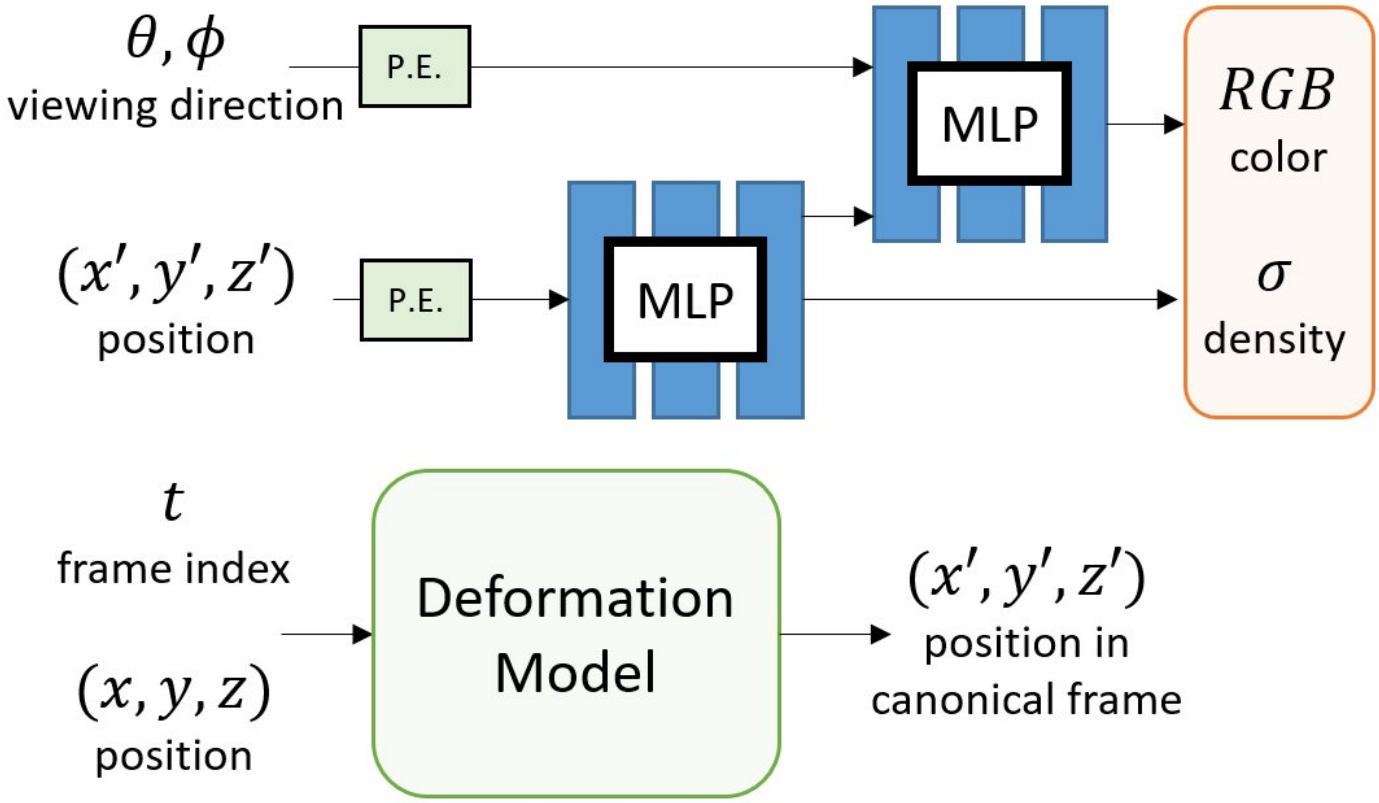
e.g., Video-NeRF, NSFF, NeRFlow



B) 3D Template with Deformation.

Inspired by non-rigid reconstruction methods, this type of approach learns a radiance field in a canonical frame (template) and predicts deformation for each frame to account for dynamics over time.

e.g., Nerfie, NR-NeRF, D-NeRF



Deformation Model

All the methods use an MLP to encode the deformation field. But, how do they differ?

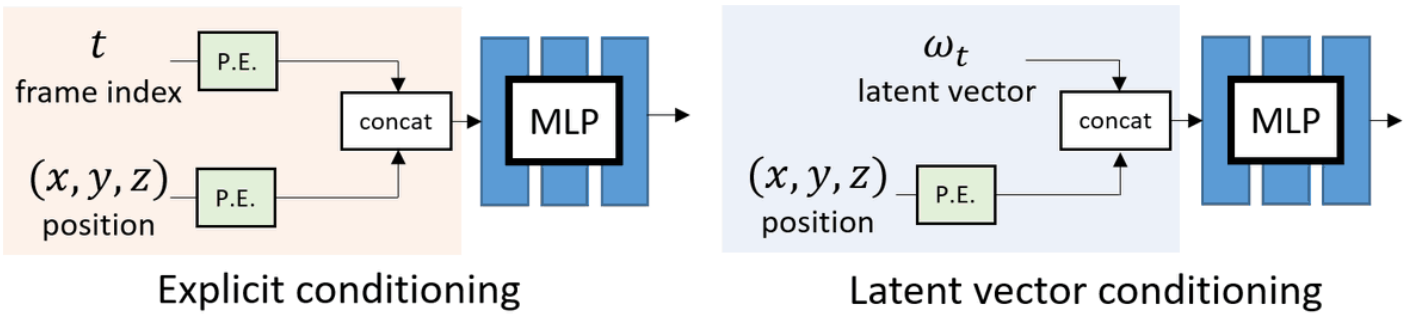
A) INPUT: How to encode the additional time dimension as input?

B) OUTPUT: How to parametrize the deformation field?

A) Input conditioning

One can choose to use EXPLICIT conditioning by treating the frame index t as input.

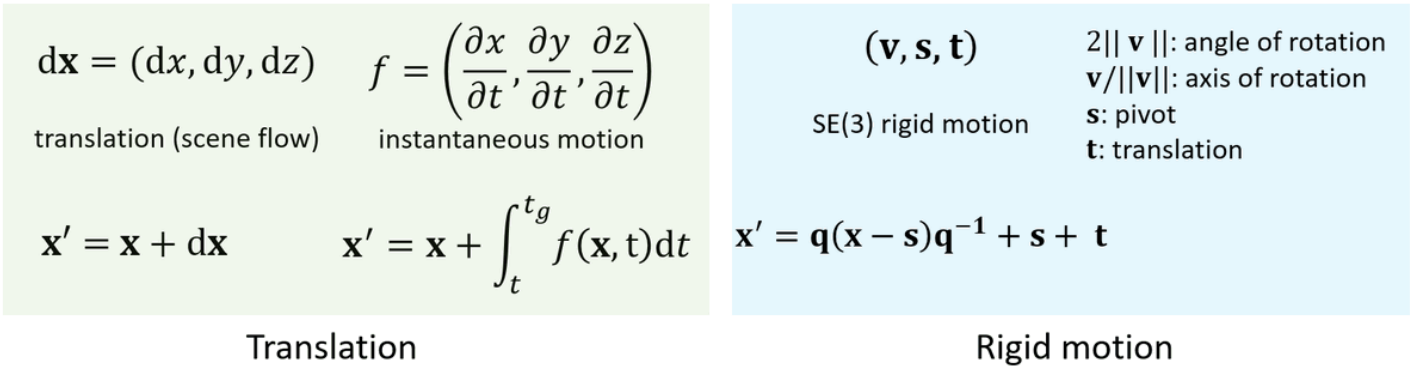
Alternatively, one can use a learnable LATENT vector for each frame.



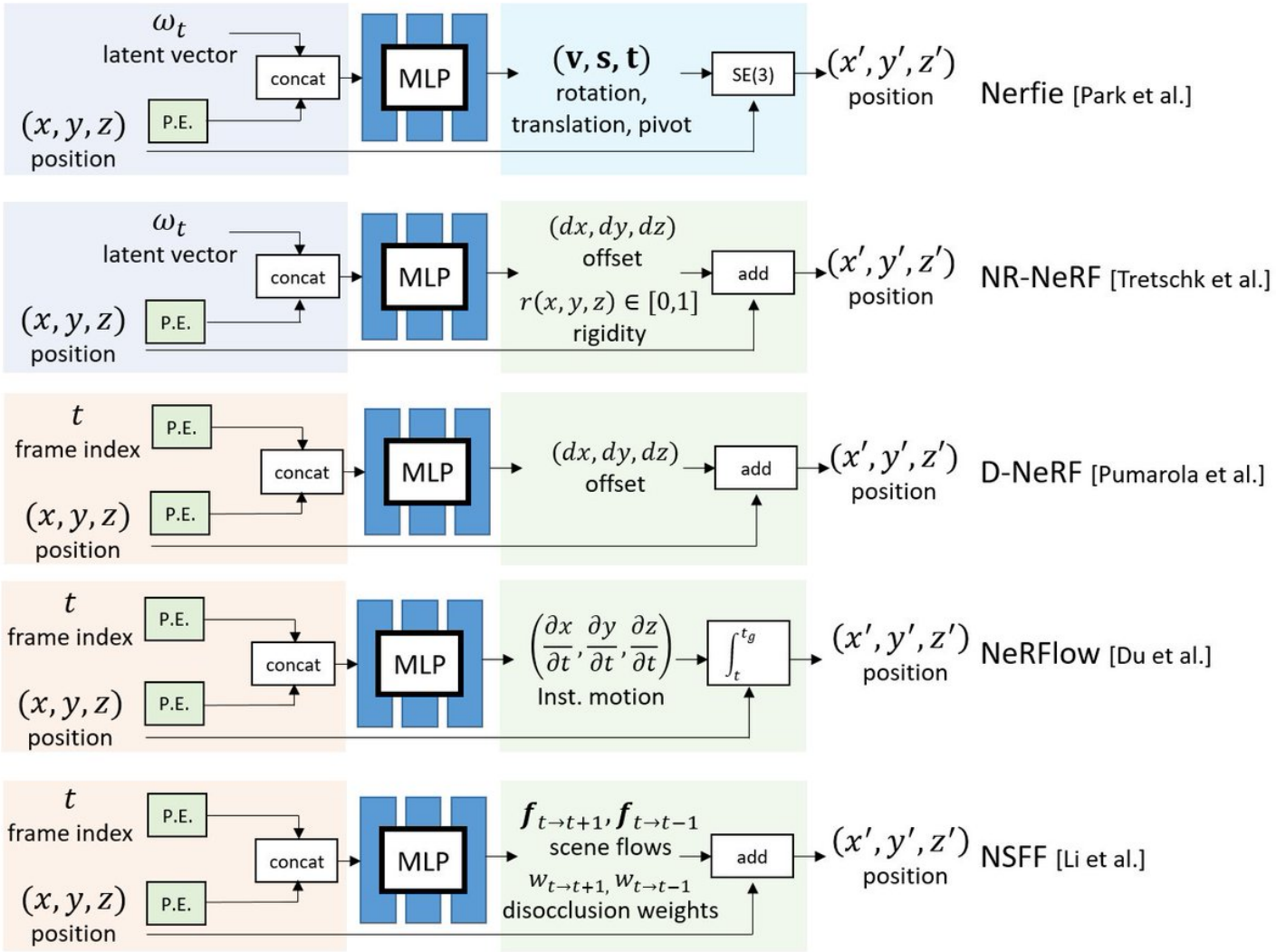
B) Output parametrization

We can either use the MLP to predict

- dense 3D translation vectors (aka scene flow) or
- dense rigid motion field



With these design choices in mind, we can mix-n-match to synthesize all the methods.



Regularization

Adding the deformation field introduces ambiguities. So we need to make it "well-behaved", e.g., the deformation field should be spatially smooth, temporally smooth, sparse, and avoid contraction and expansion.