Ray Deformation Networks for Novel View Synthesis of Refractive Objects

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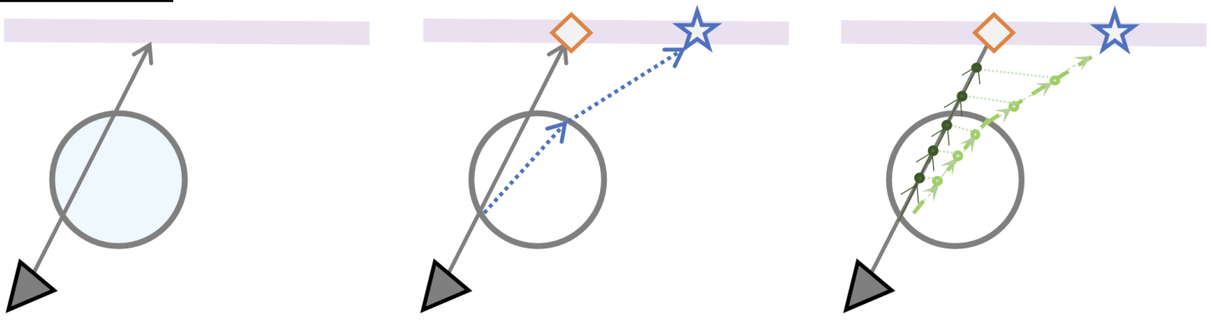
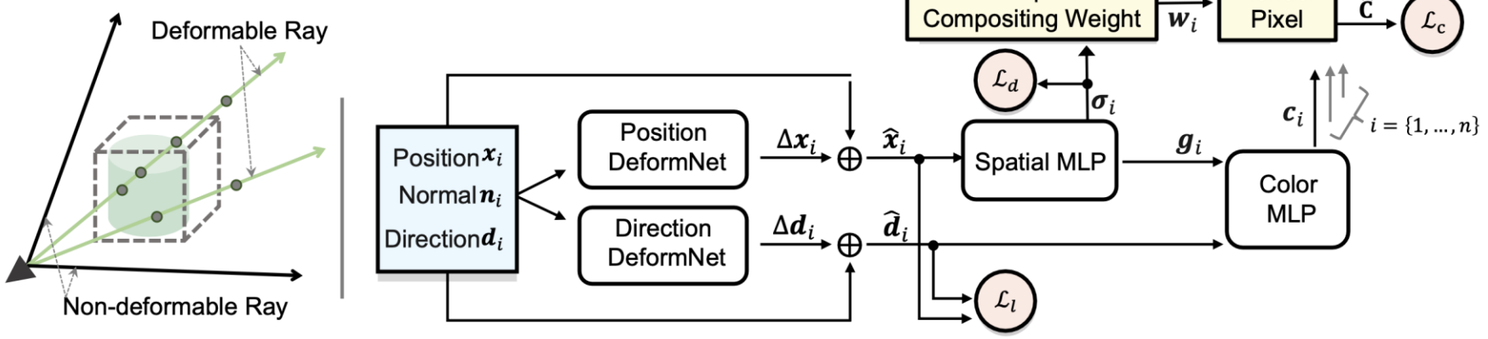
I Motivation



(a) Opaque Object (b) Refractive Object (c) Ray Deformation

- NeRF methods learn the density field based on **light transports along straight path**
- When light paths intersect refractive objects, **they may curve** (dashed line), depending on the angle of incidence
- We propose to **bend the light rays** by predicting position and direction offsets for sample points along the rays

II Ray Deformation Networks



(a) Identify deformable ray

Roughly draw bounding boxes on few training views and project into 3D space

(b) Ray Deformation

Predict offsets for the sample points along deformable ray

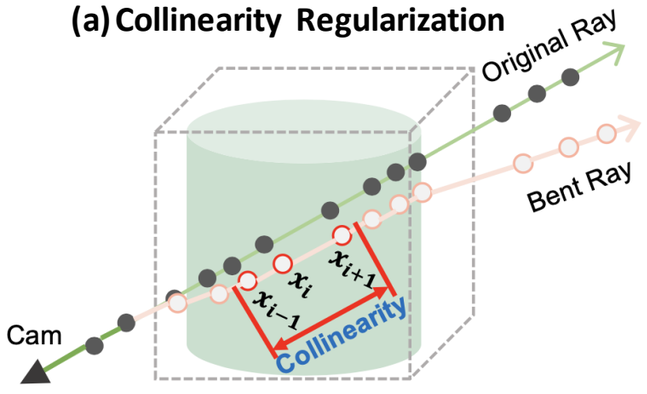
(c) NeRF Modeling

Compute density and color on deformed rays for rendering

- ✖ Known geometry
- ✖ Controlled setup
- ✖ Refractive index
- ✖ Infinitely distant background

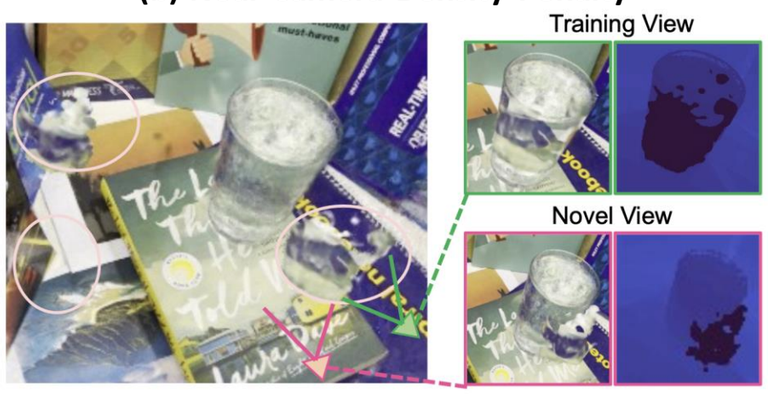
III Regularization

(a) Collinearity Regularization



- Snell's law: refracted rays are piece-wise linear
- Encourage neighborhood points to be linear

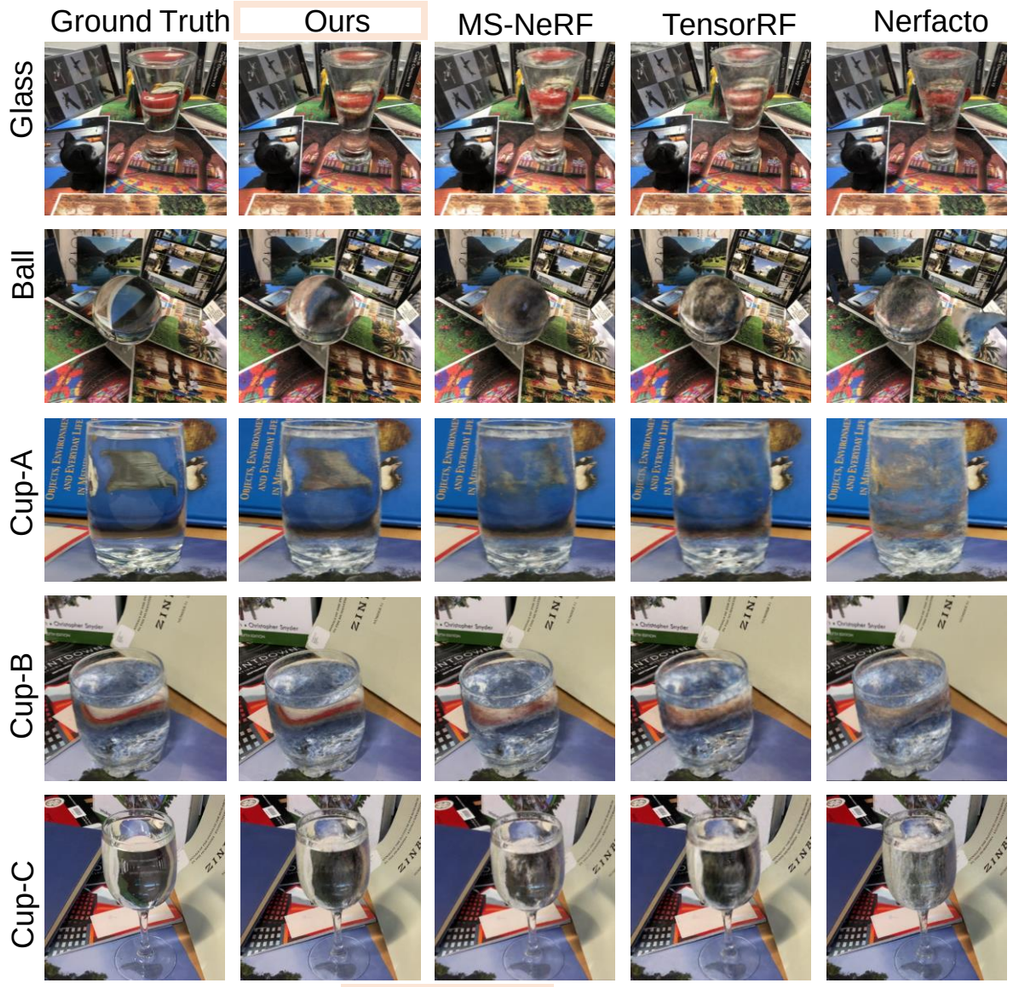
(b) Near-Camera Density Penalty



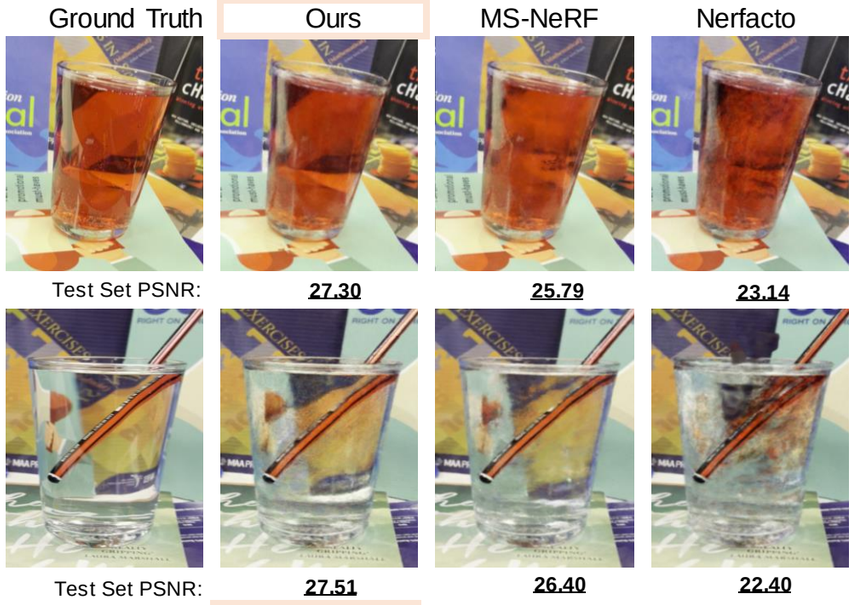
- NeRF tends to produce artifacts near the camera
- Penalize the density field near camera to be empty

IV Experiment

Improved Novel View Synthesis



Robust to Tint and Occlusion



Improved Geometry