Neural Lens Modeling

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Motivation

Camera lenses come in all kinds of forms and shapes

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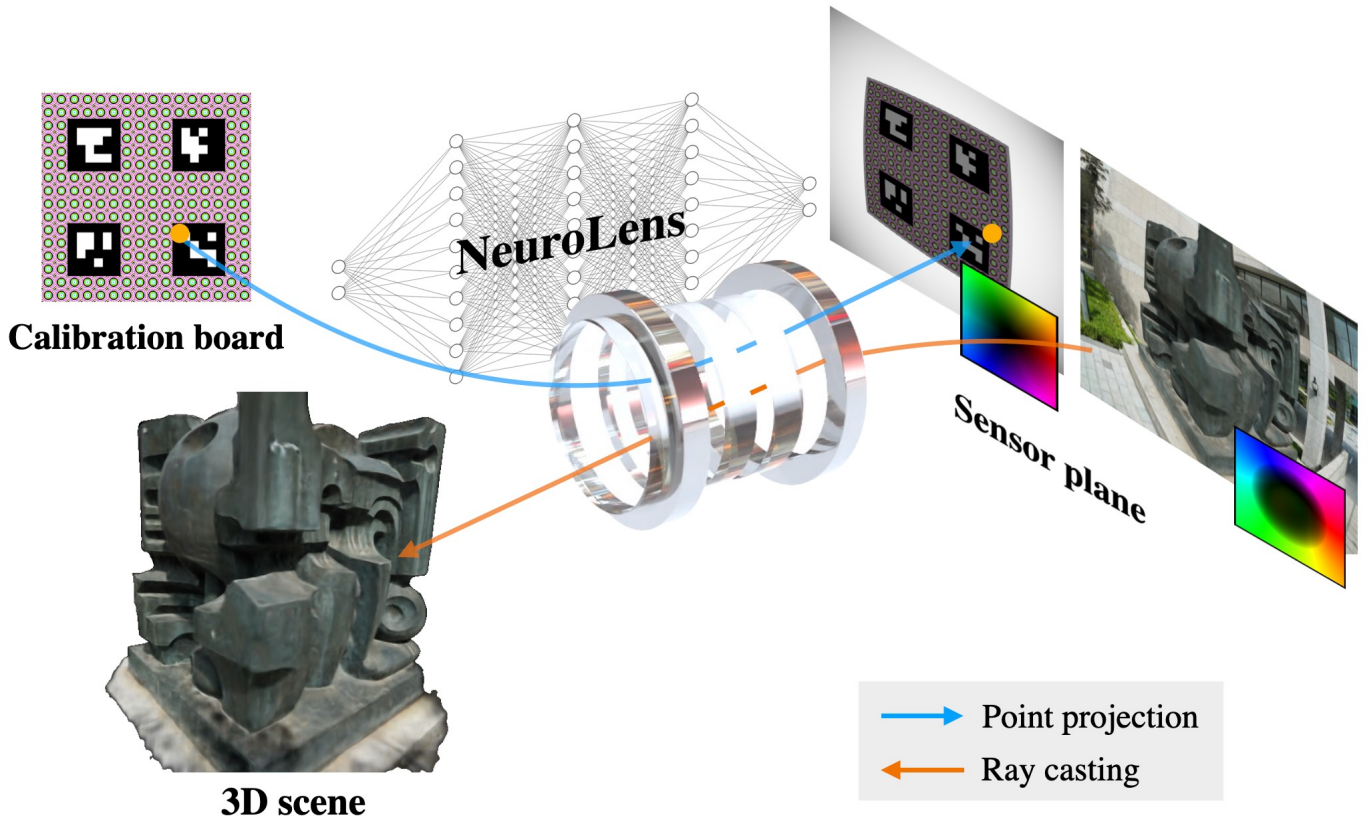
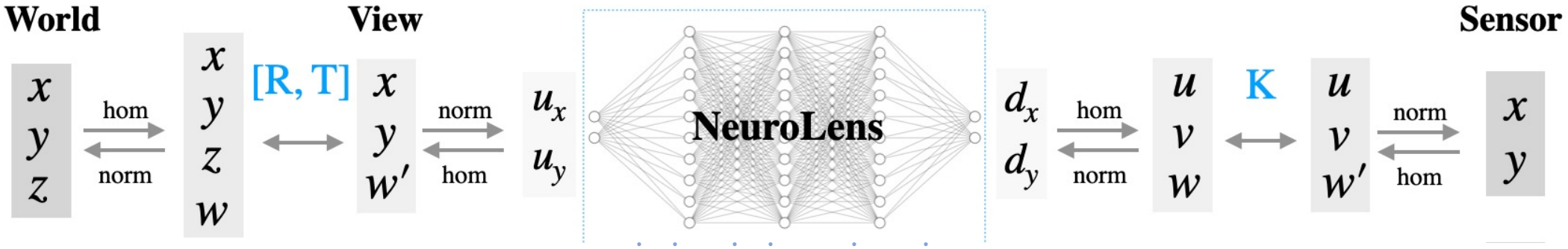
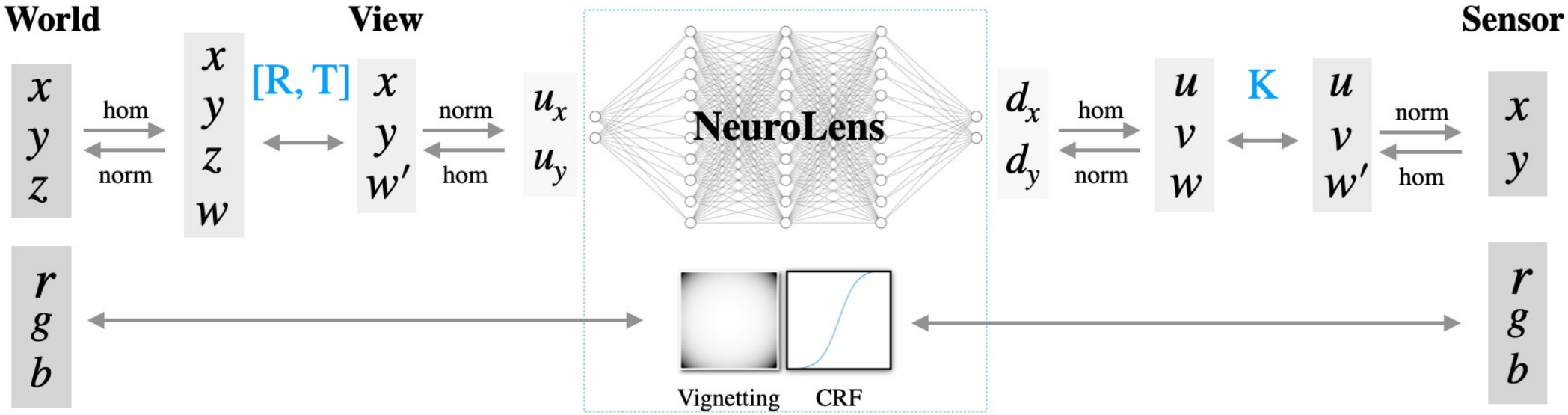
Existing lens models lack easy integration into differentiable rendering pipelines



Camera lens model

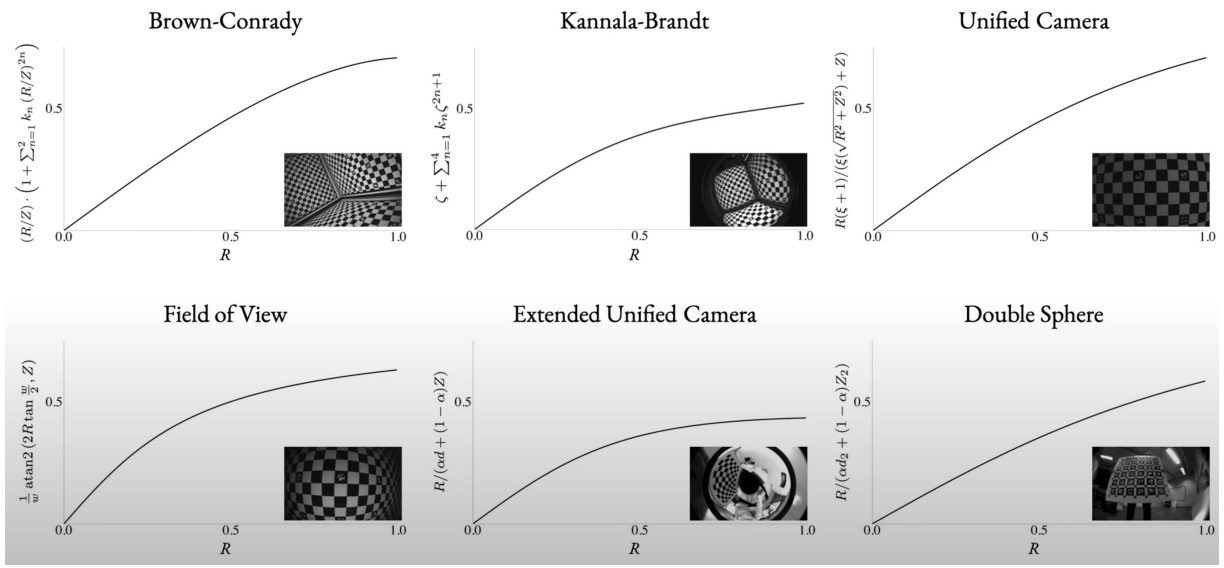


Camera lens model



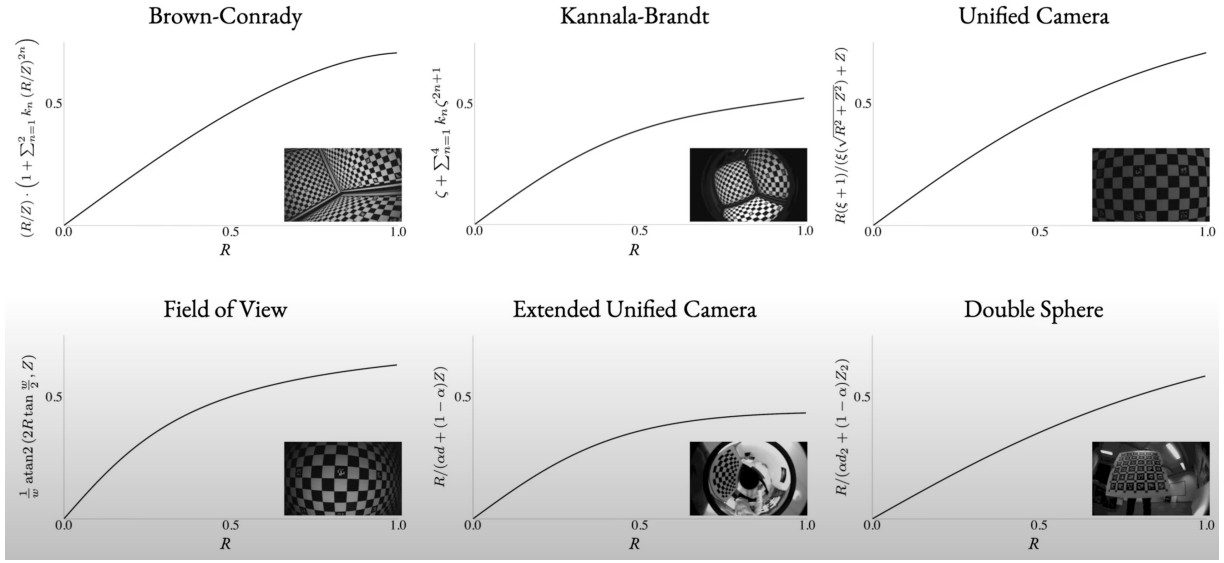
Existing camera lens model

Parametric model

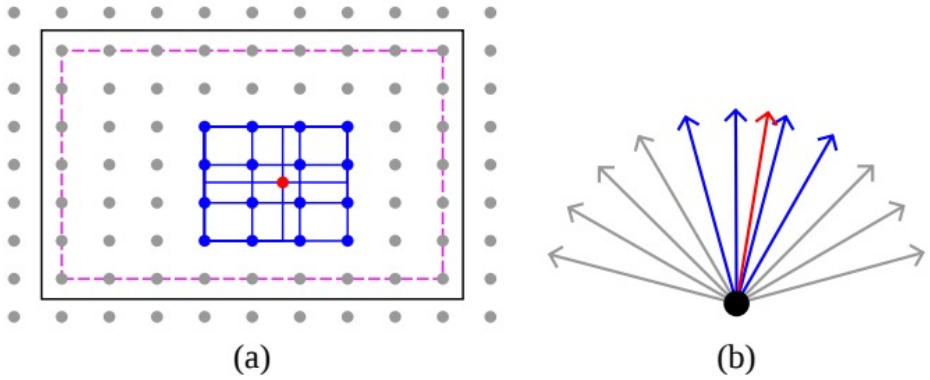


Existing camera lens model

Parametric model



Generic model



Schops et al. 2020 (“Why Having 10,000 Parameters in Your Camera Model is Better Than Twelve”)

Key insight

Use INNs to model camera lens distortion as **diffeomorphism**

Invertible Neural Networks (INNs) are bijective function approximators which have a **forward mapping**

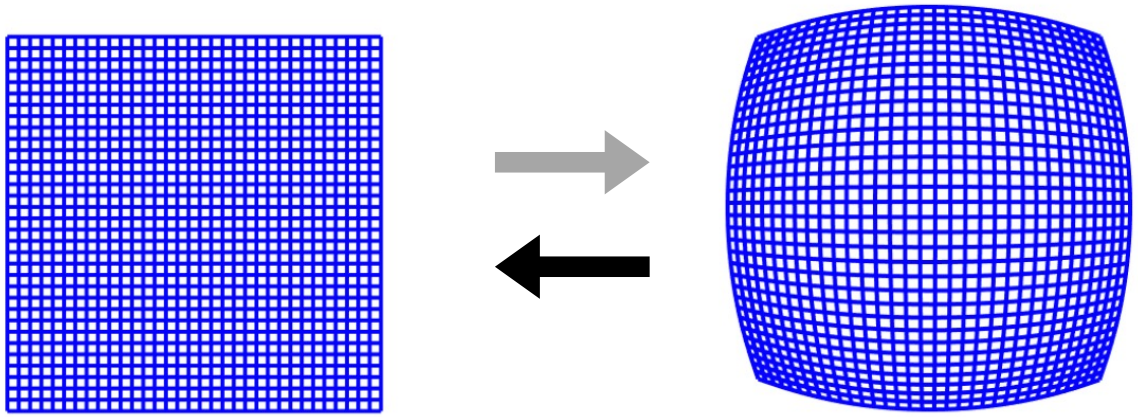
$$F_\theta : \mathbb{R}^d \to \mathbb{R}^d$$

$$x \mapsto z$$

and an **inverse mapping**

$$F_\theta^{-1} : \mathbb{R}^d \to \mathbb{R}^d$$

$$z \mapsto x$$



Camera pre-calibration steps

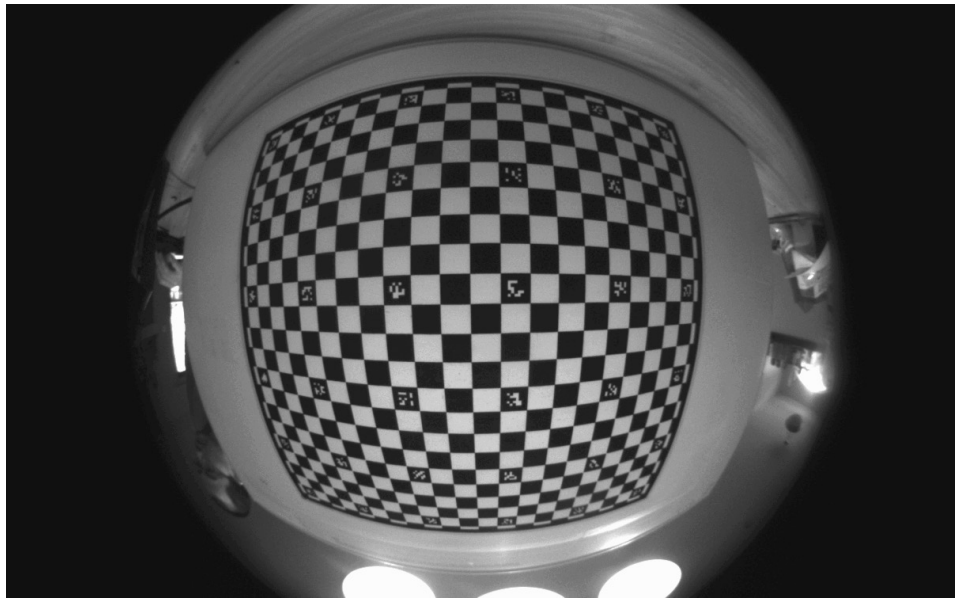
OmniVision camera collected by BabelCalib

Data capture

Feature extraction

Model initialization

Model optimization



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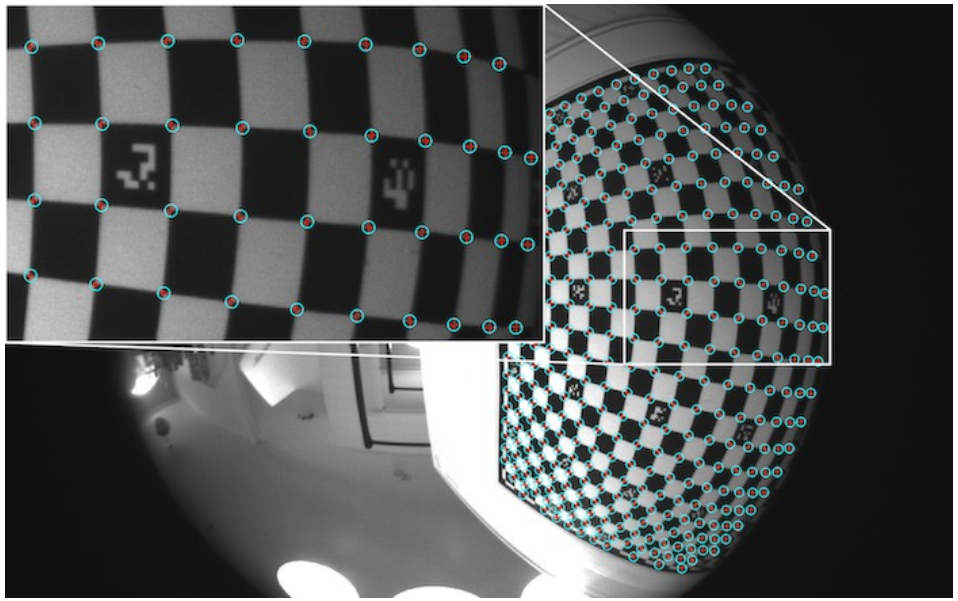
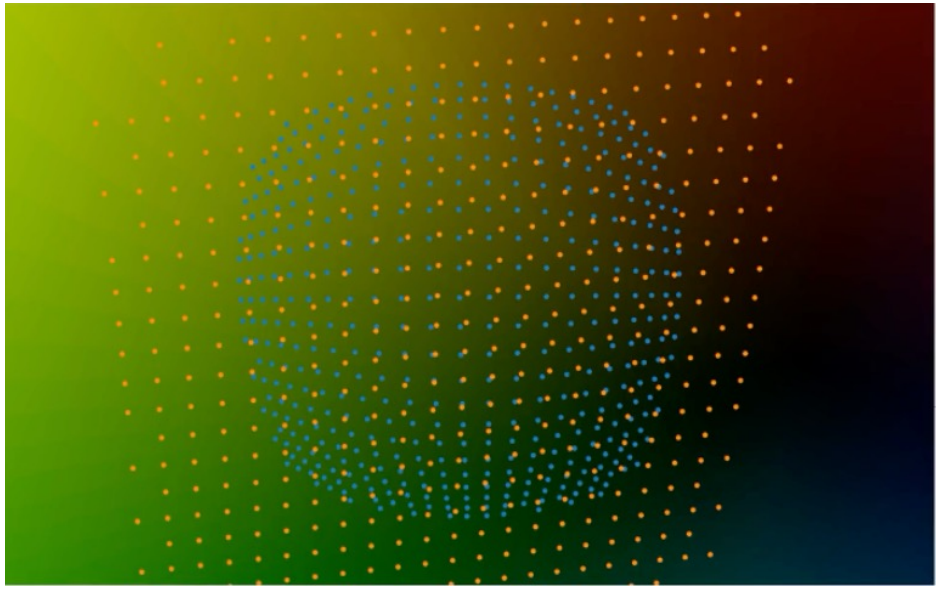
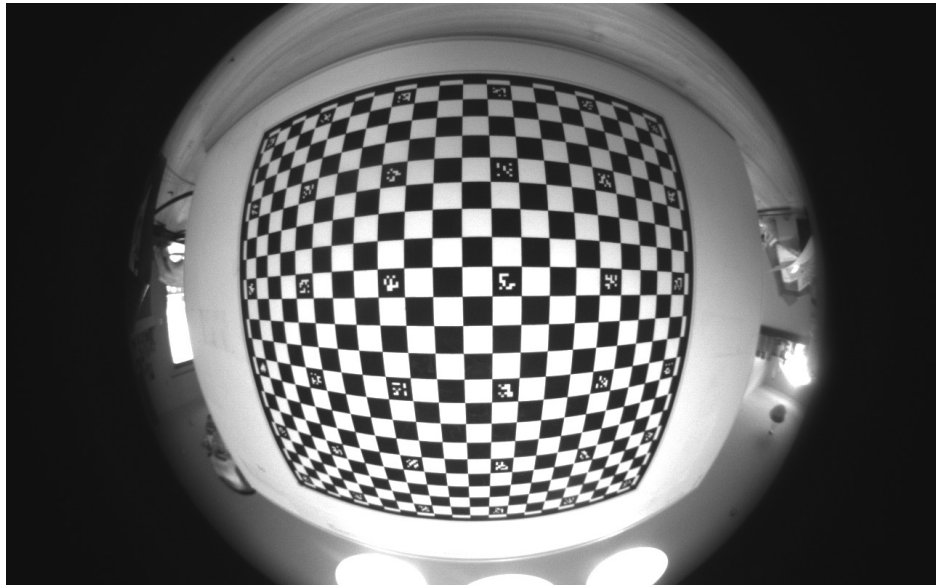


Camera pre-calibration steps

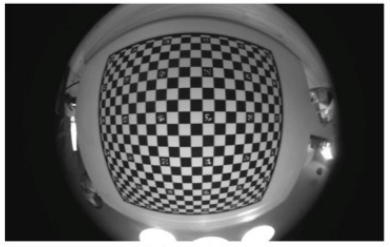
Data capture | Feature extraction | **Model initialization** | Model optimization



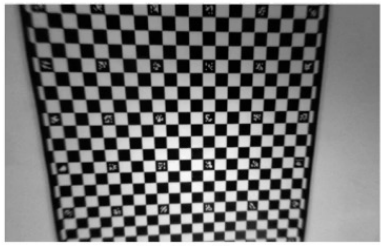


Camera pre-calibration steps

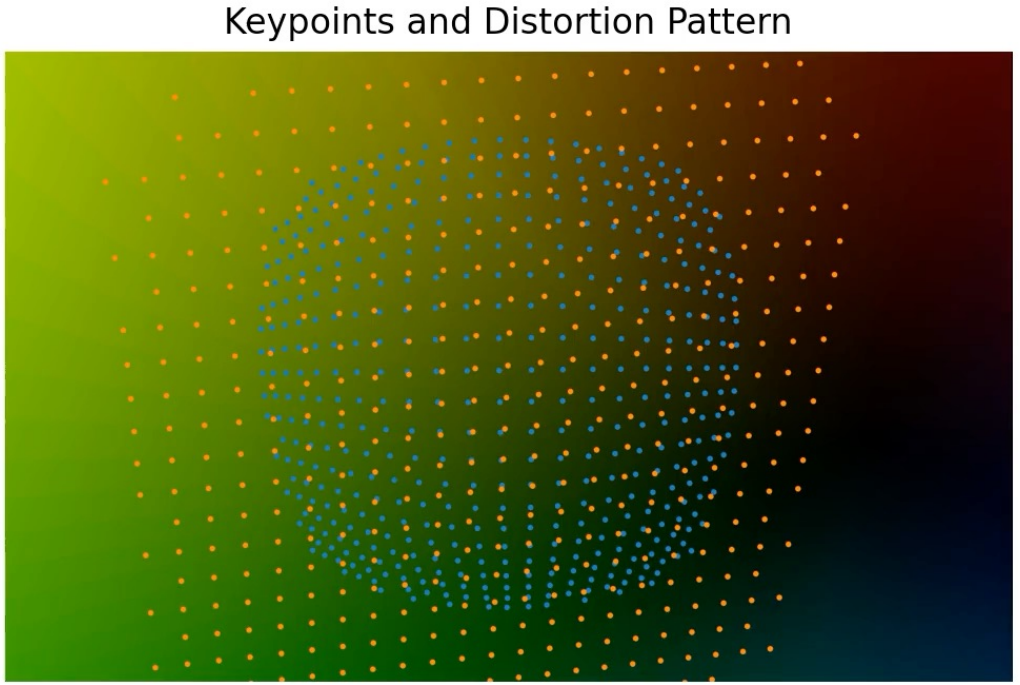
Data capture | Feature extraction | Model initialization | **Model optimization**

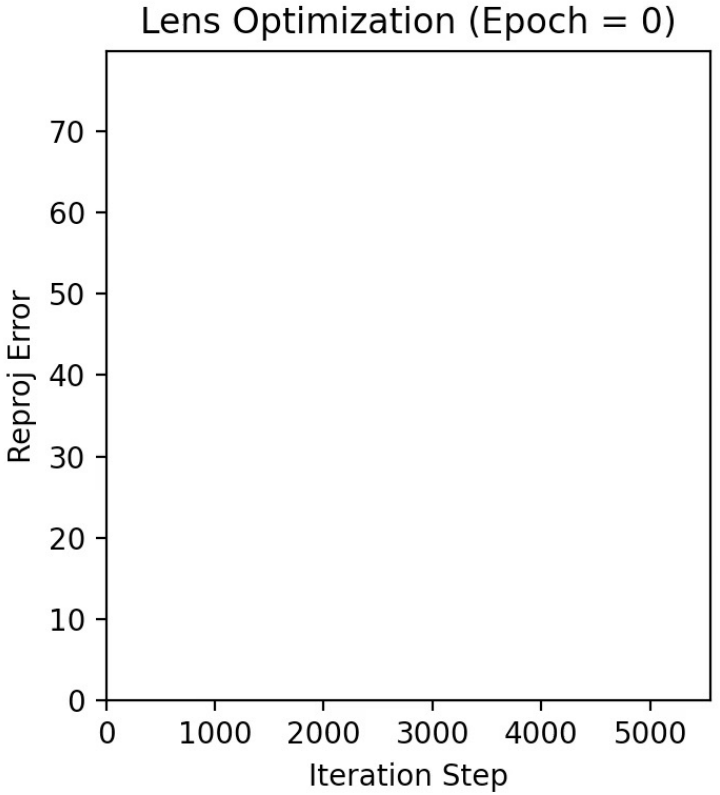


Fisheye View



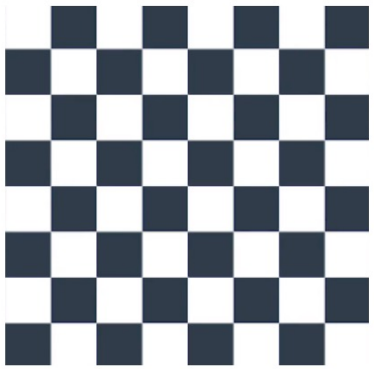
Undistortion



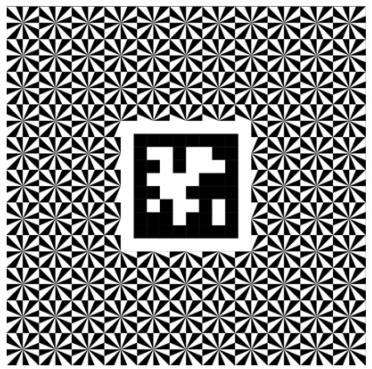


Marker-based Calibration

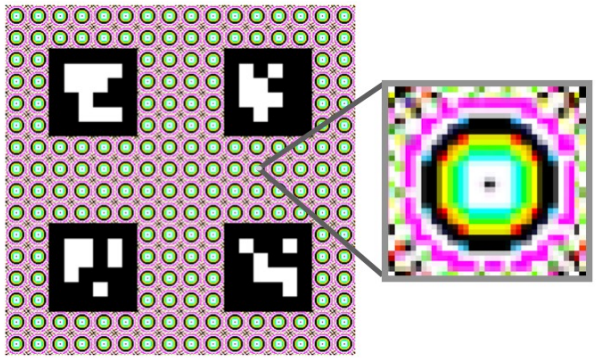
Our proposed keypoint marker jointly optimized with a keypoint detect



Checkerboard



Schops et al.



Ours

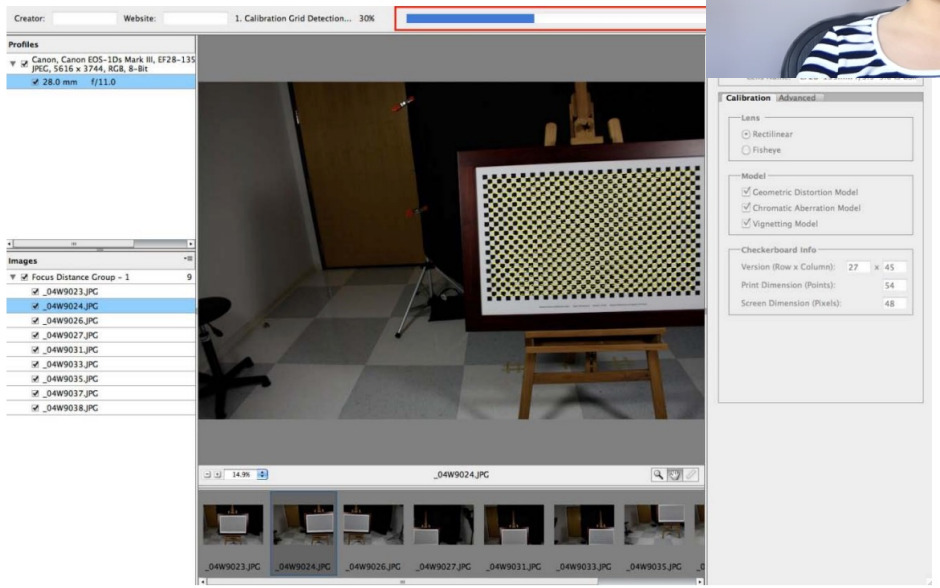
SynLens dataset

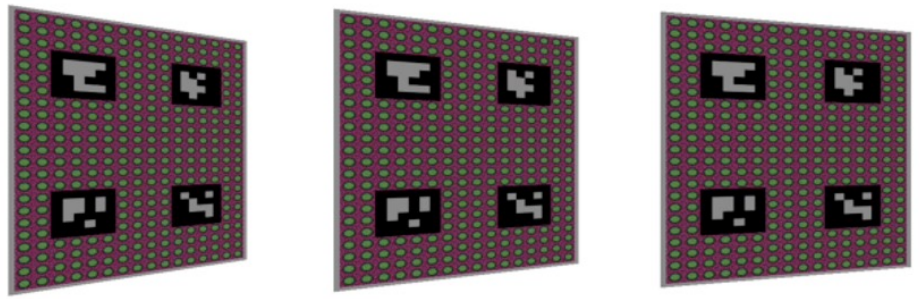
LensFun: 40 different camera makers

e.g. Canon, Nikon, action cams, etc.

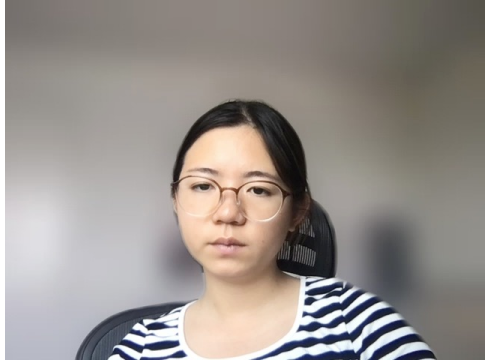
- 10 different Lens models for each camera
- Field of view between 60 to 80 degrees
- Distortion model types:

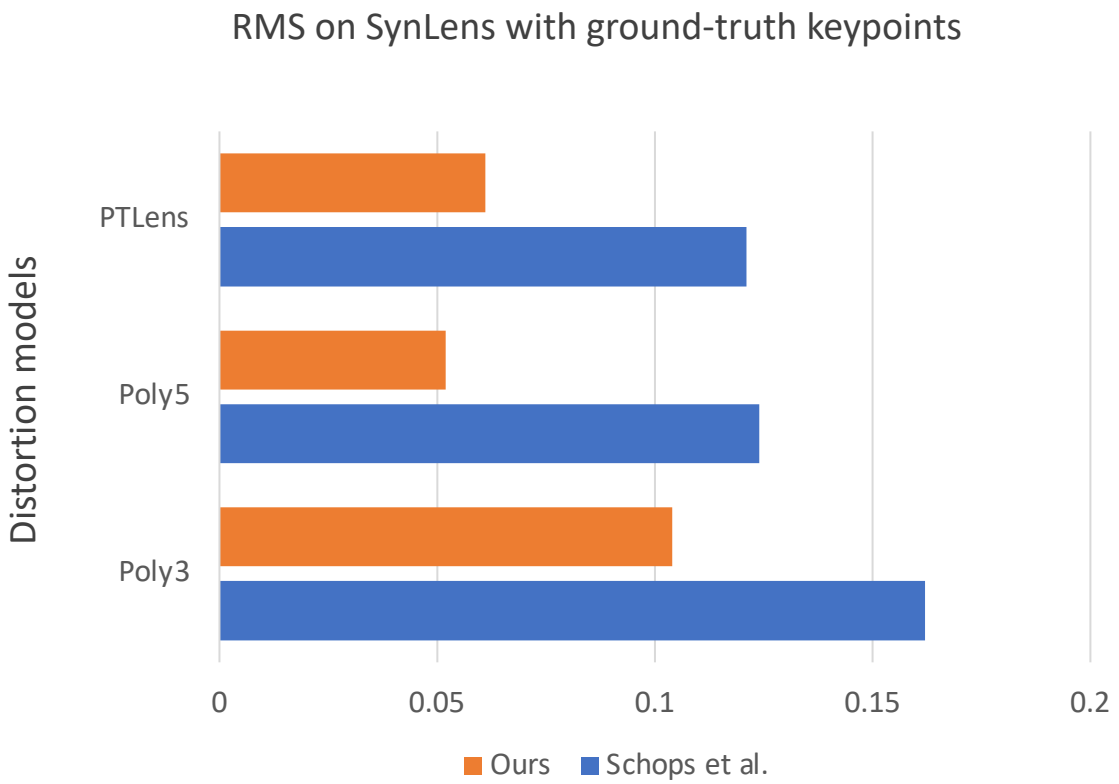
Poly3, Poly5, PTLens

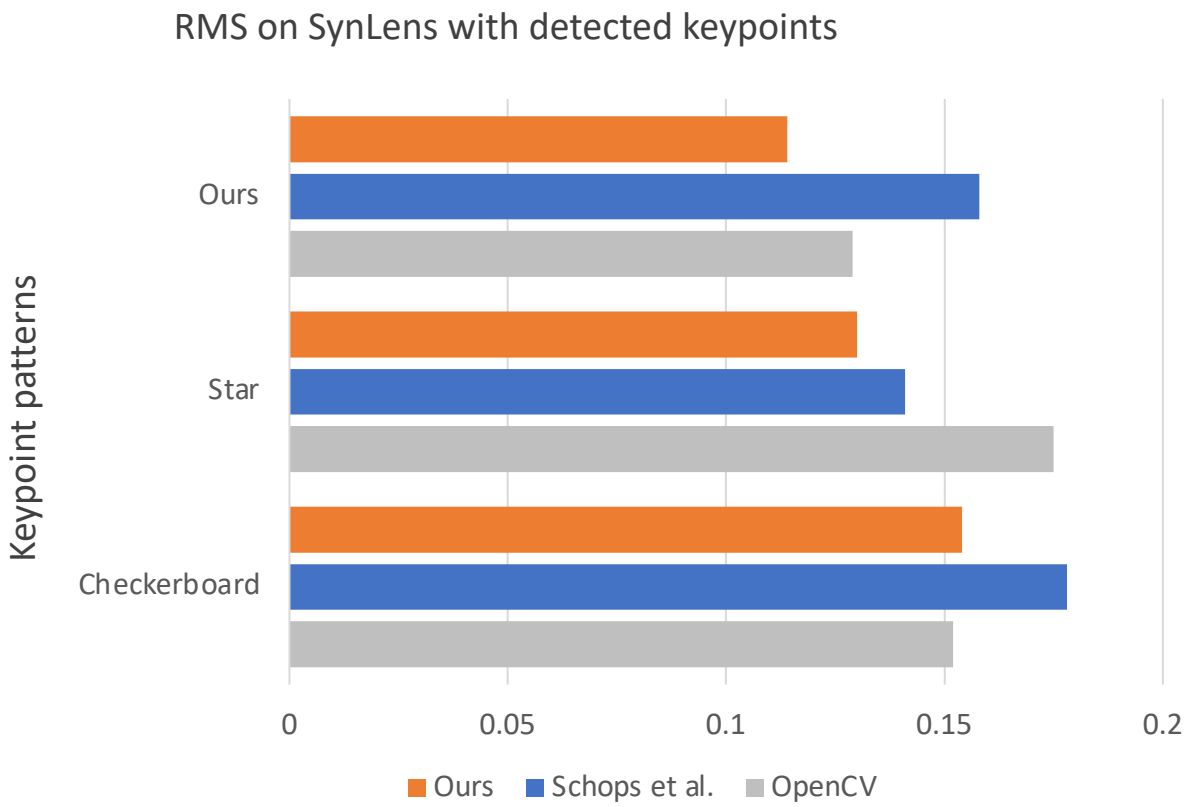




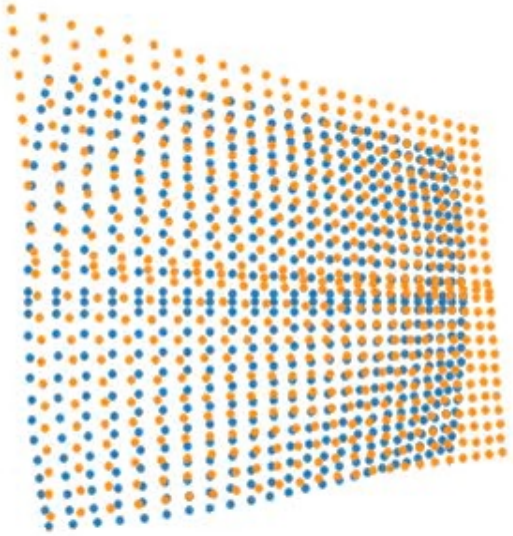
Evaluation on SynLens







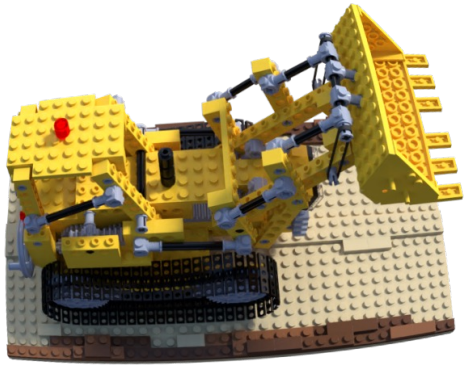
i-ResNet vs. ResNet

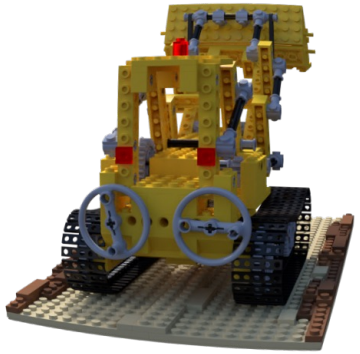


i-ResNet

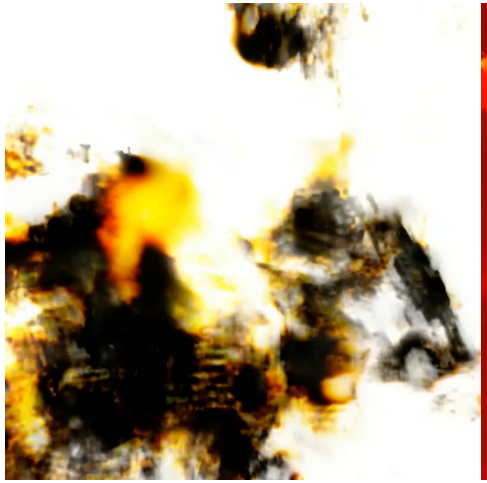
ResNet

NeRF with NeuroLens

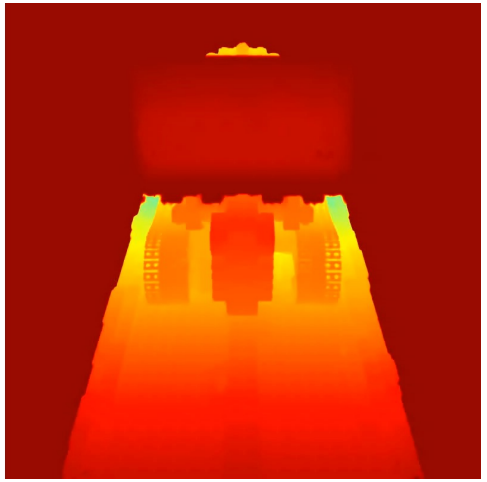




Input views



NeRF (val)



Ours undistorted (val)

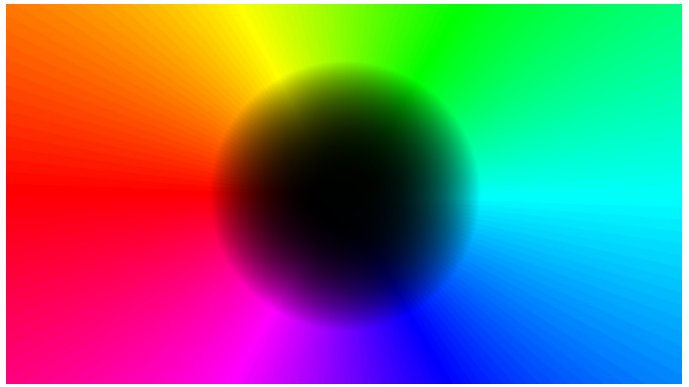
NeRF with NeuroLens

Ground truth

Self Calibrating NeRF (train)

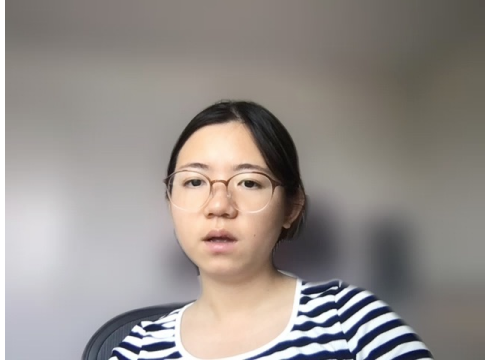
Ours (train)

Ours undistorted (novel view)



Distortion pattern

Summary



- Generic lens distortion model that generalizes across many lens types, easy to implement and extend;
- A new keypoint pattern and a large-scale camera lens benchmark for evaluating the performance of marker detection and camera calibration;
- Integration of the proposed method into a neural rendering pipeline.