Image Enhancement Using Calibrated Lens Simulations

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C S A I L

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Contribution

- We compute PSFs using the lens CAD model, called lens prescription, by geometric-wave hybrid ray tracing

- We can predict PSFs at any positions and focal distances

- We take the spec and measured PSFs at a single distance as input, calibrate the accurate lens prescription for image enhancement

Goal: Remove optical aberrations

- All lenses have optical aberrations [Seidel, 1856]

  ❑ Spherical aberration   ❑ Chromatic aberration

  PSF   PSF

- The restoration requires lens point spread functions (PSFs)

- PSFs are spatially-variant, and changing with focal distance. Measuring all PSFs is expensive

Motivation

- The simulation is different from the measurement

Measured PSFs

Simulated PSFs using lens prescription from the spec

- The lens manufacturing tolerance can cause the actual lens prescription different from the spec

Our Method

- We can predict PSFs at any positions and focal distances

- The lens prescription includes
  - Number of glasses-
  - Dispersion function
  - Radius, xyz positions of each glass

- Calibrate the lens prescription using damped gradient descent

Experiments

6mm #58202

18mm #54857   12mm #54854

❑ PSFs measurement

Lens

Camera

Pinhole arrays (light sources) 20x20 holes

Results

- Fitting set

- Unfitted set

unfitted | fitted

Cross Validation

- Fitting using measurement at 279 mm, and synthesize PSFs at 368 mm

Fitted

Measure

Unfitted