Image Enhancement Using Calibrated Lens Simulations

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Contribution

- We compute PSFs using the lens CAD model by hybrid geometric-wave ray tracing
- The lens CAD model is fitted to measured data from a single picture
- The fitted model is used to predict PSFs at any position and focal distance

Goal: Remove optical aberrations

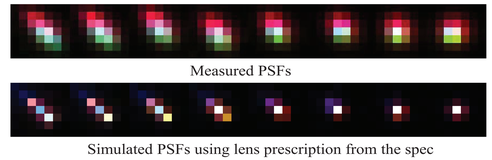
- All lenses have optical aberrations [Seidel, 1856]

❑ Spherical aberration ❑Chromatic aberration

- The restoration requires lens point spread functions (PSFs)
- PSFs are spatially-variant, and change with focal distance. Measuring all PSFs is time consuming

Motivation

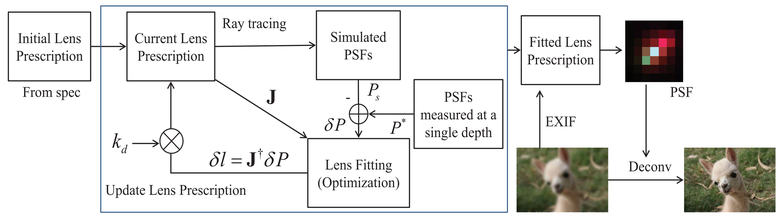
- The simulation is different from the measurement



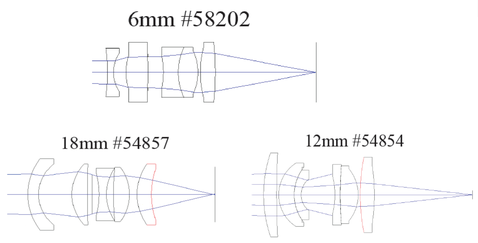
- The actual lens prescription differs from the CAD model because of manufacturing tolerances

Our Method

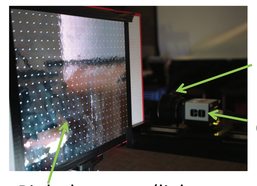
- We can predict PSFs at any positions and focal distances
- The lens prescription includes
  - Number of lens elements
  - Dispersion function
  - Radius, xyz positions of each glass
- Calibrate the lens prescription using damped gradient descent



Experiments

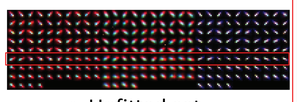


❑ PSFs measurement

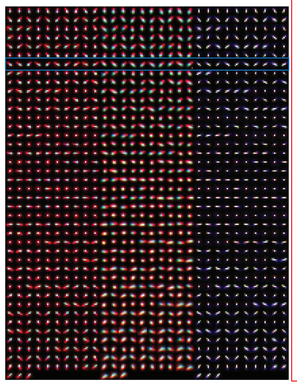


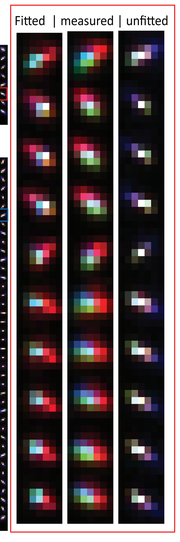
Results

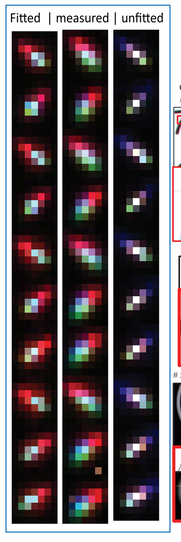
- Fitting set

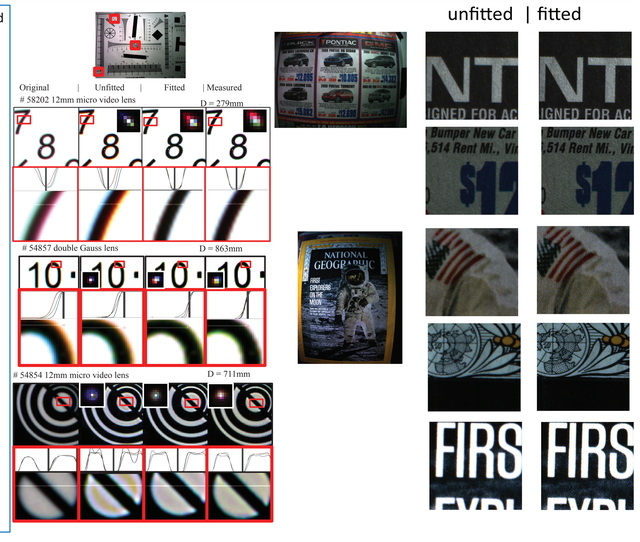


- Unfitted set









Cross Validation

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