Phase Retrieval by a Conditional Wavelet Flow: Applications to Near-field X-ray Holography

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Near-Field X-ray Holography

Conventional algorithms
- Assume certain object properties and optical propagation regimes
- Time-consuming process of tuning a wide range of free parameters
- Inference: minutes/projection

Machine learning-assisted phase retrieval
- Fast inversion for large image datasets
- Parallelized training of different image resolutions
- Inference: seconds/projection

Fresnel free-space propagator:
\[ \mathcal{D}_F(\Psi) = z^{-1} \exp \left( \frac{-i\pi}{\lambda z} \right) \exp \left( \frac{-i\pi}{2 \lambda r} \right) \exp \left( \frac{-i\pi}{2 \lambda r} \right) \]

The dimensionless Fresnel number used as a single parameter shows the generality and transferability of the model.

Conditional Wavelet Flow

Training
- Input x is decomposed by a Haar wavelet transform.
- Coupling layers learn the conditional distribution of the details. The remaining average is forwarded to the next Conditional Wavelet Flow level.
- Hologram is used as a conditional input from which features are extracted from.

Reconstruction
- To reconstruct images with the trained model, the “flow” is simply reversed (from z to x).
- The path of the hologram remains the same.

The number of trainable parameters and FLOPs stand for model capacity and complexity, respectively.

↑ model capacity and complexity,
↑ computational resources and time

References