

Using Supervised Learning for Strain Analysis of 4DSTEM Datasets

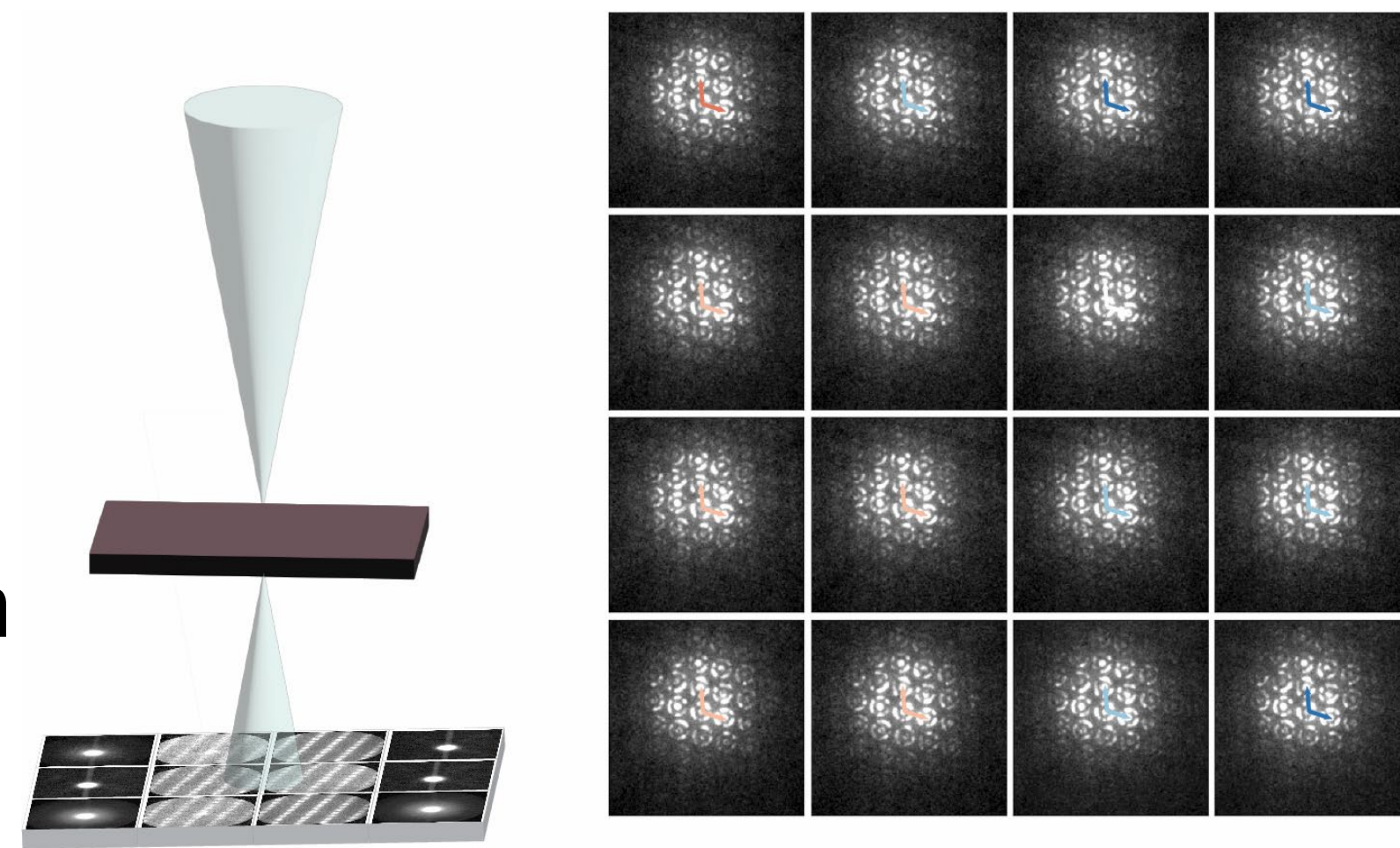
Miti Shah

Department of Electrical Engineering, Stanford University

Motivation

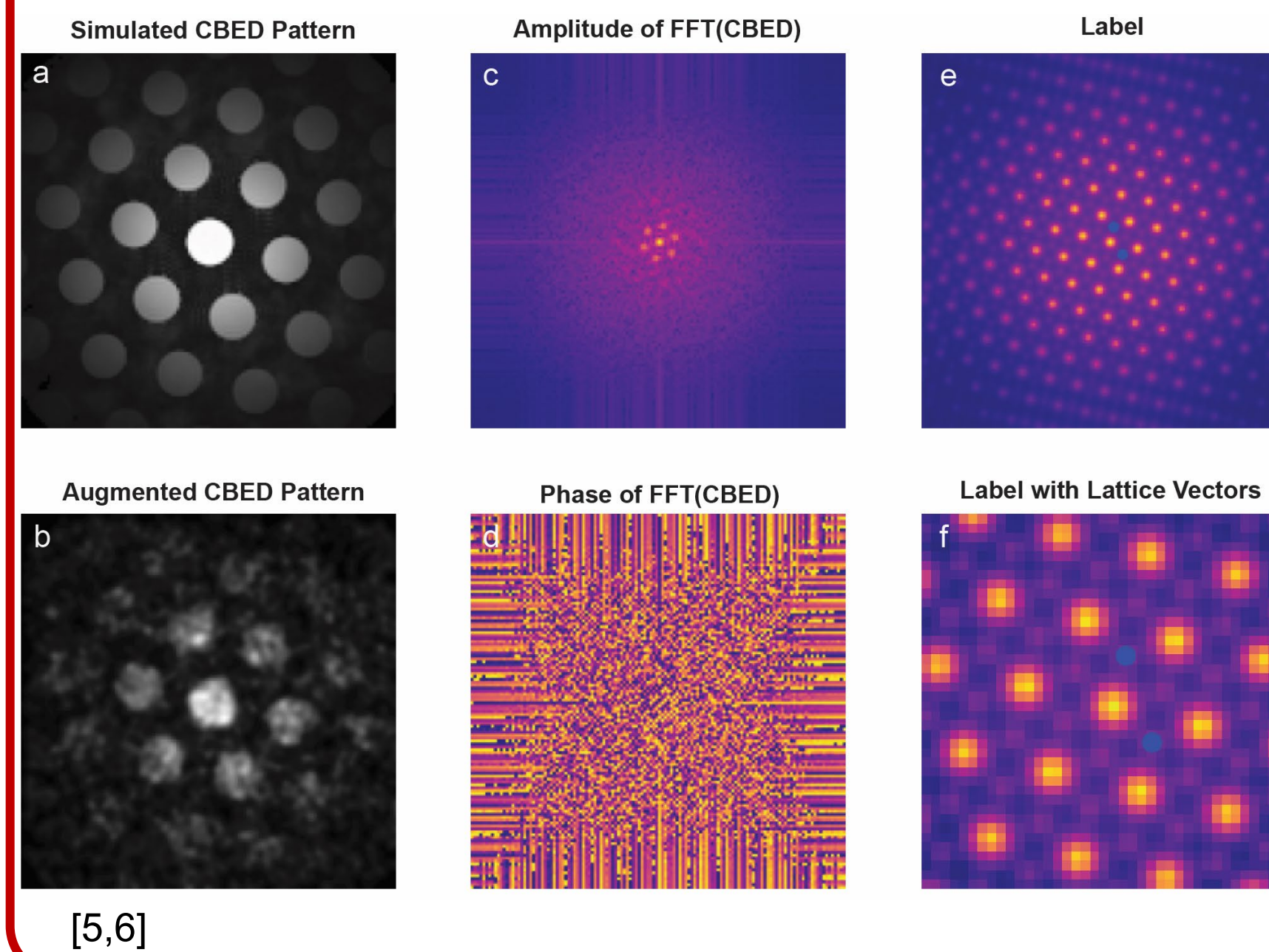
4DSTEM is a technique in electron microscopy which collects a diffraction pattern over a 2D pixel grid, providing localized crystal information.

Strain is calculated by measuring the change in lattice vectors for each pattern from a given reference [1].

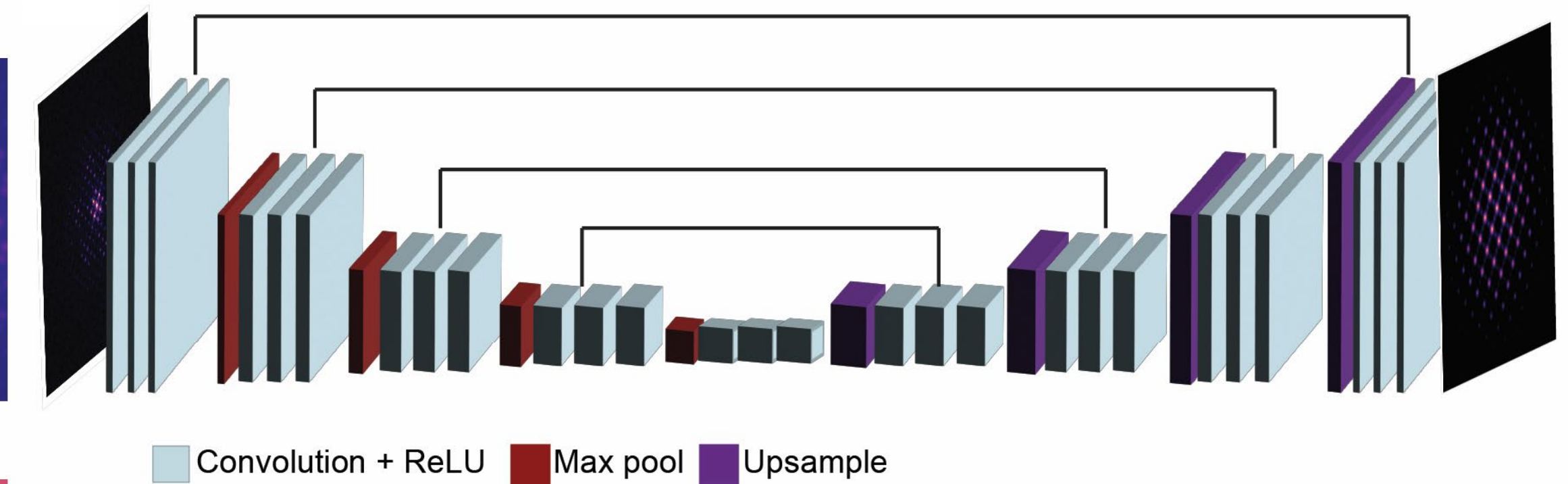


New Technique

Data Generation



Model Architecture



Loss Function

$$\mathcal{L}_{total} = \mathcal{L}_{BCE}(b_p, b_t) + \left(\mathcal{L}_{MSE}(p, t) \right)^\gamma$$

$p = \text{predicted}$
 $t = \text{target}$
 $\text{gamma} = \text{MSE weight}$

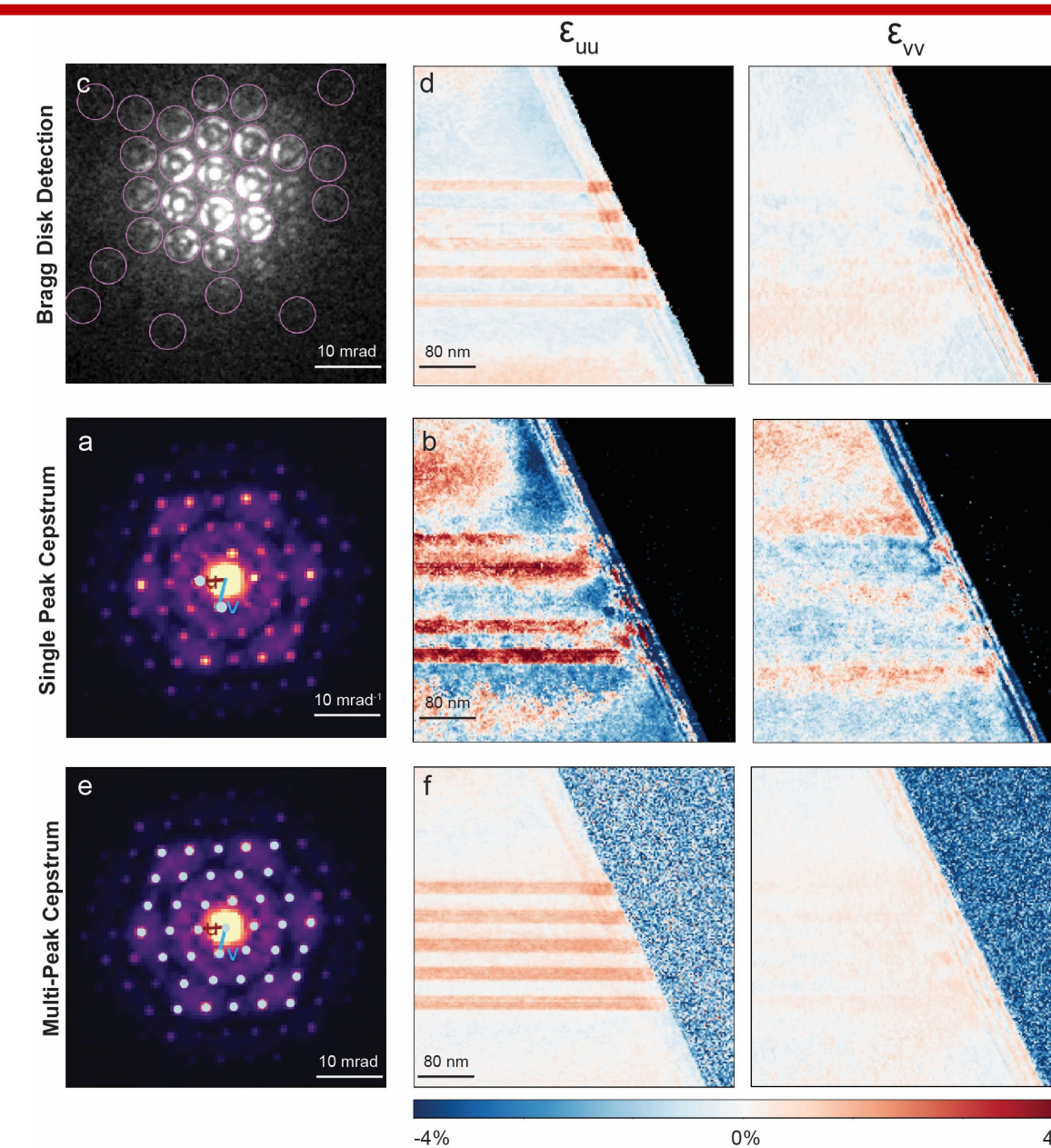
$$b_p = \text{PredictedImage}_{p>0}, \quad b_t = \text{TargetImage}_{t>0}$$

Related Work

Current Methods for Strain mapping using 4DSTEM datasets include:

- Bragg Disk Detection [2]
- Cepstral Transform [3]
- Multi-peak cepstral analysis

Data [4]

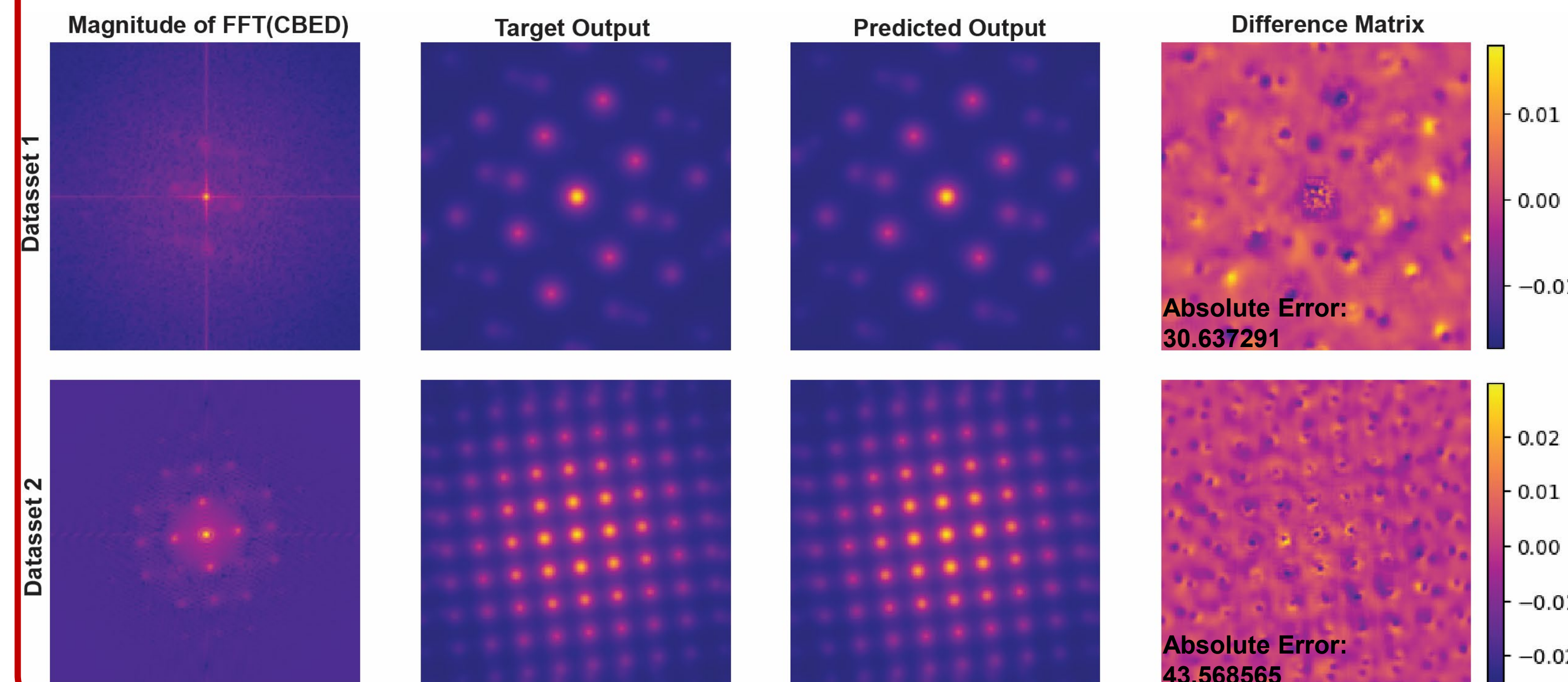


References

- [1] Ophus, Four-dimensional scanning transmission electron microscopy (4d-stem): From scanning nanodiffraction to ptychography and beyond, Microscopy and Microanalysis, 2019.
- [2] Pekin et al., Optimizing disk registration algorithms for nanobeam electron diffraction strain mapping, Ultramicroscopy, 2017.
- [3] Padgett et al., The exit-wave power-cepstrum transform for scanning nanobeam electron diffraction: robust strain mapping at subnanometer resolution and subpicometer precision, Ultramicroscopy, 2020.
- [4] Ribet et al., Multi-angle precession electron diffraction, Microscopy and Microanalysis, 2025.
- [5] Munshi et al., Disentangling multiple scattering with deep learning: application to strain mapping from electron diffraction patterns, npj Computational Materials, 2022.
- [6] Madsen and Susi, The abtem code: transmission electron microscopy from first principles, Microscopy and Microanalysis, 2021

Experimental Results

Simulated Datasets



Experimental Dataset

