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Adaptive iterative guided filtering for suppressing background noise in ptychographical imaging

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INTRODUCTION & AIM

Ptychographic iterative engine (PIE) is a phase retrieval algorithm which can transcend the resolution limitation of imaging beam elements [1-4]. As shown in Fig. 1, through the aperture constraint irradiation beam to the object superficially. CCD is manipulated to collect diffraction patterns corresponding to backlit regions. Diffraction patterns can be reconstructed into the object with iterations.

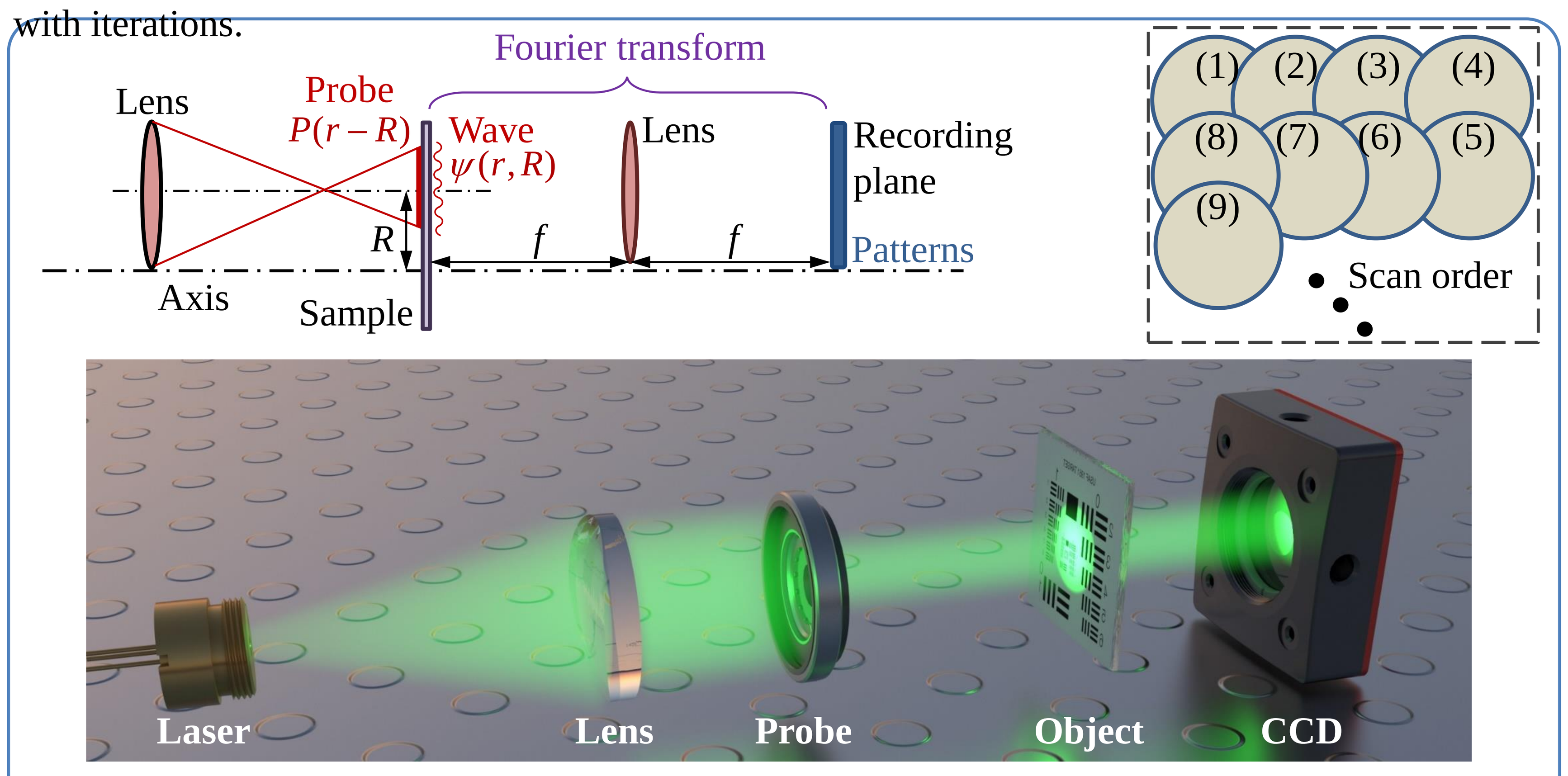

Fig. 1. Ptychography optical model

In the imaging proceeding of PIE, noise is generated both at the edges and inside of the beam probe, because light passes through the probe to the object plane and diffuses to the image plane. After the original noise is iterated through the PIE process, irregular background noise will be generated in the final reconstruction consequence.The noise in ptychography will interfere with the iterative process, reduce the iteration speed and iteration quality, and even lead to the failure of the reconstructed image.

METHOD

In order to get a clear image in PIE, we desigen an adaptive iterative guided filtering method. In Fig. 2, the guided filter is incorporated into the computation process of ptychography. Through a aperture, the illumination beam is constrained as a probe p(r) to record the image, and the object o(r) gets the corresponding pattern through diffraction. The outgoing wavefront of object φ (r), can be obtained by altering the relative position of the probe and a minor step Rj. the guided filter requires inputting the guided image g, where o(r) can also be input as the guided image g. When the input image and the guided image are the same image, the algorithm becomes an edge preserving filter.

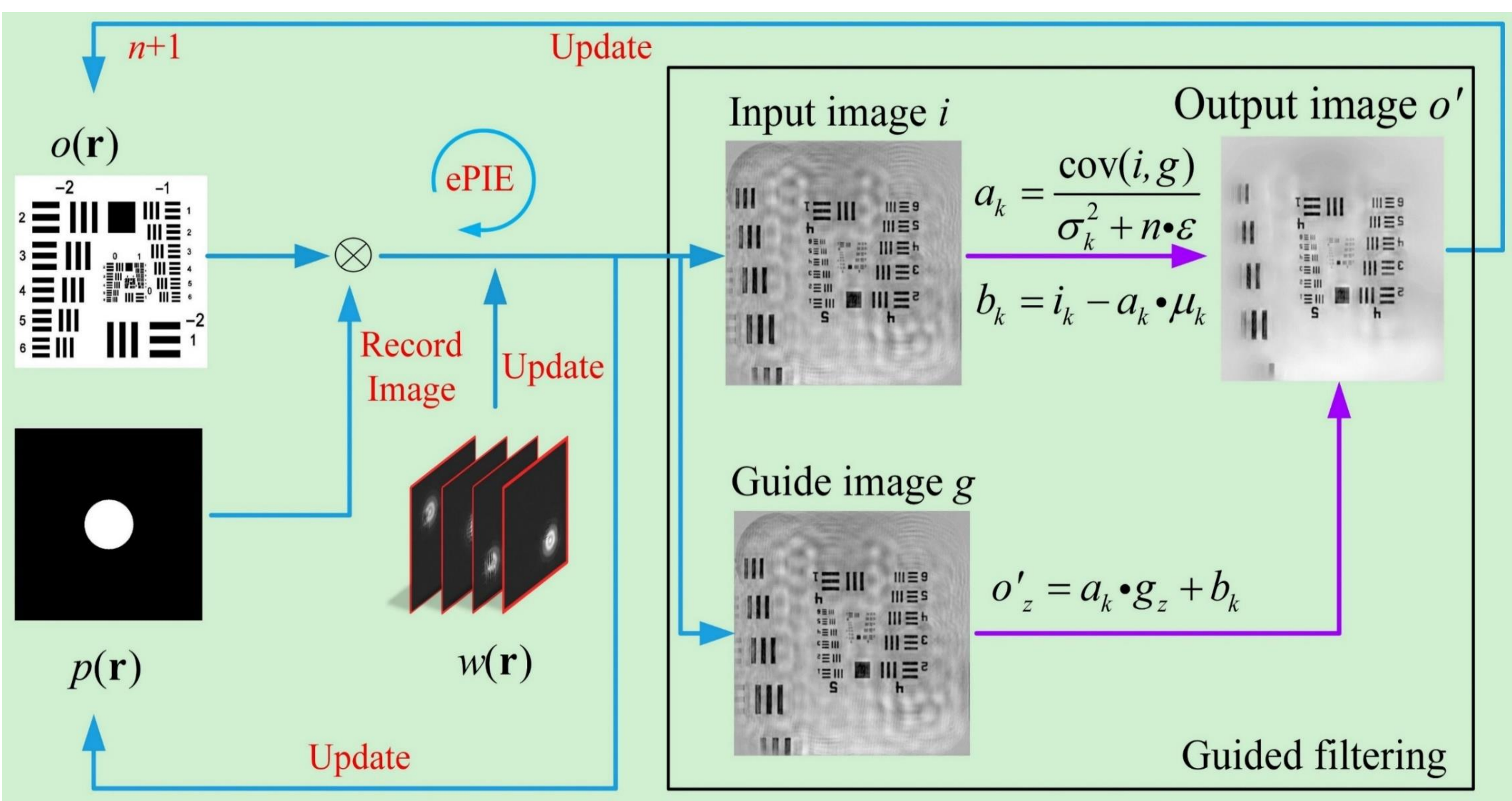

Fig. 2. Flow chart of imaging and filtering

In Fig. 3, through the changes of PSD values of high and low frequency parts, it can be concluded that the image (low- frequency) we actually desire is nicely conserved, while the main noise position (high-frequency) is successfully smoothed and denoised.

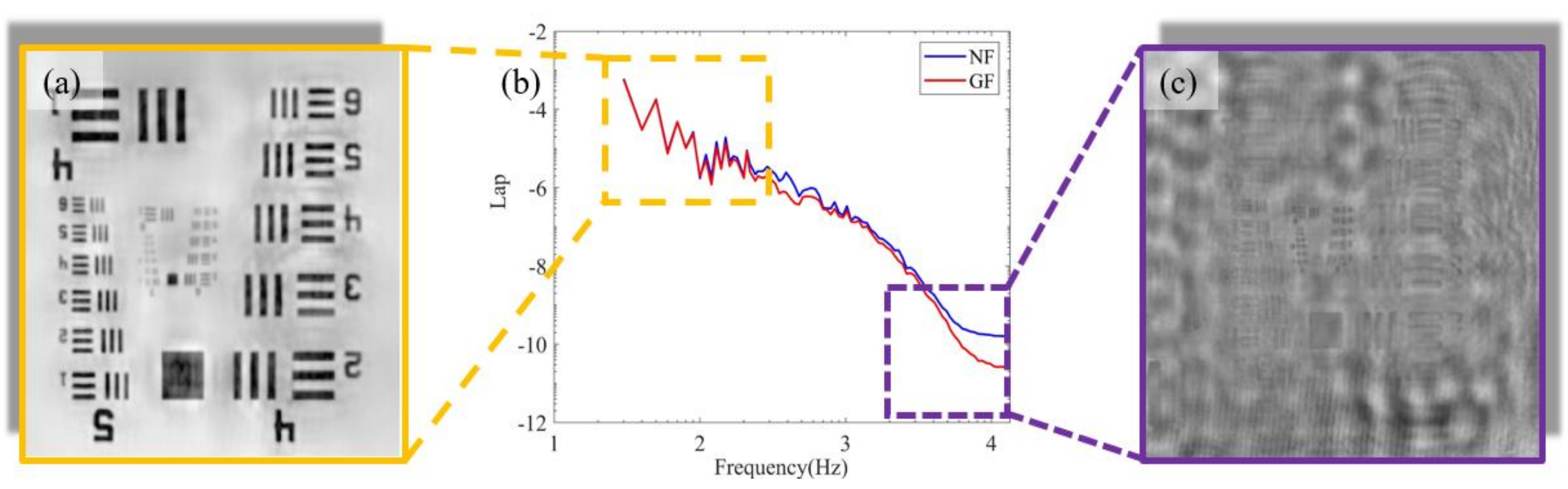

Fig. 3. Power spectral density function noise representation

RESULTS & DISCUSSION

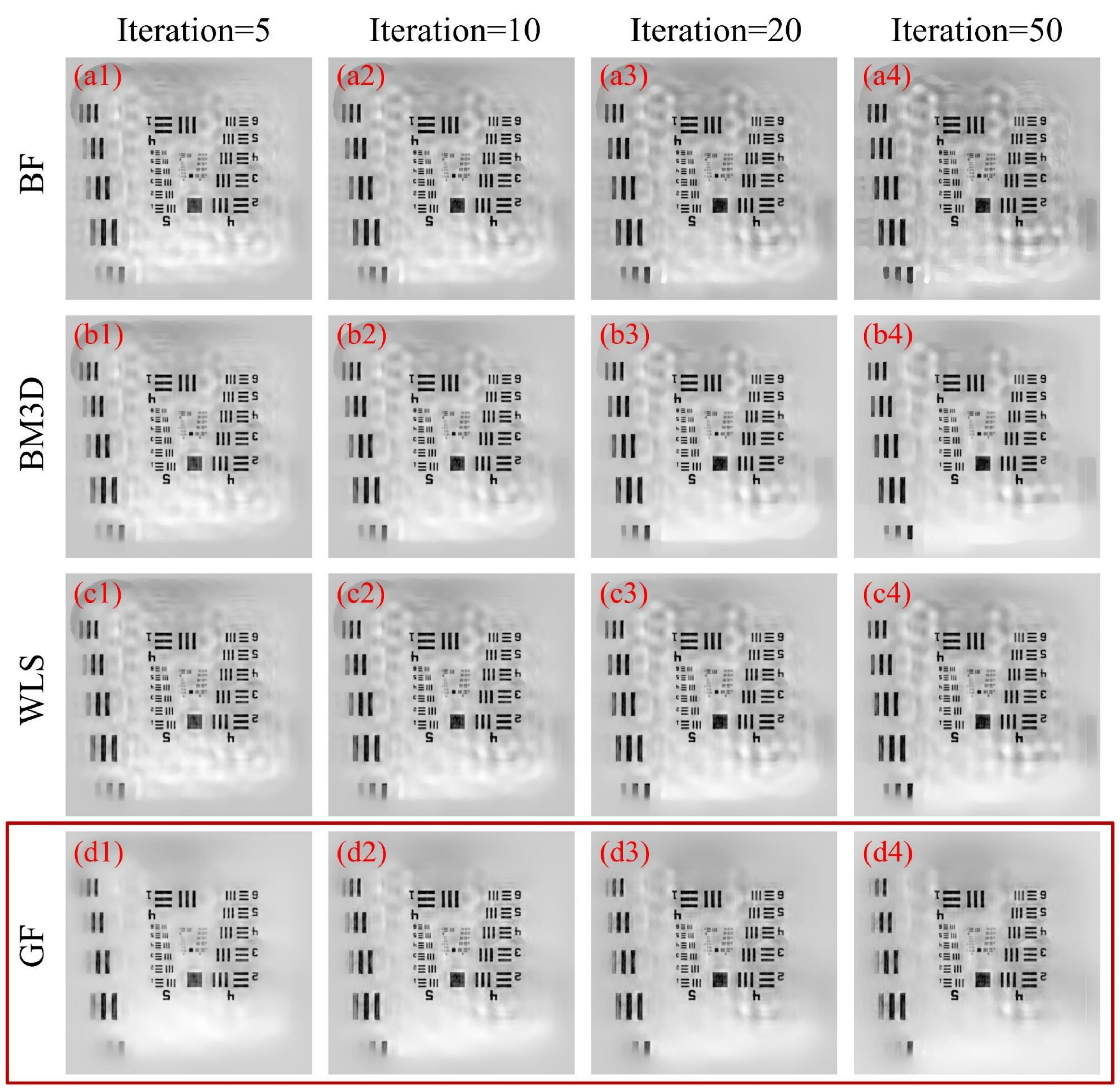

Fig. 4. Experiments result

The high edge-preserving performance of the guided filter can exclude background noise without weakening the resolution and preserving the pinpoint information. At the same time, the proposed filtering method is compared with the classical spatial filtering methods such as BM3D, BF, and WLS filtering under the same conditions, which verifies that the proposed method has the best reconstruction quality (Fig. 4) and the fastest operation efficiency (Table. 1).

Table. 1. Comparison of PIE reconstruction time for different filtering algorithms

Iterations	NF(s)	BM3D(s)	BF(s)	WLS(s)	GF(s)
5	76.3	282.1 (269.7%)	103.7 (35.9%)	89.0 (16.6%)	**77.3 (1.3%)**
10	149.9	613.8 (309.5%)	225.6 (50.5%)	186.1 (24.1%)	**159.8 (6.6%)**
20	293.7	1261.3 (329.4%)	432.6 (47.2%)	340.2 (15.8%)	**301.1 (2.5%)**
50	748.3	3324.6 (344.3%)	1113.7 (48.8%)	923.1 (23.3%)	**807.1 (7.9%)**

CONCLUSION

We proposed an adaptive iterative guided filtering method for background noise in PIE. The method combines guided filtering and PIE. The constraint parameter was regulated by iteration cycle number to achieve filtering effect.. By comparison to BM3D, bilateral filter and weighted least squares filter, the effectiveness of this method for background noise excision is verified. Compared with other filtering methods, this algorithm also had apparent advantages in the efficiency of the actual program.

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