

Comparison Study of ISTA and BM3D Algorithms for Image Denoising

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Abstract

This paper compares the Iterative Shrinkage-Thresholding Algorithm (ISTA) and Block-Matching and 3D Filtering algorithm (BM3D) for image denoising. Experimental results show BM3D significantly outperforms ISTA in quality, particularly for mixed noise, while ISTA offers better computational efficiency.

1 Introduction

This study compares ISTA and BM3D denoising algorithms. ISTA uses optimization theory while BM3D uses statistical methodology. Experiments quantify performance differences between these approaches.

2 Experimental Results

2.1 Quantitative Results

Table 1: Performance Comparison Results

Noise Type	Alg.	PSNR (dB)	SSIM	Time (s)	$p = 0.2$
Gaussian $\sigma = 50$	ISTA	12.90	0.1579	0.049	ISTA and BM3D results.
	BM3D	26.81	0.8109	9.713	
Mixed $\sigma = 25, p = 0.1$	ISTA	11.10	0.1514	0.049	ISTA and BM3D results.
	BM3D	25.81	0.7634	9.645	
Mixed $\sigma = 50, p = 0.2$	ISTA	8.55	0.0753	0.497	ISTA and BM3D results.
	BM3D	20.48	0.4346	10.399	
Mixed $\sigma = 75, p = 0.3$	ISTA	7.65	0.0466	0.054	ISTA and BM3D results.
	BM3D	17.42	0.3010	11.800	

2.2 Visual Results

Figure 1 shows denoising results for mixed noise ($\sigma = 50, p = 0.2$):



Figure 1: Denoising results for mixed noise ($\sigma = 50, p = 0.2$). Top: Original and noisy images. Bottom: ISTA and BM3D results.

3 Analysis

3.1 Algorithm Comparison

BM3D Advantages:

- Non-local similarity
- 3D collaborative filtering
- Two-stage processing
- Robust to mixed noise

ISTA Limitations:

- Pixel sparsity assumption
- Local processing only
- Sensitive to parameters
- Poor with impulse noise

3.2 Time Analysis

Table 2: Computational Efficiency

Noise Type	ISTA Time (s)	BM3D Time (s)	Speedup
Gaussian $\sigma = 50$	0.049	9.713	199.4×
Mixed $\sigma = 25, p = 0.1$	0.049	9.645	196.3×
Mixed $\sigma = 50, p = 0.2$	0.497	10.399	20.9×
Mixed $\sigma = 75, p = 0.3$	0.054	11.800	217.2×

4 Conclusion

4.1 Summary

Key findings:

1. BM3D: +9.77 to +14.72 dB PSNR advantage
2. ISTA: 20-200 times faster
3. BM3D: 3-5× higher SSIM
4. BM3D more robust to mixed noise