ADAPTIVE THRESHOLDING HOSVD ALGORITHM WITH ITERATIVE REGULARIZATION FOR IMAGE DENOISING

*Rodion Movchan, Zhengwei Shen**

School of Mathematics and Physics, University of Science and Technology Beijing, Beijing 100083, China

ABSTRACT

In this paper, we propose a very simple 3D patch stack based image denoising method by Higher Order Singular Value Decomposition (HOSVD). We used the idea of iterative regularization from spatially adaptive iterative singular-value thresholding(SAIST) to design our algorithm, which indicates more faster convergence speed than some other methods. By using the parallel computing technique for implementing the algorithm, the computational complexity is highly reduced. The experiments also show good PNSR result with different noise levels.

Algorithm 1 Adaptive HOSVD iterative regularization

Require: Noise Image Y, patch size p, stack size k, Iterations I and parameters σ, β, γ;
Ensure: Clean Image X;
1: Initialize: $X^0 \leftarrow Y, Y^0 \leftarrow Y$;
2: **for** n=1 in 1:I **do**
3: Re-estimate Y^n by (6);
4: Re-estimate noise variance σ_N^n of Y^n (7);
5: **for** each patch y_j in Y^n **do**
6: Find similar patches by (4).
7: Estimate $U^{(1)}$, $V^{(2)}$ and $W^{(3)}$;
8: Find tensor core S by (2);
9: For each $\lambda_i^{(n)}$ in S compute τ_i by (5)
10: Apply threshold τ_i to each $\lambda_i^{(n)}$ in S;
11: Estimate denoised patch stack by (1);
12: **end for**
13: Obtain the denoised image X^n by (9);
14: **end for**

Fig. 3: *Result on the noisy ($\sigma = 20$) 512×512 image Lena. (a) original, (b) noisy image, (c) denoised result.*

Fig. 4: *Result on the noisy ($\sigma = 50$) 256×256 image House. (a) original, (b) noisy image, (c) denoised result.*

Table 1: *Comparison PSNR denoising result of four different algorithms.* ***First****: This paper,* ***second****: LASSC[3],* ***third****: BM3D[15],* ***fourth****: exemplar-based method[16]*

	Noise level		
	$\sigma = 10$	$\sigma = 20$	$\sigma = 50$
Barbara	34.51	31.38	25.92
	25.23	32.10	27.54
	34.87	31.77	27.51
	33.79	30.37	24.09
Lena	35.44	32.88	28.40
	35.90	33.08	29.01
	35.83	33.03	29.08
	35.18	32.64	28.38
House	35.96	33.64	28.89
	36.67	33.90	30.20
	36.37	33.54	29.65
	35.26	32.90	28.67
Boats	33.40	30.62	26.12
	33.91	30.81	26.66
	33.79	30.65	26.71
	33.09	30.12	25.93

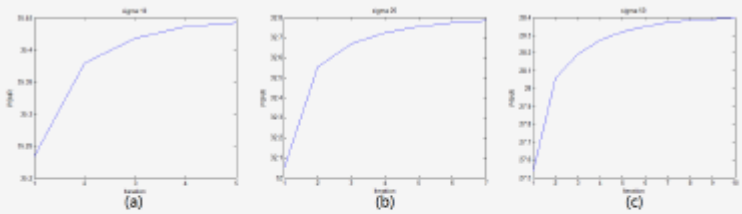

Fig. 5: *Dependence of PSNR to iteration count for Lena image with (a) is $\sigma = 10$ noise corrupted, (b) is $\sigma = 20$ noise corrupted and (c) is $\sigma = 50$ noise corrupted, where the beginning value is equal to HOSVD method without iterative regularization.*

5. CONCLUSION

In this article, we proposed an adaptive thresholding HOSVD method with iterative regularization which combining ideas about HOSVD low-rank decomposition with SAIST iterative regularization. We show what does mean of SVD in applicability for image denoisng, and how it related with HOSVD. We show how better about grouping image patches to stacks, and then how to apply HOSVD to it. Some suggestions of how better to choose patches size and how much patches should be in patch stack also are considered. The C# Code of this algorithm can be found at `https://github.com/stargox/Iterative_HOSVD_denoising.git`.