웨이블렛 기반 잡음 추정 및 영상복원에 적용

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Wavelet Based Noise Variance Estimation and Its Application to Image Restoration

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Abstract

The wavelet transform has an advantage over the Fourier transform for representing in homogeneous functions that have discontinuities, sharp peaks, ike images. This paper proposes a noise variance estimation method by utilizing the wavelet transform.

I. Introduction

For estimation of noise variance many approaches have been proposed in the literature [1]. Major contribution of this paper is that it can selectively use the proper frequency components using wavelet transform.

II. Background Mathematical Theory

The discrete wavelet transform (DWT) of $f(x,y)$ of size $M \times N$ is defined as

$$W_{\phi}(j_0,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \phi_{j_0,m,n}(x,y), \quad (2)$$

and

$$W_{\Psi}^{i}(j,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \Psi_{j,m,n}^{i}(x,y), \quad \text{for} \quad i = H, V, D, \quad (3)$$

where index i identifies the direction of each wavelet, such as horizontal(H), vertical(V), and diagonal(D) [3].

Ⅲ. Wavelet-Based Noise Variance Estimation

Fig. 1 shows the DWT for degraded image $g(m,n)$ [2, 3], where $d^{D}(m,n)$ is assumed to haul only noise and edge components because its low pass component is filtered twice by directional high pass filters [1, 3].

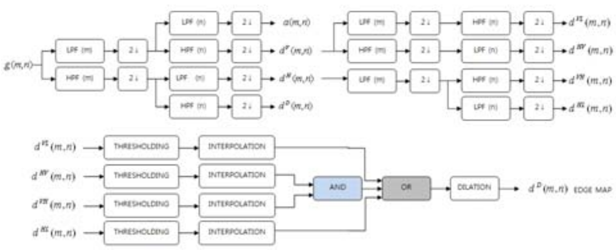

Fig. 1. Block diagram of the wavelet transform and our algorithm

For extracting the purely noise component, we need to remove edge components in $d^{D}(m,n)$. Since it is hand to completely separate noise and edge components, we use 1-level horizontal and vertical wavelets, that is $d^{H}(m,n)$ and $d^{V}(m,n)$. The proposal noise variance estimation algorithm based on edge separation is summarized as follows.

Step 1: Perform 1-level DWT of the degraded image. Step 2: Perform the DWTs of $d^{H}(m,n)$ and $d^{V}(m,n)$ as shown in Fig. 2. Step 3: Make the 2-level wavelets edge map using threshold and interpolation. Step 3: Make the 2-level wavelets edge map using threshold and interpolation. Step 4: Make the 1-level diagonal wavelet$d^{D}(m,n)$'s edge map in Fig. 2. Step 5: Noise variance is estimated by computing the energy of the edge-removed diagonal wavelet.

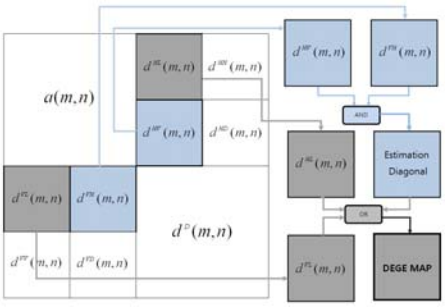

Fig. 2. 2-level wavelets for horizontal component $d^{H}(m,n)$ and vertical component $d^{V}(m,n)$

Ⅳ. Experimental Results

Experiments are conducted on a gray scale test image Lena of size 256×256. The threshold value for the 2-level wavelet edge map is determined as

$$[5\times\max d^{HL}(m,n),d^{HV}(m,n),d^{VH}(m,n),d^{VL}(m,n) \qquad (4)$$
$$+4\times\min d^{HL}(m,n),d^{HV}(m,n),d^{VH}(m,n),d^{VL}(m,n)]/9$$

Table 1 shows the results obtained by using the proposed method, and Table 2 shows comparison with other method [4]. Our method is adjacent for real noise variance.

Table 1. Estimation noise variance

SNR	Real noise variance	Estimation noise variance
0 dB	3.2195e+003	3.1714e+003
10 dB	321.9475	320.9356
20 dB	32.1947	32.0687
30 dB	3.2195	3.3656
40 dB	0.3219	0.3806
50 dB	0.0322	0.0848

Table 2. Comparison by the other method

Noise variance	0.1	0.2	0.5	1.0	2.0
Other method	0.08	0.17	0.44	0.88	1.76
Proposed method	0.15	0.25	0.54	1.07	2.12

We use Wiener filter as an image restoration filter, where noise power is replaced by noise variance [3]. Signal power of the degraded image is used as the original power spectrum.

(a) (b)

Fig3. (a) Degraded image by 7×7 uniform blur and 50 dB additive noise and (b) the restored image using wiener filter.

Ⅴ. Conclusion

In this paper we presented a new wavelet-based for noise variance estimation [2, 3]. The primary advantage of the method is acceptable accuracy and simplicity. The proposed algorithm can accurately estimate a wide range of noise variance as shown in Table 2. A comparison with several previously published estimation methods indicates the improved accuracy of the proposed algorithm.

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