Introduction to Image Processing final project group 4

Introduction – When we do the image processing, image deblurring and sharpness enhancement are two discrete processes. But deblurring does not necessarily lead to sharpness enhancement. In this paper, presenting a unified solution to both image deblurring and sharpness enhancement. Our purpose is to do an adaptive deblurring and sharpening operation to different areas of the lightly blurred image. The advantages of this algorithm are three. First, the noise can't be discarded, so it will not be magnified. Second, the result is not over-sharpening. Final, the algorithm is automated, you don't need to make manual setup.

1. METHOD OVER YEARS

Unsharp Masking (UM) – New image = original + fraction of high-pass filtered version. This method can amplify the high frequency component, so the edge can be enhanced. But the noise signal is high frequency too, so the algorithm is sensitive to noise. Another defect is the method may cause halo effect or unpleasant ringing in areas of sharp edges.

Histogram Equalization (HE) – this method is to manipulate the image contrast, when contrast raise, the edge may be clearer. The defect of this method is it only work well for noise-free images.

Sub-Regions Histogram Equalization (SRHE) – this method is to divide image into sub-images based on its weighted average value of neighboring pixels, and do histogram equalization. The advantage is that the result maintain similar brightness from original image. It is also sensitive to noise, so only work well for noise-free images.

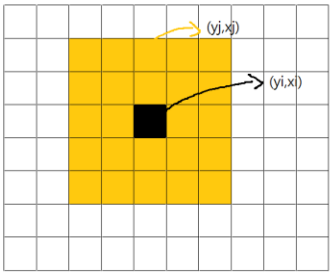
Adaptive Bilateral Filter (ABF) – This algorithm is using filter to increasing the slope of the edges. It can enhance edges and textures, and smooth the noise. But this method may excessively sharpen image, the result is not good on smooth part. The time it cost is more than other algorithm, so the time cost is one point our method improve.

2. LOCALLY ADAPTIVE BILATERAL FILTER

In our proposed approach of segmenting pixels into clusters of similar local structure, the first step is a signal augmentation process.

First, we catch the neighboring pixels of one pixel into a set N, and sorting them by the radiometric y_j into another set N_S.

$$\mathbf{N} = \{ (y_j, x_j) \mid |j| \le L \}$$



$$\mathbf{N}_S = \{(y_1, x_j), (y_2, x_j), (y_3, x_j), \ldots, (y_{(2L+1)^2-1}, x_j)\}$$
$$= \{\mathbf{N}_S(1), \mathbf{N}_S(2), \mathbf{N}_S(3), \ldots, \mathbf{N}_S((2L+1)^2-1)\}.$$

y1	y2	y3	y4	y5	y6	y7	......	y(2L+1)^2-1

Second, we compute the variational series V by taking the absolute difference, and use Huber influence function, exponential function, and a scaling constant T_s to augment the signal. The enhanced signal is represented as VA.

$$V(m) = |y_{m+1} - y_m| \quad ; \quad m = 1, 2, 3, \ldots, (2L+1)^2 - 2.$$

$$F(m) = \begin{cases} 0.0 & : \quad V(m) \le T_L \\ \dfrac{V(m) - T_L}{T_H - T_L} & : \quad T_L < V(m) < T_H \\ 1.0 & : \quad V(m) \ge T_H \end{cases}.$$

$$V_A(m) = \exp\left[T_S \cdot F(m)\right] - 1.0$$

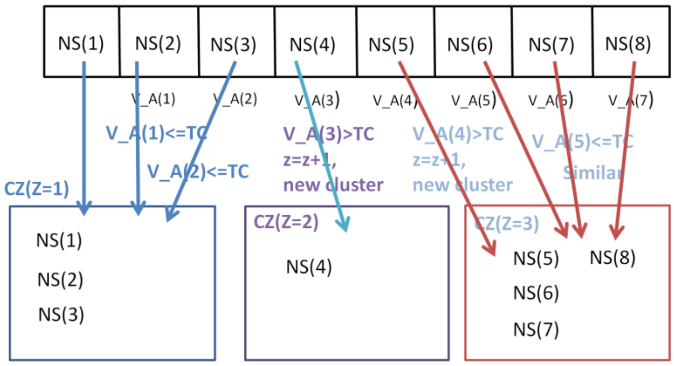
Third, we segment N_s, with close y_j as condition, into same cluster by using augmented variational series.

$$\mathbf{C}_z = \{ \mathbf{N}_S(n) \mid n = 1, 2, 3, \ldots, (2L+1)^2 - 1 \},$$

agglomeratively segments $\mathbf{N}_S$ according to

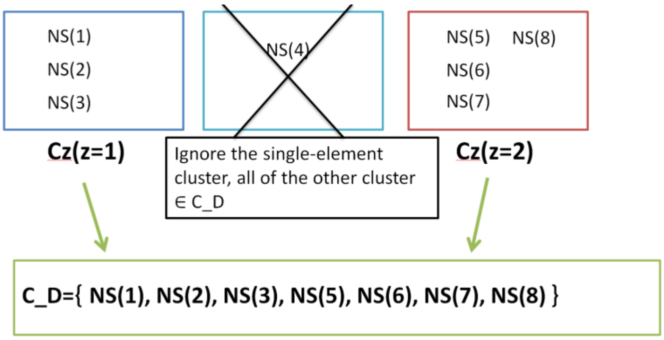
$$z \leftarrow z + 1 \quad \Leftrightarrow \quad V_A(m) > T_C$$

3*3 filter as example, in which VA(3), VA(4) > Tc,



Forth, due to the clusters consists of only single membership are outlier, we discard them. Therefore, the remaining nonsingle membership clusters can form the dominant cluster CD.

3*3 filter as example, in which VA(3), VA(4) > Tc,



Fifth, we use the member in dominant cluster to calculate the weight of the pixel. S(n) for spatial weights, and R(n) for radiometric weights. σ_s represents the variance of the distance between the location of Ns member and xi. σ_r represents the variance of the intensity of C_D. $\varepsilon(n)$ is an offset function for local gradient estimation.

$$S(n) = \exp\left[\frac{-\left\|N_{S,x}(n) - x_i\right\|_2^2}{2\sigma_s^2}\right], \quad n \in \mathbf{C_D}$$

$$R(n) = \exp\left[\frac{-\left|N_{S,y}(n) - y_i - \varepsilon(n)\right|^2}{2\sigma_r^2}\right], \quad n \in \mathbf{C_D}.$$

$$\delta = y_i - \mathrm{MEAN}(y_j)$$

$$\varepsilon(n) = \begin{cases} \mathrm{MAX}(y_j) - y_i & : \ \delta > 0 \\ \mathrm{MIN}(y_j) - y_i & : \ \delta < 0 \\ 0 & : \ \delta = 0 \end{cases}$$

Last, we use the weight multiply the intensity of neighboring pixels to calculate the intensity of center pixel. The result y_i_bar is the new x_i value.

$$\bar{y}_i = \frac{\sum_{n \in \mathbf{C_D}} R(n) \cdot S(n) \cdot N_{S,y}(n)}{\sum_{n \in \mathbf{C_D}} R(n) \cdot S(n)}.$$

3. THE PROBLEM WE MET

Too small variance– Cause the paper said that the appropriate range of σ_s and σ_r is [0.01, 4.0] and [25.0, 625.0], so we first tried to limit the σ_s and σ_r between the appropriate range. But maybe the divisor -- σ_s and σ_r – was too small in the range, that made the S(n) and R(n) was too large.

So that we had the wrong result image in which only contained black and white or maybe some gray color blocks like the figure when you tried to limit the σ_s and σ_r in a small range.

Wrong algorithm – At first, we were according to the paper's algorithm to implement our code. But later, we found that there was something wrong. No matter we how to change our parameter and tried, the result image was always be more blurred than the original image.

We thought it maybe something wrong. Maybe was the parameter or the algorithm been wrong. So we tried to study the reference paper which the paper cited. Finally, in the paper which researched the issue of adaptive bilateral filter, we found that the correct algorithm and the result image being good.

Our algorithm,

$$\varepsilon(n)=\begin{cases}\mathrm{MAX}(y_j)-y_i & : \quad \delta>0\\ \mathrm{MIN}(y_j)-y_i & : \quad \delta<0\\ 0 & : \quad \delta=0\end{cases}$$

where $\delta = \boxed{\mathrm{MEAN}(y_j) - y_i,}$ and MIN,

Correct algorithm,

respectively. Let $\boxed{\Delta_{m_0,n_0} = g[m_0,n_0] - \mathrm{MEAN}(\Omega_{m_0,n_0}).}$ We will demonstrate the effect of bilateral filtering with a fixed domain Gaussian filter ($\sigma_d = 1.0$) and a range filter ($\sigma_r = 20$) shifted by the following choices for ζ.

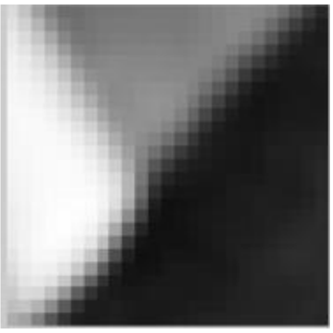
1) No offset (conventional bilateral filter): $\zeta[m_0,n_0] = 0$.
2) Shifting towards the MEAN: $\zeta[m_0,n_0] = -\Delta_{m_0,n_0}$.
3) Sifting away from the MEAN: $\zeta[m_0,n_0] = \Delta_{m_0,n_0}$.
4) Shifting away from the MEAN, to the MIN/MAX

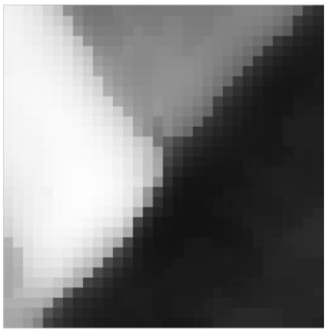
$$\zeta[m_0,n_0]=\begin{cases}\mathrm{MAX}(\Omega_{m_0,n_0})-g[m_0,n_0], & \text{if } \Delta_{m_0,n_0}>0\\ \mathrm{MIN}(\Omega_{m_0,n_0})-g[m_0,n_0], & \text{if } \Delta_{m_0,n_0}<0\\ 0, & \text{if } \Delta_{m_0,n_0}=0.\end{cases} \tag{6}$$

4. RESULT

Image - The processed image is more sharpened and deburred than the original image.

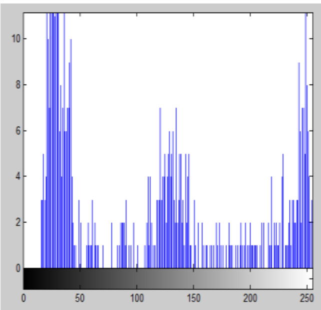
The original image The processed image

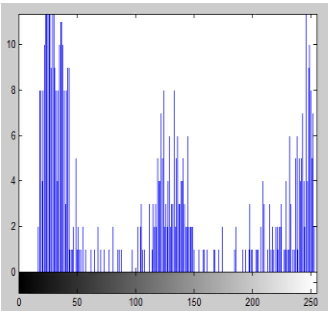




Histogram -

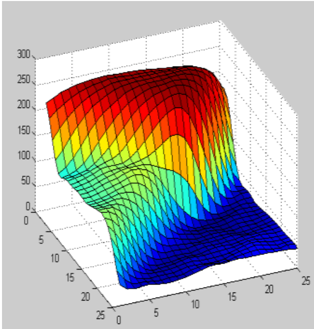
The original image The processed image

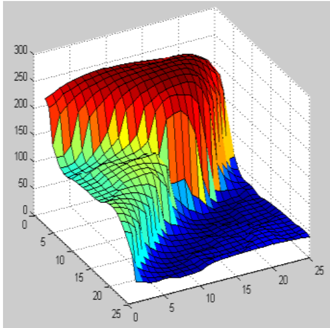




3D surface plot – the processed image's edge of the plot is more sharped.

The original image The processed image





Another image to implement –

The original image The processed image

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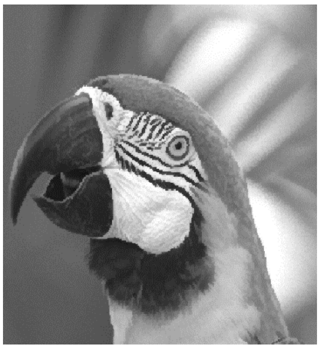

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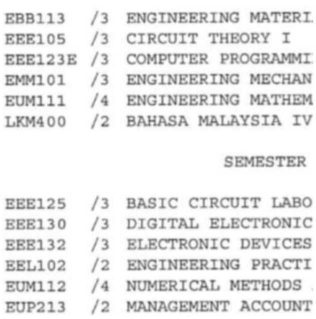

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EUM111 /4 ENGINEERING MATHEM
LKM400 /2 BAHASA MALAYSIA IV

SEMESTER

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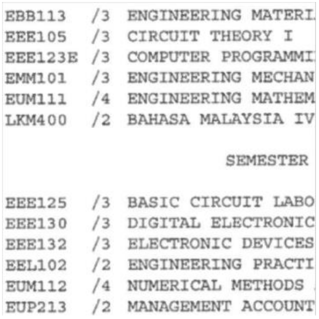

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EUP213 /2 MANAGEMENT ACCOUNT

Another image to implement –

The original image The processed image

5. REFERENCE

Paper –

B. Zhang and J. P. Allebach, “Adaptive bilateral filter for sharpness enhancement and noise removal,” IEEE Trans. Image Process., vol. 17, no. 5, pp. 664-678, 2008.

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