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Review on Reducing Noise Over Color Image Processing Pipeline for Digital Camera.

[1]Payun S. Tembhurne, [2]Prof. V.K. Shandilya

[1,2] Dept.of computer science and engg
Sipna college of engg.& tech.Amravati,India.

Abstract

Although many image processing pipelines were proposed to integrate colour image processing for the digital camera. Many of them reduces the sharpness of image while filtering that result into the blurred image therefore it is necessary to take some action that will not allows noise-level as a by product. In this paper we are reviewing colour edge detection, bilateral noise filter edge and colour enhancement based on suitable colour space. We then observe different scene of picture and result shows that these approaches can effectively reduces noises while preserving and enhancing edges.

Keywords: IPP, RGB, CIELAB, bilateral filters, YCbCr

1. Introduction

Apart from the basic desire of removing noise prior to presenting the images to the observer, smoothing images also makes it easier for many image processing algorithms. An ideal noise filter aims at preserving the image details while removing the random noises. This is achieved with local adaptive recovery methods such as anisotropic diffusion, weighted least squares and robust estimation [1].The main drawback of these methods is that they usually require several iterations to smooth out different characteristics of noises. A good non-iterative filter called bilateral filter [2]-[3] considers both their geometric bilateral filter highly relies on the parameter settings of the penalty functions for both domain and range filters. In this paper, we propose a multistage processing approach that integrates two types of noise filtering algorithms to work with two types of edge detection and one edge enhancement stage. The approach considers different characteristics of noises and edges by applying different algorithms to closeness and photometric similarity between the center pixel and the neighbouring pixels. It prevents averaging the pixels across global edges, but still averages them within the same colour regions of the image. Unfortunately, bilateral filter highly relies on the parameter settings of the penalty functions for both domain and range filters.

In this paper, we are studying a multistage processing approach that integrates two types of noise filtering algorithms to work with two types of edge detection and one edge enhancement stage. The approach considers different algorithms to accommodate for respective properties. The design concepts come from the fact that the images are usually corrupted by many noise sources.

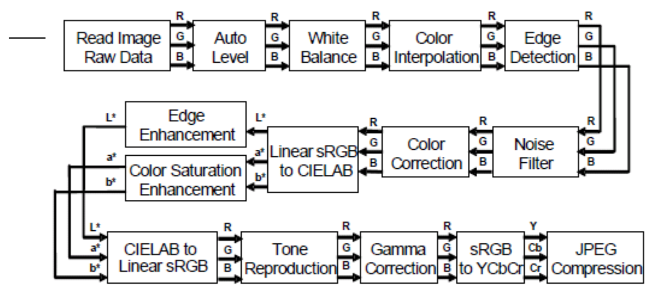

Fig1. Image processing pipeline.

2.THE APPROACH

We review a robust processing flow to deal with the image noise and edge issues described above as shown in Fig.1. The design philosophy of the proposed approach is to solve the noise problem by using different types of noise filter or edge extractor for handling different classes of noise. Since different classes of noisy pixels have different variations on spatial distance and amplitude difference, it is unlikely to find a single noise filtering algorithm that can deal with all classes of noises. The noises with amplitude close to that of the neighbours are filtered out in the “Noise filtering 1” stage with a range filter. The noises with amplitude much larger than that of the neighbours may not be filtered out in "Noise filtering

1" stage, but most of this type of noise will not be identified as edge points in "Edge detection 1" stage with a Sobel operator, since the Sobel operators consider the eight neighbouring pixels at the same time. Unless there are two or more high amplitude noises corrupting the neighbouring pixels, the Sobel operators will not identify these noises as edge points.

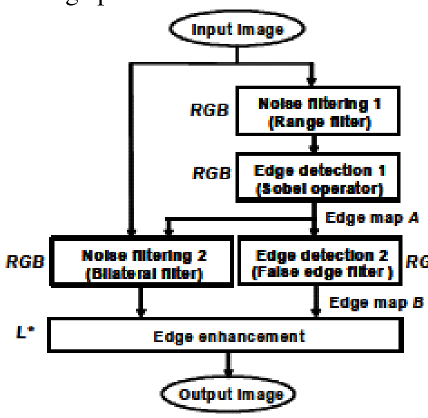

Fig2: The given noise filtering and edge enhancement processing flow

2.1 The Range Filter

A low-pass range filter applied to an *M* · *N* imageproduces an output image ( ) (1 , 1) , *h x i M j N r i j* δ δ δ δ as defined in (1) where *k* (*x*) *r* defined in (2) is the normalization factor for preserving the DC component after filtering, and*s*(∑ , *x*) defined in (3) represents the photometric similaritybetween the pixel at the neighbourhood center x and a nearby point ∑. The simplest but robust similarity function *s*(∑ , *x*) usually adopts shift-invariant Gaussian function of the Euclidean distance as defined in (4). The photometric spread parameter *r* ʃ in the image range is set to achieve the desired amount of combination of pixel values.

$$h_r(x_{i,j}) = k_r^{-1}(x)\sum_{p=i-m}^{i+m}\sum_{q=j-n}^{j+n} f(x_{i,j}) \times s(f(x_{p,q}), f(x_{i,j})) \quad (1)$$

$$k_r(x) = \sum_{p=i-m}^{i+m}\sum_{q=j-n}^{j+n} s(f(x_{p,q}), f(x_{i,j})) \quad (2)$$

$$s(\varepsilon, x) = e^{\frac{-1}{2}\left(\frac{\delta(f(\varepsilon), f(x))}{\sigma_r}\right)^2} \quad (3)$$

$$\delta(f(\varepsilon), f(x)) = \left\| f(\varepsilon) - f(x) \right\| \quad (4)$$

2.2 The Modified Bilateral Filter

Bilateral filter combines range and domain filter based on Gaussian kernels. The range filter has been described previously whereas the domain filter considers the geometric closeness between the pixel at the center x and a nearby point∑ .

A bilateral filter applied to an *M* · *N* image (1 , 1) , *f x i M j N i j* δ δ δ δ produces an output image ( ) (1 , 1) , *h x i M j N b i j* δ δ δ δ as defined in (5), where *kb* (*x*) shown in (6) is the normalization factor for preserving the DC component after filtering, and *c*(∑ , *x*) represents the geometric distance between the pixel at the neighbourhood center *x* and a nearby pixel ∑ . Similar to the range filter, the spatial distance function *c*(∑ , *x*) usually adopts shift-invariant Gaussian function of the Euclidean distance as shown in (7) and (8). The geometric spread parameter *d* ʃ in the domain is chosen based on the desired amount of low pass filtering. A larger *d* ʃ blurs the image stronger, which combines values from more distant image locations.

$$h_b(x_{i,j}) = k_b^{-1}(x) \times \sum_{p=i-m}^{i+m}\sum_{q=j-n}^{j+n} f(x_{i,j}) \times c(x_{p,q}, x_{i,j}) \times s(f(x_{p,q}), f(x_{i,j})) \quad (5)$$

$$k_b(x) = \sum_{p=i-m}^{i+m}\sum_{q=j-n}^{j+n} s(f(x_{p,q}), f(x_{i,j})) \times c(x_{p,q}, x_{i,j}) \quad (6)$$

$$c(\varepsilon, x) = e^{\frac{-1}{2}\left(\frac{d(\varepsilon, x)}{\sigma_d}\right)^2} \quad (7)$$

$$d(\varepsilon, x) = \left\| \varepsilon - x \right\| \quad (8)$$

The main difficulty with the bilateral filter is that *d* ʃ need to be adjusted according to the resolution and photometric dynamic range of the images, respectively. To conquer the problems of the images being burred by the bilateral filter, we incorporate the edge detection information from the previous stages into the bilateral noise filter. The edge map *A* shows the edge status, which indicates whether the pixel *i j x* , is recognized as an edge point (1 , *A* = *i j e*) or not (0 , *A* =*i j e*). By incorporating this edge information, the output ( ) *i*, *j h x* of the modified bilateral is defined in (9).

3.The Edge Enhancement.

The main concepts of the proposed edge enhancement method comes from the following two observations: (a) Edge enhancement need to be performed conservatively. Only a few important global edges, such as longer edges, need to be enhanced because human eyes are more sensitive to these features. (b) If the tri-stimulus values *RGB* of the image pixel are enhanced separately, it is possible to introduce unexpected colours or artifacts. Hence the proposed edge enhancement is performed on the edge pixels under the uniform *CIELAB* colour space to prevent the edge enhancement from introducing colour artifacts. Only the luminance components (L^*) of the edge pixels are enhanced, but the chrominance values (a^* and b^*) of the edge pixels are kept the same.

3.1 The False Edge Filter

Although range filter can smooth out the image before applying Sobel operators, some false edges may also be extracted. The proposed false edge filter analyzes the density i, j ⎤of the edge pixels surrounding the current point $i\ j\ x$, .Only the edge pixels that locate in the cluster of edge pixels in edge map A are selected for enhancement (1 , B =
$i\ j\ e$) in the next stage. Any isolated edge pixels in edge map A will be recognized as normal pixels (0 , $B = i\ j\ e$) in edge map B. The above concept can be formulated as (10) and (11), where a and b is the window size for counting edge pixels, and ⌠ is the predefined parameter for controlling the strength of the false edge filter.

$$e^B_{i,j} = \begin{cases} 1 & if\ a_{i,j} \geq \mu \\ 0 & if\ \omega_{i,j} < \mu \end{cases} \quad (10)$$

$$\omega_{i,j} = \sum_{p=i-a}^{i+a} \sum_{q=j-b}^{j+b} e^A_{p,q} \quad (11)$$

3.2 Edge Enhancement

The inherent property of *CIELAB* colour space is that radial distance and angular position represent the chroma and hue of the colour, respectively. It is much easier to handle colour consistency and brightness in *CIELAB* colour space than in other types of colour space such as *sRGB* or *YCbCr*. For each edge pixels, the gradient of luminance values on the edge pixels can be enlarged by changing the L^* component only, while hue and colour saturation values are kept unchanged. The concept of edge enhancement (also called sharpening) is to try to highlight fine details by enlarging the luminance difference between the two sides of the boundary corresponding to the processed edge. The sharpening concepts described above can be realized by (12) and (13), where ( ) $_{i,j}L\ x$ and ( ) $_{i,j}L_E\ x$ represent the original and the enhanced stimulus valueL_* of the pixel $i\ j\ x$, , respectively. The edge status $_B\ i\ j\ e$,indicates whether the pixel $_{ij}x$,is recognized as an edge point (1 $_{,B}$= $_{ij}e$) or not (0 $_{,B}$= $_{ij}e$) in edge map B.

The enhanced value ⎞ can be determined by the percentage of the luminance difference between the two sides of the edge.

$$L^E(x_{i,j}) = \begin{cases} L(x_{i,j}) + \phi & if\ \ e^B_{i,j} = 1 \ \wedge \ L(x_{i,j}) > \theta_{i,j} \\ L(x_{i,j}) - \phi & if\ \ e^B_{i,j} = 1 \ \wedge \ L(x_{i,j}) < \theta_{i,j} \\ L(x_{i,j}) & if\ \ e^B_{i,j} = 0 \ \vee \ L(x_{i,j}) = \theta_{i,j} \end{cases} \quad (12)$$

$$\theta_{i,j} = \frac{1}{9} \sum_{p=i-1}^{i+1} \sum_{q=j-1}^{j+1} L(x_{p,q}) \quad (13)$$

4. Sample Example

The partial results are shown in the figures:
(a) the raw image,
(b) the image after auto-level stretch,
(c) the image after AWB,
(d) the image after colour correction,
(e) the image colour saturation enhanced,

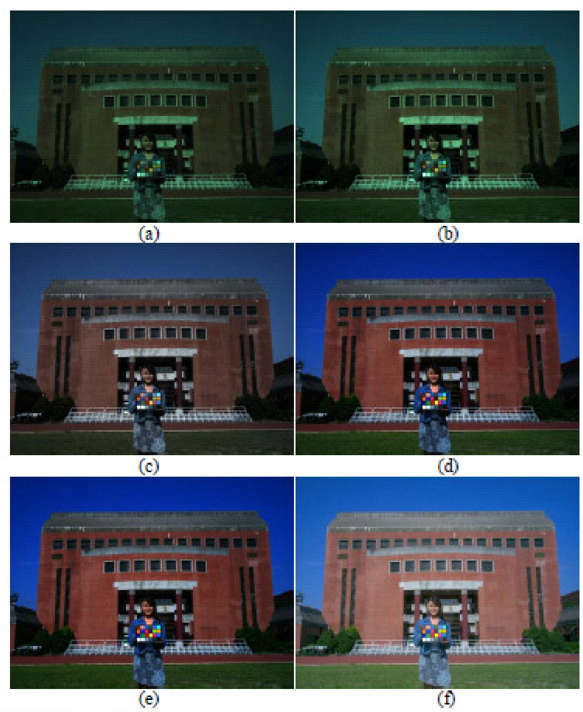

Figure 3. The filtering result by the proposed system. (a) (σ_d, σ_r)=(1,30), (b) (σ_d, σ_r)=(1,90), (c) (σ_d, σ_r)=(10,30), and (d) (σ_d, σ_r)=(10,90).

5. Conclusions

Given image processing pipeline (IPP) that will focusing on Sequencing image processing steps for digital camera This image processing pipeline provide good reference, which can be implemented using multistage bilateral filters that integrates two types of noise filtering algorithms to work with two types of edge detection and one edge enhancement stage optimized further based on the adopted hardware platforms. The bilateral filter shows good performance on noise filtering, but many image details are also removed. by using the proposed multistage strategies to identify the edges and smooth out the noises, the image lines can be kept, but most of the image noises can be filtered out. It is also possible to design an IPP chip with such a robust flow for real-time video and still image processing, which will be future work.

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