Journal of Pattern Intelligence
ISSN: 2230-9330 & E-ISSN: 2230-9349, Volume 2, Issue 1, 2012, pp.-19-21.
Available online at http://www.bioinfo.in/contents.php?id=49

PERFORMANCE EVALUATION OF ADAPTIVE BILATERAL FILTER FOR IMPULSE AND GAUSSIAN NOISE REDUCTION

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Received: February 21, 2012; Accepted: March 15, 2012

Abstract- In this paper implementation of Adaptive Bilateral filter is carried out. This filter is used for the sharpness enhancement of degraded images and performs well for Impulse and Gaussian noise reduction. In this approach we calculated responses of the centre pixel of the constructed window. We tested the effects of bilateral filtering with a fixed domain Gaussian filter and a range filter shifted by the various choices for offset value. The performance of the implemented filter evaluated with four different images. We compared the performance of the filter with bilateral and trilateral filter.
Keywords- Filter, Impulse noise, Gaussian noise, Denoising, Enhancement.

Citation: Sarode M.V. and Deshmukh P.R. (2012) Performance Evaluation of Adaptive Bilateral Filter for Impulse and Gaussian Noise Reduction. Journal of Pattern Intelligence, ISSN: 2230-9330 & E-ISSN: 2230-9349, Volume 2, Issue 1, pp.-19-21.

Introduction

The aim of the image restoration techniques is to recover a high quality original image from a degraded version of that image. Noise smoothing and image enhancement are conflicting objectives in most image processing applications. The objectives of image enhancement are to remove impulsive noise as well to remove Gaussian noise. Noise is a random signal. It plays a crucial role in today's communication systems. In practice it determines the number of errors occurring in a digital communication. It can be introduce into images during digitization and transmission. The nature of problem depends on the type of noise added to the image. Basically, two noise models can adequately represent most noise added to the images. Gaussian noise is a special case of white noise also called normal noise. Its intensity does not decrease with increasing frequency. Impulse noise is characterized by replacing a portion of an image's pixel value leaving the remainder unchanged. An ideal Impulse noise is an important input signal that enables the use of linear mathematical theory in the domain of continuous image functions. In this paper, we described the implementation as well as performance evaluation of Adaptive bilateral filter which reduces Impulse and Gaussian noise from noisy images. This method enhances the Signal to Noise ratio and perceives the original features of the images

Implementation of Adaptive Bilateral Filter (ABF)

We implemented Adaptive Bilateral filter for image sharpening and smoothing algorithm. The response at $[m_0, n_0]$ of the implemented shift variant ABF to an impulse at $[m, n]$ is given by

$$h(m_0, n_0) = \begin{cases} r^{-1}_{m_0, n_0} \exp\left(-\frac{(m-m_0)^2+(n-n_0)^2}{2\sigma_d^2}\right)\exp\left(-\frac{(g(m,n)-g(m_0,n_0)-offset(m_0,n_0))^2}{2\sigma_r^2}\right) & (m,n)\in\Omega m_0,n_0 \\ 0 & else \end{cases} \quad (1)$$

In an Adaptive Bilateral filter offset is introduced. If offset is zero and σ_r is fixed, the ABF will become bilateral filter.
For the bilateral filter, the range filter is located on the histogram

at the gray value of current pixel. Let Ω_{m_0,n_0} denote the set of pixels in the $(2N+1)\times(2N+1)$ window of pixels centered at $[m_0,n_0]$. Let MIN, MAX and MEAN denote the operation of taking the minimum, maximum, and average value of the data in Ω_{m_0,n_0}, respectively.

$$\Delta_{m_0,n_0} = g[m_0,n_0] - MEAN(\Omega_{m_0,n_0}) \quad (2)$$

The effect of bilateral filtering with a fixed domain Gaussian filter $(\sigma_d = 1)$ and a range filter $(\sigma_r = 20)$ shifted by the following choices for offset,

1)No offset (conventional bilateral filter).
2)Shifting towards the MEAN.
3)Shifting away from the MEAN.
4)Shifting away from the MEAN, to the MIN/MAX

$$Offset\ [m_0,n_0] = \begin{cases} MAX(\Omega_{m_0,n_0}) - g[m_0,n_0], & if\ \Delta_{m_0,n_0} > 0 \\ MIN(\Omega_{m_0,n_0}) - g[m_0,n_0], & if\ \Delta_{m_0,n_0} < 0 \\ 0 & f\ \Delta_{m_0,n_0} = 0 \end{cases} \quad (3)$$

Results and Performance Evaluation

The performance of the Adaptive Bilateral filter is evaluated with four images. All four images are degraded by according to degradation model. The results obtained with these images shows its robustness. We compared the performance of the ABF with bilateral filter. The ABF restored images appeared sharper on the edges and textures and less noisy in the smooth regions. The degraded images are generated by introducing noise levels from 10% to 60% using degradation procedure. Before applying ABF, offset value is to be set in the range from -60 to +60.The conventional bilateral filter does not restore the sharpness of the image. The bilateral filter has been widely applied since it was first proposed. The ABF is an extension of the traditional bilateral filter. With its capability of adaptive sharpening and smoothing, it offers the potential for wider application and better image quality. Although the ABF is developed in the framework of image restoration, it can be used as an image enhancing algorithm, as we have demonstrated with the test images. In particular, our main motivation for implementing the ABF is to enhance the quality of digital images that consumers want to view and print. Therefore we chose a noise model and blur PSF that mimics a real world hybrid imaging system to generate the training images. Figure 1 to figure 4 shows comparative performance of the ABF with bilateral filter. Comparatively ABF performs well than the bilateral filter. Bilateral Filter's output image creates blur effects if the percentage of noise increases. Figure 1 shows a) Degraded Lena image with Gaussian noise 10%, b) shows restored image by ABF and c) shows restored image by bilateral filter. Figure 2 shows a) Degraded Mandrill image with Gaussian noise 20%, b) shows restored image by ABF and c) shows restored image by bilateral filter. Figure 3 shows a) Degraded Bridge image with Gaussian noise 40%, b) shows restored image by ABF and c) shows restored image by bilateral filter. Figure 4 shows a) Degraded Sailboat image with Gaussian noise 500%, b) shows restored image by ABF and c) shows restored image by bilateral filter.

Fig. 1a- Degraded Lena image with Gaussian noise 10%, **b)** shows restored image by ABF and **c)** shows restored image by bilateral filter

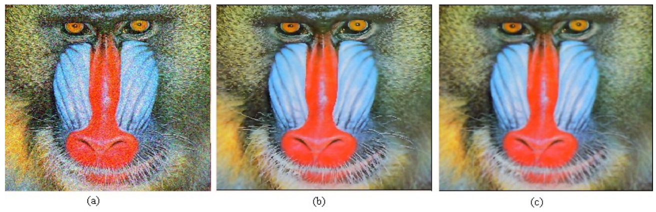

Fig. 2a- Degraded Mandrill image with Gaussian noise 20%, **b)** shows restored image by ABF and **c)** shows restored image by bilateral filter

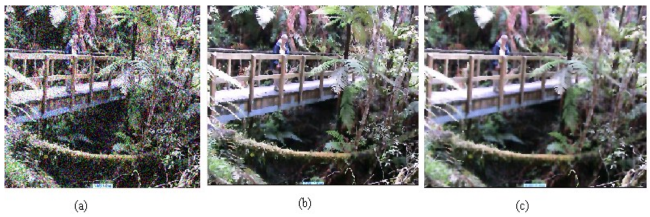

Fig. 3a- Degraded Bridge image with Gaussian noise 40%, **b)** shows restored image by ABF and **c)** shows restored image by bilateral filter

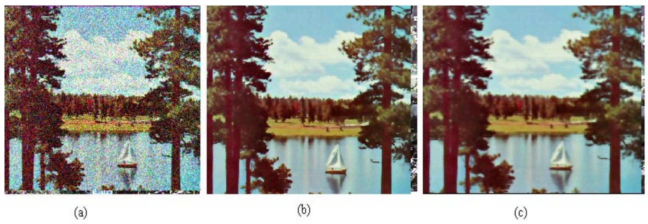

Fig. 4a- Degraded Bridge image with Gaussian noise 50%, **b)** shows restored image by ABF and **c)** shows restored image by bilateral filter

Implications and Suitability

Following are some implications for the algorithms we implemented.

1) Increase in visual quality of the denoised image, measure of best quality of restored image.
2) Decrease in required computational time and increase in the visual quality of an image improves the performance of the denoising algorithms.
3) Higher quality restoration than non special adaptive restoration method and Variational distribution approximation algorithm with improvement in the visual quality.

Suitability

1) Application of the algorithm will be at such places where the analysis or processing of remote sensing satellite data takes place such as Regional Remote Sensing Service Centre, Department of Space, etc.
2) Proposed algorithms are suitable for the application at Research Laboratories, Defense / Military, Airlines, Medical systems, Agriculture field etc.
3) Applications of the proposed filters will be at school and colleges.
4) Algorithms are suitable for Institutions of Medical sciences, Hospitals, society etc.
5) In Mechanical Engineering, for Carbon spot denoising in Automatic
6) Interpretation of Temperature-sensing Thermal paints, Universal
7) noise removal algorithm performs well.

Conclusion

The Adaptive Bilateral Filter (ABF) outperforms the bilateral filter in noise removal. At the same time, it renders much sharper images than the bilateral filter does. As a result, the overall quality of the restored image is significantly improved. The ABF is efficient to implement, and provides a more reliable and more robust solution to slope restoration. We have demonstrated the performance of ABF in figure 1 to figure 4 which illustrates that the ABF works well for natural images.

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