Noise Suppression using Local Parameterized Adaptive Iterative Model in Areas of Interest

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Abstract— Digital Image Processing means processing of digital images by using a computer via algorithms. Noise corrupts the image during sensing with malfunctioning cameras, storing in faulty memory location, or sending through a noisy channel. Sometimes, intensity of noise with which an image can be corrupted is different in its various areas. The main objective of this paper is to develop a faster and better algorithm for suppressing salt and pepper noise in different areas of interest from noisy images. This paper proposes a method for noise suppression using a Local Parameterized Adaptive Iterative Model in areas of interest. The proposed method provides good results subjectively as well as objectively for both gray scale and true color images. The proposed method is useful for interactive image processing applications as it has a family of possible denoisy images for a single noisy image.

Index Terms— Digital Image Processing (DIP), Parameterized Adaptive Iterative (PAI), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Area of Interest (AOI)

I. INTRODUCTION

The image enhancement is one of important block in the fundamental steps in DIP as it provides visually acceptable images without knowing the source of degradation for human viewers and/or automated image processing techniques. Spatial domain image enhancement modifies the image pixels directly where as in frequency domain involves finding transform of image, multiply with required transfer function and then finding inverse transform. We reviewed enhancement techniques for gray scale images in spatial domain and implemented them using MATLAB [1]. These techniques have been extended to true color images also in [2]. Image enhancement through contrast improvement can be done by using a Linear Parameterized Gradient Intercept (PGI) model [3]. Image enhancement through noise suppression can be done using a Nonlinear Parameterized Adaptive Recursive (PAR) model [4]. Image enhancement through contrast improvement and noise suppression can be done using a Parameterized Hybrid Model [5]. The above three global models work well when an entire image is corrupted uniformly. It fails to enhance when various areas of an image corrupts differently. Local models [6] can be developed to enhance an image in AOI. This paper proposes a method for noise suppression using a local PAI model in areas of interest in spatial domain.

II. PROPOSED METHOD

Let \( f(x, y) \) be original image, \( f_n(x, y) \) be its noisy image and \( g(x, y) \) be the denoisy image. Relation between noisy image and denoisy image of the proposed method for \( i=1, 2, 3 \ldots n \) is:

\[
g(x, y) = \text{cmd}(f_n(x, y))
\]  

(1)

where \( \text{cmd} \) means Conditional median filter that performs filtering to noisy pixels only, \( n \) is the number of areas of interest. For an \( i^{th} \) area of interest in noisy image, \( A_i \) is window size that is adaptive and \( I_i \) is iteration or recursive number. \( A_i \) and/or \( I_i \) can be varied for suppressing the salt and pepper noise. This filter has high Peak Signal to Noise Ratio (PSNR) as it performs filtering to only noisy pixels of noisy image. The proposed nonlinear method is given the name Local Nonlinear Parameterized Adaptive Iterative (LPAI) model³, as a family of possible denoisy images can be obtained to achieve effective noise suppression for an area of interest. As the proposed model performs condition median filtering to only noisy pixels for area of interest LPAI model can also be named as Local Conditional Median Filter (LCMF).

III. PROPOSED ALGORITHM

The following are the steps involved in image enhancement through noise suppression in AOI using LPAI algorithm for gray scale and true color images.

Gray scale image:

1. Read an input image \( f(x, y) \).
2. \( f_n(x, y) \) is a noisy image of \( f(x, y) \).
3. Divide \( f_n(x,y) \) into two sub images
   Based on AOI: \( f_{n1}(x, y) \) and \( f_{n2}(x, y) \)
4. For \( f_{n1}(x, y) \), select values of \( A_1 \) and \( I_1 \).
5. Pad all sides of the image with noisy image with \( (A_1-1)/2 \) zeros to get \( f_{p1}(x, y) \).
6. If \( 0< f_{p1}(x, y) < L-1 \), go to next pixel.
   Perform cmsd filtering to get \( g_{p1}(x, y) \).
7. If \( g_{p1}(x, y) \) is noisy, vary \( A_1 \) and/or \( I_1 \).
8. If \( A_1 \) varies go to step 4 otherwise go to step 5.
9. Remove the padded zeros in \( g_{p1}(x, y) \) to get denoisy image \( g_1(x, y) \).
10. For \( f_{n2}(x, y) \), select values of \( A_2 \) and \( I_2 \).
11. Pad all sides of the image with noisy image with \( (A_2-1)/2 \) zeros to get \( f_{p2}(x, y) \).
12. If \( 0< f_{p2}(x, y) < L-1 \), go to next pixel.
   Perform cmsd filtering to get \( g_{p2}(x, y) \).
13. If \( g_{p2}(x, y) \) is noisy, vary \( A_2 \) and/or \( I_2 \).
14. If \( A_2 \) varies go to step 11 otherwise go to step 12.
15. Remove the padded zeros in \( g_{p2}(x, y) \) to get denoisy image \( g_2(x, y) \).
16. Get denoisy image \( g(x, y) \) from two denoisy sub images \( g_1(x, y) \) and \( g_2(x, y) \).

**IV. RESULTS**

The proposed Local Conditional Median Filter (LCMF) performance can be compared to that of conventional global and local methods: Global Traditional Median Filter (GTMF), Local Traditional Median Filter (LTMF), Global Adaptive Median Filter (GAMF), Local Adaptive Median Filter (LAMF), Global Recursive Median Filter (GRMF), Local Recursive Median Filter (LRMF), and Global Conditional Median Filter (GCMF). Consider four grayscale images of file TIF type: man (256x256), Lena (512x512), birds (254x198), and moon (306x420). These images are shown in Fig. 1 have been corrupted by salt and pepper noise by two different intensities: half the area with 0.1 and rest of the area with 0.5. Noisy images are then applied to four global methods: GTMF, GAMF, GRMF, and GCMF.

Let the noisy image be divided into two areas: \( AOI_1 \) and \( AOI_2 \). They are either left half and right half or top half and bottom half. Noisy sub images obtained using image segmentation are then applied to four local methods: LTMF, LAMF, LRMF, and LCMF. The window size for traditional median filters size is 3x3, for adaptive median filters, it 5x5, and for recursive filters window size is 3x3 with repetition number 2. The window size and repetition number for conditional median filter are same for global and different for local in area of interest. Noise suppression can be judged ([7]-[15]) by visual inspection of the subjective results as shown in figures (Fig. 1-10) and objective results are presented in Table I. The proposed method has highest Peak Signal to Noise Ratio (PSNR) and also there is no effect of rounding the corners in its denoisy images.

**Peak Signal to Noise Ratio (dB):**

\[
PSNR = 20 \log_{10} \left[ \frac{L-1}{\text{MSE}} \right] \quad (2)
\]

where Mean Square Error:

\[
\text{MSE} = \frac{1}{MN} \sum_{i=1}^{N} \sum_{j=1}^{M} (f(i, j) - g(i, j))^2 \quad (3)
\]

**TABLE I: PEAK SIGNAL TO NOISE RATIO (DECIBELS)**

<table>
<thead>
<tr>
<th>Image</th>
<th>Man</th>
<th>Lena</th>
<th>Birds</th>
<th>Moon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>58.43</td>
<td>58.58</td>
<td>58.95</td>
<td>57.38</td>
</tr>
<tr>
<td>GTMF</td>
<td>65.09</td>
<td>66.09</td>
<td>65.31</td>
<td>64.88</td>
</tr>
<tr>
<td>LTMF</td>
<td>65.23</td>
<td>66.13</td>
<td>65.42</td>
<td>64.99</td>
</tr>
<tr>
<td>GAMF</td>
<td>68.27</td>
<td>72.67</td>
<td>69.15</td>
<td>74.77</td>
</tr>
<tr>
<td>LAMF</td>
<td>68.77</td>
<td>73.08</td>
<td>68.66</td>
<td>72.94</td>
</tr>
<tr>
<td>GRMF</td>
<td>68.24</td>
<td>70.39</td>
<td>68.37</td>
<td>70.63</td>
</tr>
<tr>
<td>LRMF</td>
<td>68.52</td>
<td>70.53</td>
<td>68.60</td>
<td>71.21</td>
</tr>
<tr>
<td>GCMF</td>
<td>74.70</td>
<td>80.92</td>
<td>72.84</td>
<td>78.38</td>
</tr>
<tr>
<td>LCMF</td>
<td>79.76</td>
<td>80.99</td>
<td>80.85</td>
<td>85.97</td>
</tr>
</tbody>
</table>
Fig. 6: LAMF images

Fig. 7: GRMF images

Fig. 8: LRMF images

Fig. 9: GCMF images

Fig. 10: LCMF images
V. CONCLUSIONS

Noise suppression using Local Parameterized Adaptive Iterative model in area of interest has been successfully implemented for grayscale images and can be extended to true color images in spatial domain. Proposed model work well for different types of images. Choice of A and I depends on type of image. LPAI method can be used as a tool for any photo editing software like photo shop or any existing image processing software by providing two sliding bars for selecting spatial coordinates for x and y of AOI and then two more sliding bars A and I for noise suppression.

Sometimes an image can be corrupted by both poor contrast and unwanted noise differently in its areas. The future scope will be the development of two models: first one is local parameterized hybrid model for achieving both contrast improvement and noise suppression in AOI where as second one is parameterized model for achieving effective spatial domain image enhancement for binary images (grayscale and true color) like text, document, medical, pencil art, vehicle’s licence plate and finger prints.

REFERENCES


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