Adaptive probability filter for removing salt and pepper noises

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***Abstract*—The adaptive Probability filter was proposed in this paper which is used to overcome the drawbacks of the existing filters to remove the salt and peppers noise.Based on the distribution of the salt and pepper noise over the image the minimum intensity and maximum intensity will be detected.For a noise pixel, based on the probability of the neighbourhood pixels if the noise free pixels was repeat with certain probability, the highest noise free pixel repeated will be used to replace the noise pixel, else the median of the neighbourhood pixel intensities is used to replace the noise intensity pixel.**

***Index Terms*—image, Salt pepper, noise, neighbour, Median,Intensity**

I. Introduction

During the process of acquisition, transmission, and storage, the image will be corrupted by the impulse noise. The impulse noise happens mainly by the two types of fixed and random values.The salt and pepper noise comes under the fixed type which takes minimum and maximum intensities over the image distribution.Standard Median filters are commonly used to remove these type of noised by their computational complexity and are limited to low density noise, they show poor performance on higher densities So improved filters perform based on the neighbourhood pixels, the neighbourhood sizes of which vary adaptively with the noise densities. These filters deal with all pixels uniformly without protecting noise free pixels.
Here we used an adaptive probability filter (APF) that performs better in noise detection and noise removal.

II. Noise Detection Based on Statistics

A. Statistical features of salt and pepper noise

The salt and pepper noises are randomly distributed over the image with intensities '0' for salt and '255' for pepper pixels.
The salt and pepper has the below statistical characteristics:
i. Salt and pepper noise was evenly and randomly distributed with equal probability over the image.
ii. There is a sturdy correlation amongst noise-free pixels in a neighbourhood, so the noise-free pixel with intensities 0 (or 255) isn't always isolated, and the intensities of its neighbouring pixels are in all likelihood to shut to 0 (or 255).
iii. It is noteworthy that during a white neighbourhood corrupted with the aid of using salt and pepper noises, the salt noise is assimilated and lost; all of the pixels with intensities 255 are taken noise free, whilst all of the pixels with intensities zero are noise. Similar for the blacks.

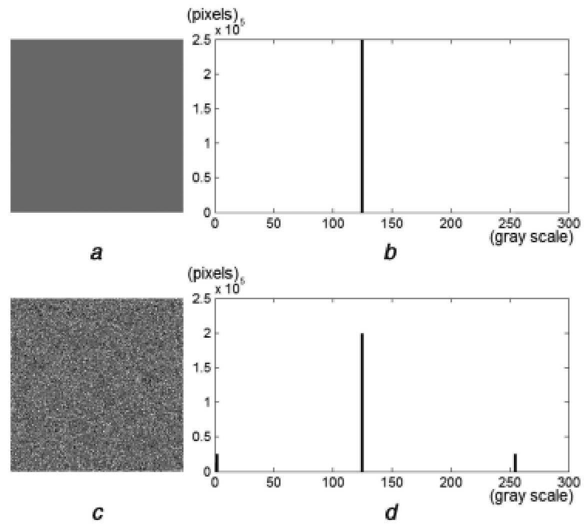

Fig. 1. Characteristic analysis of salt and pepper noise
(a) Single Intensity image, (b) Histogram of fig(a), (c) Image of (a) with noise density 20%, (d) Intensity Histogram of (c)

B. Detection of noise based on statistics

Based on the above analysis, the pixels with intensities 0 and 255 are further detected by below method. For an image I, I(p) represents the intensity of the pixel p, which varies from 0 to 255.Let $N_p^{(k)}$ of pixel p with size $k \times k$, here we consider k equals to 5 where k equals to 3 is very small which makes the neighbourhood pixels lacking statistical significance while $k \geq 7$ which makes neighbourhood pixels lacking correlation. n_i denotes the number of pixels in $N_p(k)$ with intensity i, $n_{i\_}$ represents other than intensity i.

III. Removal of noise based on statistics

Based on the above analysis, the pixels with intensities 0 and 255 are further detected by below method.
In general the pixels intensities are strongly correlate with the neighbourhood pixel intensities, which many times the intensities are repeated
For a noisy pixel p, P(i) is the probability of repetition of noise free intensity i in the neighbourhood $N_p^{(k)}$

$$i_{max}{=}argmax_{i\epsilon N_p^{(k)}}P(i)$$

Let T be the adaptive threshold if $P(i_{max}) \geq$ T, tl i_{max} is used to replace the original intensity at pi p. Otherwise we use Median Filter at the intensity of p.

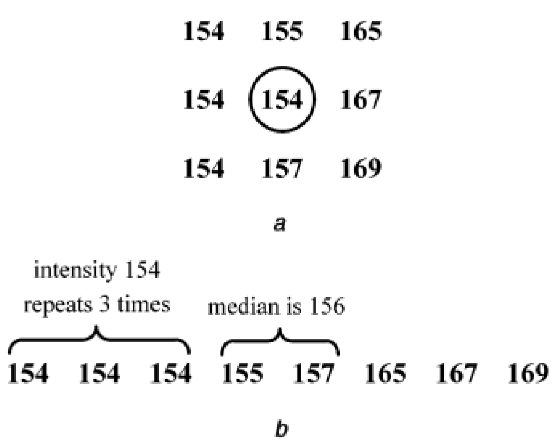

Fig. 2. Comparison of median denoising and denoising based on statistics (a) Neighbourhood of centre pixel p, (b) Median and intensity with highest repeated frequency

If there are no noise free pixels in the neighbourhood then enlarge k to get the noise free pixels.We define T equals to $numel[N_p^(k)]/4$ where $numel[N_p^(k)]$ represents number of noise free pixels in the neighbourhood of size k.

IV. Procedure of Adaptive Probability Filter(APF)

Initialize R with zeros of size I, where R is used to find the noise where intensities are 0 or 255 at every pixel of the noised image.Here we used $N_P^{(5)}$ as initial size of the neighbourhood which can go upto $n_p^{(k_{max})}$ where k_{max} is 11. For the high density noise k_{max} will be enlarged to 11.

The algorithm of this APF method as follows:

i. For every pixel in I(p) with intensity 0 or 255 set R(p) to 1.
ii. For every pixel p with R(p)=1 in its Np(5), if V(p)=0 and $n0 > n0_{-}$,or V(p)=255 and $n255 > n255_{-}$, reset R(p)=0.
iii.For each pixel p with R(p)=1, calculate the number of noise free pixels in $N_p^{(k)}$ and find Threshold ”T”,
$T = Numel(N_p(k))/4$.
iv. If $P(i_{max}) \geq T$ then p takes i_{max}, or it will be replaced by median of the noise free pixels in$N_P^{(k)}$.
v. increase the size of the neighbourhood with $k = k+2$ with $k_{max} = 11$

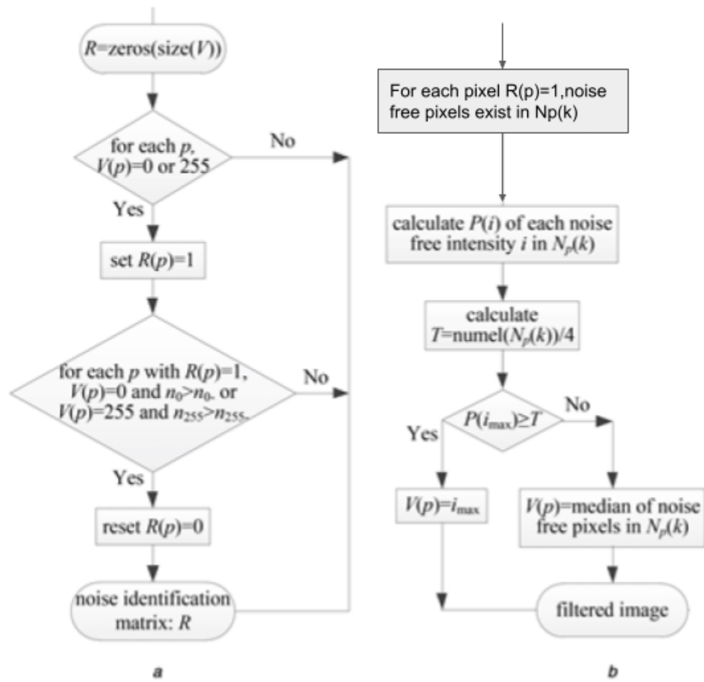

Fig. 3. Flowchart of the APF

V. Simulation Results and Discussion

- The APF algorithm was performed on the images like peppers and cameraman.
- The experiments are conducted using MATLAB R2022b

Below are the experiment results with noise density 10 %

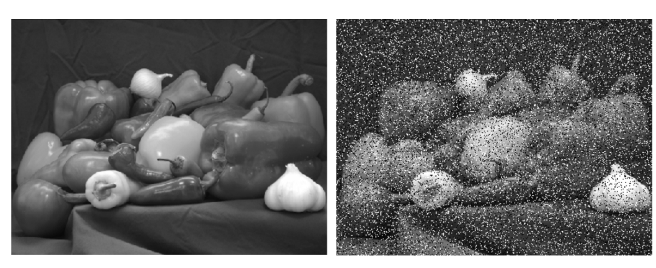

Fig. 4. (1) is the original image,
(2) is the noise image with noise density 10%

By taking the Neighbourhood matrix $N_p(k)$ of size k= 5,7,9 and 11 below are the results after denoising shown in figure 5,6

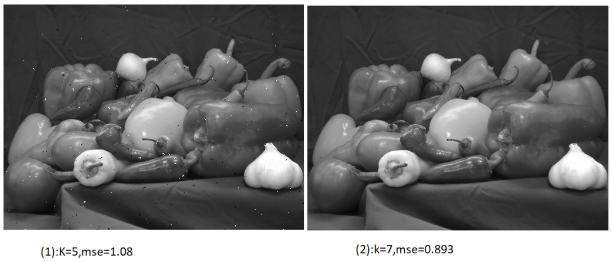

Fig. 5. (1) with K=5, (2) with k=7

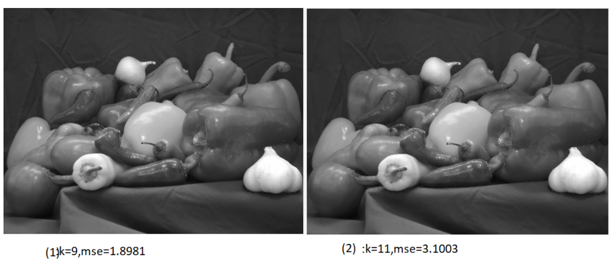

Fig. 6. (1) with K=9, (2) with k=11

The Filtering was done on cameraman.tiff image, below are the results shown in figure 7,8.

Fig. 7. (1) with K=5, (2) with k=7

A. *Performance measures of noise detection*

Peak Signal to Noise ratio(PSNR) and Mean Square Error(MSE) were evaluated on the APF method.

The higher the PSNR,better the noise removed and lower the MSE, better the noise removed.

$$PSNR = 10 \times lg \frac{m \times n \times 255^2}{\sum_{i=1}^{m} \sum_{j=1}^{n} (f(i,j) - g(i,j))^2}$$

Fig. 8. (1) with K=9, (2) with k=11

$$MSE = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (f(i,j) - g(i,j))^2}{m \times n}$$

m,n denotes the size of the original image ”f”, where ”g” is the denoised image.

Below is the graph for PSNR vs noise density for ”peppers” image

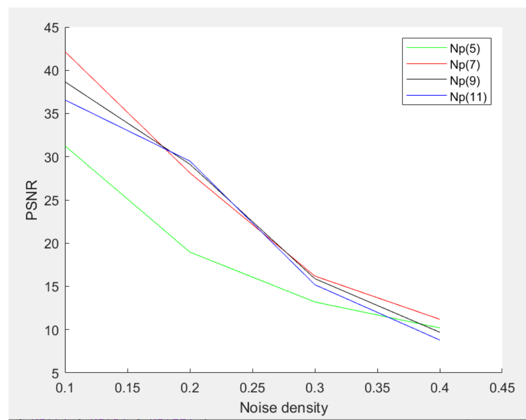

Fig. 9. Comparison of the APF method for PSNR with different noise densities

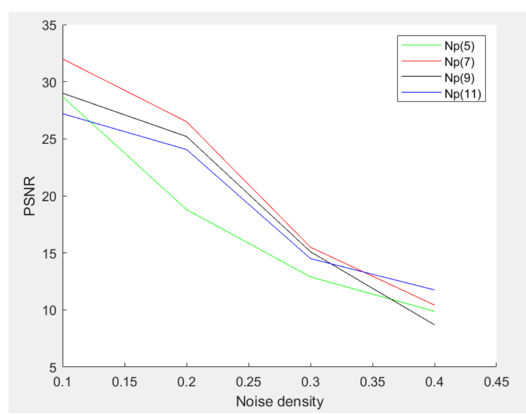

Fig. 10. Comparison of the APF method for PSNR with different noise densities

VI. Conclusion

An APF method is proposed on this paper to come across salt and pepper noises primarily based totally at the traits of minimum and maximum intensity values of an image, in addition to the distribution of salt and pepper noises.If the noise-free intensities repeat with a positive possibility in neighbourhood, in keeping with the statistical significance, the noise-free intensity with the very best repeated frequency is used to get rid of noise.It turned into discovered through the experimental outcomes that noise detection by proposed APF is greater accurate.

References

[1] Author(s): Jiayi Chen 1 ; Yinwei Zhan 2 ; Huiying Cao 1 ; Xingda Wu1,Source: Volume 12, Issue 6, June 2018, p. 863 – 871 DOI: 10.1049/iet-ipr.2017.0910 , Print ISSN 1751-9659, Online ISSN 1751-9667