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A Survey on Image Restoration Techniques

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Abstract: *Image restoration is the process of improving the appearance of the digital image. The aim of this paper is introduce digital image restoration to the reader, who are just beginners in this field. There are various types of noises but this paper only discussing about Gaussian noise and impulse noise (salt and pepper noise).This paper discuss about wavelet based image restoration, fuzzy logic based image restoration and image restoration using image inpainting.*

Keywords: *Gaussian Noise, Salt and Pepper Noise, Inpainting, Wavelet*

1. INTRODUCTION

Image restoration is the process of reconstructing or recovering an image from degraded stage. Knowledge of degradation is need for successful restoration. Image restoration has two techniques

1. Spatial domain techniques
2. Frequency domain techniques

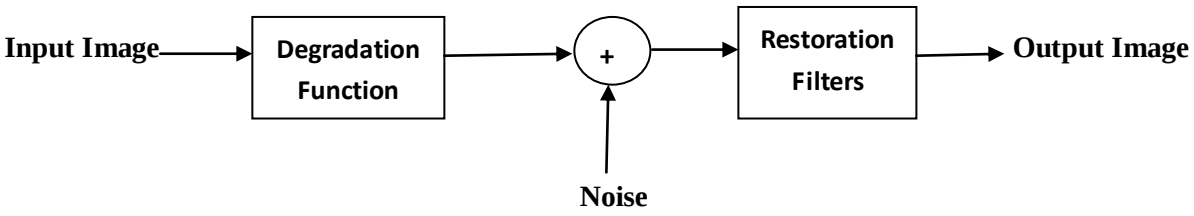

Fig1. *Model of Restoration process*

The source of noise in digital images arises during image acquisition and/or transmission. Different noises are available, but this paper discussing about salt and pepper, Gaussian noise. Principle source of Gaussian noise in digital image arise during acquisition eg sensor noise caused by poor illumination and/or high temperature. In digital image processing Gaussian noise can be reduced using a spatial filter, though when smoothing an image ,an undesirable outcome may results in the blurring of fine scaled image edges and details because they also correspond to blocked high frequencies.

Gaussian noise

PDF of Gaussian noise

$$p_G(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}} \quad (1)$$

Where

Z=grey level

μ=mean value

σ=standard deviation

Impulse noise is sometimes called salt and pepper noise or spike noise. An image containing salt and pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by ADC errors, bit errors in transmission

Salt and pepper noise (impulse noise)

PDF of impulse noise

$$P(Z) = \begin{cases} P_a & Z=a \\ P_b & Z=b \\ 0 & \text{Otherwise} \end{cases} \quad (2)$$

2. WAVELET BASED IMAGE RESTORATION

The principle of wavelet transform is split up the signal into a bunch of signals, representing the same signal, but all corresponds to frequency bands. The idea of wavelet de-noising based on the assumption that the amplitude, rather than the location of the spectra of the signal to be as different as possible for that of noise. This allows clipping, thresholding and shrinking of the amplitude of the co-efficient to separate signals or remove noise.

2.1 Steps in Wavelet De-noising

1. DWT of the image is calculated
2. Resultant co efficient are passed through threshold testing
3. The coefficients less than threshold are removed, others shrinked
4. Resultant coefficients are used for image reconstruction with IWT

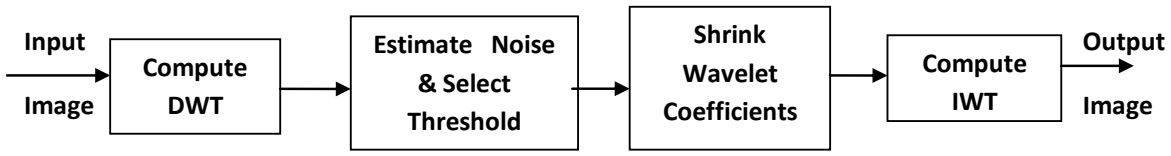

Fig2. *Wavelet based de-noising steps*

3. FUZZY BASED IMAGE RESTORATION

Fuzzy image processing has three main stages:

1. Image Fuzzification
2. Modification of membership values
3. Image Defuzzification

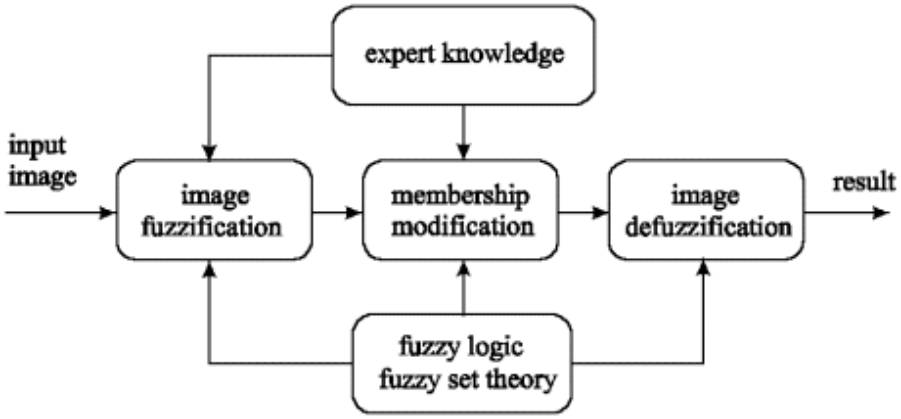

Fig3. *The general structure of fuzzy image processing*

The steps fuzzification and defuzzification are due to the fact that there is no fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) make possible to process images with fuzzy techniques. The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data are transformed from gray-

level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering; a fuzzy rule-based approach, a fuzzy integration approach and so on.

3.1. Steps of Fuzzy Image Processing

This system presents a new technique for filtering noise in compound images by a fuzzy filter. Two important features are fuzzy derivative and fuzzy smoothing.

First, the filter estimates a "fuzzy derivative" in order to be less sensitive to local variations due to image structures such as edges. Second, the membership functions are adapted accordingly to the noise level to perform "fuzzy smoothing."

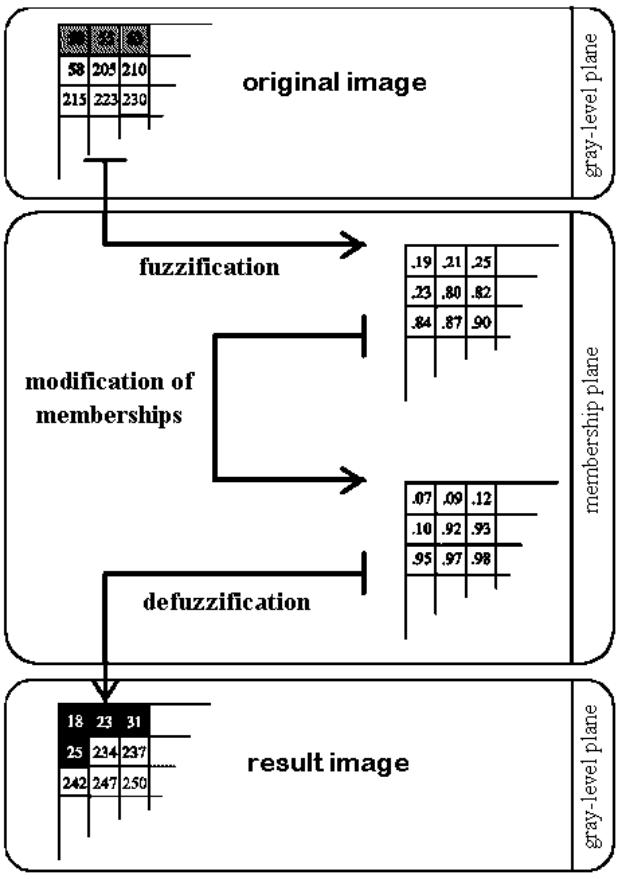

Fig4. *Steps of fuzzy image processing*

For each pixel that is processed, the first stage computes a fuzzy derivative. Second, a set of 16 fuzzy rules is fired to determine a correction term. These rules make use of the fuzzy derivative as input. Fuzzy sets are employed to represent the properties, and. While the membership is adapted after each iteration

The general idea behind the filter is to average a pixel using other pixel values from its neighborhood, but simultaneously to take care of important image structures such as edges. The main concern of the proposed filter is to distinguish between local variations due to noise and due to image structure. In order to accomplish this, for each pixel we derive a value that expresses the degree in which the derivative in a certain direction is small. Such a value is derived for each direction corresponding to the neighboring pixels of the processed pixel by a fuzzy rule.

The further construction of the filter is then based on the observation that a small fuzzy derivative most likely is caused by noise, while a large fuzzy derivative most likely is caused by an edge in the image. Consequently, for each direction we will apply two fuzzy rules that take this observation into

account (and thus distinguish between local variations due to noise and due to image structure), and that determine the contribution of the neighboring pixel values. The result of these rules (16 in total) is defuzzified and a "correction term" is obtained for the processed pixel value.

In particular, the shape of the membership functions is adapted according to the remaining noise level after each iteration, making use of the distribution of the homogeneity in the image. A statistical model for the noise distribution can be incorporated to relate the homogeneity to the adaptation scheme of the membership functions.

3.2. Fuzzy Derivative Estimation

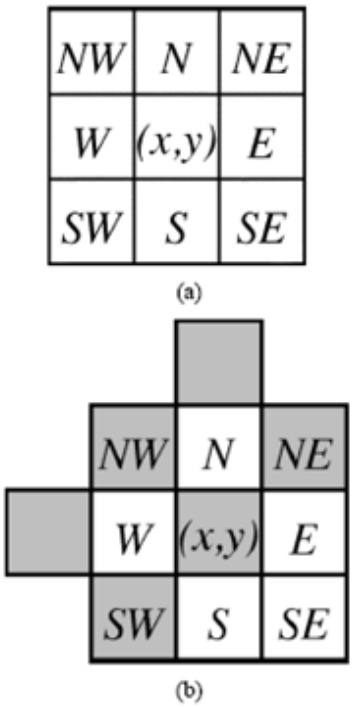

Fig5. *a) neighborhood of centre pixel (x,y), b)pixel values indicated in gray are used to derive fuzzy derivatives of the centre pixel (x,y)for the NW direction*

3.3. Table for Fuzzy Derivatives

PIXELS INVOLVED TO CALCULATE THE FUZZY DERIVATIVES IN EACH DIRECTION

direction	position	set w.r.t. (x, y)
NW	$(x-1, y-1)$	{(-1,1),(0,0),(1,-1)}
W	$(x-1, y)$	{(0,1),(0,0),(0,-1)}
SW	$(x-1, y+1)$	{(1,1),(0,0),(-1,-1)}
S	$(x, y+1)$	{(1,0),(0,0),(-1,0)}
SE	$(x+1, y+1)$	{(1,-1),(0,0),(-1,1)}
E	$(x+1, y)$	{(0,-1),(0,0),(0,1)}
NE	$(x+1, y-1)$	{(-1,-1),(0,0),(1,1)}
N	$(x, y-1)$	{(-1,0),(0,0),(1,0)}

3.4. Membership Function

Membership functions can

- Either be chosen by the user arbitrarily, based on the user's experience (MF chosen by two users could be different depending upon their experiences, perspectives, etc.)
- Or be designed using machine learning methods (e.g., artificial neural networks, genetic algorithms, etc.)

There are different shapes of membership functions; triangular, trapezoidal, piecewise-linear, Gaussian, bell-shaped, etc.

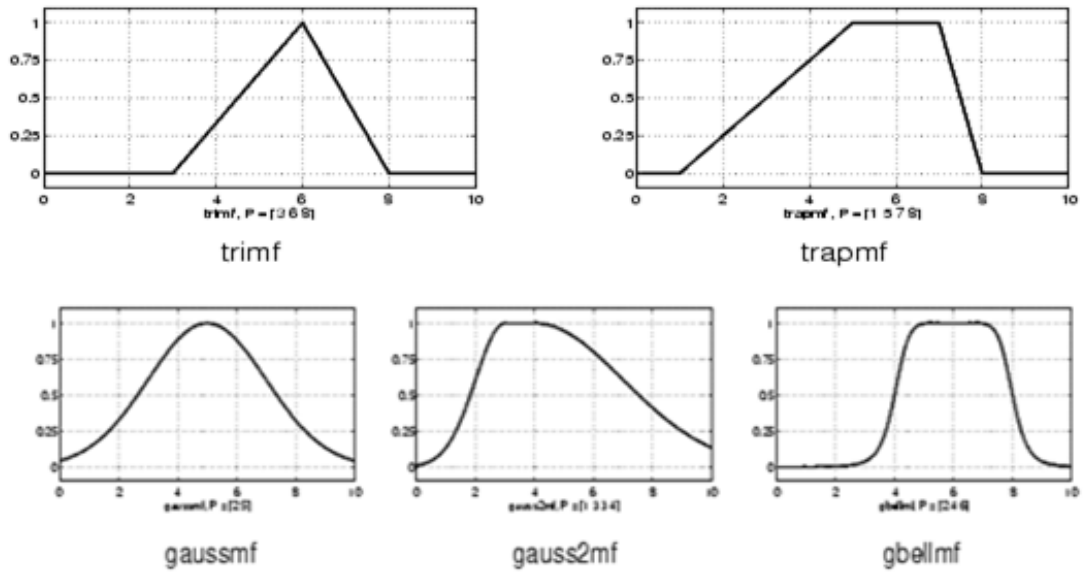

Fig6. *Examples of membership functions*

4. IMAGE RESTORATION USING INPAINTING

Image Inpainting is technique which is used to recover the damaged image and to fill the regions which are missing in original image in visually plausible way. Inpainting, the technique of modifying an image in an invisible form, it is art which is used from the early year. Applications of this technique include rebuilding of damaged photographs& films, removal of superimposed text, removal/replacement of unwanted objects, red eye correction, image coding. The main goal of the Inpainting is to change the damaged region in an image.

Various Image Inpainting Techniques

- Partial Differential Equation (PDE) based
- Texture synthesis based
- Exemplar and search based
- Wavelet Transform based
- Semi-automatic and Fast Inpainting.

Image Inpainting methods can be classified broadly into

- *Texture Synthesis Algorithm:* These algorithms sample the texture form the region outside the region to be inpainted. It has been demonstrated for textures, repeating two dimensional patterns with some randomness.

- *Structure Recreation:* These algorithms try to recreate the structures like lines and object contours. These are generally used when the region to be inpainted is small. This focuses on linear structures which can be thought as one dimensional pattern such as lines and object contours.

Applications of Image Inpainting

- *Repairing Photographs:* With age, photographs often get damaged or scratched. We can revert deterioration using inpainting.
- *Remove Unwanted Objects:* Using inpainting, we can remove unwanted objects, text, etc. from the image.
- *Special Effects:* This may be used in producing special effect.
- *Video Inpainting:* If extended to video inpainting, it would be able to provide a great tool to create special effects etc.

5. CONCLUSION

The main goal of this survey is to understand the usage of wavelet concept, fuzzy logic and inpainting in image restoration. These studies also explain about some MFs (Membership Functions) and also list out various inpainting techniques used for image Restoration.

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