Fuzzy Based Adaptive Filters in Color Image Processing

D. Sreenivasa Rao, Y. Gangadhar, V.S. Giridhar Akula

***Abstract*— Noise reduction is the very important stage of image processing and pattern reorganization. Many researches find new tools and filters for noise reduction. This paper proposed a fuzzy based adaptive filter. The proposed filter is composed with the existing filter like VDF, VMF and VRF with Gaussian noise, impulse noise and mixed Gaussian Noise. The proposed method is proved to be a best suitable one with a P value of 0.23.**

***Index Terms*— Rectangular Window, Rational Functions, Fuzzy Logic, Color Space, Trapezoid Fuzzy Subsets, Fuzzy Membership Function, Distances Function Sub Filters, Power Parameter.**

I. INTRODUCTION

The concept of color image processing has gained regionally attention in computer vision and pattern recognition, because color image convey more information about objects than gray scale images.

In the applications of remote sensing, electron microscopy, satellite imaging and biomedical image processing filters are widely used to reduce the noise. Adaptive filters are those whose behavior changes based on statistical characteristics of the image inside the filter region defined by the $m \times n$ rectangular window Sxy. Mean and variance are the two important parameters related to adaptive filters, because they are closely related to the appearance of an image. The mean gives the value of average intensity in the region. Whereas the variance gives a major contrast in the region the response of the filter is based on four quantities: $G(x,y)$ (the value of the noisy image at (x,y)), σ_η^2 (the variance of the noise corrupting $f(x,y)$ to form $g(x,y)$), m_l (local mean of the pixel in Sxy) and σ_l^2 (local variance of the pixels in Sxy).

In this paper, the proposed adaptive filter is compared with other existing filters like VRF, VDF, and VMF etc.

II. MATERIALS AND METHODS

Many non linear filters are used to reduce noise with presenting the integrity of edges and detail information.

Vector medium filters [1] are used to minimize the distance in the vector space. Those filters are used for exponential distribution. These filters are more suitable for a long-tailed distribution.

Vector rational filters [2] are another category of filters which is use to rational functions in these input/output relations.

The angle between the image vectors is the basic measure in vector Directional filters [3], but these filters do not includes the magnitudes of image vectors. The recent development in image processing filter stricture is the vector medium rational hybrid filters [4] and is a 2 stage filters.

Fuzzy logic is introduced by Lotfi A. Zadeh in the year 1965 digital image processing and pattern reorganization techniques widely used fuzzy logic and fuzzy sets for various regions. Fuzzy techniques are widely used for different types of noise elimination. Fuzzy sets and fuzzy rules are very dynamic tools to model complex control systems.

This paper proposes a new adaptive filter in association with fuzzy components of images in color spaces.

III. IMAGE COLOR SPACE

RGB is the most widely used color space to represent color, and Red, Green and Blue are the primary color involved in this color space. Many color histograms uses in this color space to identify the uniqueness among the images [5].

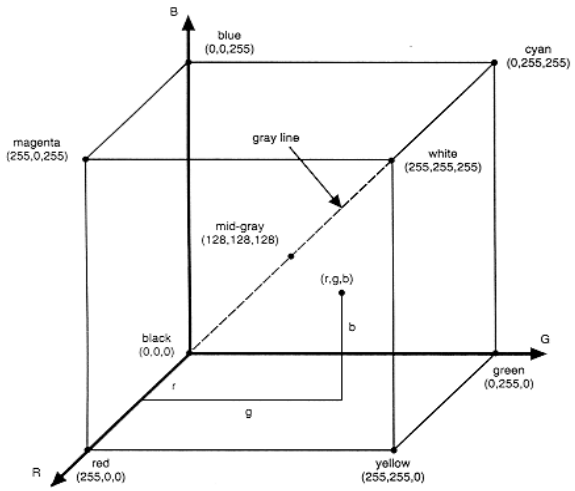

Fig (1): RGB Color Space

As RGB color space uses three dimensions, it leads to find difficulty in defining degree of membership. There is another way of identifying the color directly with only one dimension and that is HLS space. In Hue, lightness, saturation (HLS) color space hue itself recognizes the color.

Manuscript received December 23,2011.

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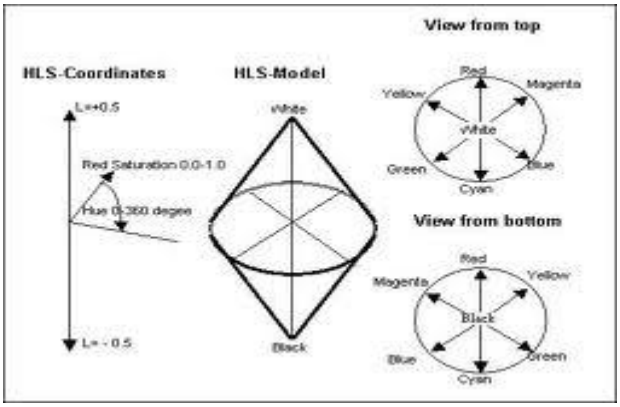


Fig (2): HLS Color Space

The Hue's definition interval make an angle, the complete or pure red corresponds are makes an angle equal to 0 to 4, a saturation equal to 255 and lightness equal to 128. For some colors, we obtained a wide interval and it's represented by trapezoidal fuzzy subsets as shown in the fig (3).

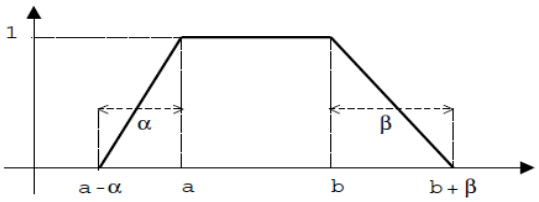


Fig (3): Trapezoidal Fuzzy Subset.

When the trapezoidal fuzzy subset (a, b, α, β) is compressed to a single point, It is a triangular subset represented by a tuple (a, α, β) [6] because $a = b$ at this point.

IV. FUZZY CENTER WEIGHTED VECTOR DIRECTIONAL SUB FILTERS

The fuzzy membership function is represented as

$$\forall t \epsilon T, f_t(h) = \begin{cases} 1 & if\ h \geq a \\ & and\ h \leq b \\ 0 & if\ h \leq a - \propto \\ & and\ h \geq b + \beta \\ \frac{h-(a-\propto)}{\propto} & if\ h > a - \propto \\ & and\ h < a \\ \frac{(b+\beta)-b}{\beta} & if\ h > b \\ & and\ h < b + \beta \end{cases} \quad (1)$$

The weights of the proposed filter are identified with the help of membership functions at different locations of the image. Let the three input functions are $\phi_1, \phi_2\ and\ \phi_3$ and $y(f_i)$ is the output vector. Here ϕ_2 is fixed as fuzzy counter weighted vector directional sub filters and is defined as

$$y(f_i) = \phi_2(f_i) + \frac{\sum_{j-1}^{3} \propto_j \phi_j(f_i)}{h + kD[\phi_1(f_i), \phi_3(f_i)]} \quad (2)$$

Here D is a scalar function.
The sub filters $\phi_1 and\ \phi_3$ plays very vital role to reduce noise in an acceptable fashion.

The membership function can also be represented (based an equation (1)) by the comparison of vector under use with the ideal vector which leads to a distance function is follows.

$$w_j = \frac{\beta}{1 + \gamma(f_j)}$$

Where γ is a distance function.

V. PROPOSED METHODS

With the help of sub filter $\phi_1 and\ \phi_3$, the distance function is combined to find fuzzy weights. As these filters are not sensitive with ordinary, this proposed method is more adaptable compared to the existing traditional filters. The sub filter produces output with a vector valued signal which leads to the efficient image restoration
The magnitude distance $\tilde{a_i}$ is represented as

$$\tilde{a_i} = \frac{1}{N} \sum_{j=1}^{N} \| f_i - f_j \|$$

$$= \frac{1}{N} \left[\sum_{j=1}^{N} O(f_i - f_j) \right]^{p} \left[\sum_{j=1}^{N} \| f_i - f_j \| \right]^{1-p}$$

$$p \epsilon [0,1],\ \ i = 1, 2, \ldots \ldots \ldots N$$

Where $O(f_i, f_j)$ defines the angular distance. Here the power parameters P control the importance of the angle criteria versus the distance criteria in the general fuzzy membership function.
We have considered constant P value as 0.23.

VI. RESULTS

Proposed filters are compared with the traditional non linear filters. Noise attenuation properties of various comparable filters are tested with some testing images.

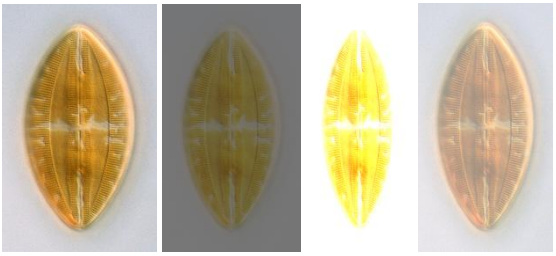
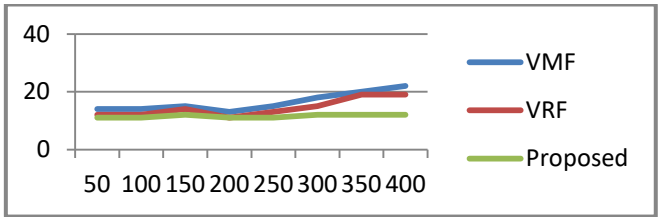


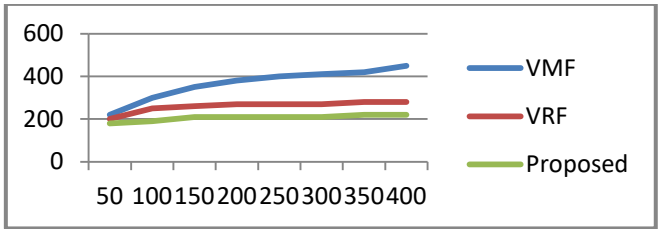
Fig (4) Diatom images With Gaussian. Impulsive and Mixed Gaussian Noise

With mean absolute error, mean square error and the normalized color difference are the majors used in comparison. It is identified that the equal color differences leads to equal distances [7].
Image mixed with Gaussian noise, impulsive noise and mixed Gaussian with impulsive noise are tested with the existing filters [8].

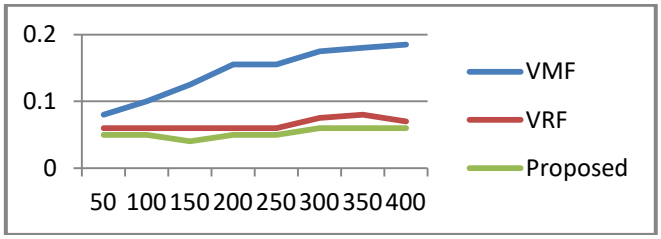
Sample Graphs of Results



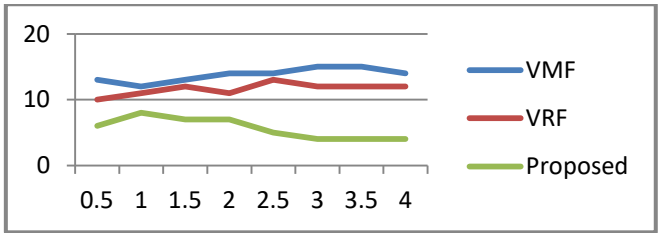
Graph 1



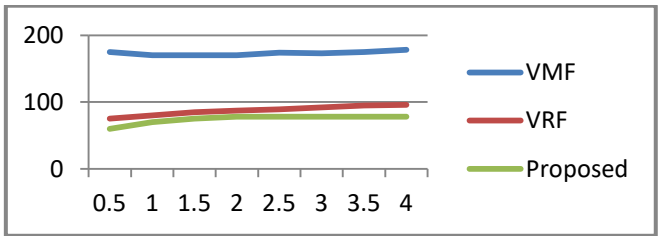
Graph 2



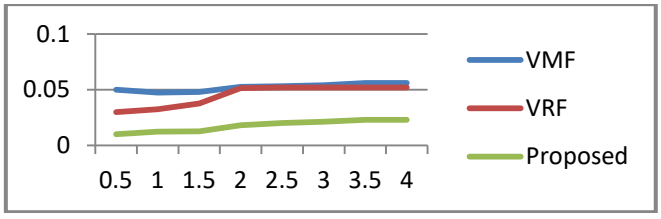
Graph 3



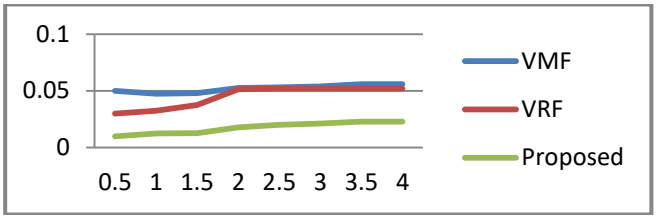
Graph 4



Graph 5



Graph 6



Graph 7

VII. CONCLUSION

This paper explains the new adaptive filter used to reduce noise from an image obtained in color space. Using the fuzzy subsets $\phi_1, \phi_2 \, and \, \phi_3$ and the distance function, we obtained an efficient method of filtering diatom images which are added with Gaussian noise, impulsive noise and mixed Gaussian noise. The value of power parameter P is used as 0.23 and with this we had achieved regarding good results compared with other filters.

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