Image Enhancement Based On Fuzzy Logic

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Summary

Removing and reducing impulse noise is very active research area in image processing. Present day applications require various kinds of images and pictures as sources of information for interpretation and analysis. Whenever an image is converted from one form to another, some form of degradation occurs at the output. The output image has to undergo a process called image enhancement. An effective method for image enhancement was presented by Russo, which was controlled by tuning of one parameter. In this paper, a filter is introduced which will remove the noise and improve the contrast of the image. To achieve this goal fuzzy-logic-control based approach is used. The filter is tested on the colored images.

Keywords: Image Enhancement, Fuzzy Logic.

1. INTRODUCTION

In the process of imaging and transmission [1], it's hard to avoid the interference of different kinds of noise. So, in the presence of noise, pre-processing steps such as image enhancement are widely used. The objectives of image enhancement are to remove impulsive noise, to smooth non impulsive noise, and to enhance the edges or other salient structures in the input image. In the techniques of image enhancement, image smoothing and image sharpening are two important methods.

Images can be contaminated [2] with different types of noise, for different reasons. For example, noise can occur because of the circumstances of recording, transmission, or storage, copying, scanning etc. Impulse noise and additive noise are most commonly found. It is a great challenge to develop algorithms that can remove noise from the image without disturbing its content. The neighborhood averaging and smoothing by image averaging are the classical image processing techniques for noise removal.

Because fuzzy set theory [3] has the potential capability to efficiently represent input/output relationships of dynamic systems, this theory has gained popularity, especially in pattern recognition and computer vision applications. In the well-known rule-based approach, for image processing one, may use human knowledge expressed heuristically in linguistic terms. Yang and Tou applied heuristic fuzzy rules to improve the performance of the traditional multilevel median filter.

2. PREVIOUS WORK

A number of non linear, multi channel filters, which utilize correlation among multivariate vectors using various distance measures, have been proposed to date. The most popular non linear, multi channel filters are based on the ordering of vectors in a predefined moving window [4]. The output of these filters is defined as the lowest ranked vector according to a specific vector-ordering technique. Let $\mathbf{F}(x)$ represent a multi channel image and let W be a window of finite size n (filter length). The noisy image vectors inside the filtering window W are denoted by $\mathbf{F}_j$, j =0, 1. . . n−1. If the distance between two vectors $\mathbf{F}_i$, $\mathbf{F}_j$ is denoted by $\rho\ \{\mathbf{F}_i,\mathbf{F}_j\}$, then the scalar quantity $R_i = \sum_{j=0}^{n-1} \rho\{\mathbf{F}_i,\mathbf{F}_j\}$ is the total distance associated with the noisy vector $\mathbf{F}_i$. The ordering of the R_i's: $R_{(0)} \le R_{(1)} \le \cdots \le R_{(n-1)}$, implies the same ordering of the corresponding vectors $\mathbf{F}_i$: $\mathbf{F}_{(0)} \le \mathbf{F}_{(1)} \le \cdots \le \mathbf{F}_{(n-1)}$. Nonlinear ranked-type multi channel estimators define the vector $\mathbf{F}_{(0)}$ as the filter output. However, the concept of input ordering, initially applied to scalar quantities, is not easily extended to multi channel data since there is no universal way to define ordering in vector spaces.

To overcome this problem, distance functions are often utilized to order vectors. As an example, the vector median filter (VMF) uses the L1, L2 norms to order vectors according to their relative magnitude differences.

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3. PROPOSED WORK

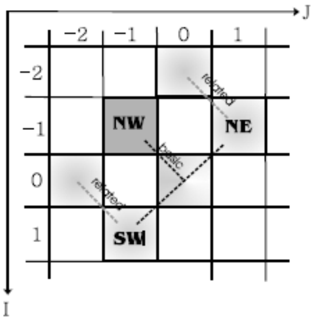
The proposed algorithm mainly involves two broad steps:

1. Removal of impulse noise.
2. Improving contrast of the image.

These two steps are discussed in this section.

3.1 Removal of Impulse noise

We start from a gray scale image in order to better explain how the new algorithm is constructed. Let the grayscale image be represented by a matrix F of size N1 ×N2, F ={F(i, j)€ {0, . . . ,255}, i = 1, 2, . . . ,N1, j = 1, 2, . . . ,N2}. Our construction starts with the introduction of the similarity function μ: [0 ;∞) →R. We will need the following assumptions for μ:
(1) μ is decreasing in [0;∞),
(2) μ is convex in [0;∞),
(3) μ(0) = 1, μ(∞) = 0.
In the construction of filter, the central pixel in the window W is replaced by that one, which maximizes the sum of similarities between all its neighbors. Basic assumption is that a new pixel must be taken from the window W.



For each pixel (i, j) of the image (that isn't a border pixel) use a 3 X 3 neighborhood window. Each neighbor with respect to (i, j) corresponds to one direction {NW = North West, N = North, NE = North East, W = West, E = East, SW = South West, S = South, SE= South East}. Each such direction with respect to (i, j) can also be linked to a certain position.

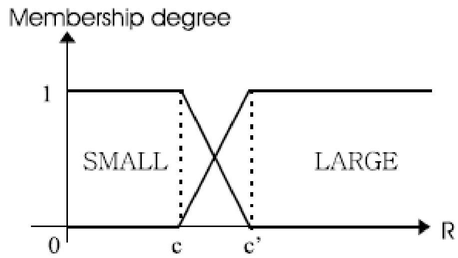
INVOLVED GRADIENT VALUES TO CALCULATE THE FUZZY GRADIENT.

R	basic gradient	related gradients
NW	$\nabla_{NW}A(i,j)$	$\nabla_{NW}A(i+1,j-1), \nabla_{NW}A(i-1,j+1)$
N	$\nabla_{N}A(i,j)$	$\nabla_{N}A(i,j-1), \nabla_{N}A(i,j+1)$
NE	$\nabla_{NE}A(i,j)$	$\nabla_{NE}A(i-1,j-1), \nabla_{NE}A(i+1,j+1)$
E	$\nabla_{E}A(i,j)$	$\nabla_{E}A(i-1,j), \nabla_{E}A(i+1,j)$
SE	$\nabla_{SE}A(i,j)$	$\nabla_{SE}A(i-1,j+1), \nabla_{SE}A(i+1,j-1)$
S	$\nabla_{S}A(i,j)$	$\nabla_{S}A(i,j-1), \nabla_{S}A(i,j+1)$
SW	$\nabla_{SW}A(i,j)$	$\nabla_{SW}A(i-1,j-1), \nabla_{SW}A(i+1,j+1)$
W	$\nabla_{W}A(i,j)$	$\nabla_{W}A(i-1,j), \nabla_{W}A(i+1,j)$

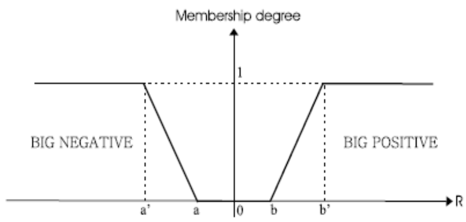
Each direction R corresponds to central position. Column 2 gives the basic gradient for each direction; column 3 gives the two related gradients. The fuzzy gradient value for direction R is calculated by following fuzzy rule:

IF $|\nabla_R A(i,j)|$ is large AND $|\nabla'_R A(i,j)|$ is small
OR
$|\nabla_R A(i,j)|$ is large AND $|\nabla''_R A(i,j)|$ is small
OR
$\nabla_R A(i,j)$ is big positive AND $\left(\nabla'_R A(i,j)\right.$ AND $\left.\nabla''_R A(i,j)\right)$ are big negative
OR
$\nabla_R A(i,j)$ is big negative AND $\left(\nabla'_R A(i,j)\right.$ AND $\left.\nabla''_R A(i,j)\right)$ are big positive
THEN $\nabla^F_R A(i,j)$ is large

The membership function used are LARGE (for the fuzzy set large), SMALL (for the fuzzy set small), BIG POSITIVE (for the fuzzy set big positive) and BIG NEGATIVE (for the fuzzy set big negative).



The above graph shows the membership function for fuzzy set SMALL and LARGE.



The above graph shows the membership function for fuzzy set BIG NEGATIVE and BIG POSITIVE.

The pixels of the image are arranged in these membership functions. The noisy pixels are then sort out and form the member of the function more or less impulse noise. The noisy pixel values are then changed according to the following formula:

$$F(i,j) = \frac{\sum_{h=-1}^{1}\sum_{l=-1}^{1}[1-\mu(A(i+h,j+l))]A(i+h,j+l)}{\sum_{h=-1}^{1}\sum_{l=-1}^{1} 1-\mu(A(i+h,j+l))}$$

3.2 Improving contrast of the image

For improving the contrast of the image following steps are done:

1. setting the shape of membership function (regarding to the actual image)
2. setting the value of fuzzifier Beta
3. calculation of membership values
4. modification of the membership values by linguistic hedge
5. generation of new gray-levels

Using the notation of fuzzy sets, we can write,

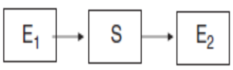
$$X = \begin{pmatrix} \mu_{11}/x_{11} & \mu_{12}/x_{12} & \cdots & \mu_{1M}/x_{1M} \\ \mu_{21}/x_{21} & \mu_{22}/x_{22} & \cdots & \mu_{2M}/x_{2M} \\ \vdots & \vdots & & \vdots \\ \mu_{N1}/x_{N1} & \mu_{N2}/x_{N2} & \cdots & \mu_{NM}/x_{NM} \end{pmatrix}$$

where $0 \leq \mu mn \leq 1, m = 1, 2 \ldots M, n = 1, 2 \ldots N$.

Contrast within an image is measure of difference between the gray-levels in an image. The greater the contrast, the greater is the distinction between gray-levels in the image. Images of high contrast have either all black or all white regions; there is very little similar gray-levels in the image, and very few black or white regions. High-contrast images can be thought of as crisp, and low contrast ones as completely fuzzy. Images with good gradation of grays between black and white are usually the best images for purposes of recognition by humans.

The object of contrast enhancement is to process a given image so that the result is more suitable than the original for a specific application in pattern recognition. As with all image-processing techniques we have to be especially careful that the processed image is not distinctly different from the original image, making the identification process worthless. The technique used here makes use of modifications to brightness membership value in stretching or contracting the contrast of an image.

Many contrast enhancement methods work as shown in the figure below, where the procedure involves primary enhancement of he image, denoted with an E1 in the figure, followed by a smoothing algorithm, denoted by an S, and a subsequent final enhancement, step E2.



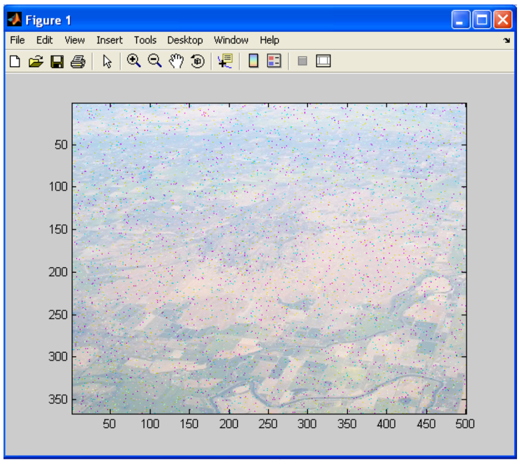
Method of contrast enhancement

The function of the smoothing operation of this method is to blur (make fuzzier) the image and this increased blurriness then requires the use of final enhancement step E2. Generally smoothing algorithms distribute a portion of the intensity of one pixel in the image to adjacent pixels. This distribution is greatest for pixels nearest to the pixels being smoothed, and it decreases for pixels farther from the pixel being smoothed.

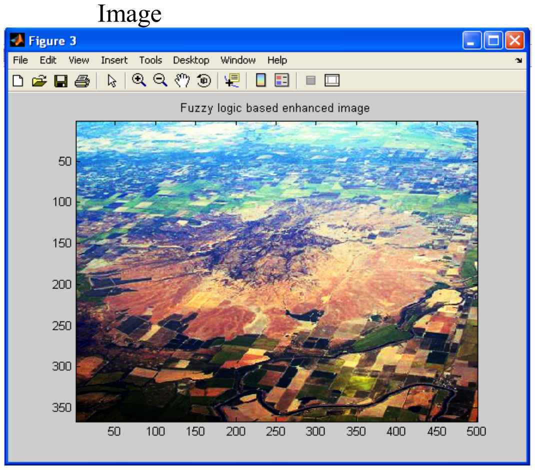
4. RESULTS AND DISCUSSION

4.1 Results

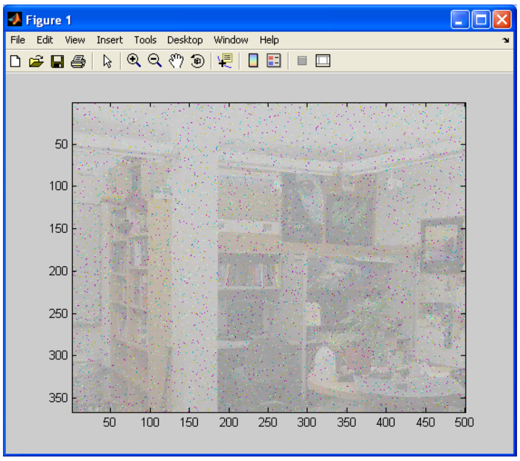
The proposed algorithm was applied to the images and following output was generated:



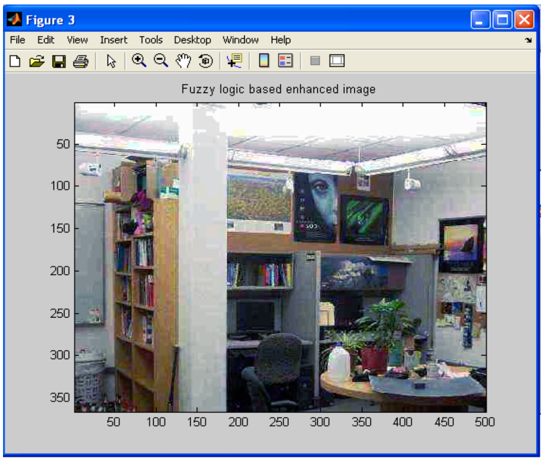
(a) Noisy & low contrast and enhanced Pout Image



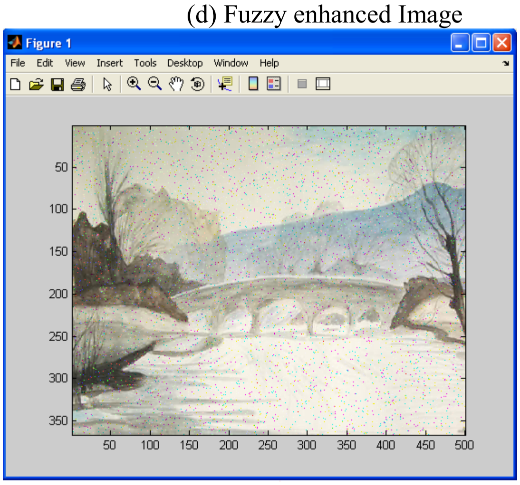
(b) Fuzzy Enhanced Image



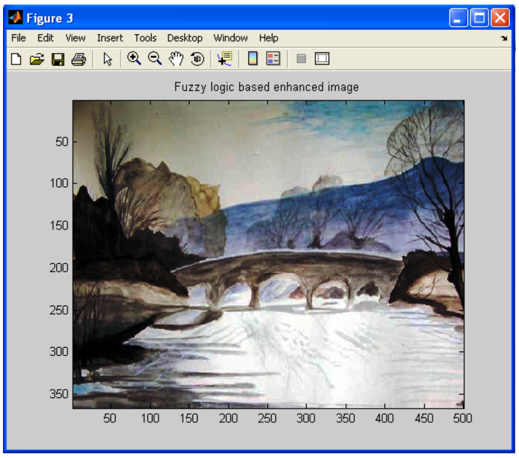
(c) Noisy & low contrast and enhanced Room Image



(d) Fuzzy enhanced Image



(e) Noisy & low contrast and enhanced Painting Image



(f) Fuzzy Enhanced Image

4.2 Discussion

The above are the test images as well as the output generated by applying the algorithm. The output generated is an enhanced image with no noise. The contrast is also improved. Thus, the above mentioned method proves the best approach for enhancing the corrupted images.

5. REFERENCES

[1] Bing Qi, Jing Zhang, Liang-rui-Tang. An improved Fuzzy Image Enhancement Algorithm.

[2] Dr. D.H. Rao. A Survey on Image Enhancement techniques: Classical Spacial filter, Neural Network, Cellular Neural Network, Fuzzy filter.

[3] Farzam Farbiz, Mohammed Bager Menhaj, Sayed A. Motamedi and Martin T. Hagan. A new fuzzy logic filter for image enhancement.

[4] Stefan Schulte, Mike Nachtegael, Val´erie De Witte, Dietrich Van der Weken and Etienne E. Kerre. Fuzzy Impulse noise detection and reduction method.

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