Distinguishing the Noise and image structures for detecting the correction term and filtering the noise by using fuzzy rules

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***Abstract*— A fuzzy filter is constructed from a set of fuzzy IF-THEN rules, these fuzzy rules come either from human experts or by matching input-output pairs .in this paper we propose a new fuzzy filter for the noise reduction of images corrupted with additive noise. here in this approach ,initially fuzzy derivatives for all eight directions that is N,E,W,S, NE,NW,SE,SW are calculated using "fuzzy IF-THEN rules " and membership functions . Further the fuzzy derivative values obtained are used in the fuzzy smoothing for determining the correction term. Finally correction term can be added to the processed pixel value. Iteratively apply the fuzzy filter to reduce the noise and at each and every iteration membership function is calculated based on the remaining noise level. A statistical model for the noise distribution can be incorporated to relate the homogeneity to the adaptation scheme of the membership functions.**

Keywords: Filtering, fuzzyfication, defuzzyfication, membership function

I.INTRODUCTION

Noise removal and image smoothing are useful pre-processing steps in many image processing applications

1.1. Introduction to Image processing

A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels. A pixel is the smallest visual element on a video display screen

Digital image processing focuses on two major tasks

- Improvement of pictorial information for human interpretation
- Processing of image data for storage, transmission and representation for autonomous machine perception

The number of bits used to represent each pixel determines how many colors or shades of gray can be displayed. For example, in 8-bit color mode, the color monitor uses 8 bits for each pixel, making it possible to display 2 to the 8th power (256) different colors or shades of gray. For a gray scale images, the pixel value is a single number that represents the brightness of the pixel. The most common *pixel format* is the *byte image*, where this number is stored as an 8-bit integer giving a range of possible values from 0 to 255. Typically zero is taken to be black, and 255 is taken to be white. Values in between make up the different shades of gray. A Gray-Scale Image is a series of shades from white to black. The more shades, or levels, the more realistic an image can be recorded and displayed, especially a scanned photo. Scanners differentiate typically from 16 to 256 gray levels.

Image processing techniques were first developed in 1960 through the collaboration of a wide range of scientists and academics. The main focus of their work was to develop medical imaging, character recognition and create high quality images at the microscopic level. And mainly the image processing techniques are used to remove the noise present in the image and enhancing some features present in the image to get quality image.

Filtering is the process of reducing the noise. : The sub image is called the filter, mask, kernel, template, window spatial filtering is the filtering operations that are performed directly on the pixels of an image. This process consists of simply moving the filter mask from point to point in an image. At each point the response of the filter is calculated using a predefined relation ship

1.2 Introduction to Fuzzy

In recent years, many researchers have applied the fuzzy set theory to develop new techniques for contrast improvement Fuzzy set theory is the extension of conventional (crisp) set theory. It handles the concept of partial truth (truth values between 1 (completely true) and 0 (completely false)). The idea of fuzzy sets is simple and natural. . For instance, we want to define a set of gray levels that share the property dark. In classical set theory, we have to determine a threshold, say the gray level 100. All gray levels between 0 and 100 are element of this set, the others do not belong to the set

But the darkness is a matter of degree. So, a fuzzy set can model this property much better. To define this set, we also need two thresholds, say gray levels 50 and 150. All gray levels that are less than 50 are the full member of the set, all gray levels that are greater than 150 are not the member of the set. The gray levels between 50 and 150, however, have a partial membership in the set (right image in Fig.1).

Figure 1.2: Difference between crisp set and fuzzy set

Member ship function:

For any set *X*, a membership function on *X* is any function from *X* to the real unit interval [0, 1].Membership functions on *X* represent fuzzy subsets of *X*. The membership function which represents a fuzzy set $\tilde{A}$ is usually denoted by μ_A. For an element x of X, the value $\mu_A(x)$ is called the *membership degree* of x in the fuzzy set $\tilde{A}$.The membership degree $\mu_A(x)$ quantifies the grade of membership of the element x to the fuzzy set $\tilde{A}$.

The value 0 means that x is not a member of the fuzzy set; the value 1 means that x is fully a member of the fuzzy set. The values between 0 and 1 characterize fuzzy members, which belong to the fuzzy set only partially

1.2.1. Fuzzy Image Processing

Fuzzy image processing has three main stages:

1) Image fuzzification 2) modification of membership values, and, if necessary 3) image defuzzification

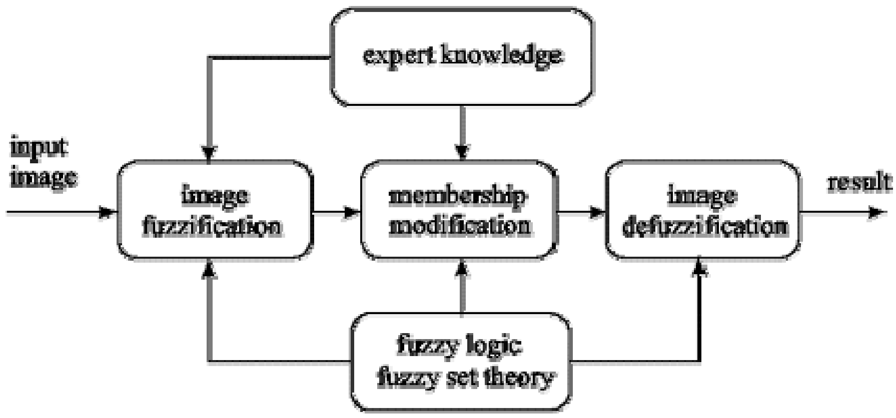


Figure. 1.2.1. The general structure of fuzzy image processing.

1. Fuzzy techniques are powerful tools for knowledge representation and processing.

2. Fuzzy techniques can manage the vagueness and ambiguity efficiently.

1.2.2. Fuzzy IF-THEN rules

In many image processing applications, we have to use expert knowledge to overcome the difficulties (e.g. object recognition, scene analysis). Fuzzy set theory and fuzzy logic offer us powerful tools to represent and process human knowledge in form of fuzzy if-then rules.

If we interpret the image features as linguistic variables, then we can use fuzzy if-then rules to segment the image into different regions.

A simple fuzzy segmentation rule may seem as follows:

IF the pixel is *dark*
AND its neighborhood is also *dark* AND *homogeneous*
THEN it *belongs* to the background.

Example: Threshold by minimization of fuzziness

There are many (classical) thresholding techniques. For example, a membership function (standard S function) is moved pixel by pixel over the existing range of gray levels in each position, a measure of fuzziness is calculated. The position with a minimum amount of fuzziness can be regarded as a suitable threshold

II.PROBLEM DEFINITION

The main aim of the proposed filter is to average a pixel using other neighboring pixels here we take the neighboring pixels based on the directions such as north, east ….this filter mainly distinguishes local variations due to noise and due to image structures. 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.

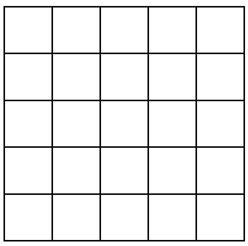
The result of these rules (16 in total) is defuzzified and a “correction term” is obtained for the processed pixel value the correction term obtained can be replaced with the central pixel there by removing the certain amount of noise at that position and this same process is applied to the next neighboring pixels until the total image is processed and this filter is applied repetitively until the noise is removed

III. EVOLUTION

3.1. Read the pixel values from the Input image

There are a wide range of options for storing digital images on a computer. Some common ones include GIF, JPEG, TIFF, and BMP. GIF, or Graphics Interchange Format, has a bit-depth of 1-8 bitonal, grayscale or color. It is limited to a 256 color palette. JPEG, or Joint Photographic Experts Group, has a grayscale of 8 bits and a 24-bit color scale. JPEG is most often used on web pages. TIFF, or Tagged Image File Format, is commonly used for scientific imaging. It supports an 8-bit color palette and 8- to 16-bit grayscale. TIFF 6.0 can provide up to 64-bit color, but most TIFF readers will support only a maximum of 24-bit color.

Generally the image sizes are of various types such as 1024x1024, 516x516,256x256 pixels to process the image initially we have to read the pixel values from the image and then apply the proposed filter on those values. The window can be taken as 5*5 or 9*9 and it is moved over the pixels from left to right and top to bottom



Window :5 x 5

3.2. Compute 'k' the threshold selection using

The value of the threshold value is calculated based on the standard deviation

$$k=\alpha\sigma$$
$$\sigma = (1-\ \mu)\ \gamma M$$

Where σ is standard deviation and α is amplification factor
γM is the slope

We start by dividing the image in small N x N non overlapping blocks. For each block B, we compute a rough measure for the homogeneity of this block by considering the maximum and minimum pixel value.

$$\mu = 1 - \frac{\max_{(x,y)\in B} I(x,y) - \min_{(x,y)\in B} I(x,y)}{L}$$

Max and min are the maximum and minimum intensity values in the block

L=255 for gray scale image

3. 3.Calculate Simple Derivative values

A simple derivative at the central pixel position (x,y) in the direction where (D∈ dir={NW,W,SW,S,SE,E,NE,N}) is defined as the "difference between the pixel at (x,y) and its neighbor in the direction D ".

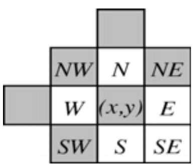
The simple derivative values for North and North-West direction is as follows where I represents the intensity values at that particular location.

$$\nabla_N (X,Y) = I(X,Y-1) - I(X,Y)$$

$$\nabla_{NW} (X,Y) = I(X-1,Y-1) - I(X,Y)$$

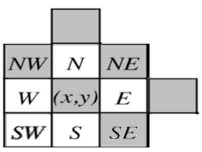
Neighborhood of a central pixel (x; y)

Pixel values indicated in gray are used to compute the "fuzzy derivative" of the central pixel(x; y) for the specified-direction.



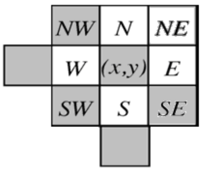
North-west

If an edge is passing through SW-NE direction, then calculate the derivative value in the NW direction for the central pixel and neighboring pixels



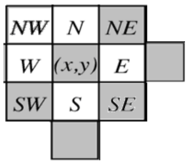
North-east

If an edge is passing through NW-SE direction , then calculate the derivative value in the NE direction for the central pixel and neighboring pixels



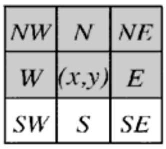
South-west

If an edge is passing through SE-NW direction , then calculate the derivative value in the SW direction for the central pixel and neighboring pixels



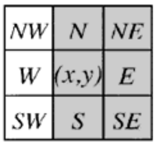
South-east

If an edge is passing through NE-SW direction , then calculate the derivative value in the SE direction for the central pixel and neighboring pixels



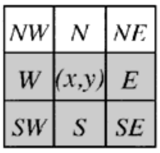
North

If an edge is passing through E-W direction, then calculate the derivative value in the N direction for the central pixel and neighboring pixels



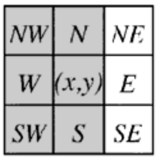
E**ast**

If an edge is passing through S-N direction, then calculate the derivative value in the E direction for the central pixel and neighboring pixels



South

If an edge is passing through W-E direction, then calculate the derivative value in the S direction for the central pixel and neighboring pixels



West

If an edge is passing through N-S direction, then calculate the derivative value in the W direction for the central pixel and neighboring pixels

3.4. Fuzzy derivative estimation

The value that expresses the degree in which the derivative in a certain direction is small is most likely caused by noise, and a large fuzzy derivative is caused by an edge[2].

The principle of the fuzzy derivative is based on the following observation. Consider an edge passing through the neighborhood of a pixel in the **SW-NE** direction. The derivative value $\nabla_{NW}(X, Y)$ will be large, but also derivative values of neighboring pixels perpendicular to the edge's direction can expected to be large.

For example, in the NW-direction we can calculate the values. $\nabla_{NW}(X, Y)$, $\nabla_{NW}(X\text{-}1,Y\text{+}1)$, $\nabla_{NW}(X\text{+}1,Y\text{-}1)$

The idea is to cancel out the effect of one derivative value which turns out to be high due to noise. Therefore, if two out of three derivative values are small, it is safe to assume that no edge is present in the considered direction.

To compute the value that expresses the degree to which the fuzzy derivative in a certain direction is small, we will make use of the fuzzy set small.

3. 5.Calculate member ship function for the set small

$$m_k \text{ (u)} = 1-\frac{|\mu|}{K}, \quad 0 \le |\mu| \le \text{K}$$

$$m_k \text{ (u)} = 0, \quad |\mu| > K$$

The member ship function is adapted in each and every iteration according to the remaining noise level .based on the remaining noise the member ship value can be changed [4].

3.6.FuzzySmoothening

Computing the correction term Δ with the help of fuzzy rules, by using these fuzzy rules mainly we will filter the noise . If no edge is present in that direction then the crisp derivative value can be used to compute the correction term for the processed pixel here we will distinguish whether the derivative values are positive and negative by applying two fuzzy rules[1].

λ_{NW}^{+} : if $\nabla_{NW}^{F}(X,Y)$ is small and ∇_{NW} (X,Y) is positive then c is positive

λ_{NW}^{-} : if $\nabla_{NW}^{F}(X,Y)$ is small and ∇_{NW} (X,Y) is negative then c is negative

3.7.Defuzzification

The final step in computation of fuzzy filter is the defuzzification [3]

$$\Delta = \frac{L}{8}\sum_{D\in dir}(\lambda_D^{+} - \lambda_D^{-})$$

The obtained correction term is replaced with the processed pixel

Peak signal to noise ratio:

The peak signal-to-noise ratio, **PSNR**, is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.[5]

The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression codec’s (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codec’s it is used as an *approximation* to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR (a higher PSNR would normally indicate that the reconstruction is of higher quality). One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content.

It is most easily defined via the mean squared error (**MSE**) which for two $m \times n$ monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR is defined as:

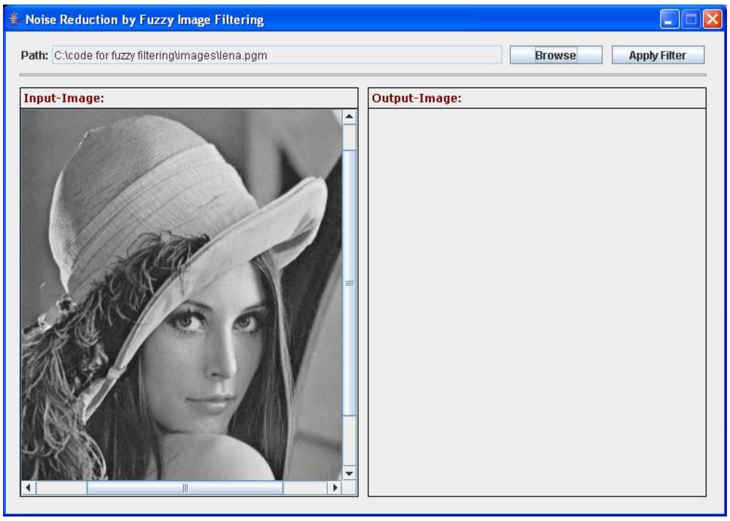
$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

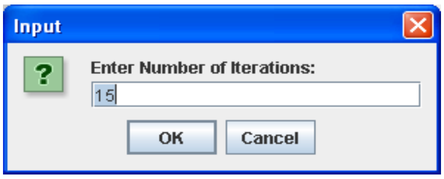
Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAX_I is 2^B-1. For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE is the sum over all squared value differences divided by image size and by three. Alternately, for color images the image is converted to a different color space and PSNR is reported against each channel of that color space, e.g.,

Typical values for the PSNR in lossy image and video compression are between 30 and 50 dB, where higher is better. Acceptable values for wireless transmission quality loss are considered to be about 20 dB to 25 dB

When the two images are identical, the MSE will be zero. For this value the PSNR is undefined (see Division by zero).

IV .RESULTS

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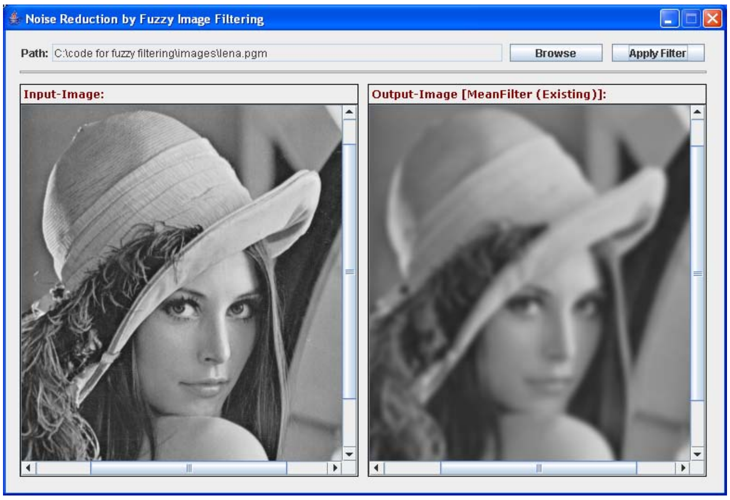
OK
Cancel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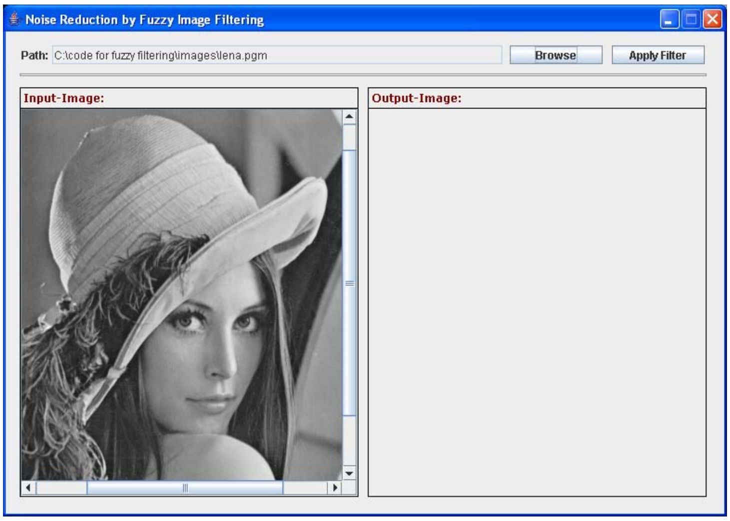
Browse
Apply Filter
Input-Image:
Output-Image [MeanFilter (Existing)]:


Noise Reduction by Fuzzy Image Filtering
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Browse
Apply Filter
Input-Image:
Output-Image:


Fuzzy Noise Filtering
Select FilterType:
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OK
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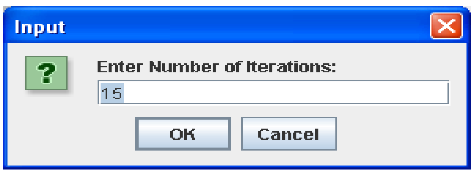
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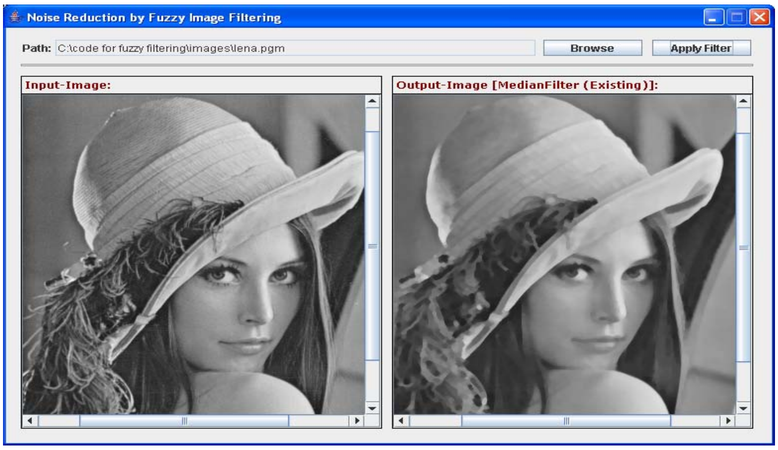
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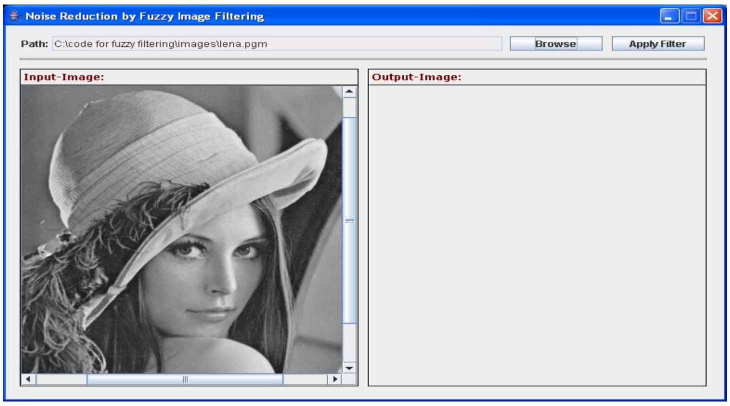
Output-Image [MedianFilter (Existing)]:


Noise Reduction by Fuzzy Image Filtering
Path: C:\code for fuzzy filtering\images\lena.pgm
Browse
Apply Filter
Input-Image:
Output-Image:


Fuzzy Noise Filtering
Select FilterType:
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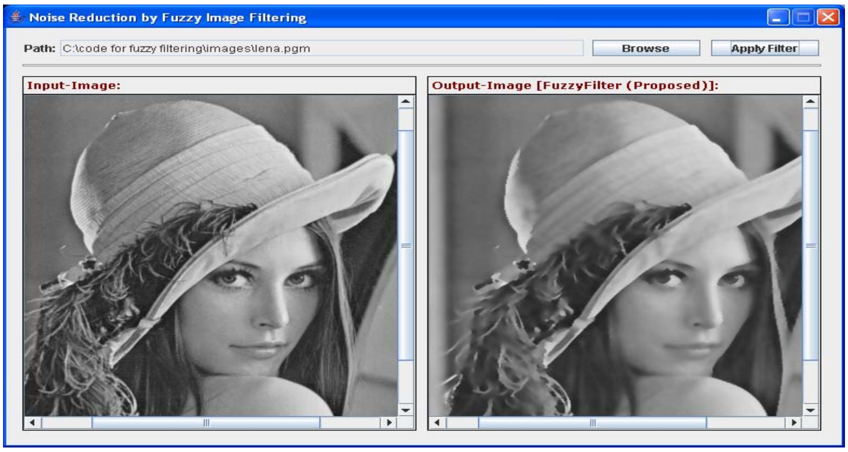
OK
Cancel


Input
Enter FuzzyFilter Depth (Stopping Criterion):
2
OK
Cancel



V.CONCLUSION

The proposed fuzzy filter for additive noise reduction distinguishes between local variations due to noise and due to image structures, using a fuzzy derivative estimation. Fuzzy rules are fired to consider every direction around the processed pixel. Additionally, the shape of the membership functions is adapted according to the remaining amount of noise after each iteration. Although it's relative simplicity and the straightforward implementation of the fuzzy filter.

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