International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-01, Issue-06, September 2014

Fuzzy Image Filtering Technique using for Noise Reduction

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Abstract— **The novel fuzzy filter is presented for the noise reduction of images corrupted with additive noise. The filter consists of two stages. The first stage computes a fuzzy derivative for eight different directions. The second stage uses these fuzzy derivatives to perform fuzzy smoothing by weighting the contributions of neighboring pixel values. Both stages are based on fuzzy rules which make use of membership functions. The filter can be applied iteratively to effectively reduce heavy noise. 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 statistical model for the noise distribution can be incorporated to relate the homogeneity to the adaptation scheme of the membership functions. Experimental results are obtained to show the feasibility of the proposed approach. These results are also compared to other filters by numerical measures and visual inspection.**

Index Terms— **edge preserving filtering, fuzzy image filtering, noise reduction.**

I. INTRODUCTION

Image processing usually refers to digital image processing, but optical and analog image processing also are possible. This article is about general techniques that apply to all of them. The acquisition of images (producing the input image in the first place) is referred to as imaging. The application of fuzzy techniques in image processing is a promising research field [1]. Fuzzy techniques have already been applied in several domains of image processing (e.g., filtering, interpolation [2], and morphology [3], [4]), and have numerous practical applications (e.g., in industrial and medical image processing [5], [6]).

In this paper, we will focus on fuzzy techniques for image filtering. Already several fuzzy filters for noise reduction have been developed, e.g., the well-known FIRE-filter from[7]- [9], the weighted fuzzy mean filter from[10], and[11] the iterative fuzzy control based filter from[12]. Most fuzzy techniques in image noise reduction mainly deal with fat-tailed noise like impulse noise.

These fuzzy filters are able to outperform rank-order filter schemes (such as the median filter). Nevertheless, most fuzzy techniques are not specifically designed for Gaussian (-like) noise or do not produce convincing results when applied to handle this type of noise.

Therefore, this paper presents a new technique for filtering narrow-tailed and medium narrow-tailed noise by a fuzzy filter. Two important features are presented: 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." 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 functions for and are fixed, the membership function for is adapted after each iteration.

The adaptation scheme is extensively and can be combined with a statistical model for the noise. The result of this method can be compared with those obtained by other filters.

II. PROPOSED WORK

This system presents a new technique for filtering narrow-tailed and medium narrow-tailed noise by a fuzzy filter. Two important features are 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." 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 functions for and are fixed, the membership function for 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

Manuscript received Sep 09, 2014
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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.

III. FUZZY FILTERS

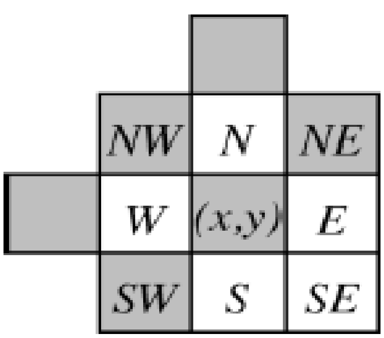
The general idea behind the filter is to average a pixel using other pixel values from its neighborhood, but simultaneously to take care of important image structures such as edges. The main concern of the proposed filter is to distinguish between local variations due to noise and due to image structure. 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 must 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.

3.1 Fuzzy Derivative Estimation

Estimating derivatives and filtering can be seen as a chicken-and-egg problem; for filtering we want a good indication of the edges, while to find these edges we need filtering. For that if you take particular point as image co-ordinate (x, y) then consider the neighborhood pixel.

NW	*N*	*NE*
W	*(x,y)*	*E*
SW	*S*	*SE*

The fuzzy derivatives are calculated from the co-ordinates mentioned in the gray shading.



The pixel involved to calculate the fuzzy derivative in each direction as mentioned in the below table.

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)}

The simple derivative at the central pixel position (x, y) in the direction D

Where D belongs to dir = {NE, 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. This derivative value is denoted by

Delta $_{N}$ (x, y) = 1(x, y-1) – I(x, y)
Delta $_{NW}$ (x, y) = 1(x-1, y-1) – I(x, y)

Now consider the edge passing through the neighborhood of pixel (x, y) in the direction SW – NE direction. The derivative value delta $_{NW}$ will be large, but also derivative values of neighbor pixels perpendicular to the edge’s direction can expected to be large. 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. This observation will be taken into account when we formulate the fuzzy rule to calculate the fuzzy derivative values. In the table an overview of the pixels we use to calculate the fuzzy derivative for each direction. Each direction (column 1) corresponds to a fixed position (column 2); the sets in column 3 specify which pixels are considered with respect to the central pixel. 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.

Figure1. Original image (cameraman)

Figure (2) (a)"cameraman" with adaptive Gaussian noise(σ=5)(b)after wiener filtering(3x3) (c) After fuzzy mean(FM).(d) After proposed fuzzy filter(σ=1).

IV. RESULTS

The proposed filter is applied to grayscale test images (8-bit,), after adding Gaussian noise of different levels. Such a procedure allows us to compare and evaluate the filtered image against the original one. Fig. 2 shows two representative test images: "cameraman" for the original image, but also for the image corrupted with different noise levels, i.e., , , and . Using the 20% percentile and (8), the estimates for the noise levels are, respectively, 5.2, 9.4, and 17.7. For these noise levels our filter is applied using different values for the amplification factor, namely. To evaluate the results, we computed the mean squared error (MSE) between the original image and the filtered image. Also, a low amplication factor gives the best results. The MSE of "cameraman" surprisingly increases with the number of iterations, this is mainly due the image content, i.e., the grass is very similar to noise and gets increasingly filtered. For other images, such as "boats," this increase does not occur. Therefore, images with low noise levels and containing fine textures should be treated carefully. For high noise levels (Fig. 2), the results of "cameraman" are much more stable. A few iterations (3–4) are sufficient to effectively smooth out the noise. Also, a somewhat higher value of gives better results. Another possible stop criterion could be when the change with respect to the previous iteration is small. The parameter affects the amount of smoothing which is applied by the filter. Based on our observations of the MSE- curves could also be determined using the estimate: a high noise level corresponds to a higher value of, while a low noise level corresponds to a lower value of. We also compared our fuzzy filter with several other filter techniques: the mean filter, the adaptive Wiener filter [14], fuzzy median (FM) [15], the adaptive weighted fuzzy mean (AWFM1 and AWFM2) [10], [11], the iterative fuzzy filter (IFC), modified iterative fuzzy filter (MIFC), and extended iterative fuzzy filter (EIFC) [12]. Table I summarizes the results we obtained. For "cameraman," the proposed filter performs very well. Only the fuzzy median (FM) gives a better MSE for. In particular, this image restoration scheme could be used to enhance satellite images. Of course, since the original image is already corrupted by noise, it is not possible to obtain a numerical measure which indicates how "good" the image is. Fig. 2 shows the original image and the results after fuzzy filtering with different parameters. Depending on the application (e.g., visual inspection, segmentation), one could prefer lighter or heavier filtering (by choosing correspondingly).

CONCLUSION

This paper proposed a new fuzzy filter for additive noise reduction. Its main feature is that it 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. Experimental results show the feasibility of the new filter and a simple stop criterion. Although its relative simplicity and the straightforward implementation of the fuzzy operators, the fuzzy filter is able to compete with state-of-the-art filter techniques for noise reduction. A numerical measure, such as MSE, and visual observation show convincing results. Finally, the fuzzy filter scheme is sufficiently simple to enable fast hardware implementations.

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