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A PARALLEL ROUGH SET BASED SMOOTHING FILTER FOR MEDICAL IMAGE ENHANCEMENT

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ABSTRACT

Image processing is a special form of signal processing which provides valuable information toward human image. The most important image processing step in human picture recognition system consists of Edge enhancement process. In this paper we propose a new idea for edge enhancement using smoothing filters based on Rough sets. Rough set theory is an important tool (it is a mathematical tool) that process uncertainty and non-integrity[1][10]. This theory is efficient in analysing and processing inconsistent information, and then detecting connotative information. Rough set theory is to classify the pixel in each part then noise pixels can be separated and removed, which is to provide `better' input for other automated image processing techniques. Smoothing is often used to reduce noise within an image or to produce a less pixel image. Edges are the representations of the discontinuities of image intensity functions. For processing these discontinuities in an image a good edge enhancement technique is essential. This paper proposes a new idea for enhancement of a medical image using smoothing techniques and Image noise is mostly unwanted and manifested in the pixels of an image and the main application of image averaging is noise removal. In this paper, we deal with Rough set based medical image smoothening filters in order to improve the quality of the image and as well as to help to solve various complex image processing tasks in the future. This paper focuses on an approach which tries to combine the advantages of the various smoothing filters techniques.

Keywords: Rough sets, smoothing filters, Image averaging function.

1. INTRODUCTION

Rough set theory which was firstly defined by Z.Pawlak in 1982 have successful applications in many fields, such as artificial intelligence, image processing, decision analysis, pattern recognition, cluster analysis, machine learning, and many others [1] [11]. It has become an important tool in processing uncertainty information. The

theory of rough sets is traditionally formulated based on an equivalence relation on an object set called the universe. The basic idea of rough set theory is problem solving.
As image contains much uncertainty information, many efforts have been made to use fuzzy set theory to process image. The results have improved better effect than hard computing method. Rough sets has potential application for processing image, Recently, Rough sets theoretic image processing is concerned, but there is less investigation reported so far on the application of Rough set theory in image processing. Edge enhancement techniques falls under two categories smoothening filters and sharpening filters. Smoothing filters are used for blurring and for noise reduction. Blurring is used in pre-processing steps, such as removal of small details from an image prior to object extraction, and bridging of small gaps in lines or curves. Noise reduction can be accomplishing by blurring with a linear filter and also by nonlinear filtering such as mean, median, mode, circular, pyramidal and cone filters. Sharpening filters are used to highlight fine detail in an image or to enhance detail that has been blurred. These filters include Laplacian, Sobel, Prewitt and Robert filters which are widely used in applications but because of their results of complexity and image quality, smoothening filters are used which involves simple subtractive smoothened image concept which reduces complexity and makes the images look sharper than they really are.

2. DIFFERENT TYPES OF SMOOTHING FILTERS

2.1 What is edge enhancement?

Edge Enhancement is a digital image processing filter that is used to make pictures look artificially sharper than they really are. The key word here is *looking* sharper, because the picture isn't really any more detailed than before. The human eye is simply *tricked* into thinking the picture is sharper.

2.2 Smoothing filters:

Mean filter: The mean filter is a simple sliding-window spatial filter that replaces the center value in the window with the average (mean) of all the pixel values in the window [2]. The window, or kernel, is usually square but can be any shape. An example of mean filtering of a single 3x3 window of values is shown below.

unfiltered values		
5	3	6
2	1	9
8	4	7

5 + 3 + 6 + 2 + 1 + 9 + 8 + 4 + 7 = 45
45 / 9 = 5

mean filtered		
*	*	*
*	5	*
*	*	*

Center value is replaced by the mean of all nine values.

Median filter

The median filter is also a sliding-window spatial filter, but it replaces the center value in the window with the median of all the pixel values in the window. As for the mean filter, the kernel is usually square but can be any shape [2]. An example of median filtering of a single 3x3 window of values is shown below.

unfiltered values		
6	2	0
3	97	4
19	3	10

In order:
0, 2, 3, 3, **4**, 6, 10, 15, 97

median filtered		
*	*	*
*	4	*
*	*	*

Center value is replaced by the median of all nine values.

Mode Filter

The mode filter replaces the pixel at the centre of the mask by the mode of all the pixel values in the mask. The mode value is nothing but the maximally repeated value in the mask.

Circular Filter

In this filter, we will convolute the image the mask provided [1, 3]. This filter is slightly different from the mean filter [2]. The filter is shown below

$$\frac{1}{21}\begin{bmatrix} 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Circular Filter Mask

Triangular filter

In this, the output image is based on a local averaging of the input filter, where the values within the filter support have differing weights. In general, the filter can be seen as the convolution of two identical uniform filters either mean or circular and this has the direct consequence for computational complexity. Transfer functions of these filters do not have the negative values and hence it will not exhibit the phase reversal. There are two filters of this kind, namely Pyramidal filter and Cone filter. The convolution masks for these are shown below**.**

$$\frac{1}{81}\begin{bmatrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 4 & 6 & 4 & 2 \\ 3 & 6 & 9 & 6 & 3 \\ 2 & 4 & 6 & 4 & 2 \\ 1 & 2 & 3 & 2 & 1 \end{bmatrix} \qquad \frac{1}{25}\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 2 & 2 & 2 & 0 \\ 1 & 2 & 5 & 2 & 1 \\ 0 & 2 & 2 & 2 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Cone Filter Mask Pyramidal Filter Mask

Medical images

Medical image analysis poses a far tougher challenge.[3][9] First, there is an even greater need for image filtering, because medical images have a poorer noise-to-signal ratio than scenes taken with a digital camera, the spatial resolution is often frustratingly low, the contrast between anatomically distinct structures is often too low to be computed reliably using a standard image processing technique, and artefacts are common (e.g. motion and bias field in MRI). Second, changes to image content must be done in a highly controlled and reliable way that does not compromise clinical decision-making. For example, whereas it is generally acceptable to filter out local bright patches of noise, care must be taken in the case of mammography not to remove microcalcifications.This paper briefly explores some of the key areas of development in the area of filtering in Medical Imaging and how these techniques impact generally available software packages in routine use in a diagnostic setting.

3. IMPLEMENTATION

This model uses a parallel structure. The filters are arranged in parallel and the results are obtained independent of each other which are the passed to an array as shown in fig 3.1. This array is then sent to the processor where in the image enhancement mean is generated

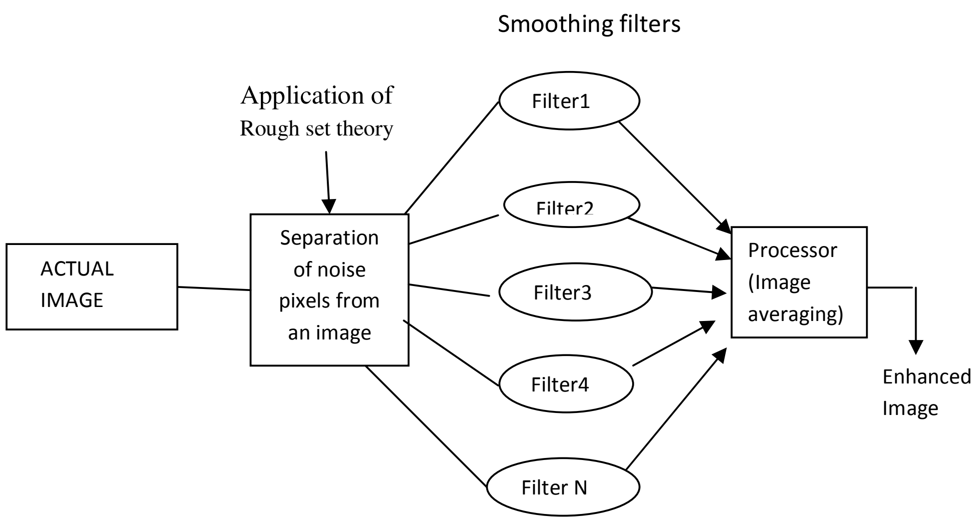


Fig 3.1 A hybrid smoothing filter using Rough sets

The advantage of this model is that it is time efficient as the calculation of each filter is done in parallel.

However the limitations are: The system requires all the filters to be available at the same time.

1. The system has to wait for the result of each independent filter to calculate the mean

Total time taken =Separation of noise pixels using Rough set + Max time of slowest filter + Processing time.

The available free time of the filters waiting for completion of processing of slowest filter can be used to update image which can improve the time efficiency.

Algorithm based on Rough sets using smoothing filter

When we separate image noise with Rough set theory, the equivalence relation R can be defined in many ways.[12] One algorithm is to calculate the grey value margin between the mean of all pixels. Then, compared with the pre-defined threshold, the pixel whose margin is greater than the threshold is considered a noise pixel. Another algorithm to classify pixels is according to the relationship between the pixels value and the maximum and minimum values in its neighbourhood, the pixel whose value is greater than maximum value or less than the minimum is regarded as a noise. Both algorithms are focused on single pixel, more processing time consuming to obtain all pixels mean value or extreme within a neighbourhood. In the algorithm, the algorithm may take non-noise pixels as noise pixels.

To reduce the time of the noise detection and the possibility of misjudgement of the noise points, in this paper we divide the image into several parts with the size, then setup the indiscernible relation of Rough sets and divide sets to separate noise pixels from the normal ones, finally process the noise pixels with the filters for smoothing the image.

Let U denotes an image that has L gray-level, and its size is M x N. Divide U into S parts, let A_k(k= 0,1,……S-1) denotes one part of U and f(i,j) denotes the grey value of the pixel point (i,j). the set of all pixels grey-value in A_k can be defined as formula

$U_k = \{f(i,j) \mid (i,j) \in A_k, k=0,1,\ldots\ldots S-1\}$

A_k can be seen as a knowledge system, let k=(A_k,R) denotes the approximation space that is made up with A_k and equivalence relation R. As the impulse noise points grey-value usually far more or far less than the others, therefore, in a local area, the points whose gray value close to the maximum or minimum value may be noise points. Suppose that pixel x is an object of A_k and its grey-value is f(x), let max $f(x_t)$ denotes minimum, noise pixels can be separated by the equivalence relation based on the description of the noise threshold Q

Divide image A_k by a duality equivalence relation R as formula

$A_k|R=\{c_1,c_2\}$

Where c_1 is the set of all noise pixels and $c_2$is the set of all normal pixels they can be defined as

$C_1=\{|f(x)-\max f(x_t)|<Q \text{ or } |f(x)-\min f(x_t)|< Q\}\ (1\leq t\leq M)$

$C_2=\{|f(x)-\max f(x_t)|\geq Q \text{ and } |f(x)-\min f(x_t)|\geq Q\}\ (1\leq t\leq M)$

Where Q is initialise threshold

According to the classification of image based on Rough sets theory, an algorithm will be available as follows

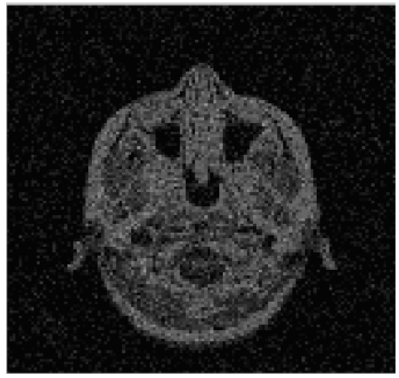
(1) To divide the orginal image into S parts, the kth (k=0,1,…..S-1) region is marked as A_k.

(2) Such the maximum grey-value max $f(x_t)$ and the minimum grey-value min $f(x_t)$ in A_k(size M_k x N_k).

(3) If any pixel x_0 in the set A_k can satisfy the condition $|f(x_0-\max f(x_t)|<Q$ or $|f(x_0)-\min f(x_t)|<Q$, operate step (4), else operate step (5)

(4) To process the pixels with all smoothing filters.

(5) Not to process the pixels but keep them invariable.



Noisy image

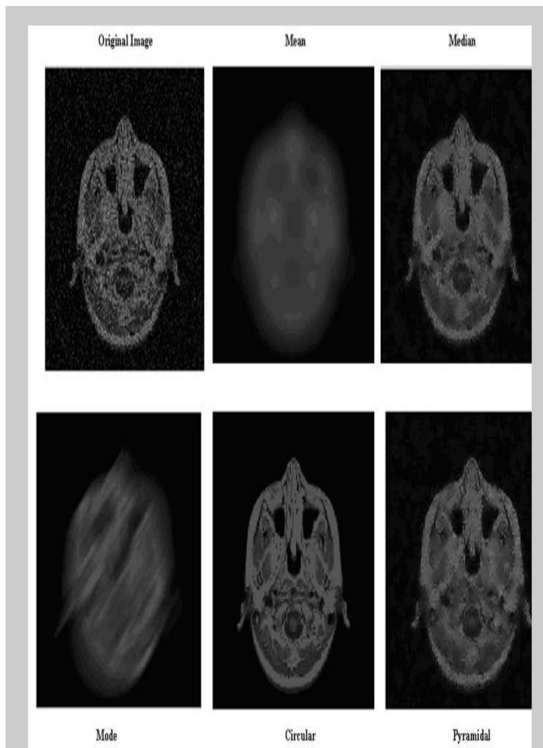


Fig: **Image after applying different smoothing filters. In the clockwise direction from top left are original image, mean filter output, median, pyramidal, circular and mode**

4. FUNCTION DONE BY THE PROCESSOR

Image Averaging [6]

Suppose noise $\eta(r, c)$ is a zero mean pair wise uncorrelated. Then a set of n noisy images $\{g_i(r, c)\}$ can be given by

$g_i(r, c) = f(r, c) + \eta_i(r, c)$

Also suppose that $\eta_i(r, c)$ follows the same distribution for all i, $\sigma\eta 2(r, c)$ be its variance. The assumptions are approximately valid if we consider, say, transmission channel noise only. That means if an image f(r, c) is transmitted n times over some communication channel we may receive a set of noisy images $\{g1(r, c), g_2(r, c), \ldots, g_n(r, c)\}$ at the receiver end. The objective is to recover f(r, c) from the given set {gi(r, c)}. By averaging n such images we get

$g(r,c) = (1/n) \sum_{i=0}^{n} g_i(r,c) = f(r,c) + (1/n) \sum_{i=0}^{n} \eta_i(r,c) = f(r,c) + \eta(r,c)$

For all r and c. Since noise has zero mean, for large n, g(r, c) approaches f(r, c) and

$_\sigma{}^2 \eta(r, c) = {}_\sigma{}^2 g(r, c) = (1/n)\, {}_\sigma{}^2 \eta(r,c)$

tends to zero as n increases.

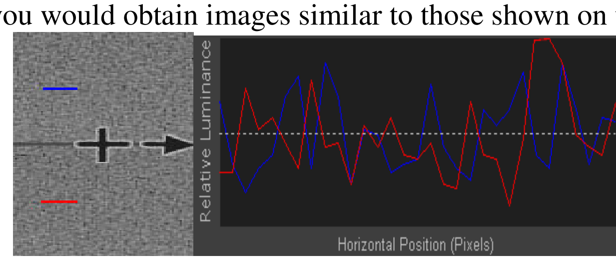
APPLICATION OF IMAGE AVERAGING

The main application of image averaging is noise removal. Image noise is mostly unwanted and manifested in the pixels of an image.[11] It is inherent to digital cameras and is generated, in part, by heat and low light conditions, and is often prominent in long exposures and photographs taken at high ISO sensitivity. Its effect is analogous to film grain. When images of an unchanging scene are corrupted by random noise, a sequence of these images can be averaged together in order to reduce the effects of the noise. This works because noise perturbs pixel grey levels, and a positive perturbation of a given magnitude tends to be just as likely as a negative perturbation of the same magnitude. Hence there is a tendency for these 'errors' in pixel grey level to cancel each other out to an increasing degree, as the number of averaged images increases.

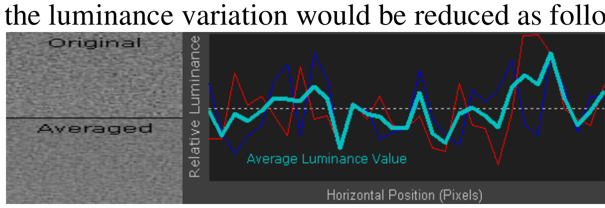
5. NOISE REDUCTION BY IMAGE AVERAGING

CONCEPT

Image averaging works on the assumption that the noise in your image is truly random. This way, random fluctuations above and below actual image data will gradually even out as one average more and more images.[6] If you were to take two shots of a smooth gray patch, using the same camera settings and under identical conditions (temperature, lighting, etc.), then you would obtain images similar to those shown on the left.



The above plot represents luminance fluctuations along thin blue and red strips of pixels in the top and bottom images, respectively. The dashed horizontal line represents the average, or what this plot look like if there were zero noise. Note how each of the red and blue lines uniquely fluctuates above and below the dashed line. If we were to take the pixel value at each location along this line, and average it with value for the pixel in the same location for the other image, then the luminance variation would be reduced as follows:



Even though the average of the two still fluctuates above and below the mean, the maximum deviation is greatly reduced. Visually, this has the affect of making the patch to the left appear smoother. Two averaged images usually produce noise comparable to an ISO setting which is half as sensitive, so two averaged images taken at ISO 400 are comparable to one image taken at ISO 200, and so on. In general, magnitude of noise fluctuation drops by the square root of the number of images averaged, so you need to average 4 images in order to cut the magnitude in half.

Note how averaging both reduces noise and brings out the detail for each region. Noise reduction programs such as Neat Image are the best available arsenal against noise, and so this is used as the benchmark in the following comparison:

A noise free image after image averaging

6. CONCLUSION

By analysing the above Rough set theory approach provides better image quality with smoothening filters and also provides the best results for displaying the output image. This new method is compared against all the smoothening filters presented in the paper. By using Image averaging noise is removed more efficiently.

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