Color Image Enhancement Using a New Edge-Stopping Function for Anisotropic Diffusion

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Abstract:

Image enhancement plays an important role in many machine vision applications such as noise smoothing and edge enhancing. Anisotropic diffusion filtering is a popular, and theoretically well understood, technique for denoising images such that it provides smoothing of intra-region areas preferentially over inter-region areas, thereby providing a good prospective tool for removing unwanted noise and preserving the edges of desired objects.

In this paper a color image is enhanced using a new edge –stopping function for anisotropic diffusion algorithm to improve the performance of the anisotropic diffusion filter.

The experimental results show that the new edge-stopping function of the anisotropic diffusion filter can gives better performance compared with the previously employed diffusivity functions for enhancing the colored image. The comparisons are based on Root Mean Square Error (*RMSE*), Peak Signal to Noise Ratio (*PSNR*), and Mean Structural Similarity Index value (*MSSIM*) measurements. Experiments show that the anisotropic diffusion filter with the new function can effectively remove noise from low PSNR images with minimum edge blurring.

1. Introduction

With the rapid increase in the usage and applications of color images, it has become a necessity to develop tools and algorithms for color image processing. Improvement of the quality of images has always been one of the central tasks of digital image processing.

In modern terms, improvements in sensitivity, resolution and noise reduction have equated higher quality with greater informational throughput. Image noise is an unwanted feature, which is either contained in the relevant light signal or is added by the imaging process and it compromises a precise evaluation of the light signal distribution, which should be measured.

In this paper a color image is enhanced using a new edge –stopping function for anisotropic diffusion algorithm.

Section 2 introduces the background of this work, section 3 describes a method use a new-edge stopping diffusion function to enhance the color images, section 4 shows the image quality metrics which are used to measure the performance of using a new edge-stopping function to denoising the color images, section 5 shows the experimental results of this work, and finally section 6 reports conclusions.

2. Background

Different filtering schemes based on nonlinear diffusion, developed for image enhancement. Since first proposed by Perona and Malik in 1990 [1], anisotropic diffusion has been developed and applied to different areas of image processing. To avoid blurring at the edges, instead of using the constant diffusion coefficients based on the original linear isotropic diffusion, an edge stopping function was proposed to estimate the diffusion coefficients, which ensures the diffusion process taking place mainly inside of the regions rather than at their boundaries and thus the smoothing happens only in the interior of regions without crossing the edges.

Anisotropic diffusion equation with the anisotropic diffusion coefficient *c(x,y)* where t is the time [2]:-

$$\frac{\partial I}{\partial t} = div(c(x,y,t)\nabla I) = c(x,y,t)\nabla^2 I + \nabla c \nabla I \qquad \textbf{(1)}$$

Where *div* = divergence operator

c(x,y,t)=**diffusion coefficient**

∇ **= gradient operator**

This anisotropic is discretised by a moving operator with a four-pixel neighborhood though also other pixel neighborhoods are possible [2]:

$$I_{i,j}^{t+1} = I_{i,j}^{t} + \lambda(c_N.\nabla_N I + c_S.\nabla_S I + c_E.\nabla_E I + c_W.\nabla_W I). \qquad (2)$$

Where $I_{i,j}^{t+1}$ **= new gray value.**

$I_{i,j}^{t}$ **= current gray value.**

λ **= weight value (0.25 for four pixel neighborhood).**

c_x **= directional diffusion coefficient, subscript** ***x*** **indicates direction (North, South, East, and West), function of the directional gray value gradient.**

$\nabla_x I$ **= directional gray value gradients (gray value of neighboring pixel minus current pixel)**

The location of edges is unknown. As a simple estimate, the directional gray value gradients c_x **are used, denoted as** ***c(s)***, **where** ***s*** **=** $\|\nabla I\|$, **termed "edge-stopping" function; the behavior of the anisotropic diffusion depends heavily on the choice of the edge-stopping function. There are many edge-stopping function forms have been introduced, the most common diffusivity function forms are introduced by Perona and Malik (1990) [1], Charbonnier,Tukey and Weickert diffusivity functions from [3]. These functions are:**

Perona and Malik (1990) [1]:

$$c(s) = e^{-\left(\frac{s}{K}\right)^2} \qquad (3)$$

Charbonnier diffusivity:

$$c(s) = \frac{1}{\sqrt{1+\frac{s^2}{K^2}}} \qquad (4)$$

Weickert diffusivity:

$$c\ (s)=\begin{cases}1 & s=0\\ 1-\exp\left(\dfrac{-3.31488}{\left(s/K\right)^{8}}\right) & s>0\end{cases} \tag{5}$$

Tukey diffusivity:

$$c\ (s)=e^{\left(\frac{-s^{2}}{2*K^{2}}\right)} \tag{6}$$

I introduced a new edge stopping function for anisotropic diffusion filter [4], such that it can effectively remove noise from low PSNR images with edge enhancing. The equation of this new function is as follow:

$$c\ (s)=\exp\left(\frac{1}{0.9K^{2}}(1-s^{2})\right) \tag{7}$$

where s = $\|\nabla I\|$, the directional gray value gradients and K is the diffusion constant, it is chosen to preserve the edge of the object boundary and to reduce noise contribution. The parameter K is chosen according to the noise level and the edge strength such that the results gives the higher values of PSNR, and MSSIM metric and the lower values of RMSE metric.

The correct choice of the constant 0.9 is essential to yield good results.

Fig (1) shows the behavior of the proposed function compared with the previous functions. From this fig it is clear that the diffusion coefficient of the proposed function drops dramatically and approximates to zero with large gradient magnitude. Therefore, it can not effectively eliminate noises with large gradient such that a discontinuity is assumed and the diffusion is halted. Therefore the behavior of the proposed function is the best. This function is a nonnegative monotonically decreasing function chosen with $c(0)$ = 1 and $\lim_{\|\nabla I\|\to\infty} c(\nabla I)=0$, which should result in low coefficient values at image edges that have large gradients, and high coefficient values within image regions that have low gradients. This function tested on gray images [4] and it gives better results compared with the common ones (Perona and Malik (1990) [1], Charbonnier, and Weickert) diffusivity functions. In this paper it's compared with another diffusivity function which is Tukey function from [3].

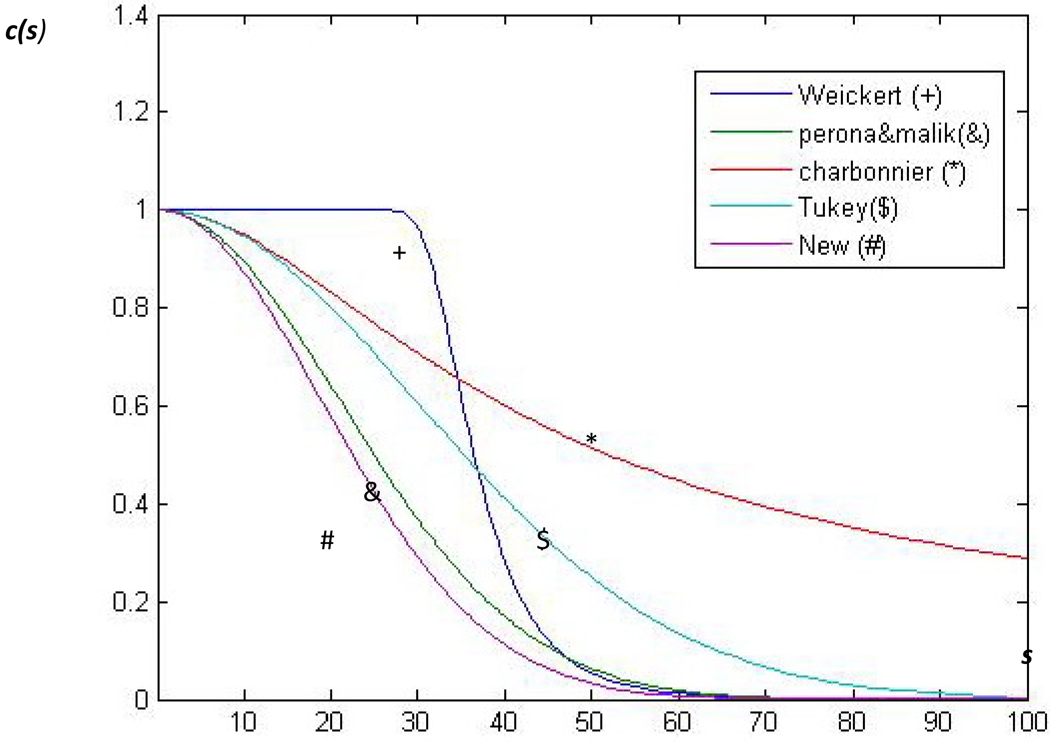


Fig (1) The behavior of the proposed edge-stopping function compared with the previous (Weickert, Perona&Malik, Charbonnier,and Tukey).

3. Color Image Enhancement using a New-Edge Stopping Function

With the widespread usage of digital cameras, color photo noise removal has become an important research subject. Enhancement of noisy color images is done in this work by transforming a noisy image to a color space that has image intensity as one of its components. One such color space is *L*a*b [5]. Use color transform functions to convert the image from RGB to *L*a*b** color space, and then work on the luminosity layer 'L*' of the image. Manipulating luminosity affects the intensity of the pixels, while preserving the original colors. Therefore the second stage is diffused the luminance component 'L*' using anisotropic diffusion filter with the new edge-stopping function (eq.(7)).**

4. Quality Measurements

The image quality can be measured by the similarity between the (noisy or reference) and test image. The Peak Signal Noise Ratio (*PSNR*) is a common factor used to quantify the differences between images; it is defined as follow [6]:

$$PSNR = 20\log_{10}\frac{255}{RMSE} \qquad \textbf{(8)}$$

where the RMSE is the root mean square error estimated between the ground truth and the denoised image as follow [7]:

$$RMSE = \left[\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\left[s_i - r_j\right]^2\right]^{\frac{1}{2}} \qquad \textbf{(9)}$$

Where i, j are the positions of pixels in the image, $s_{i,j}$ refers to the i^{th} row and j^{th} column pixel value of the source image and $r_{i,j}$ refers to the i^{th} row and j^{th} column pixel value of the reproduced image.

Also the Mean Structural Similarity Index (MSSIM) based on the Structural Similarity Index (SSIM) metric is used to measure the quality of the image using the following form [8]:

$$MSSIM = \frac{1}{M}\sum_{j=1}^{M} SSIM_J \qquad \textbf{(10)}$$

$$SSIM = \frac{\left(2\mu_x\mu_y + C_1\right)\left(2\sigma_{xy} + C_2\right)}{\left(\mu_x^2 + \mu_y^2 + C_1\right)\left(\sigma_x^2 + \sigma_y^2 + C_2\right)} \qquad \textbf{(11)}$$

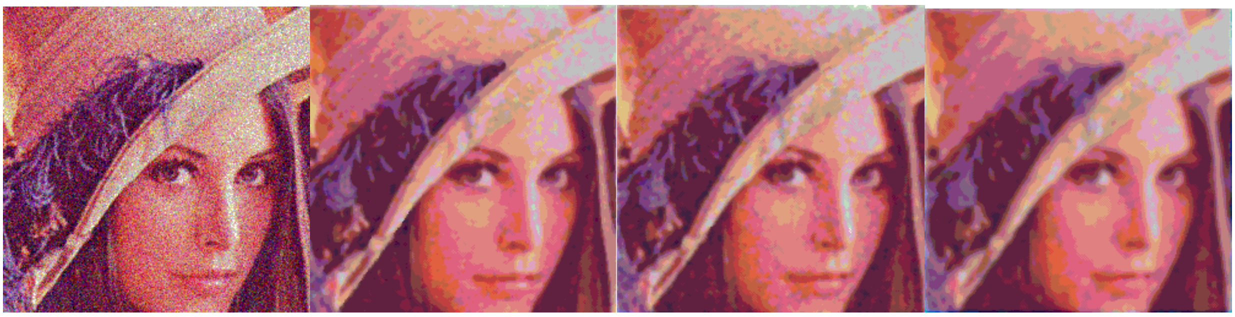
$$\mu_x = \frac{1}{n}\sum_{i=1}^{n} x_i \quad , \quad \mu_y = \frac{1}{n}\sum_{i=1}^{n} y_i \qquad \textbf{(12)}$$

where x_i, y_i, i= 1,...n, represent the original and distorted signals, respectively. Also:

$$\sigma_x^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \mu_x\right)^2,$$
$$\sigma_y^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(y_i - \mu_y\right)^2, \qquad (13)$$
$$\sigma_{xy}^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \mu_x\right)\left(y_i - \mu_y\right)$$

5. Experimental Results

Various types of colored images corrupted with various types of noises were filtered using anisotropic diffusion function with the new edge-stopping function. Fig (2) (a) shows the "*Lena.bmp*" colored image (256 $\times$ 256) corrupted by Gaussian noise of (zero mean and variance=0.02) then filtered by anisotropic diffusion filter with a new edge-stopping function (equation (7)). The filtered image seems to be much smoother with less noise in the flat areas and sharper in the edgy regions with different values of parameters (K, and number of iterations, Note that the optimal value of *K* and the iteration parameters were searched until the maximum PSNR value was achieved.) as shown in fig (2) (b), (c) and (d).



(a) (b) (c) (d)

Fig (2) "Lena.bmp" colored image: (a) corrupted by Gaussian noise of (zero mean and variance=0.02), (b) filtered by diffusion filter with a new edge-stopping function (K=70 and iteration=5), (c) filtered with (K=100 and iteration=5), (d) filtered with (K=100 and iteration=100).

Also this filter using a new edge stopping function can enhance the edges of the corrupted images. Fig (3) (a) shows the origin "*Peppers.jpg*" (384 $\times$ 384), (b) shows the edge map of the image corrupted by Gaussian noise of (zero mean and variance=0.03) using the Sobel edge detector, and (c) shows the edge map of the filtered image by the anisotropic diffusion filter using a new edge stopping function, which has less noise and less edge corruption such

that, a thin edge is better because the edge rather than the details in the neighborhood was only wanted.

(a) (b) (c)

Fig (3) (a) origin "Peppers.jpg" image, (b) the edge map of the image corrupted by Gaussian noise of (zero mean and variance=0.03) using the Sobel edge detector, and (c) the edge map of the filtered image by the anisotropic diffusion filter using a new edge stopping function.

The performance of this filter using the new edge-stopping function was tested using the quality metrics (RMSE, PSNR, and MSSIM) applied on many randomly selected colored images such examples shown in fig (4). This performance was compared with the performance of the filter using other most common edge-stopping functions such as (Perona and Malik, Charbonnier, Tukey, and Weickert) [3]. First, table (1) list the experiment results of MSSIM, RMSE, and PSNR metrics of denoising twelve color images corrupted by Gaussian noise of (zero mean and variance=0.01)using anisotropic diffusion filter with different edge-stopping functions and with the parameters (K=100, and iteration = 5). Fig (5) illustrates the charts of the average of these results. From table (1) and the charts in fig (5) it can be seen that performance of the filter using the new scheme is better compared with the other previous schemes, such that it gives the higher values of PSNR values, the higher values of MSSIM and the lower values of RMSE.

"*West.jpg*" image (368×368), corrupted by Gaussian noise of (zero mean and variance=0.02) was filtered using the new and the pervious edge-stopping functions with (K=100) and multiple number of iterations. The comparative results of the metrics can be illustrated in table (2). The average of these results showed using the charts in fig (6). From table (2) and the charts in fig (6) it can be seen that the new scheme gives the higher values of PSNR, and MSSIM metric and the lower values of RMSE metric.

Testing can be done using images corrupted with different types of noise such as "*Peppers.jpg*" image (384×384), corrupted by Poisson noise and "*Home.jpg*" image (288×288), corrupted by Speckle noise with (variance =0.04). The comparative results of the quality metrics for filtering the two images by anisotropic diffusion filter with a new and the previous edge-stopping functions with (K=100) and multiple number of iterations were illustrated in table (3) and fig (7) for "*Peppers.jpg*" image and table (4) and fig (8) for "*Home.jpg*" image.

From these results it can be seen that the filter with the new edge-stopping function gives better performance (higher values of PSNR, and MSSIM metrics and the lower values of RMSE metric) over the other most common previous schemes. This means that the filter using the new scheme can reduce the noise and enhance the colored image better than using the other schemes.

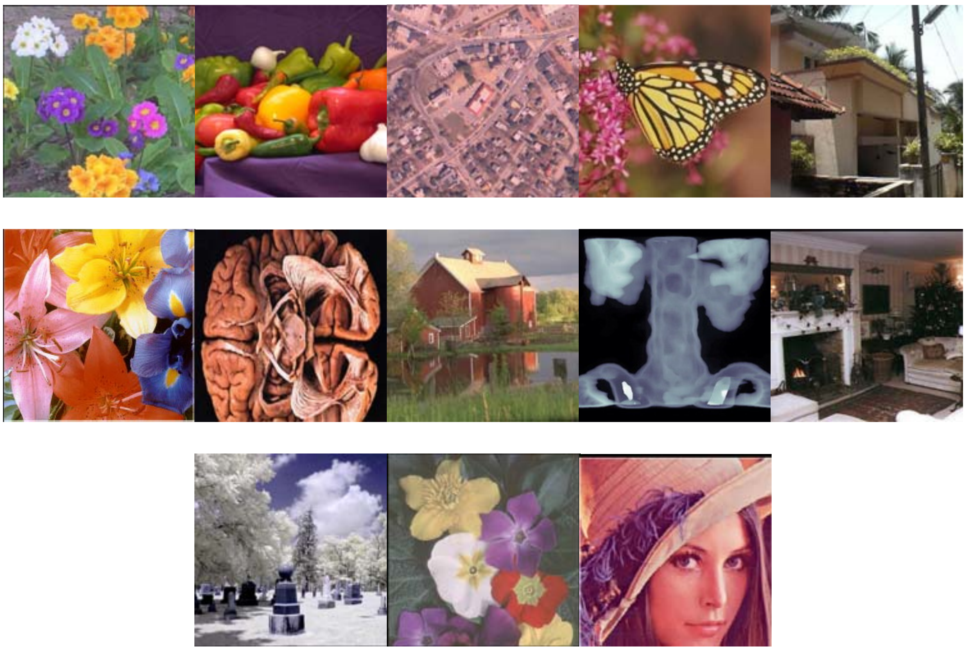


Fig (4) examples of some of colored images used in this work

6. Conclusions

In this paper, a color image was enhanced by denoising it using anisotropic diffusion filter with a new edge-stopping function. The behavior of the anisotropic diffusion depends heavily on the choice of the "edge-stopping function". The new function is a nonnegative monotonically decreasing function, which should result in low coefficient values at image edges that have large gradients, and high coefficient values within image regions that have low gradients. Therefore the behavior of the proposed function is the best. The performance of this function was measured using PSNR, MSSIM, and RMSE metrics and compared with the performance of the other most common previous functions.

The experiments revealed that better results of noise reduction using the new function were achieved with much smoother in the flat areas and sharper in the edgy regions after a small number of iterations. It is clear that the proposed scheme gives the best result, which is better than: the Perona & malik scheme by 0.1422 dB for PSNR and 0.00213 for MSSIM as an average, the Charbonnier scheme by 0.8878 dB for PSNR and 0.0132 for MSSIM as an average, the Weickert scheme by 0.7306 dB for PSNR and 0.0116 for MSSIM as an average and the Tukey scheme by 0.5646 dB for PSNR and 0.0085 for MSSIM as an average.

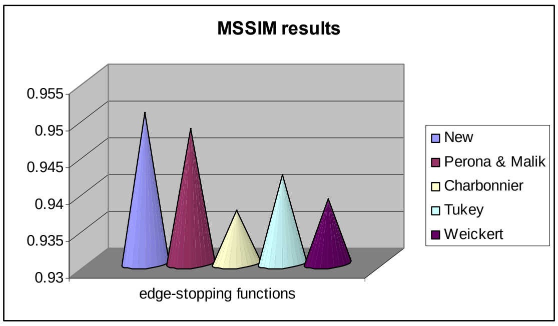
The main advantages of this filter with new function is that it will work for most types of noise (besides additive Gaussian noise, it also gave good results on multiplicative speckle noise and Poisson noise), also it gives significant improvement of image denoising, edge enhancement with little number of iterations over previous schemes.

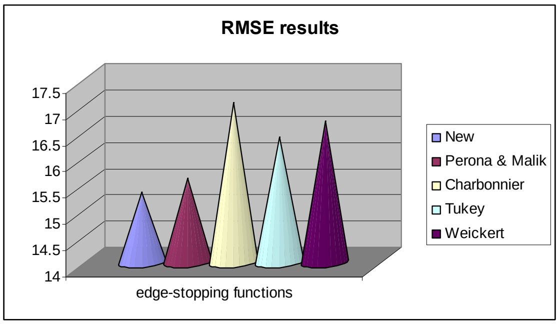
Table (1): Comparison of PSNR, RMSE, and MSSIM results of denoising twelve color images using anisotropic diffusion filter with different edge-stopping functions

Image name	New			Perona & Malik			Charbonnier		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
Clip28.jpg	23.843	16.381	0.927	23.761	16.536	0.925	23.188	17.664	0.910
Clip22.jpg	27.062	11.308	0.955	26.982	11.414	0.954	26.669	11.832	0.949
Clip30.jpg	22.535	19.044	0.934	22.375	19.398	0.931	21.146	22.346	0.907
Peppers.jpg	24.066	15.967	0.957	24.029	16.035	0.956	23.836	16.394	0.954
West.jpg	24.330	15.487	0.901	24.24	15.651	0.898	23.474	17.092	0.880
Home.jpg	23.162	17.718	0.953	22.888	18.285	0.950	21.797	20.734	0.936
Snow.bmp	22.119	19.979	0.937	21.957	20.355	0.934	21.275	22.018	0.922
utterfly.bmp	24.643	14.941	0.953	24.407	15.351	0.949	23.785	16.492	0.939
House.bmp	25.056	14.247	0.959	24.971	14.387	0.958	24.373	15.412	0.949
Spine.jpg	26.587	11.944	0.981	26.411	12.189	0.980	25.913	12.908	0.976
Lena.bmp	25.368	13.744	0.971	25.233	13.958	0.970	24.106	15.894	0.962
Room.jpg	25.729	13.184	0.970	25.542	13.472	0.968	24.286	15.567	0.958
Average	24.542	15.329	0.950	24.399	15.586	0.948	23.654	17.029	0.937

Continue Table1

Image name	Tukey			Weickert		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
Clip28.jpg	23.403	17.232	0.915	23.273	17.492	0.912
Clip22.jpg	26.761	11.707	0.950	26.609	11.914	0.947
Clip30.jpg	21.766	20.808	0.922	21.842	20.627	0.921
Peppers.jpg	23.916	16.240	0.955	23.785	16.490	0.953
West.jpg	23.845	16.378	0.888	23.698	16.657	0.884
Home.jpg	22.219	19.749	0.941	22.070	20.091	0.938
Snow.bmp	21.556	21.317	0.927	21.426	21.638	0.925
Butterfly.bmp	23.900	16.274	0.941	23.530	16.982	0.933
House.bmp	24.650	14.928	0.953	24.494	15.198	0.951
Spine.jpg	25.996	12.786	0.977	25.659	13.291	0.974
Lena.bmp	24.678	14.881	0.964	24.581	15.047	0.962
Room.jpg	25.036	14.279	0.964	24.765	14.731	0.961
Average	23.977	16.381	0.941	23.811	16.680	0.938





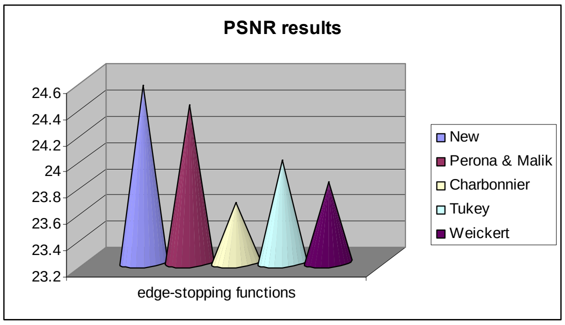


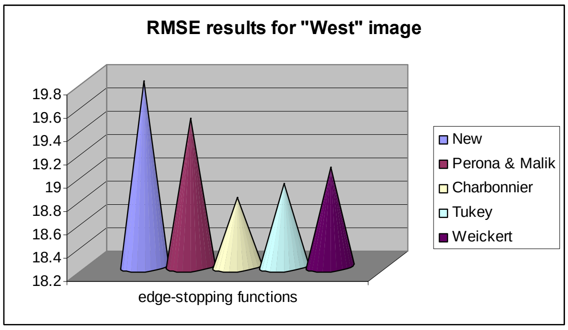
Fig (5): Charts of the average of PSNR, RMSE, and MSSIM results of denoising twelve color images using anisotropic diffusion filter with different edge-stopping functions

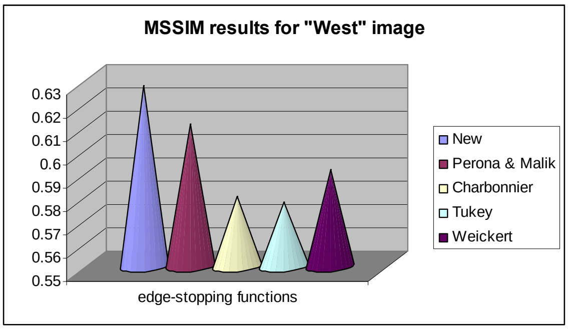
Table (2): Comparison of PSNR, RMSE, and MSSIM results of denoising “West.jpg” color image corrupted by Gaussian noise of (zero mean and variance=0.02) using anisotropic diffusion filter with different edge-stopping functions and iterations

iterations	New			Perona & Malik			Charbonnier		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
5	24.330	15.487	0.901	24.24	15.651	0.898	23.836	16.394	0.954
10	22.885	19.609	0.827	22.782	18.510	0.841	21.771	20.795	0.810
20	21.448	21.582	0.766	21.231	22.130	0.759	20.101	25.202	0.742
30	20.592	23.818	0.708	20.253	24.766	0.696	19.226	27.874	0.642
40	19.956	25.627	0.664	19.533	26.905	0.646	18.642	29.815	0.591
50	19.427	27.237	0.623	18.960	28.743	0.600	18.204	31.355	0.547
60	18.976	28.690	0.588	18.487	30.349	0.560	17.858	32.628	0.512
70	18.606	29.936	0.557	18.140	31.586	0.528	17.586	33.668	0.483
80	18.260	31.152	0.528	17.825	32.753	0.499	17.335	34.654	0.456
100	17.731	33.111	0.479	17.361	34.551	0.452	16.96	36.186	0.414
300	15.490	42.857	0.255	15.342	43.591	0.237	15.210	44.258	0.223
Average	19.791	27.191	0.627	19.469	28.139	0.610	18.794	30.257	0.579

Continue Table2

Image name	Tukey			Weickert		
iteration	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
5	23.845	16.378	0.888	23.698	16.657	0.884
10	22.165	19.874	0.824	22.281	19.609	0.827
20	20.347	24.499	0.724	20.630	23.713	0.739
30	19.380	27.385	0.652	19.671	26.482	0.672
40	18.750	29.445	0.599	18.976	28.690	0.619
50	18.29	31.048	0.554	18.486	30.354	0.573
60	17.926	32.374	0.518	18.089	31.772	0.536
70	17.644	33.445	0.488	17.799	32.851	0.507
80	17.385	34.457	0.460	17.526	33.900	0.479
100	16.999	36.024	0.417	17.121	35.52	0.435
300	15.223	44.194	0.224	15.250	44.055	0.229
Average	18.905	29.920	0.577	19.048	29.418	0.591





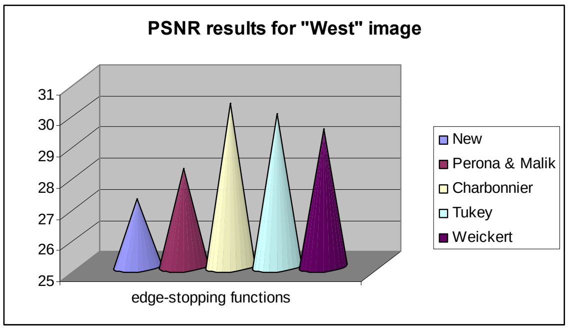


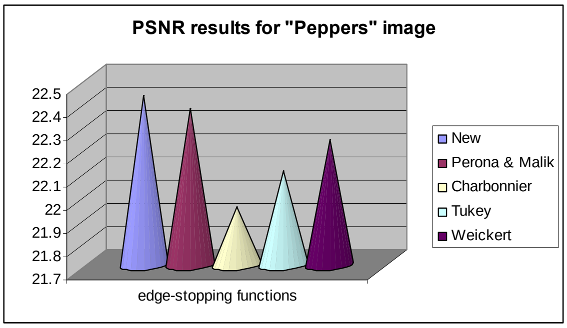
Fig (6): Charts of the average of PSNR, RMSE, and MSSIM results of denoising "West.jpg" color image corrupted by Gaussian noise of (zero mean and variance=0.02)using anisotropic diffusion filter with different edge-stopping functions and iterations

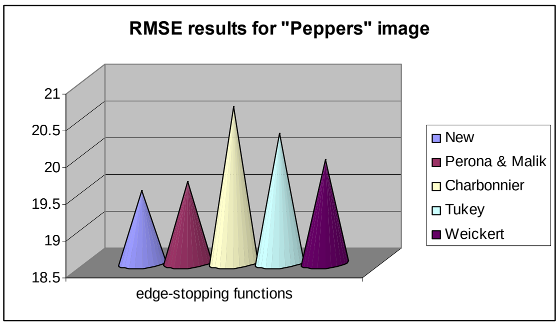
Table (3): Comparison of PSNR, RMSE, and MSSIM results of denoising "Peppers.jpg" color image corrupted by Poisson noise using anisotropic diffusion filter with different edge-stopping functions and iterations

iterations	New			Perona & Malik			Charbonnier		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
5	24.870	14.555	0.959	24.835	14.613	0.959	24.647	14.934	0.957
10	24.336	15.478	0.952	24.285	15.569	0.951	23.990	16.106	0.948
20	23.520	17.002	0.938	23.460	17.120	0.937	23.069	17.909	0.933
30	22.943	18.171	0.926	22.871	18.321	0.925	22.440	19.253	0.920
40	22.478	19.169	0.916	22.405	19.330	0.914	21.957	20.356	0.909
50	22.104	20.014	0.906	22.039	20.163	0.905	21.574	21.272	0.899
60	21.789	20.753	0.897	21.730	20.893	0.896	21.252	22.075	0.889
70	21.504	21.444	0.889	21.452	21.573	0.888	20.965	22.818	0.881
80	21.273	22.022	0.881	21.222	22.151	0.880	20.725	23.455	0.873
90	21.060	22.569	0.874	21.009	22.701	0.873	20.506	24.056	0.865
100	20.868	23.073	0.867	20.816	23.211	0.866	20.309	24.606	0.858
Average	22.431	19.477	0.909	22.375	19.604	0.908	21.948	20.622	0.903

Continue Table3

iteration	Tukey			Weickert		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
5	24.733	14.787	0.9583	24.652	14.924	0.957
10	24.140	15.831	0.9497	24.087	15.928	0.948
20	23.291	17.457	0.9351	23.279	17.480	0.934
30	22.687	18.714	0.9227	22.720	18.642	0.922
40	22.192	19.812	0.9117	22.278	19.617	0.912
50	21.776	20.784	0.9015	21.925	20.429	0.902
60	21.416	21.663	0.8919	21.623	21.152	0.894
70	21.096	22.475	0.8831	21.348	21.833	0.886
80	20.833	23.167	0.8748	21.117	22.421	0.878
90	20.599	23.798	0.8673	20.905	22.975	0.871
100	20.390	24.378	0.8598	20.710	23.496	0.864
Average	22.105	20.260	0.9050	22.240	19.900	0.906





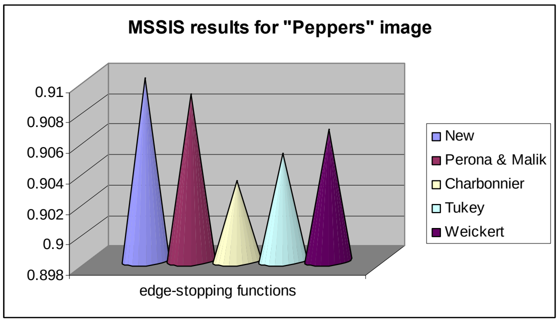


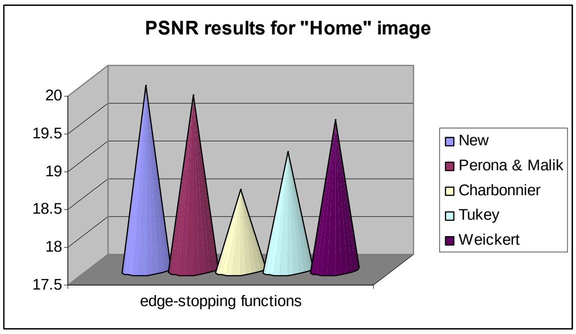
Fig (7): Charts of the average of PSNR, RMSE, and MSSIM results of denoising "Peppers.jpg" color image corrupted by Poisson noise using anisotropic diffusion filter with different edge-stopping functions and iterations .

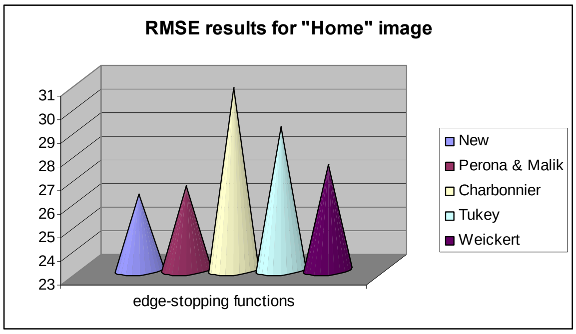
Table (4): Comparison of PSNR, RMSE, and MSSIM results of denoising "Home.jpg" color image corrupted by Speckle noise (variance =0.04) using anisotropic diffusion filter with different edge-stopping functions and iterations .

iterations	New			Perona & Malik			Charbonnier		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
5	24.870	14.555	0.959	24.835	14.613	0.959	24.647	14.934	0.957
10	24.336	15.478	0.952	24.285	15.569	0.951	23.990	16.106	0.948
20	23.520	17.002	0.938	23.460	17.120	0.937	23.069	17.909	0.933
30	22.943	18.171	0.926	22.871	18.321	0.925	22.440	19.253	0.920
40	22.478	19.169	0.916	22.405	19.330	0.914	21.957	20.356	0.909
50	22.104	20.014	0.906	22.039	20.163	0.905	21.574	21.272	0.899
70	21.789	20.753	0.897	21.730	20.893	0.896	21.252	22.075	0.889
Average	22.431	19.471	0.909	22.375	19.604	0.908	21.948	20.622	0.903

Continue Table3

iterations	Tukey			Weickert		
	PSNR	RMSE	MSSIM	PSNR	RMSE	MSSIM
5	24.733	14.787	0.958	24.652	14.924	0.957
10	24.140	15.831	0.949	24.087	15.928	0.948
20	23.291	17.457	0.935	23.279	17.480	0.934
30	22.687	18.714	0.922	22.720	18.642	0.922
40	22.192	19.812	0.911	22.278	19.617	0.912
50	21.776	20.784	0.901	21.925	20.429	0.902
70	21.416	21.663	0.891	21.623	21.152	0.894
Average	22.105	20.260	0.905	22.240	19.900	0.906





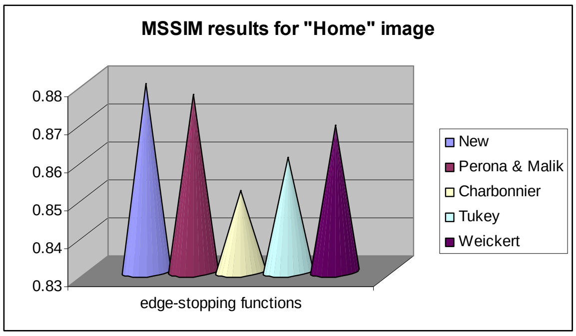


Fig (8): Charts of the average of PSNR, RMSE, and MSSIM results of denoising "Home.jpg" color image corrupted by Speckle noise (variance= 0.04) using anisotropic diffusion filter with different edge-stopping functions and iterations.

References

1. Perona, P. and Malik, J., "Scale-*Space and Edge Detection Using Anisotropic Diffusion*", IEEE transaction on pattern analysis and machine intelligence. VOL. 12 NO. 7. July **1990**, 629-639.
2. Schmidt, R., Heipkea, C., Neukumb, G. and the HRSC Co-Investigator Team, "*Improving Tie Point Extraction By Anisotropic Diffusion*". Web site:
, **2006**.http://www.ipi.unihannover.de/uploads/tx_tkpublikationen/schmidt_heipke_ISPRS_2006.pdf.

3. Rajan, J., Kannan, K.and Kaimal, M.R., " *An Improved Hybrid Model for Molecular Image Denoising*", journal of Mathematical Imaging and vision, vol 31, may **2008**, pp: 71-78.
4. Hussain, Z., M., "Image Denoising Using a New Edge-Stopping Function for Anisotropic Diffusion", Proceeding of 3rd scientific conference of the College of Science, University of Baghdad, March **2009**, P.P 869-878.
5. Westland, S. and Ripamonti, C., "Computational Colour Science using MATLAB" John Wiley & Sons Ltd, **2004**, **www.4electron.com**
6. Ling, J. and Bovik A. C., "*Smoothing Low SNR Molecular Images Via Anisotropic Median-Diffusion*", IEEE transaction on medical imaging, vol 21, no. 4, **2002**, pp: 377-384.
7. Saravanan C, and Ponalagusamy R.," Gaussian Noise Estimation Technique For Gray Scale Images Using Mean Value", Journal of Theoretical and Applied Information Technology, **2007**, www.jatit.org
8. Wang, Z., Bovik, A. C., Sheikh, H. R. and Simoncelli, E. P.,"Image quality assessment: from error measurement to structural similarity," *IEEE Transactions on Image Processing*,Vol. 13, No. 4, April **2004**.

تحسين الصورة الملونة باستخدام دالة إيقاف حدود جديدة لانتشار انايزوتروبك

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المستخلص:

يَلْعبُ تحسينُ الصورةِ دوراً مهماً في العديد مِنْ تطبيقاتِ رؤيةِ الماكنةِ مثل صَقْل الضوضاءِ وتَحسين الحافةِ. انتشار(انايزوتروبك Anisotropic) تقنية شائعة ونظريا جيدة الفهم لإزالة الضوضاء بحيث ان ترشيح انتشار انايزوتروبك يوفر تنعيم لمساحات المناطق الداخلية تفضيلا على مساحات بين المناطق، وبذلك يوفر أداة متوقعة لإزالة الضوضاء الغير مرغوب بها ويبقي على حدود الأجسام المطلوبة.

في هذا البحث تم تحسين الصورة الملونة باستخدام دالة إيقاف الحدود المقترحة لخوارزمية الانتشار والتي أستخدمت لتحسين أداء مرشح انتشار انايزوتروبك في تحسين الصورة الملونة.

ُالنَتائِجَ التجريبية ترينا بأنّ دالة إيقاف الحافةِ المُقتَرَحةِ لمرشِح إنتشار انايزوتروبك يُمْكِنُ أنْ تَعطي أداءَ أفضل بكثيرَ مقارنة بالدوال المُسْتَخْدمة سابقاً لتَحسين الصورةِ المُلوَّنةِ.الدالة المقترحة تم مقارنتها بالاعتماد على جذر معدل مربع الخطأ (RMSE)،(PSNR) وكذلك مقياس التشابه(MSSIM).

التجارب وضحت أن مرشح انتشار انايزوتروبك مع الدالة المقترحة يمكنه إزالة الضوضاء من الصور المنخفضة ال PSNR مع تشويه اقل للحدود.