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A modified PSS Filter for an objective image Quality enhancement of noisy images

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Abstract— ***A problem of fundamental importance in image processing is edge detection since an edge characterizes the boundaries. Due to limitations of the existing techniques finding a better method for edge detection is still an active area of research. The disagreeable properties perverted in the image are called noise. During image acquisition and transmission abundant factors accountable for noise. The most important humiliating attribute of an image is noise, which may become obvious during image capturing, communication or processing and may conceivably be reliant on or sovereign of image. In order to supplement the high-frequency components in this paper a new class of filters called PSS filters is proposed which implies spatial filter shape that has a high positive component at the centre. Since restraint of noise can only be achieved by smoothing the image. Sharpening with PSS filters highlights the fine details of an image and enhances the clarity of the image at the boundaries. Since the perception of human of image quality is not adequate some image quality metrics like Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Average Difference (AD), Normalized Absolute Error (NAE), Structural Content (SC), Normalized Cross Correlation (NCC) and Maximum Difference (MD) were employed for measurement of image quality. Experimental results show that the proposed PSS filter displayed better performance and superior noise resilience. The performance of the PSS filter is measured not only on various images but also on images corrupted with various levels of noise.***

Keywords: image processing, spatial filter, image sharpening, image smoothing, PSS filter, image quality metrics.

I. INTRODUCTION

An image may be defined as a two dimensional function, f(x, y), where x and y are spatial (Plane) coordinates, and the amplitude at any pair of co-ordinates (x, y) is called the intensity or grey level of the image at that point.

Edge detection is one of the most regularly used operations in image analysis, and there is probably supplementary number of algorithms for enhancing and detecting the boundaries of an image in the literature. The rationale for this is that edges form the outline of an object. An edge is the boundary between an object and the background, and indicates the boundary between overlapping objects. All the objects can be positioned and indispensable properties such as shape, area, and perimeter can be measured accurately if the boundaries identified precisely. Since computer vision involves the detection and categorization of objects in an image. Noise is an imperative preventative aspect in image enhancement. Noise steadily effects the image, predominantly when the interaction of noise with the visual sign of the image.

Smoothening[2, 3, and 4] helps in lessen counterfeit effects and noise in an image during image acquisition as a corollary of sampling, quantization, communication. There are quite a few algorithms for image smoothing[2, 4] and sharpening. The design of these algorithms is often pricey to intend, implement, as well as calculate with superior performance.

The noise captured by an image during acquisition and transmission can be classified as Impulse noise (Salt-and-pepper noise), Amplifier noise (Gaussian noise), Poisson noise, Multiplicative noise (Speckle noise) and Periodic noise. The above said PSS filter is also applied on the images which are corrupted with Speckle noise with variance 0.01, Poisson noise and Gaussian noise Variance 0.01.

There are two ways through which image quality can be assessed, Subjective and Objective. The evaluation based on observers is called Subjective which are time consuming and less accurate. Whereas the subsequent method is objective method of testing the image quality based on mathematical calculations [9].

SHARPENING FILTERS

The important area in the field of computer vision is edge detection. Edges classify the boundaries flanked by regions in an image an edge is the boundary between an object and the background, and indicates the boundary between overlapping objects [6]. As the colour and brightness values for each pixel are interpolated, some image softening is applied to even out any fuzziness that has occurred. To preserve the impression of depth, clarity and fine details, the image processor must sharpen edges and contours. It therefore must detect edges correctly and reproduce them smoothly and without over-sharpening.

Sobel, Prewitt and Laplacian filters are one among the sharpening filters where each point in the image are done convolution with these two kernels. One kernel has a maximum response to the usual vertical edges and the other kernel has a maximum response to the horizontal edge. It is estimated in 8 possible directions and convolution result of greatest magnitude indicates the greatest direction.

II. PSS FILTER

PSS operators perform a 2-Dimensional spatial ascent measurement on an image. Typically it can be used to unearth the approximate absolute gradient magnitude in an input gray scale image at every point. This edge detector uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows). The size of a convolution mask is typically much smaller than the actual image. The ensuing image is untrained by sliding mask over an area of the input image, changing that pixel's value and then shifts one pixel to the right and continues until it reaches the end of a row. It then starts at the beginning of the next row. The proposed operators are in the form of a non singular matrix whose determinant is equal to zero.

The Gx mask brightens the edges in the horizontal direction while the Gy mask highlights the edges in the vertical direction. After taking the magnitude of both, the resulting output detects edges in both directions. The value of the gradient of proposed operators (both in X and Y-directions) is positive so it identifies the boundaries clearly.
The Gx mask brightens the edges in the horizontal direction while the Gy mask highlights the edges in the vertical direction. After taking the magnitude of both, the resulting output detects edges in both directions. The value of the gradient of proposed operators (both in X and Y-directions) is positive so it identifies the boundaries clearly.

-1	-1	-2
-1	12	-2
-1	-2	-2

Gx

-1	-1	-1
-1	12	-2
-2	-2	-2

Gy

$$Gx= (- (Z1+Z2+Z4+Z7)-2(Z3+Z6+Z8+Z9) +12Z5)$$
$$Gy= (- (Z1+Z2+Z3+Z4)-(Z6+Z7+Z8+Z9) +12Z5)$$

The above formula shows the way value of a particular pixel in the output image is calculated. The centre of the mask is placed over the pixel to be manipulated in the image.

PSS FILTER OF 3*3

In the present case we use simplest approximations to a first derivative that satisfy the condition in equation [1] is used and the appropriate filter mask may be formulated as:

$$\nabla f \approx \left|12Z5\right| - \left|-(z1+z2+z4+z7)-2(Z3+Z6+Z8+Z9)\right| + \left|12z5-(z1+Z2+Z3+Z4)-(Z6+Z7+Z8+Z9)+z3\right| - \left|z7+2z9\right| \rightarrow 1$$

The above equation can be implemented with the two masks and these are referred as PSS – gradient operators.Generalized formula is used to generalize the given filter, but the filter can be generalized only by generalizing the equation i.e in this case it is equation [1]. Later one may increase or decrease the filter size according to quality of the image.

In a situation where one has to apply 3*3 filter, then it is needed to divide the image into 3*3 matrixes and then 3*3 PSS mask has to slide over an area of the input image. Changing that pixel's value, and shifting one pixel to the right. It will then continue to the right and moves till the end of a row is reached. It then starts at the beginning of the next row.

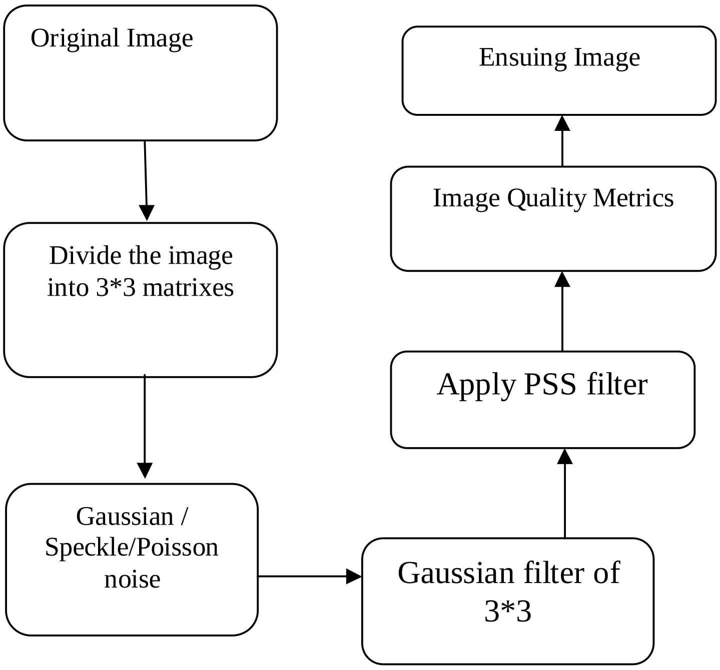
The above said PSS filter is also applied on the images which are corrupted with Speckle noise with variance 0.01, Poisson noise and Gaussian noise Variance 0.01.

ALGORITHM

Step1: Read the Image.
Step2: partition the image into 3*3 sizes.
Step 3: Apply Gaussian or Poisson noise or Speckle noise.
Step4: Smoothening the edges
Apply Gaussian filter of 3X3 size with sigma equal to 1.4 for smoothening the image.
Step5: Finding the edges of the image Work out the derivatives G_X and G_Y in x and y directions. This can be done by the application of PSS filter which is of 3*3 sizes for finding the edges of the image

0.0924	0.1192	0.0924
0.1192	0.1538	0.1192
0.0924	0.1192	0.0924

Figure 1: The Process of evaluation of PSS filter when the image is corrupted with noise.



III. EXPERIMENTAL RESULTS

This section presents the simulation results illustrating the performance of the proposed PSS filter. The fundamental significance in image processing is the measurement of image quality. In many image processing applications, assessment is required for image quality. The perception of human of image quality is not adequate. So we require some more image quality metrics like Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Average Difference (AD), Normalized Absolute Error (NAE), Structural Content (SC) and Maximum Difference (MD), Normalized Cross Correlation (NCC) and Maximum Difference for efficient measurement of image quality

TABLE - IMAGE QUALITY METRIC FORMULE

Image Quality Metric	Procedure to Calculate
Average Difference	$(1 \div MN) \sum_{J=1}^{M} \sum_{k=1}^{N} [F(X,Y)-F'(X,Y)]$ Where M and N are image rows and columns in spatial form
Peak-Signal to Noise Ratio	$20 \log_{10}(255/MSE)$ Where MSE is Mean Square Error
Mean Square Error	$(1 \div MN) \sum_{J=1}^{M} \sum_{k=1}^{N} [F(X,Y)-F'(X,Y)]^2$ Where M and N are image rows and columns in spatial form
Maximum Distance	$MAX\{\lvert F(X,Y)-F'(X,Y)\rvert\}$
Structural Content	$\sum_{J=1}^{M} \sum_{k=1}^{N} (F(X,Y))^2 \div \sum_{J=1}^{M} \sum_{k=1}^{N} (F'(X,Y))^2$ Where M and N are image rows and columns in spatial form

Normalized Absolute Error	$\sum_{J=1}^{M}\sum_{k=1}^{N}\lvert[F(X,Y)-F'(X,Y)]\rvert / \sum_{J=1}^{M}\sum_{k=1}^{N}\lvert F(X,Y)\rvert$ Where M and N are image rows and columns in spatial form
Normalized Cross Correlation	$\sum_{J=1}^{M}\sum_{k=1}^{N}\lvert[F(X,Y)*F'(X,Y)]\rvert / \sum_{J=1}^{M}\sum_{k=1}^{N}\lvert F(X,Y)\rvert^{2}$ Where M and N are image rows and columns in spatial form
Fidelity criteria	$1-\sum_{J=1}^{M}\sum_{k=1}^{N}\lvert[F(X,Y)-F'(X,Y)]\rvert^{2} / \sum_{J=1}^{M}\sum_{k=1}^{N}\lvert F(X,Y)\rvert^{2}$ Where M and N are image rows and columns in spatial form
Mean Square Error	$(1\div MN)\ \sum_{J=1}^{M}\sum_{k=1}^{N}[F(X,Y)-F'(X,Y)]^{2}$ Where M and N are image rows and columns in spatial form

The mean square error (MSE) is the measure of difference between actual and estimated value of the quantity]. Larger the value of MSE implies poor quality of the image. The most familiar image quality metric is PSNR. If PSNR value is high then the difference between the original image and reconstructed image will be small. Large the value of SC indicates that the image is of pitiable quality. In order to obtain an uncontaminated and less noisy image the value of Average Difference (AD) should be reduced. The quality of the image increases with decrease in the value of NAE, Higher the value of NAE means the quality of the image lower. NCC is the measure of calculating the degree of resemblance between two objects

Table 1: Comparison of Image Quality Metrics for PSS filter for images corrupted with Speckle noise Variance 0.01

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.87	1.060	7.26	73.35	255	0.1848	0.85
2	Cameraman	6.77	1.36	5.166	92.29	255	0.2194	0.8418
3	Characters test pattern	2.33	3.80	12.19	178	255	0.1410	0.8720
4	Chest-xray-vandy	4.57	2.26	23.27	126.29	255	0.1083	0.896
5	Circuit	6.40	1.48	7.32	114.4	240	0.1985	0.8409
6	Cktboard	6.20	1.55	4.44	107.68	255	0.3040	0.7594
7	Fractal_iris	9.45	0.736	4.27	48.57	255	0.2731	0.7992
8	headCT-vandy	7.5	1.13	9.07	66.69	255	0.1918	0.855
9	Kidney-original	7.25	1.22	12.8	98.89	255	0.144	0.8744
10	Microporcessor	8.86	0.843	1.67	55.44	255	0.55	0.658

Table 2: Comparison of Image Quality Metrics for Sobel Filter for images corrupted with Speckle noise ariance 0.01

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.38	1.18	20.92	80.8	255	0.092	0.91
2	Cameraman	6.17	1.57	8.52	99.7	255	0.12	0.91
3	Characters test pattern	1.88	4.21	22.39	188	255	0.0783	0.936
4	Chest-xray-vandy	4.30	2.41	32.9	129.7	255	0.0754	0.92
5	Circuit	5.86	1.68	12.07	122.18	255	0.1228	0.8981
6	Cktboard	5.22	1.95	4.89	110.9	255	0.2142	0.8461
7	Fractal_iris	9.030	0.857	3.75	47.85	255	0.2122	0.9050
8	headCT-vandy	7.01	1.29	9.60	68.11	255	0.115	0.9288
9	Kidney-original	7.03	1.28	18.13	101.07	255	0.112	0.8895
10	Microporcessor	6.47	1.46	3.12	78.10	255	0.239	0.888

Table 3: Comparison of Image Quality Metrics for Prewitt Filter for images corrupted with Speckle noise Variance 0.01.

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.24	1.22	31.42	83.16	255	0.069	0.93
2	Cameraman	6.07	1.6	12.82	104.18	255	0.09	0.923
3	Characters test pattern	1.76	4.32	31.62	192	255	0.059	0.9519
4	Chest-xray-vandy	4.16	2.49	51.7	132.8	255	0.0558	0.944
5	Circuit	5.70	1.74	19.47	126.64	255	0.092	0.9190
6	Cktboard	5.09	2.010	7.32	118.74	255	0.16	0.86

7	**Fractal_iris**	8.55	0.907	5.99	52.5	255	0.1609	0.9122
8	**headCT-vandy**	6.91	1.32	13.6	70.7	255	0.089	0.943
9	**Kidney-original**	6.85	1.34	29.75	104.59	255	0.084	0.9154
10	**Microporcessor**	6.44	1.47	4.59	85.96	255	0.185	0.89

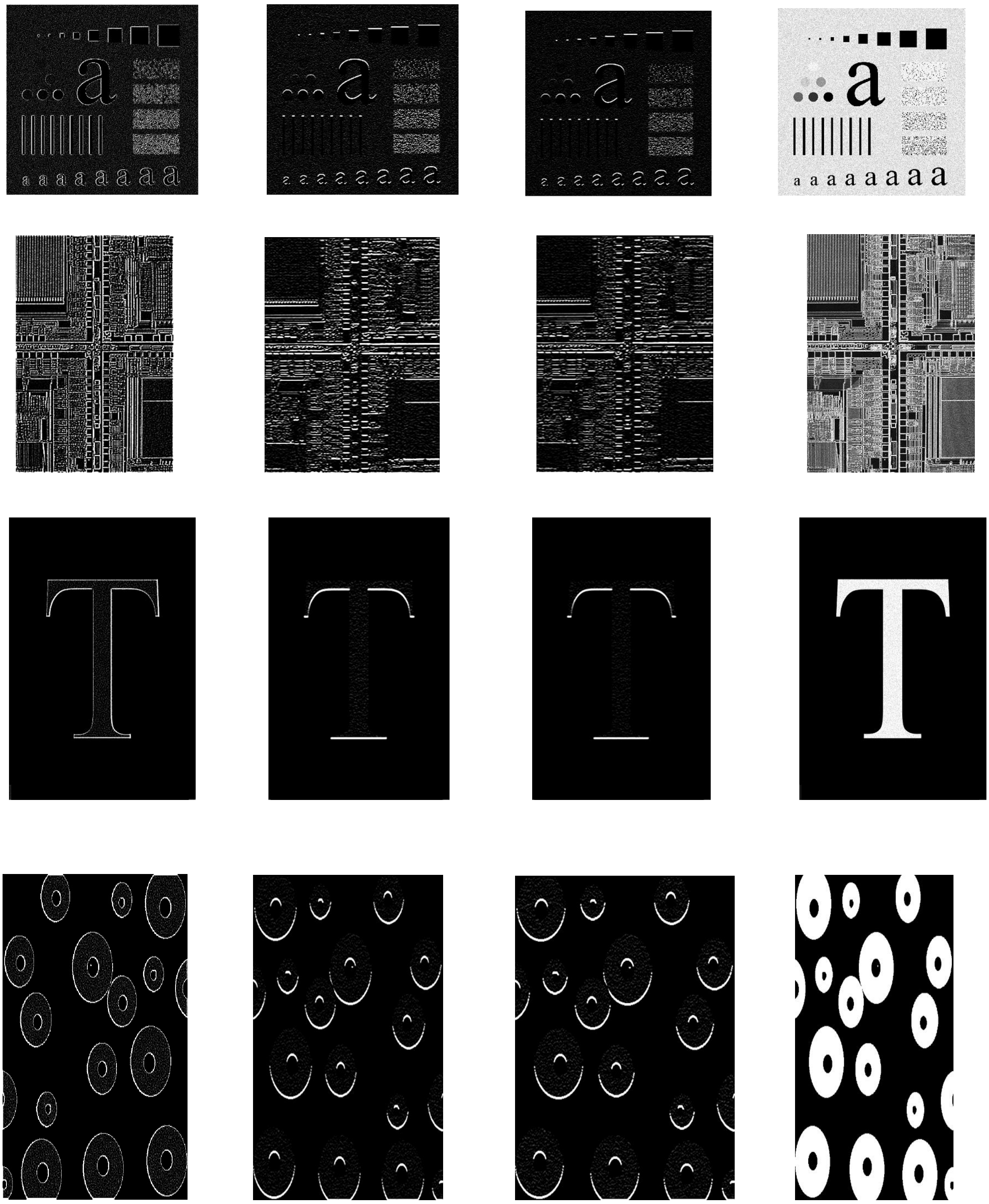
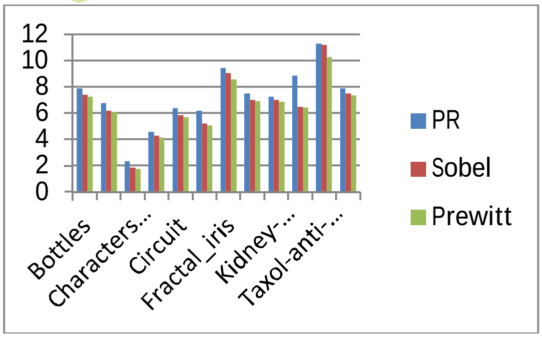
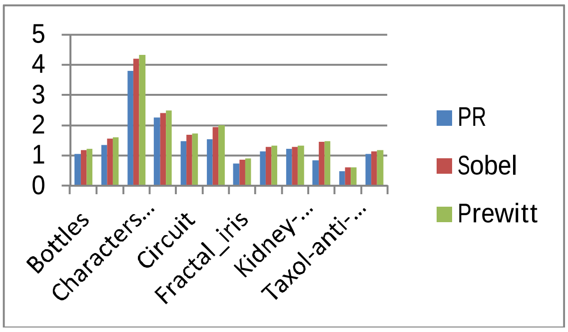


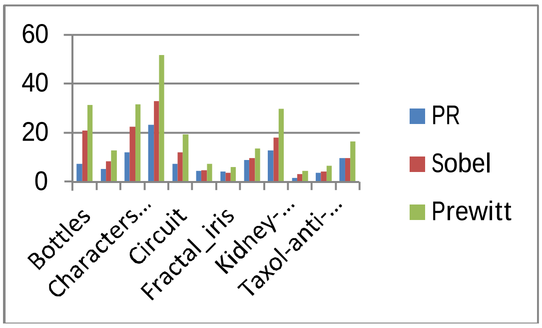
Fig 2:
(a) Sharpened with PSS filter (b) Sharpened with Prewitt (c) Sharpened with Sobel (d) Original image



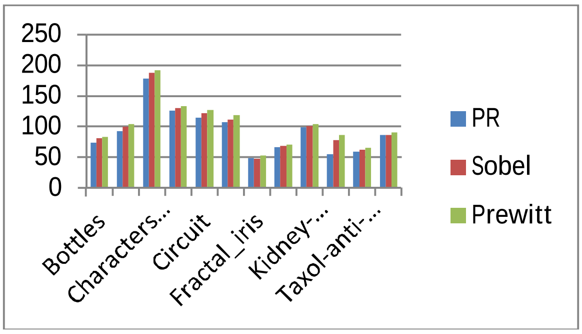
PSNR



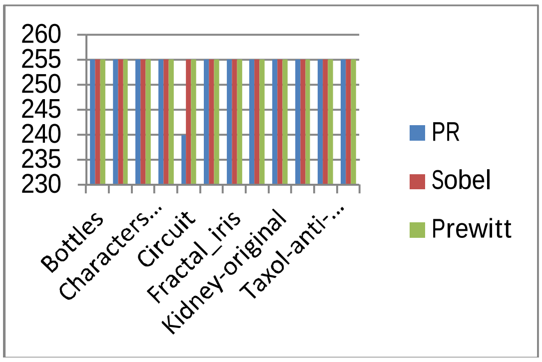
MSE



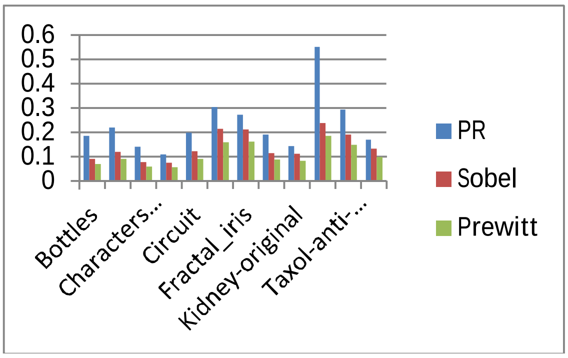
SC



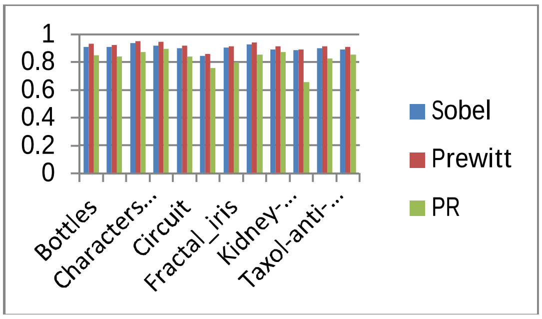
AD



MD



NCC



NAE

Table 4: Comparison of Image Quality Metrics for PSS filter for images corrupted with Poisson noise

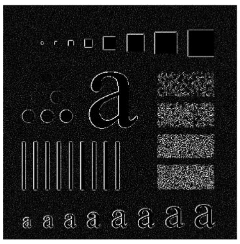
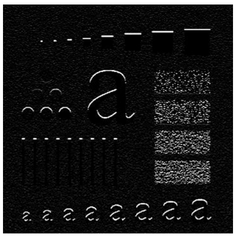
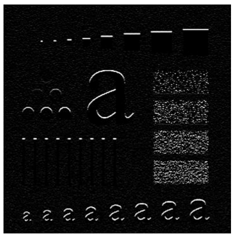
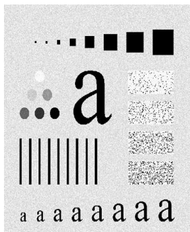
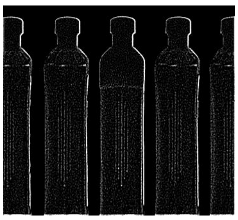
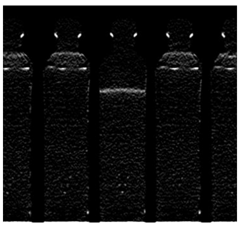
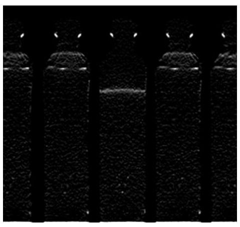
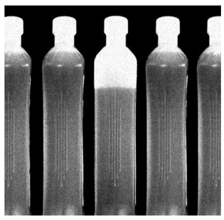
S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.735	1.09	7.4232	74	255	0.1750	0.858
2	Cameraman	6.67	1.39	5.33	93.44	255	0.2073	0.85
3	Characters test pattern	2.11	3.99	13.59	182.39	255	0.1199	0.8933
4	Chest-xray-vandy	4.40	2.35	30.85	129	255	0.085	0.91
5	Circuit	6.35	1.50	7.75	115	238	0.19	0.85
6	Cktboard	6.13	1.58	4.41	107.8	255	0.30	0.76
7	Fractal_iris	9.40	7.45	4.45	49	255	0.26	0.80
8	headCT-vandy	7.43	1.17	9.53	67.54	255	0.16	0.86
9	Kidney-original	7.19	1.24	13.71	99.5	255	0.1359	0.88
10	Microporcessor	8.84	0.84	1.67	55	255	0.55	0.65

Table 5: Comparison of Image Quality Metrics for Sobel Filter for images corrupted with Poisson noise

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.28	1.215	21.56	81	255	0.0869	0.9145
2	Cameraman	6.11	1.59	8.7	100	255	0.117	0.92
3	Characters test pattern	1.73	4.36	24.35	191	255	0.064	0.95
4	Chest-xray-vandy	4.2	2.46	38.8	131	255	0.0619	0.94
5	Circuit	5.82	1.70	12.48	123	255	0.116	0.90
6	Cktboard	5.14	1.98	4.81	110	255	0.2129	0.8474
7	Fractal_iris	9.04	8.56	3.79	48	255	0.20	0.90
8	headCT-vandy	6.91	1.32	9.72	68.5	255	0.1087	0.93
9	Kidney-original	6.99	1.30	18.8	101	255	0.1078	0.89
10	Microporcessor	6.43	1.47	3.13	78	255	0.24	0.89

Table 6: Comparison of Image Quality Metrics for Prewitt Filter for images corrupted with Poisson noise

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.14	1.225	31.89	83	255	0.0655	0.93
2	Cameraman	6.03	1.62	13.00	104	255	0.09	0.93
3	Characters test pattern	1.65	4.44	33.51	195	255	0.049	0.96
4	Chest-xray-vandy	4.1	2.52	59	134	255	0.046	0.95
5	Circuit	5.68	1.75	20	127	255	0.0877	0.92
6	Cktboard	5.02	2.04	7.15	118	255	0.167	0.86
7	Fractal_iris	8.55	9.07	6.05	52	255	0.16	0.91
8	headCT-vandy	6.82	1.35	13.76	71	255	0.084	0.95
9	Kidney-original	6.83	1.34	30.63	105	255	0.081	0.91
10	Microporcessor	6.42	1.48	4.6	85	255	0.18	0.89



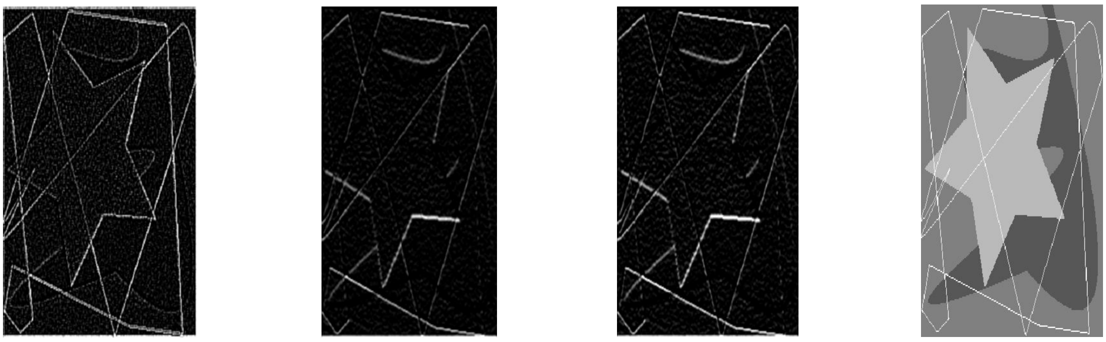
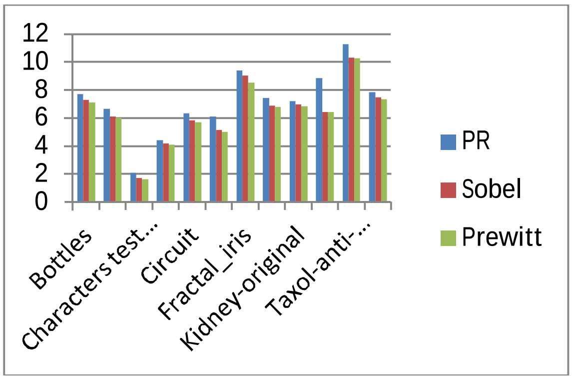
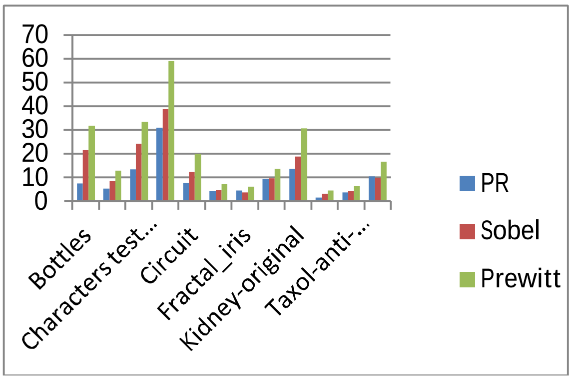
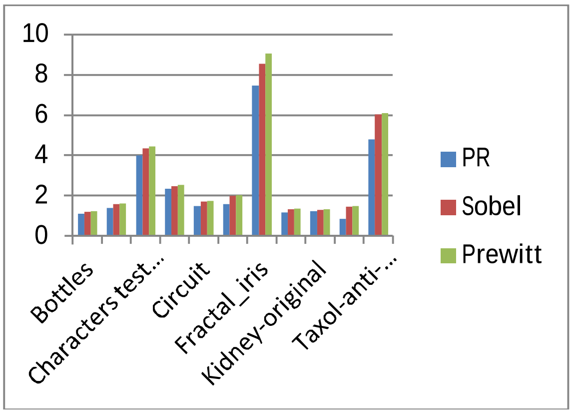


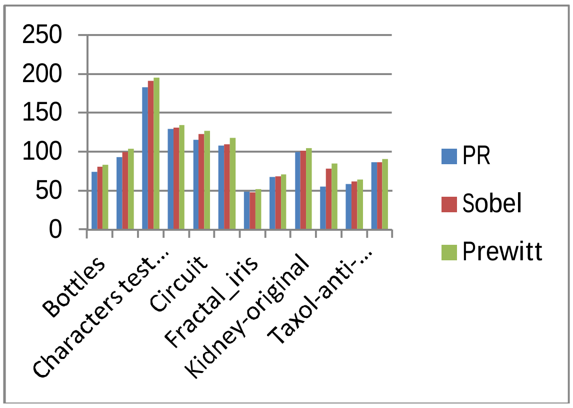
Fig 3:
(a) Sharpened with PSS filter (b) Sharpened with Prewitt (c) Sharpened with Sobel (d) Original image



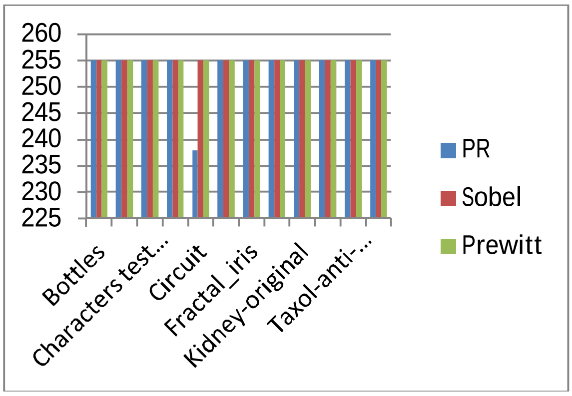


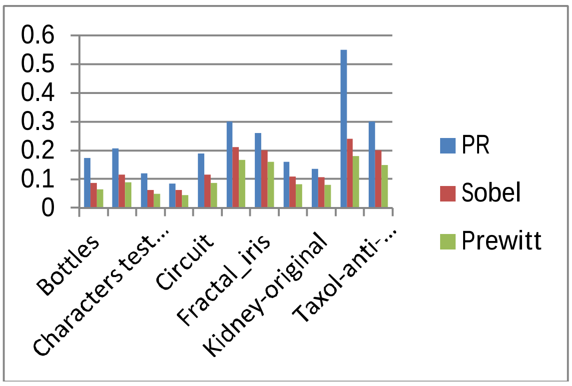
PSNR **SC**



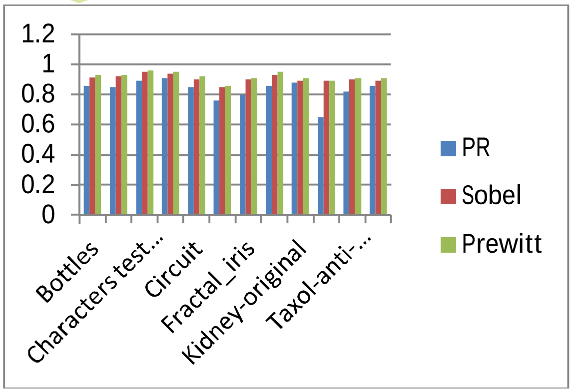


MSE **AD**





MD **NCC**



NAE

Table 7: Comparison of Image Quality Metrics for PSS filter for images corrupted with Gaussian noise Variance 0.01

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.94	1.0445	5.149	64.48	255	0.22	0.82
2	Cameraman	6.94	1.314	4.2114	85.05	255	0.26	0.811
3	Characters test pattern	2.37	3.76	12.14	177	255	0.14	0.87
4	Chest-xray-vandy	4.69	2.20	15.45	119	255	0.13	0.88
5	Circuit	6.63	1.41	5.36	107	255	0.24	0.7959
6	Cktboard	6.23	1.54	3.98	103	255	0.322	0.74
7	Fractal_iris	9.42	7.43	3.51	40.5	255	0.30	0.81
8	headCT-vandy	7.6	1.13	6.84	58	255	0.198	0.862
9	Kidney-original	7.15	1.15	6.66	88.7	255	0.21	0.81
10	Microporcessor	8.67	8.82	1.6	52.7	255	0.557	0.66

Table 8: Comparison of Image Quality Metrics for Sobel Filter for images corrupted with Gaussian noise Variance 0.01

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.4	1.18	13.22	74.54	255	0.1203	0.880
2	Cameraman	6.223	1.54	7.21	95.08	255	0.15	0.89
3	Characters test pattern	1.92	4.17	22.4	188	255	0.08	0.93
4	Chest-xray-vandy	4.35	2.38	25.41	125	255	0.0879	0.918
5	Circuit	5.96	1.64	9.69	117.7	255	0.15	0.87
6	Cktboard	5.18	1.97	4.62	108	255	0.22	0.84
7	Fractal_iris	8.52	9.13	3.57	43	255	0.22	0.91
8	headCT-vandy	7.0	1.3	8.45	62.8	255	0.129	0.93
9	Kidney-original	7.07	1.27	11.64	95.81	255	0.14	0.85
10	Microporcessor	6.43	1.47	2.97	75	255	0.25	0.88

Table 9: Comparison of Image Quality Metrics for Prewitt Filter for images corrupted with Gaussian noise Variance 0.01

S.NO	IMAGE	PSNR	MSE	SC	AD	MD	NCC	NAE
1	Bottles	7.23	1.22	21.6	78.6	255	0.089	0.9120
2	Cameraman	6.09	1.59	11.21	100.8	255	0.11	0.91
3	Characters test pattern	1.8	4.3	32	192	255	0.06	0.95
4	Chest-xray-vandy	4.20	2.47	41.5	130	255	0.065	0.93
5	Circuit	5.76	1.72	16	123	255	0.11	0.91
6	Cktboard	5.05	2.03	6.95	117	255	0.17	0.86
7	Fractal_iris	8.42	9.19	5.87	49	255	0.17	0.91
8	headCT-vandy	6.88	1.33	6.88	67	255	0.09	0.94
9	Kidney-original	6.86	1.33	20	100	255	0.10	0.89
10	Microporcessor	6.40	1.48	4.44	83.6	255	0.19	0.88

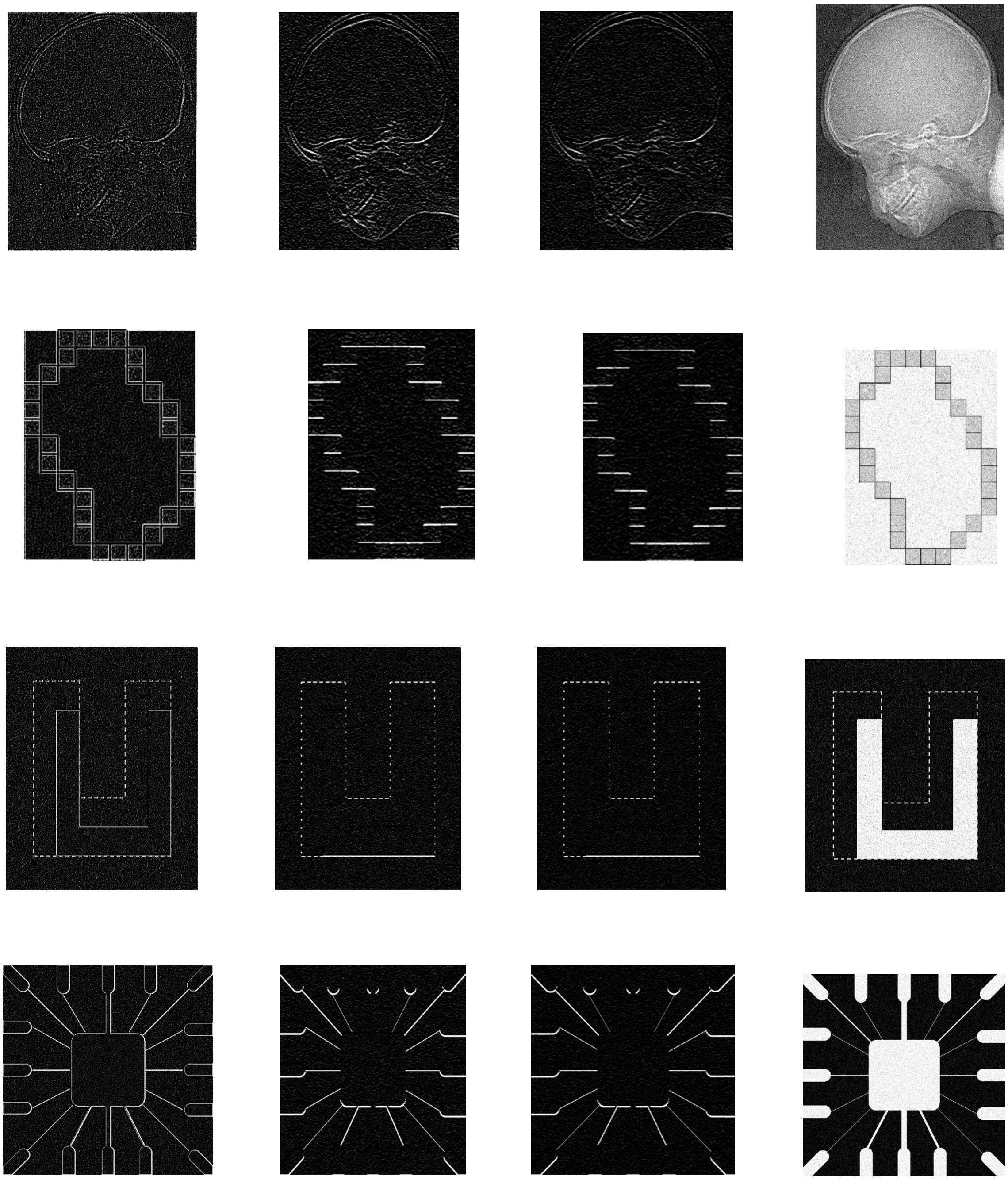
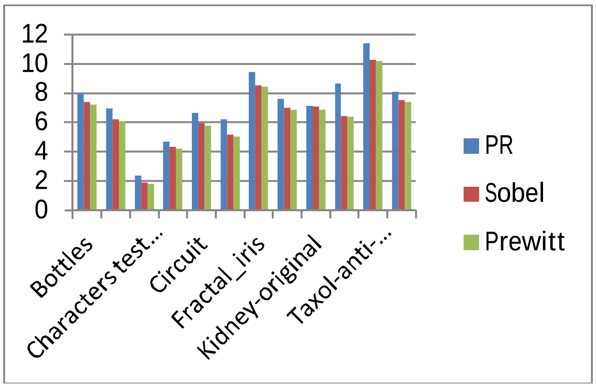
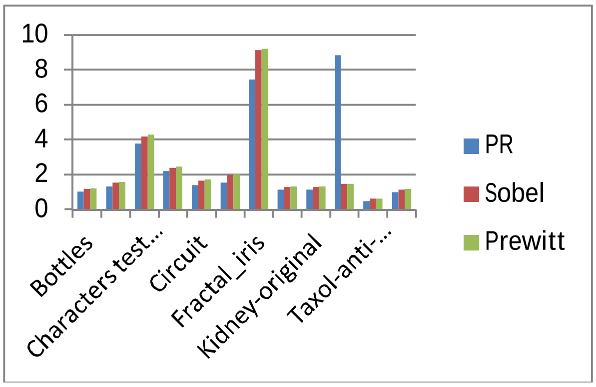
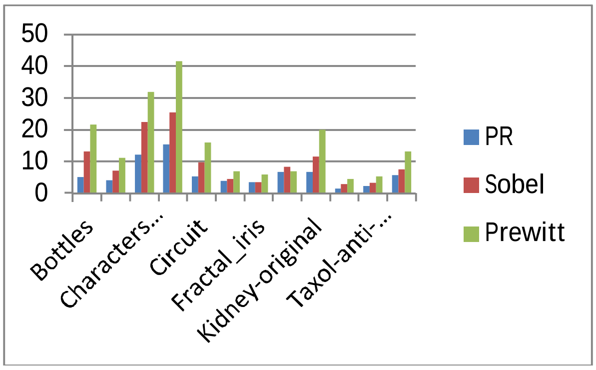


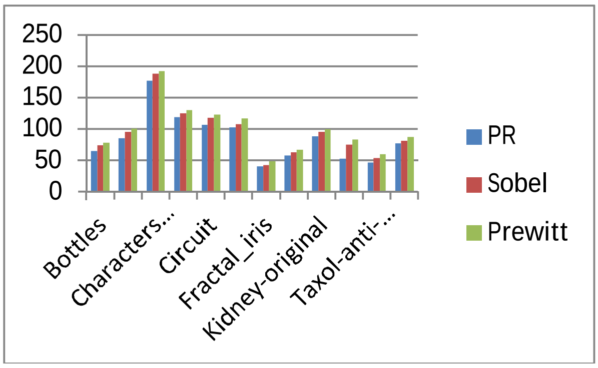
Fig 4:
(a) Sharpened with PSS filter (b) Sharpened with Prewitt (c) Sharpened with Sobel (d) Original image



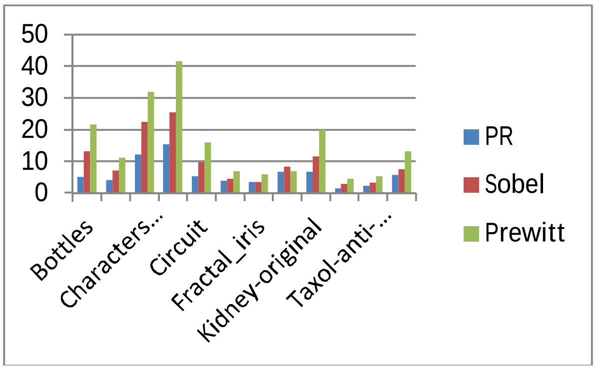


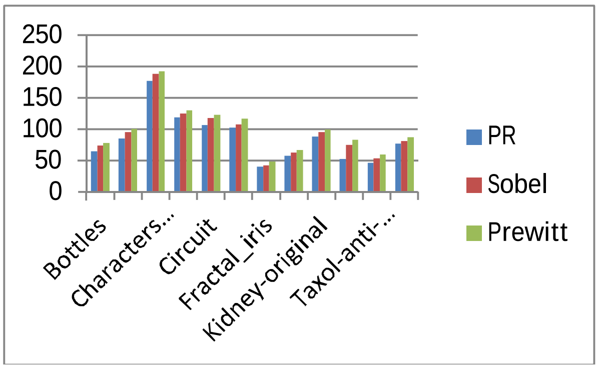
PSNR **MSE**



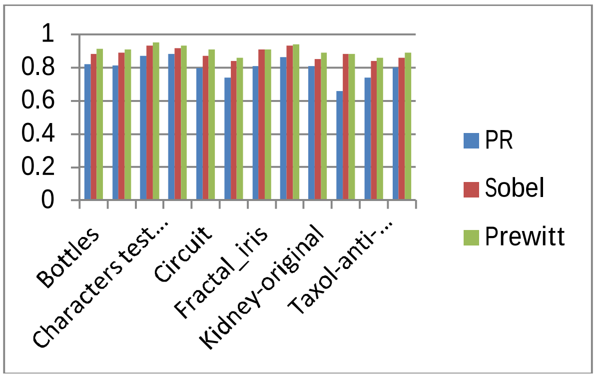


SC **AD**





NCC **NAE**



MD

IV .CCONCLUSION

Several existing techniques for edge detection in image processing have been compared with PSS filter in this effort. Some of image processing metrics such as MSE, PSNR, AD, MD, SC, NAE, NCC are engaged in this evaluation. The code for these new filters has been generated and the requisite strategies of comparisons between proposed and existing filters are tabulated. The values of MSE, SC, NAE, MD, AD are low and the values of PSNR and NCC are high for regular images and images which are corrupted with Speckle noise with variance 0.01, poisson noise and Guassian noise Variance 0.01 are enhanced with PSS filter than Prewitt, Sobel indicates that PSS filter identifies better edges than Prewitt , Sobel filters

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