An Experimental study on Fuzzy Morphology operator based JPEG compression for Image Quality Enhancement of Images corrupted with different types of Noises

VANITHA KAKOLLU[1*], P CHANDRASEKHAR REDDY[2]

[1] Research Scholar, Department of CSE, jntuh, Hyderabad
[2] Professor, Department of ECE, JNTUH, Hyderabad.
[1]vanithajntuh@gmail.com, [2]drpcsreddy@gmail.com

Abstract

The size of communicated information through internet has amplified rapidly over the past few years. Image compression is the finest way to lessen the size of the image. JPEG is the one the superlative technique associated to lossy image compression which transmits the image with less number of bits without affecting the quality of the image. In this paper an experimental study on Fuzzy Morphology based JPEG compression algorithm was presented. The competence of the wished-for algorithm compared to JPEG is presented with metrics correlated to image quality like PSNR, MSE, Number of bits transmitted. Fuzzy Morphological operator based approaches condenses the number of encoded bits and as a result dipping the magnitude of memory needed. The Comparative study is performed with various Fuzzy Morphological operators on images corrupted with Gaussian, Speckle, Poisson and Salt & Pepper noises.

Keywords: Morphology, Image, PSNR, MSE, Compression

1. Introduction

The proficient lossy compression algorithm for images is Joint Photographic Experts Group JPEG. The lossy compression indicates the image with a reduced number of bits, but JPEG compression not only reduces the size but also uses less memory, the decompressed images with JPEG looks nearly alike to the original image. The JPEG algorithm exterminates the components of high frequency that the human eye can't differentiate. JPEG compression is an exceptional choice for the images with smooth color conversion [1][2] [3] [4] [5].

2. Intended Inventive JPEG Algorithms

The planned JPEG algorithms are executed in two incongruent ways.

1) The images are infected with Poisson, Speckle, Salt & Pepper noise and Gaussian noise prior to the separation of the image into 8X8 blocks.
2) The image is to be convoluted with Fuzzy –Morphological operator like Dilation/ Erosion/ Opening/ Closing prior to the application of normalized matrix.

This paper analysis the comparative and experimental study of proposed fuzzy-morphology based approaches with the standard JPEG compression. The planned approaches typify enhanced results compared to the JPEG in terms number of bits to be transmitted. This simulation results produced in this paper are performed with MATLAB tools and the images have been downloaded from SIPI image database.

*VANITHA KAKOLLU

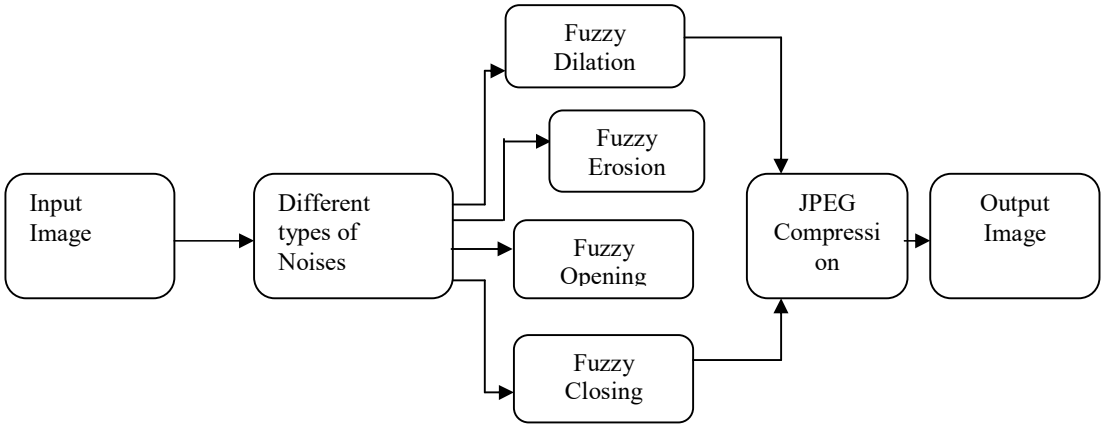


Figure1. Structure of Fuzzy-Morphology based JPEG algorithm on images corrupted with various types of noise.

Algorithm1

Fuzzy- Morphology Based JPEG algorithm on noisy images.

Step1: Read the image.
Step 2: Taint the images with speckle / Poisson/ Gaussian/ Salt & Pepper Noise.
Step 3: Apply Fuzzy-Morphological Dilation/ Erosion/ Opening/ Closing operators on the resultant Image.
Step 4: The image is estranged into non-overlapped 8x8 pixel blocks.
Step 5: There are 64 samples in each 8x8 pixel block and are level shifted by subtracting the quantity G (Gray level resolution) /2.
Step 6: The measurement of Discrete Cosine Transforms of each 8x8 block.
Step 7: Standardize the DCT blocks by standard normalization matrix.
Step 8: For decoding the encode image is being sent to the receiver.
Step 9: The decoding process is done at the receiver.
Step 10: PSNR and MSE are used **to** compute the disparity between original and compressed image.

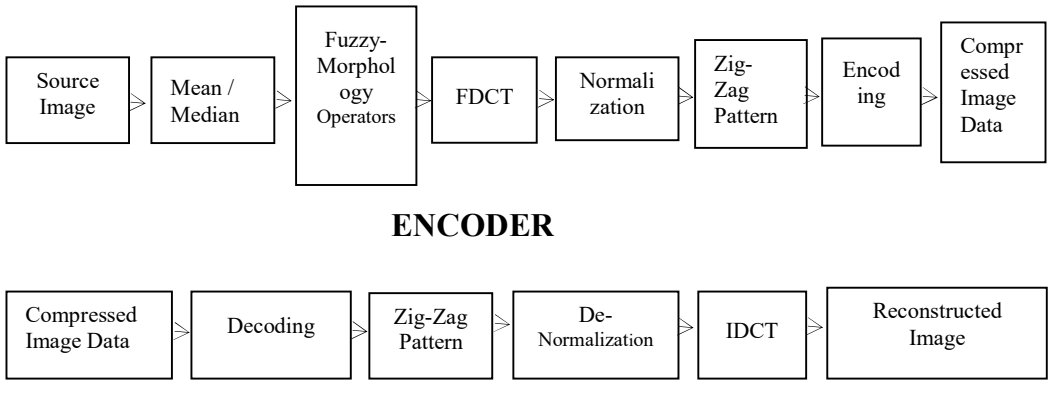


Figure 2. Architecture of Fuzzy Morphology Operator based JPEG compression

3. Morphology

Mathematical Morphology is an ingenious mathematical theory which can be used to evaluate the images. A minute outline called structuring element is used to process an image with morphological techniques. The structuring element is positioned at all probable locations in the image. Structuring elements represented as a binary image in the structure of matrices which comprises 0's and 1's [6] [7] [8] [9] [10].

3.1 Dilation

The *Dilation* process is similar convolution and is performed by sliding the structuring element **B** on the image **A.**

Dilation is represented as: $\mathbf{A} \oplus \mathbf{B}$

3.2 Erosion

The *Erosion* procedure is comparable to dilation.

Erosion is represented as: $\mathbf{A} \ominus \mathbf{B}$

3.3 Opening and Closing

Opening and closing are the complex sequences which are the combination of basic operations, dilation and erosion. *Opening* is a procedure where erosion followed by dilation and can be used to remove all pixels in regions that are too small. *Closing is used to fill the holes and is an operation where* dilation followed by erosion.

The Opening is represented as below: $A \circ B = (A \ominus B) \oplus B$

The Closing is represented as below: $A \bullet B = (A \oplus B) \ominus B$

Dilation and Erosion are used to filter the inner and outer parts of the image. Opening is process used to smoothen the breaks and narrow the gaps whereas Closing is used to merge tapered breaks and exterminate small holes.

4. Fuzzy Morphology

In Fuzzy Morphological Dilation/ Erosion/ Opening/Closing based JPEG compression the original image is fuzzified with a member function and then the fuzzified image is convoluted with Dilation/ Erosion/ Opening/ Closing with a structuring element [1 1 1; 1 1 1; 1 1 1] and then the customary JPEG compression is performed[11].

4.1Fuzzy Morphology based JPEG Compression Algorithm

Algorithm1**:** Fuzzy Morphology Based JPEG algorithm on noisy images.

Step1: Read the image.

Step 2: Apply speckle / Poisson/ Gaussian/ Salt & Pepper Noise.

Step 3: Apply the membership function on the image `r=(d+mn)/(mx+mn)`.

Step 4: Perform Morphological Dilation/ Erosion/ Opening/ Closing operation on the fuzzified image [11].

Step 5: Standard Jpeg Compression.

5. Results

In the current paper, fuzzy membership function was used to carry out the fuzzy morphology operations. At first original image was fuzzified with the fuzzy membership function [11]. Then a structuring element of 3X3 matrix was navigated on the whole image to process morphology operations. The comparative study of Fuzzy morphology operators is compared with mathematical morphological operations on the same images. The results are shown in Tables 1-14. The results accessible in this section have been produced on the images infected with Speckle, Gaussian, Poisson, and Salt & Pepper noises. The experimental results show that images processed with Fuzzy Morphological operators resulted in better PSNR compared to images processed with Mathematical morphological operations as shown Tables 1-14. As a result the images attained with Fuzzy Morphological operations are enhanced.

Analysis of results concludes that the newly planned compression techniques with Fuzzy morphology operators are extremely an imperative alternate since they have proved to be better in terms of image quality metrics like Peak Signal to Noise Ratio, Mean Square Error, Compression ratio, and RMS error.It is impossible to differentiate the decompressed images with source image with lossless compression algorithms as they not only wipe out redundancy but also eradicate the redundancy in the image data. But in case of lossy compression the decompressed images are not alike to the original images. The two types of criteria's subjective and objective criteria's are used to find out the difference between original and decompressed image. The objective fidelity is the way of finding the differences with image quality metrics.A comparison was made to check the competence of fuzzy morphological operations with morphological operations like Dilation, Erosion, Opening and Closing. A set of corrupted images were considered with speckle, Poisson, Gaussian, Salt & Pepper noises of resolution of 256 x 256, 512 x 512. A comprehensive assessment is shown in Table1-14 with image quality metrics.

Table 1. Morphology and Fuzzy Morphology based Dilation and Erosion based JPEG in terms images corrupted with speckle noise of size 256X256.

Corrupted images with Speckle Noise 256 x 256								
Image Number	**5.1.09**	**5.1.11**	**5.1.12**	**5.1.13**	**5.1.09**	**5.1.11**	**5.1.12**	**5.1.13**
Operation	***Dilation***				***Erosion***			
No Of Bits Required	40234	23944	45218	63562	43324	43261	48347	80417
Saved bits	483964	500344	479070	460726	480964	481027	475941	443871
RMS Error	2.61	1.31	3.05	3.60	2.64	2.68	2.92	4.07
Compression ratio	13.00	21.89	11.59	8.2485	12.10	12.11	10.8443	6.519
PSNR	39.84	45.81	38.48	37.03	39.75	39.62	38.85	35.96
MSE	6.79	5.15	9.30	12.97	6.95	7.16	8.53	16.60
Operation	***Fuzzy Dilation***				***Fuzzy Erosion***			
No Of Bits Required	48118	393301	35924	63562	43832	33209	98782	72333
Saved bits	476170	484987	488364	460726	480456	491079	485506	451955
RMS Error	2.29	2.25	2.35	3.60	2.71	1.97	2.43	3.90
Compression ratio	10.89	13.34	14.59	8.2485	11.96	15.78	13.51	7.24
NR	38.65	41.14	40.75	37.03	39.50	42.26	40.46	36.34
MSE	8.94	5.04	5.51	12.97	7.35	3.89	5.89	15.22

Table 2. Morphology and Fuzzy Morphology based Dilation and Erosion based JPEG in terms images corrupted with speckle noise of size 512X512

RMS Error	3.07	2.63	3.14	3.12	2.98	3.04	3.17	4.26
Compression ratio	10.6	11.21	9.94	9.89	10.9	10.15	9.45	6.03
PSNR	38.43	39.75	38.23	38.24	38.69	38.51	38.15	35.58
MSE	9.41	6.94	9.85	10.92	8.86	9.24	10.04	18.15
Operation	***Fuzzy Dilation***				***Fuzzy Erosion***			
No Of Bits Required	40324	23944	35294	64656	43832	34329	38782	72333
Saved bits	489364	500344	488364	459632	480456	491079	485506	451955
RMS Error	2.61	1.31	2.35	3.43	2.71	1.97	2.43	3.9
Compression ratio	13.00	21.89	14.59	10.82	11.96	15.78	13.51	7.24
PSNR	39.84	45.81	40.75	39.31	39.50	42.26	40.46	36.34
MSE	6.76	1.72	5.51	11.85	7.35	3.89	5.89	15.22

Table 3. Morphology and Fuzzy Morphology based Dilation and Erosion based JPEG in terms images corrupted with poisson noise of size 256X256.

Corrupted images with Poisson Noise 256 x 256								
Image Number	5.1.09	5.1.11	5.1.12	5.1.13	5.1.09	5.1.11	5.1.12	5.1.13
Operation	***Dilation***				***Erosion***			
No Of Bits Required	49457	47141	52730	63332	48076	51623	55453	86268
Saved bits	474831	477147	471558	461556	476212	472665	468835	437460
RMS Error	3.07	2.63	3.14	3.12	2.98	3.04	3.17	4.26
Compression ratio	10.6	11.21	9.94	9.89	10.9	10.15	9.45	6.03
PSNR	38.43	39.75	38.23	38.24	38.69	38.51	38.15	35.58
MSE	9.41	6.94	9.85	10.92	8.86	9.24	10.04	18.15
Operation	***Fuzzy Dilation***				***Fuzzy Erosion***			
No Of Bits Required	40324	23944	35294	64656	43832	34329	38782	72333
Saved bits	489364	500344	488364	459632	480456	491079	485506	451955
RMS Error	2.61	1.31	2.35	3.43	2.71	1.97	2.43	3.9
Compression ratio	13.00	21.89	14.59	10.82	11.96	15.78	13.51	7.24
PSNR	39.84	45.81	40.75	39.31	39.50	42.26	40.46	36.34
MSE	6.76	1.72	5.51	11.85	7.35	3.89	5.89	15.22

Table 4. Morphology and Fuzzy Morphology based Dilation and Erosion based JPEG in terms images corrupted with poisson noise of size 512X512

Corrupted images with Poisson Noise 512x 512								
Image Number	5.2.08	5.2.10	7.1.03	7.1.05	5.2.08	5.2.10	7.1.03	7.1.05
Operation	***Dilation***				***Erosion***			
No Of Bits Required	208279	257817	189274	214430	204935	238596	185108	214397
Saved bits	1888873	1839335	1907878	1882722	1892217	1858556	1912044	1882755
RMS Error	3.15	3.84	2.79	3.25	3.01	3.39	3.14	3.06
Compression ratio	10.069	8.19	11.08	9.78	10.23	8.78	11.32	9.78
PSNR	44.22	42.49	45.27	43.94	44.61	43.59	44.26	44.48
MSE	9.93	14.76	7.79	10.59	9.07	11.48	9.84	9.33
Operation	***Fuzzy Dilation***				***Fuzzy Erosion***			
No Of Bits Required	198574	258326	199422	219258	182114	227689	182851	209794
Saved bits	1898578	1838826	1897730	1877894	1915038	1869463	1914301	1887358
RMS Error	2.95	3.89	2.88	3.35	2.69	3.21	2.98	2.94
Compression ratio	10.56	8.11	10.51	9.56	11.51	9.21	11.46	9.99
PSNR	44.80	42.38	45.01	43.69	45.60	44.07	44.70	44.83
MSE	8.69	15.17	8.27	11.21	7.22	10.27	8.88	8.63

Table 5. Morphology and Fuzzy Morphology based Dilation and Erosion based JPEG in terms images corrupted with Salt & Pepper noise of size 256X256.

Corrupted images with Salt & Pepper Noise 256x256								
Images	5.1.09	5.1.11	5.1.12	5.1.13	5.1.09	5.1.11	5.1.12	5.1.13
Operation	***Dilation***				***Erosion***			
No Of Bits Required	124806	78421	81065	43694	123002	168586	165639	198986
Saved bits	399482	445867	443233	480594	401286	355702	358649	325302
RMS Error	7.10	5.2	5.14	3.01	6.42	7.05	6.86	6.76
Compression ratio	4.2	6.68	6.46	11.99	4.62	3.09	3.16	2.63
PSNR	31.14	33.84	33.95	38.58	32.01	31.20	31.44	31.56
MSE	50.44	27.07	26.41	9.09	41.22	49.67	47.09	45.75
Operation	***Fuzzy Dilation***				***Fuzzy Erosion***			
No Of Bits Required	120798	60176	82911	88564	128077	182326	161017	198096
Saved bits	403490	464112	441377	436324	396211	341932	363271	326192
RMS Error	6.94	4.15	5.1	4.86	6.6	7.11	6.71	6.78
Compression ratio	4.34	8.71	6.32	7.46	4.09	2.87	3.25	2.64
PSNR	31.34	35.81	34.02	35.6	31.77	31.13	31.63	31.54
MSE	48.13	17.20	25.99	16.94	43.56	50.55	45.04	45.96

Table 6. Morphology and Fuzzy Morphology based Dilation and Erosion based JPEG in terms images corrupted with poisson noise of size 512X512.

Corrupted images with Salt & Pepper Noise 512X512								
Images	5.2.08	5.2.10	7.1.03	7.1.05	5.2.08	5.2.10	7.1.03	7.1.05
Operation	***Dilation***				***Erosion***			
No Of Bits Required	512950	523482	487720	543943	494922	445398	516181	434962
Saved bits	1584202	1573670	1609432	1553209	1602230	1651754	1580971	1662190
RMS Error	7.05	7.03	7.00	7.30	6.35	5.90	6.65	5.99
Compression ratio	4.08	4.00	4.29	3.85	4.23	4.70	4.06	4.82
PSNR	37.22	37.25	37.29	36.91	38.13	38.77	37.73	38.64
MSE	49.67	49.41	48.94	53.35	40.32	34.81	44.20	35.82
Operation	***Fuzzy Dilation***				***Fuzzy Erosion***			
No Of Bits Required	519758	518797	446377	560254	499986	444220	550530	415640
Saved bits	1577384	1578355	1650775	1536898	1597166	1652932	1546622	1681512
RMS Error	7.09	7.01	6.62	7.39	6.37	5.86	6.74	5.77
Compression ratio	4.03	4.04	4.69	3.74	4.19	4.72	3.80	5.04
PSNR	37.17	37.27	37.77	36.81	38.10	38.83	37.61	38.96
MSE	50.28	49.15	43.80	54.62	40.60	34.32	45.40	33.34

Table 7. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Salt & Pepper noise of size 512X512.

Corrupted images with Salt & Pepper Noise 512 x 512								
Image Number	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**
Operation	***Opening***				***Closing***			
No Of Bits Required	245178	190662	165634	208158	246109	183791	144956	197047
Saved bits	1851974	1906490	1931518	1888994	1851043	1913361	1952196	1900105
RMS Error	3.56	3.07	2.76	3.06	3.67	3.02	2.36	3.07
Compression ratio	8.55	10.99	12.66	10.07	8.52	11.41	14.46	10.64
PSNR	43.15	44.45	45.37	44.46	42.90	44.58	46.73	44.44
MSE	12.68	9.41	7.61	9.39	13.44	9.13	5.57	9.43
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	244660	190214	178237	204122	247246	180164	155932	193646
Saved bits	1852492	1906938	1918915	1893030	1849906	1916988	1941220	1903506
RMS Error	3.56	3.09	2.75	3.15	3.71	2.91	2.33	3.03
Compression ratio	8.57	11.02	11.76	10.274	8.48	11.64	13.44	10.82
NR	43.17	44.39	45.39	44.22	42.81	44.92	46.85	44.56
MSE	12.64	9.54	7.57	9.92	13.71	8.44	5.41	9.17

Table 8. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Salt & Pepper noise of size 256X256.

Corrupted images with Salt & Pepper Noise 256 x 256								
Image Number	5.1.09	5.1.11	5.1.12	5.1.13	5.1.09	5.1.11	5.1.12	5.1.13
Operation	***Opening***				***Closing***			
No Of Bits Required	40886	40979	48051	81488	37173	26697	39084	52963
Saved bits	483402	483309	476237	442800	487115	497591	485204	471325
RMS Error	2.83	2.9	3.25	4.51	2.57	1.67	2.79	3.42
Compression ratio	12.82	12.79	10.91	6.43	14.10	19.63	13.41	9.89
PSNR	39.13	38.91	37.93	35.09	39.96	43.74	39.25	37.48
MSE	8.01	8.43	10.54	20.32	6.62	2.77	7.78	11.72
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	41702	41624	43360	79843	37059	27585	37608	53483
Saved bits	482586	482664	477928	444445	487229	496703	486680	470805
RMS Error	3.00	2.86	3.17	4.48	2.55	1.68	2.65	3.41
Compression ratio	12.57	12.59	11.30	6.56	14.14	19.00	13.94	9.80
NR	38.63	39.03	38.13	35.14	40.03	43.66	39.69	37.51
MSE	8.98	8.20	10.07	20.09	6.51	2.82	7.04	11.64

Table 9. Morphology and Fuzzy Morphology based Opening and Closing

Corrupted images with Speckle Noise 512 x 512								
Image Number	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**
Operation	***Opening***				***Closing***			
No Of Bits Required	240468	226285	215827	212207	272457	249205	233001	241961
Saved bits	1856684	1870867	1881325	1884945	1824695	1847947	1864151	1855191
RMS Error	3.55	3.37	3.3	3.10	4.08	3.69	3.48	3.77
Compression ratio	8.72	9.26	9.71	9.88	7.69	8.41	9.00	8.66
PSNR	43.18	43.64	43.81	44.35	41.97	42.84	43.35	42.67
MSE	12.61	11.33	10.89	9.62	16.67	13.63	12.13	14.19
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	240607	224959	230110	216351	272595	249782	258856	244289
Saved bits	1856545	1872193	1867042	1880801	1824557	1847370	1838296	1852863
RMS Error	3.58	3.34	4.00	3.21	4.13	3.75	3.80	3.79
Compression ratio	8.71	9.32	9.11	9.69	7.69	8.39	8.10	8.58
NR	43.12	43.71	42.15	44.04	41.87	42.71	42.58	42.62
MSE	12.78	11.17	15.97	10.33	17.03	14.05	14.47	14.33

Table 10. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Speckle noise of size 256X256.

Corrupted images with Speckle Noise 256 x 256								
Image Number	5.1.09	5.1.11	5.1.12	5.1.13	5.1.09	5.1.11	5.1.12	5.1.13
Operation	***Opening***				***Closing***			
No Of Bits Required	53859	67308	69886	91033	57881	56479	53112	51755
Saved bits	470429	456980	454402	433255	466407	467809	471176	472533
RMS Error	3.32	4.24	4.26	5.08	3.55	3.52	3.53	3.28
Compression ratio	9.73	7.78	7.5	5.75	9.058	9.28	9.87	10.13
PSNR	37.75	35.61	35.57	34.04	37.15	37.24	37.22	37.84
MSE	11.00	18.01	18.18	25.85	12.63	12.37	12.43	10.77
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	52646	71028	70700	91636	58808	44776	47672	51729
Saved bits	469642	453260	453588	435652	465480	465480	476616	472559
RMS Error	3.37	4.38	4.35	5.16	3.56	3.06	3.32	3.30
Compression ratio	9.59	7.38	7.41	5.72	8.91	11.07	10.99	10.13
NR	37.60	35.34	35.40	33.91	37.15	38.46	37.74	37.80
MSE	11.39	19.16	18.88	26.62	12.64	9.35	11.02	10.88

Table 11. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Poisson noise of size 512X512.

Corrupted images with Poisson Noise 512 x 512								
Image Number	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**
Operation	***Opening***				***Closing***			
No Of Bits Required	229009	185763	158326	194263	236923	189003	164336	194845
Saved bits	1868143	1911389	1938826	1902889	1860229	1908149	1932816	1902307
RMS Error	3.23	2.88	2.65	2.79	3.42	2.89	2.38	3.04
Compression ratio	9.15	11.28	13.24	10.79	8.85	11.09	12.76	10.76
PSNR	44.00	45.00	45.73	45.27	43.50	44.96	46.64	44.53
MSE	10.44	8.30	7.01	7.80	11.71	8.37	5.68	9.25
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	225906	167006	152413	183873	224851	160803	141607	175796
Saved bits	1871246	1930146	1944739	1913279	1872301	1936349	1955545	1921356
RMS Error	3.12	2.58	2.19	2.77	3.22	2.47	2.01	2.66
Compression ratio	9.28	12.55	13.75	11.40	9.32	13.04	14.80	11.92
NR	44.30	45.97	47.37	45.32	44.04	46.34	48.12	45.68
MSE	9.73	6.64	4.80	7.70	10.35	6.09	4.04	7.09

Table 12. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Poisson noise of size 256X256.

Corrupted images with Poisson Noise 256 x 256								
Image Number	5.1.09	5.1.11	5.1.12	5.1.13	5.1.09	5.1.11	5.1.12	5.1.13
Operation	***Opening***				***Closing***			
No Of Bits Required	39897	44265	49946	73373	40468	41086	50537	49157
Saved bits	484391	480023	474342	450915	483820	483202	473751	475131
RMS Error	2.52	2.66	2.87	3.81	2.6	2.29	2.95	3.08
Compression ratio	13.14	11.84	10.49	7.14	12.95	12.76	10.78	10.66
PSNR	40.15	39.66	39.01	36.54	39.85	40.97	38.78	38.40
MSE	6.33	7.08	8.21	14.53	6.78	5.24	8.68	9.46
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	60070	32207	35736	60078	32179	26407	35545	48630
Saved bits	464218	492081	488552	464210	492109	497881	488743	475658
RMS Error	3.55	1.93	2.24	3.55	2.02	1.50	2.31	3.02
Compression ratio	8.78	16.27	14.67	8.72	16.29	19.85	14.75	10.78
NR	37.17	42.46	41.17	37.17	42.06	44.63	40.90	38.56
MSE	12.57	3.72	5.00	12.57	4.08	2.26	5.33	9.12

Table 13. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Gaussian noise of size 256X256.

Corrupted images with Gaussian Noise 512 x 512								
Image Number	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**	**5.2.10**	**5.2.08**	**7.1.03**	**7.1.05**
Operation	***Opening***				***Closing***			
No Of Bits Required	266482	236884	210502	240992	262283	235870	216942	234628
Saved bits	1830670	1860268	1886650	1856160	1834869	1861282	1880210	1862524
RMS Error	3.87	3.62	3.56	3.52	3.96	3.57	3.28	3.70
Compression ratio	7.86	8.85	9.96	8.70	7.99	8.89	9.66	8.93
PSNR	42.44	43.02	43.16	43.26	42.24	43.13	43.87	42.83
MSE	14.95	13.09	12.66	12.38	15.65	12.75	10.75	13.66
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	266625	236682	218722	237613	262407	237020	223756	234230
Saved bits	1830527	1860470	1878430	1859539	1834745	1860132	1873396	1862922
RMS Error	3.85	3.63	3.31	3.58	3.97	3.59	3.25	3.61
Compression ratio	7.86	8.86	9.58	8.82	7.99	8.84	9.37	8.95
NR	42.47	42.98	43.78	43.11	42.22	43.07	**43**.94	43.04
MSE	14.84	13.19	10.98	12.81	15.74	12.92	10.57	13.00

Table 14. Morphology and Fuzzy Morphology based Opening and Closing based JPEG in terms images corrupted with Gaussian noise of size 256X256.

Corrupted images with Gaussian Noise 256 x 256								
Image Number	5.1.09	5.1.11	5.1.12	5.1.13	5.1.09	5.1.11	5.1.12	5.1.13
Operation	***Opening***				***Closing***			
No Of Bits Required	53919	55700	61028	80320	54472	53318	56290	48822
Saved bits	470369	468588	463260	443968	469816	470970	467998	475466
RMS Error	3.39	3.34	3.63	4.23	3.47	3.05	3.37	3.28
Compression ratio	9.72	9.41	8.59	6.52	9.62	9.83	9.31	10.73
PSNR	37.55	37.7	36.97	35.64	37.37	38.49	37.62	37.84
MSE	11.52	11.13	13.18	17.87	12.01	9.28	11.34	10.77
Operation	***Fuzzy Opening***				***Fuzzy Closing***			
No Of Bits Required	53437	58434	60380	80129	54700	42935	48069	48648
Saved bits	470851	465854	463908	444159	469588	481353	476219	475640
RMS Error	3.37	3.43	3.52	4.19	3.44	2.66	3.12	3.27
Compression ratio	9.81	8.97	8.68	6.54	9.58	12.21	10.90	10.77
NR	37.60	37.46	37.24	35.73	37.43	39.68	38.28	37.87
MSE	11.38	11.76	12.39	17.52	11.84	7.05	9.74	10.70

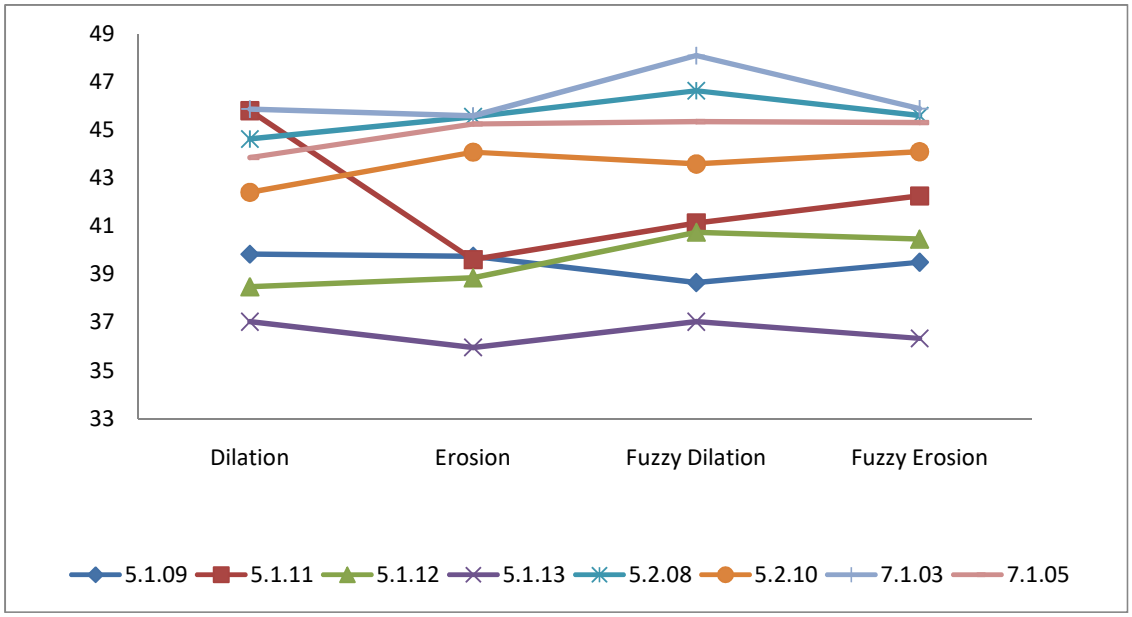


Figure 3. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with "Speckle noise".

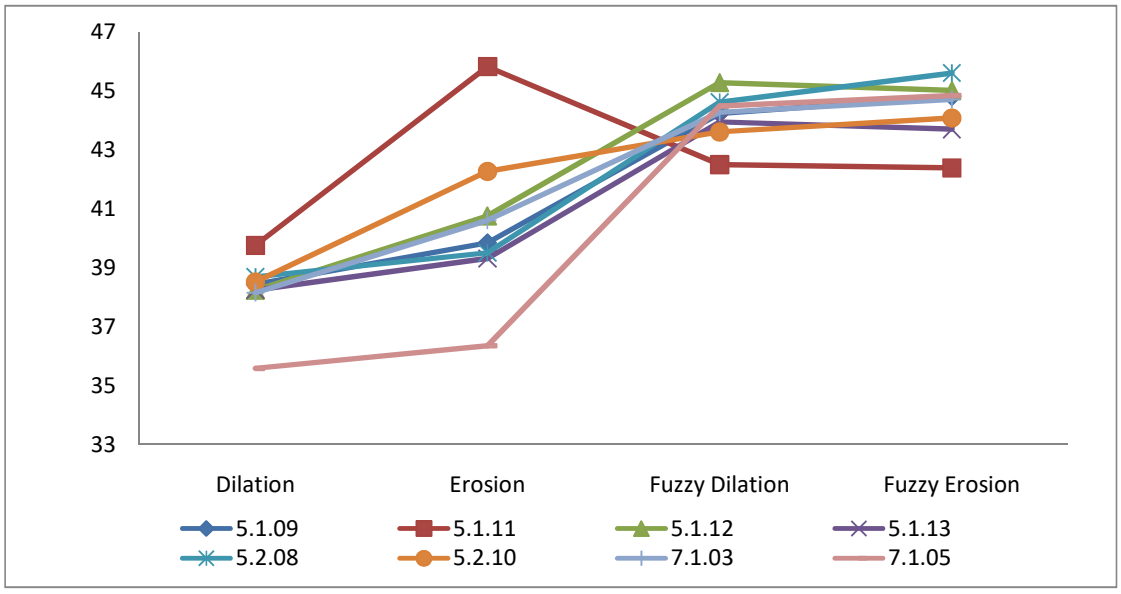


Figure 4. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with "Poisson noise".

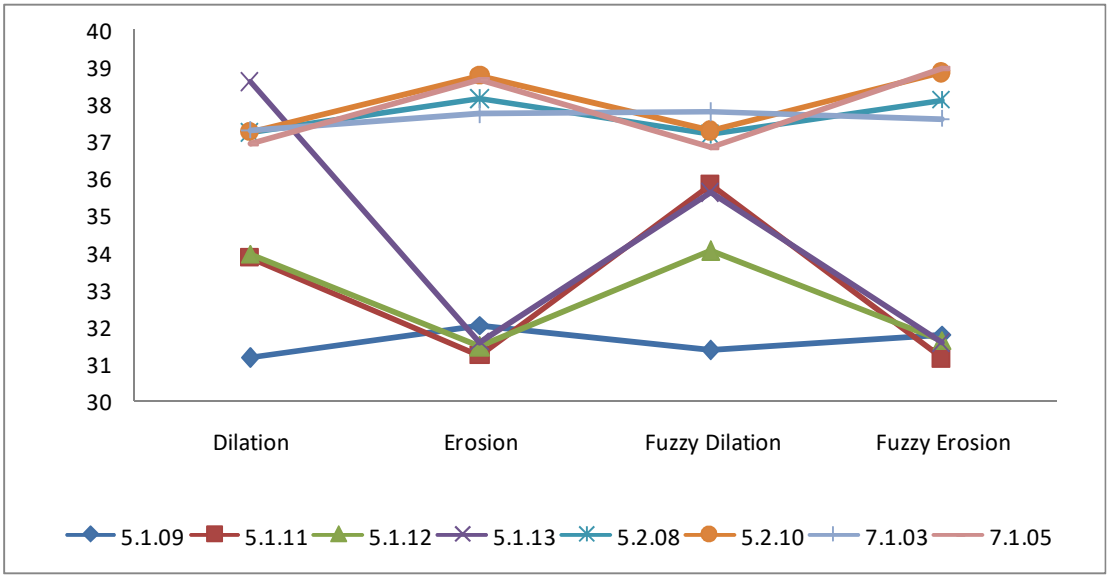
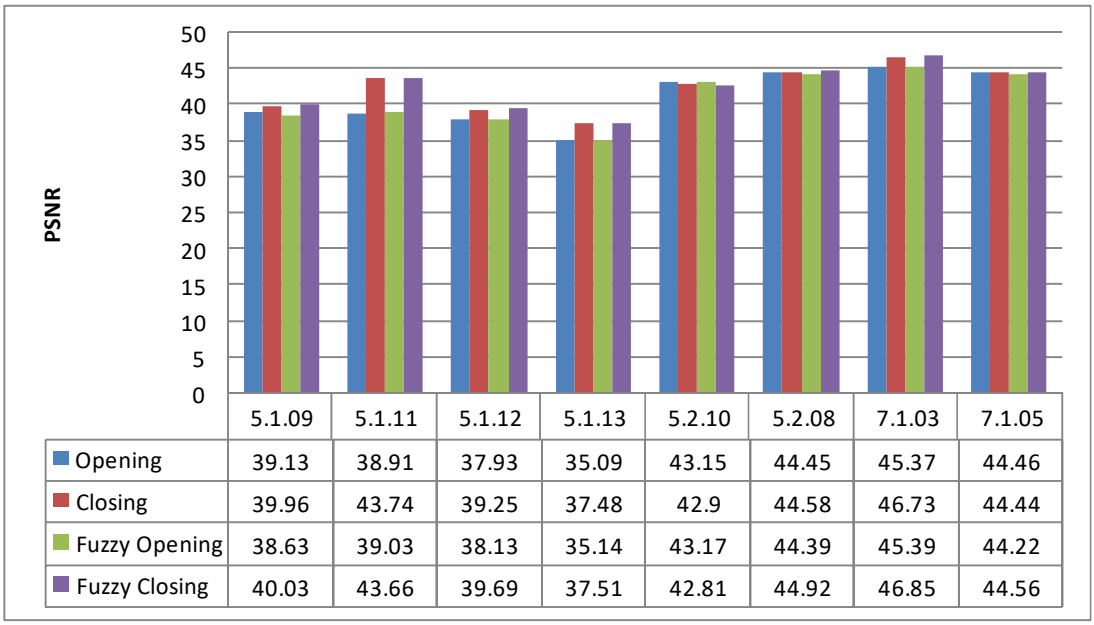
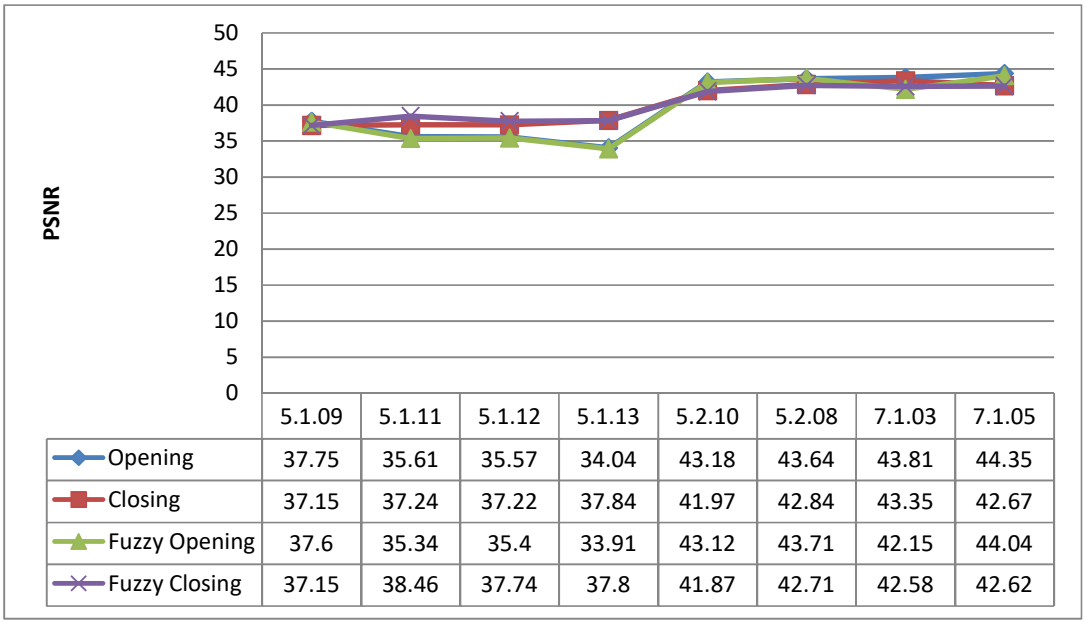


Figure 5. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with "Salt & Pepper" noise



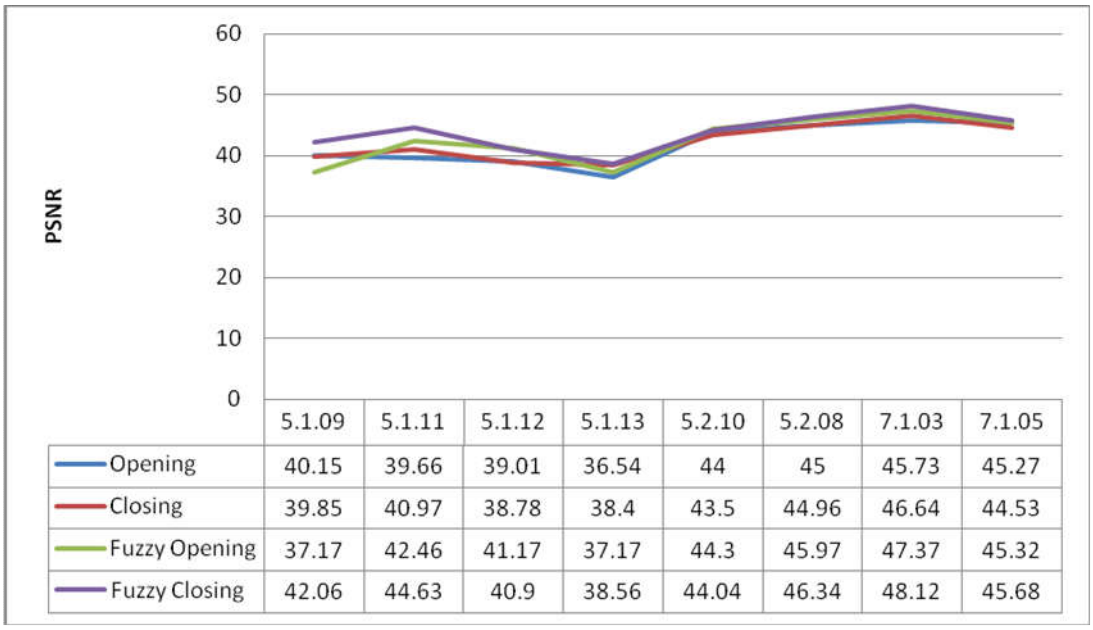
	5.1.09	5.1.11	5.1.12	5.1.13	5.2.10	5.2.08	7.1.03	7.1.05
Opening	39.13	38.91	37.93	35.09	43.15	44.45	45.37	44.46
Closing	39.96	43.74	39.25	37.48	42.9	44.58	46.73	44.44
Fuzzy Opening	38.63	39.03	38.13	35.14	43.17	44.39	45.39	44.22
Fuzzy Closing	40.03	43.66	39.69	37.51	42.81	44.92	46.85	44.56

Figure 6. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with Salt & Pepper Noise.



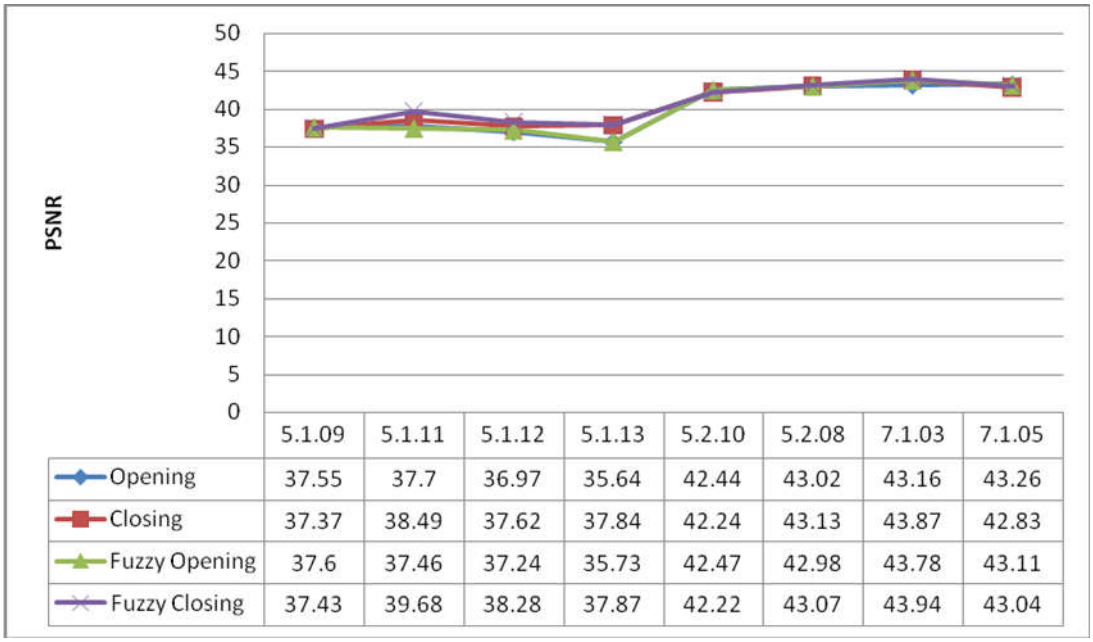
	5.1.09	5.1.11	5.1.12	5.1.13	5.2.10	5.2.08	7.1.03	7.1.05
Opening	37.75	35.61	35.57	34.04	43.18	43.64	43.81	44.35
Closing	37.15	37.24	37.22	37.84	41.97	42.84	43.35	42.67
Fuzzy Opening	37.6	35.34	35.4	33.91	43.12	43.71	42.15	44.04
Fuzzy Closing	37.15	38.46	37.74	37.8	41.87	42.71	42.58	42.62

Figure 7. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with Speckle Noise.



	5.1.09	5.1.11	5.1.12	5.1.13	5.2.10	5.2.08	7.1.03	7.1.05
Opening	40.15	39.66	39.01	36.54	44	45	45.73	45.27
Closing	39.85	40.97	38.78	38.4	43.5	44.96	46.64	44.53
Fuzzy Opening	37.17	42.46	41.17	37.17	44.3	45.97	47.37	45.32
Fuzzy Closing	42.06	44.63	40.9	38.56	44.04	46.34	48.12	45.68

Figure 8. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with Poisson Noise.



	5.1.09	5.1.11	5.1.12	5.1.13	5.2.10	5.2.08	7.1.03	7.1.05
Opening	37.55	37.7	36.97	35.64	42.44	43.02	43.16	43.26
Closing	37.37	38.49	37.62	37.84	42.24	43.13	43.87	42.83
Fuzzy Opening	37.6	37.46	37.24	35.73	42.47	42.98	43.78	43.11
Fuzzy Closing	37.43	39.68	38.28	37.87	42.22	43.07	43.94	43.04

Figure 9. Comparison between Proposed and Fuzzy Morphology based JPEG in terms PSNR on images corrupted with Gaussian Noise.

6. Conclusion

In this paper a comparative and experimental study on Fuzzy morphology based JPEG compression algorithm is projected, and this algorithm has been assessed with Mathematical Morphological operator based JPEG algorithm on images corrupted with Gaussian, Speckle, Poisson and Salt & Pepper noise. The efficiency of the proposed Fuzzy morphological operators has been compared with JPEG in terms of PSNR, RMS error, MSE and Compression ratio. The Proposed approach eliminates Speckle, Gaussian, Poisson and Salt & Pepper noise effectively than Morphological operators. The PSNR value of proposed approach is more for the images corrupted with various types of noises and as a result MSE value is less. The higher value of PSNR results in better quality image of the image.

7. References

[1] Olivier Egger and Wei Li, "VERY LOW BIT RATE IMAGE CODING USING MORPHOLOGICAL OPERATORS AND ADAPTIVE DECOMPOSITIONS" IEEE International Conference on Image Processing Vol-3, Nov-1994, PP No.326-330.

[2] Ricardo L. de Queiroz, Member IEEE, "Processing JPEG-Compressed Images and Documents" IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 7, NO. 12, DECEMBER 1998, PPNo: 1661-1672.

[3] Ravi Prakash, IEEE Member, Joan L. Mitchell, IEEE Fellow, and David A. Stepneski, "Enhanced JPEG Compression of Documents" IEEE International Conference on Image Processing Vol-3, Oct-2001, PP No: 494-497.

[4] Bai Xiangzhi, Zhou Fugen, "Edge Detection Based on Mathematical Morphology and Iterative Thresholding" IEEE International Conference on Image Processing Vol-2, Nov-2006, PP No: 1849-1852.

[5] Sreelekha G and P.S.Sathidevi, "An Improved JPEG Compression Scheme Using Human Visual System Model" EEE, June 2007, PP No: 98-101.

[6] Ch. Ramesh, N.B.Venkateswarlu and J.V.R Murthy, "Filter Augmented JPEG Compressions" IJCA, Vol-60, No-17, Dec-2012. PP No: 1-5.

[7] Vanithakakollu, Dr. P.Chandrasekharreddy," Fuzzy Morphology Based JPEG compression for Image Quality Enhancement of Noisy Images", International Journal of Computer Sciences and Engineering, , Vol.-6, Issue-9, ppno.380-384, , Sept. 2018.

[8] Marlapalli Krishna, G.Srinivas and Prasad Reddy PVGD" Image Smoothening and Morphological operators Based JPEG Compression", JATIT, Vol.85, No.3, PPNo: 252-259, March 2016.

[9] Vanithakakollu, Dr. P.Chandrasekharreddy," The Objective Image Quality augmentation of Noisy Images with Fuzzy C Means based JPEG Compression", International Journal of Computer Applications, *Volume 179 – No.52, PP no: 9-12, June 2018,*

[10] Marlapalli Krishna, Prasad Reddy PVGD and G.Srinivas " A Smoothening based JPEG Compression for an Objective Image Quality Enhancement of Regular and Noisy Images, IJAER, Vol.11, No.6, PPNo:3799-3804, 2016.

[11] G.Srinivas,P.Naga Srinivasu, T.Srinivasa rao and Ch.Ramesh "Harmonic and Contra Harmonic Mean Centric JPEG Compression for an Objective Image Quality Enhancement of Noisy Images", Springer , International conference on smart computing and its application PP No143-152, 2017.

[12] G.Srinivas, Prof Prasad Reddy P.V.G.D, and K.ramya "An N-Square Approach for Reduced Complexity Non-Binary Encoding", GJCST, PP No: 36-39, Vol: XI Issue XI, 2010.

[13] Dillip Ranjan Nayak, Ashutosh Bhoi" Image Enhancement Using Fuzzy Morphology", Journal of Engineering, Computers & Applied Sciences", Vol.3,NO.3, pp no:22-24, March 2014.

[14] G. Srinivas, Prasad Reddy P.V.G.D and K. Gayatri Devi, "N-Square Approach For Lossless Image Compression And Decompression", GJCST, Vol:10, Issue:9, pp no: 47-49, 2010.

[15] Vanitha Kakollu, P. Chandrasekhar Reddy," Alpha Trimmed Mean based JPEG Compression for an Objective Image Quality Enhancement of Noisy and Noise Less Images", Global Journal of Computer Science and Technology, Volume 17, Issue 3,PP No:10-16, 2017.

[16] Vanitha Kakollu, Dr. P.Chandrasekhar Reddy, Dr. G.Narsimha," Fuzzy C-Means-Based JPEG Algorithm for Still Image Compression", Smart Intelligent Computing and Applications,(Springer conference) volume-1, pp 447-458, 2018.