Filter Augmented JPEG Algorithms: A Critical Performance Study for Improving Bandwidth

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ABSTRACT

In the recent years, use of Digital Image Communication has increased exponentially in the day to day activities. Joint Photographic Experts Group (JPEG) is the most widely used still image compression standard for bandwidth conservation. In this paper, it is proposed and critically studied a new set of JPEG Compression algorithms by combining Mean filtering, Median filtering, and Outlier detection algorithms and conventional JPEG DCT algorithm in a staged manner. This outlier based JPEG algorithm is giving exceptionally compression compared to conventional JPEG algorithm. Experiments are carried out with many standard still images. Algorithms developed in this paper, identified to be giving almost same Peak Signal-to-Noise Ratio (PSNR) as that of standard JPEG algorithm.

Key words:-Mean, Median, Outlier, DCT, IDCT, PSNR, JPEG

1. INTRODUCTION

In the recent years, data intensive multimedia-based web applications have increased by many folds. Many remote applications such as remote monitoring, surveillance, automatic navigation systems often involves communication of captured images or videos for further processing. In these applications, it is inevitable to conserve the available bandwidth in order to reduce consumer side bills. In order to reduce the bills (or bandwidth consumption), communicating compressed images is a classical solution in communications and allied fields. In the literature, various algorithms were proposed for the image compression, and even many of them are available in embedded HW also. JPEG compression is the standard for image compression for still images. Its variants are under the name hood of MPEG (Motion Picture Experts Group) is widely followed standard for video encoding.

Image based recognition systems that are used in production industries such as IC manufacturing, fruit processing systems, automatic welding, etc., will be using original image. However, there are some recent applications such as remote monitoring, surveillance, remote surgery, etc., may involve communication of captured images to a server for processing, recognition and control. For example, [7] used compressed face images in JPEG format for the development of their face recognition system that extracts edge based features from the JPEG images and uses with a neural network. Certainly, performance of recognition system based on original images will be giving better results than compressed images as compressed images loses some details which are otherwise useful for recognition. It is reported elsewhere [12] JPEG compression induces some artifacts such as noise around edges, blurring, a smeared appearance, color distortion, and/or checkerboard-like blocking in busy regions. However, it consumes very little bandwidth. Thus, scientific community may be interested in studying about recognition system performance when it is designed to use compressed images rather than original images. Authors [13] reports that JPEG images cannot be used for character recognition as JPEG distorts the sharp edges.

Herewith the authors propose a new set of image compression algorithms which uses Mean filtering, Median filtering, and Outlier detection concepts with conventional DCT algorithm in a staged manner that shows better edge images compared to conventional JPEG images. The average peak signal to noise ratio (PSNR) [1] of our algorithms is compared with original JPEG method.

The paper is organized as follows. In section 2, a brief overview of the JPEG standard is provided. The proposed Mean, Median & Outlier based JPEG compression system is described in section 3. Experimental results are presented in section 4. Finally, conclusions are reported in section 5.

2. BRIEF OVERVIEW OF JPEG ENCODING / DECODING SYSTEM

JPEG is a well known standardized image compression technique. JPEG loses information so the decompressed picture is not the same as the original one. The main reason for use of JPEG is to reduce the size of image files. Reducing image files is an important procedure for transmitting files across networks or archiving libraries. Usually JPEG can remove the less important data before the compression; hence JPEG is able to compress images meaningfully, which produces a huge difference in the transmission time and the disk space. Fig 1 shows the basic Architecture of JPEG compression system. Here is a brief overview of the JPEG compression system. [2]

The image is first subdivided into pixel blocks of size 8X8, which are processed left to right and top to bottom. As each 8X8 block or sub image is encountered, its 64 pixels are level shifted by subtracting the quantity L/2, where L is the Gray level resolution of the image. The 2-D Forward Discrete Cosine Transform (FDCT) (Eq 1) [5] of the block is then computed, quantized using 64 corresponding step size values from the quantization table in Fig.2[3]. After quantization the DCT coefficients are rearranged in a zigzag sequence order as shown in the Fig.3. [3]

Since the one-dimensional reordered array generated under the zigzag pattern of Fig.3 is qualitatively arranged according to increasing spatial frequency, the JPEG coding procedure is designed to take the advantage of the long runs of zeros that normally result from the reordering. In particular, the nonzero AC coefficients (the term AC denotes all transform coefficients with the exception of the zeroth or DC coefficient) are coded using a variable-length code that defines the coefficient's value and number of preceding zeros. The DC coefficient is difference coded relative to the DC coefficient of the previous sub image.

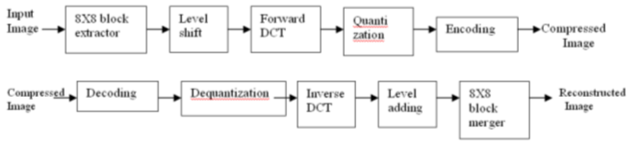

Fig. 1 Basic Architecture of JPEG Compression

The 2-D DCT is

$$C(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (1)$$

for u, v = 0, 1, 2, ... , N -1

$$\alpha(u) = \begin{cases} \sqrt{1/N} & for \quad u = 0 \\ \sqrt{2/N} & for \quad u > 0 \end{cases} \quad (2)$$

$$\alpha(v) = \begin{cases} \sqrt{1/N} & for \quad v = 0 \\ \sqrt{2/N} & for \quad v > 0 \end{cases} \quad (3)$$

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

Fig.2 Quantization Matrix [3]

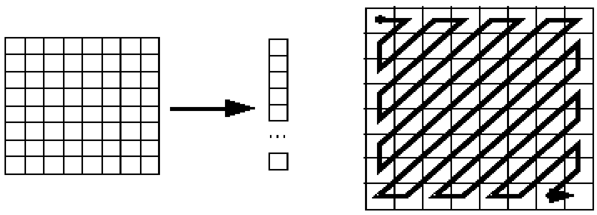

Fig.3 Zig Zag Sequence [3]

The decompression process performs an inverse procedure. It decodes the Huffman codes. Then, it makes the inversion of the Quantization step. In this stage, the decoder raises the small numbers by multiplying them by the quantization coefficients. The results are not accurate, but they are close to the original numbers of the DCT coefficients. An Inverse Discrete Cosine Transform (IDCT) (Eq.4) [6] is performed on the data received from the previous step. Finally add L/2 to each sub image. Place the sub images in their correct positions.

$$\hat{f}(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v)C(u,v)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (4)$$

The error between the original image and reconstructed image is calculated in terms of Peak signal to noise ratio
(PSNR) = 10 $\log_{10}$ (L^2/MSE) (5)

$$MSE = \frac{\sum_{x=0}^{m-1}\sum_{y=0}^{n-1}\left[\hat{f}(x,y) - f(x,y)\right]^2}{mXn} \quad (6)$$

MSE – Mean Squared Error
$\hat{f}(x,y)$ - Reconstructed Image
f (x, y) – Original Image
m x n – Size of the Image

3. NEW MEAN, MEDIAN & OUTLIER BASED JPEG ALGORITHMS

Mean filtering [8] is a simple, intuitive and easy to implement method of image smoothing i.e. reducing the amount of variation between one pixel and the next or surrounding pixels. It is often used to reduce noise in image. The idea of mean filtering is simply to replace each pixel in an image with the mean value of its neighbors including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Usually, 3x3 neighborhoods of pixels are considered while calculating mean filtered value of any pixel.

Median filter [9] is normally used to reduce noise in an image like the mean filter. However, it often does a better job than the mean filter in preserving useful detail in the image. Like the mean filter, the median filter considers each pixel in the image in turn and looks at its neighbors to decide whether or not its representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values.

An outlier [11] is an observation that is numerically distant from the rest of the data. In an image, a pixel value is very different from its surrounding pixels, it can be called as outlier. Certainly, replacing its value with mean filtered or median filtered or DCT based with induce noise into our image. Thus, the authors propose to retain its value as it is such that noise will become less and more over subsequent edge detection results will be attractive for image recognition systems.

From basic statistics, authors know that populations sample values with some confidence level can be given as mean ± C*σ, where C is weighing factor (critical value) and σ is standard deviation of the population. Table-1 shows the commonly used Confidence Levels and Corresponding

Critical Values [10]. In the outlier based algorithms, take this simple confidence limits of normal distribution in deciding whether a pixel is outlier or not. If the pixel is observed to be outlier with the given confidence level, one may retain else may take its mean filtered or median filtered value.

Table 1: Confidence Levels Vs Critical values

Confidence Level	80%	90%	95%	98%	99%	99.80%	99.90%
Critical Values	1.28	1.645	1.96	2.33	2.58	3.08	3.27

In the following, the authors listed the basic Mean, Median and outlier algorithms

3.1 MeanDCT Algorithm

1. Apply mean filtering to the original image using 3x3 window
2. Apply DCT on the mean filtered images

3.2 MedianDCT Algorithm.

1. Apply median filtering to the original image using 3x3 window
2. Apply DCT on the mean filtered images

3.3 Outlier MeanDCT Algorithm

1. Apply mean filtering with a little variation to the given original image using 3x3 window. For each pixel, calculate average and standard deviation of its neighboring 3x3 pixels. If a pixels value is observed to be outlier (not in the range of Mean ± C*σ) then its filtered value is taken as itself else mean is taken as its filtered value.
2. Apply DCT on the mean filtered image.

3.4 Outlier MedianDCT Algorithm

1 Apply median filtering with a little variation to the given original image using 3x3 window. For each pixel, calculate average and standard deviation of its neighboring 3x3 pixels. If a pixels value is observed to be outlier (not in the range of Mean ± C*σ) then its filtered value is taken as itself else median is taken as its filtered value.

2 Apply DCT on the median filtered image.

4. EXPERIMENTAL WORK

In this study, the authors have used a number of images in tiff format from USC-SIPI image database "http://sipi.usc.edu/database" [4]. Experiments are carried out under MS Windows XP version 2002, SP3 edition. The experimental system is equipped with Intel core 2 Duo 2.60 GHz processor with 1 GB RAM. Programs are written in C language under Microsoft Visual Studio 2005 version 8.0. Table 2 illustrates conventional JPEG compression ratios and PSNR values of the selected images [4]

Table 2: Compression ratios and PSNR values of the selected images with conventional JPEG.

IMAGE	SIZE	CONVENTIONAL ENCODING	
		Compression Ratio	PSNR
Apc	512x512	13.057	34.7217
Brickwall6	512x512	13.96	35.751
Car1	512x512	10.23	34.99
Grass3	512x512	13.14	33.839
Gravel	512x512	9.3	34.771
Lena	512x512	12.53	35.793
Peppers	512x512	12.31	34.7604
Raffia	512x512	13.14	33.839
Tank1	512x512	8.39	32.0536
Tank	512x512	10.24	33.578
Truck	512x512	11.12	37.428
Woolen	512x512	6.21	29.088
Airplane2	1024x1024	15.66	34.4
Airport	1024x1024	8.39	31.174
Bark2	1024x1024	6.85	31.7673
Glass	1024x1024	12.9	37.248
Leather2	1024x1024	6.49	31.422
Man	1024x1024	10.13	34.13
Metalgrates	1024x1024	14.6	33.378
Plasticbubbles2	1024x1024	7.97	32.289
Roof2	1024x1024	11.12	33.368
Sand2	1024x1024	8.3	33.19
Sea	1024x1024	18.54	38.236
Straw2	1024x1024	7.79	32.7811
Weave2	1024x1024	5.41	28.9874
Woodfence	1024x1024	5.2	34.3204

The authors have carried out extensive simulations with the selected images and proposed algorithms.Table 3 shows the Compression Benefit and PSNR values of MeanDCT algorithm Vs OutlierMeanDCT algorithm. With all the images it is found that MeanDCT and OutlierMeanDCT algorithms have better compression ratios as compared to conventional JPEG coding. The PSNR loss in MeanDCT and OutlierMeanDCT algorithms is negligible as compared to conventional JPEG coding. While comparing MeanDCT and the corresponding Outlier DCT, Compression Benefits are observed to be MeanDCT>OutlierMeanDCT (for C=1.28 to 2.58). As the value of C increases in the Outlier, Compression Benefit increases. For C=3.08 to 3.27 Compression Benefit in MeanDCT and OutlierMeanDCT is same. PSNR in MeanDCT<OutlierMeanDCT(for C=1.28 to 2.58). As the value of C decreases in the Outlier, PSNR increases. For C=3.08 to 3.27 PSNR in MeanDCT and OutlierMeanDCT is same.

Table 3: Compression Benefit and PSNR values of MeanDCT Vs Outlier Mean DCT

Image		Conventional	Mean DCT	Outlier Mean DCT (C=3.27)	Outlier Mean DCT (C=3.08)	Outlier Mean DCT (C=2.58)	Outlier Mean DCT (C=2.33)	Outlier Mean DCT (C=1.96)	Outlier Mean DCT (C=1.645)	Outlier Mean DCT (C=1.28)
Apc	Compression Benefit in %	-	29.49	29.49	29.49	28.74	27.2	23.63	18.91	11.88
	PSNR	34.594	33.203	33.203	33.203	33.206	33.222	33.269	33.371	33.647
Brickwall6	Compression Benefit in %	-	22.47	22.47	22.47	22.54	21.52	18.87	14.99	10.67
	PSNR	35.751	34.597	34.597	34.597	34.599	34.605	34.626	34.723	34.961
Car1	Compression Benefit in %	-	24.69	24.69	24.69	24.65	24.42	23.22	20.47	15.27
	PSNR	34.99	33.542	33.542	33.542	34.543	33.548	33.596	33.73	34.024
Grass3	Compression Benefit in %	-	36.5	36.5	36.5	36.22	34.85	29.47	22.33	12.82
	PSNR	33.839	32.939	32.939	32.939	33.043	33.054	33.1	33.189	33.389
Gravel	Compression Benefit in %	-	18.92	18.92	18.92	18.9	18.76	18.05	16.53	12.78
	PSNR	34.771	32.817	32.817	32.817	33.818	32.82	32.842	32.905	33.142
Lena	Compression Benefit in %	-	19.08	19.08	19.08	18.95	18.56	17.61	15.71	12.15
	PSNR	35.793	32.937	32.937	32.937	33.936	32.936	32.952	33.009	33.347
Peppers	Compression Benefit in %	-	19.2	19.2	19.2	19.02	18.51	16.8	14.4	11.06
	PSNR	34.7604	32.105	32.105	32.105	32.106	32.197	32.126	32.176	32.307
Raffia	Compression Benefit in %	-	36.5	36.5	36.5	36.22	34.85	29.47	22.33	12.82
	PSNR	32.839	33.039	33.039	33.039	33.043	33.954	33.1	33.189	33.389
Tank1	Compression Benefit in %	-	28.55	28.55	28.55	28.45	28.12	26.13	22.05	15.06
	PSNR	32.0536	30.288	30.288	30.288	30.29	30.3	30.367	30.52	30.873
Tank	Compression Benefit in %	-	29.62	29.62	29.62	29.41	28.86	26.37	22.31	14.51
	PSNR	33.578	31.903	31.903	31.903	31.906	31.919	31.977	32.109	32.457
Truck	Compression Benefit in %	-	16.83	16.83	16.83	16.79	16.73	16.58	16.1	14.26
	PSNR	37.428	36.886	36.886	36.886	35.888	35.892	35.902	35.938	36.081
Woolen	Compression Benefit in %	-	33.2	33.2	33.2	33.13	32.55	29.8	24.6	16.42
	PSNR	29.088	26.715	26.715	26.715	26.716	26.729	26.819	27.026	27.473
Airplane2	Compression Benefit in %	-	35.38	35.38	35.38	34.73	32.86	27.62	20.73	11.77
	PSNR	34.4	33.5	33.5	33.5	33.502	33.508	33.524	33.585	33.79
Airport	Compression Benefit in %	-	30.67	30.67	30.67	30.53	29.98	27.63	23.38	16.13
	PSNR	31.174	28.615	28.615	28.615	28.617	28.623	28.667	28.799	29.207
Bark2	Compression Benefit in %	-	22.14	22.14	22.14	22.11	21.92	20.9	18.69	14.42
	PSNR	31.7773	29.625	29.625	29.625	29.625	29.634	29.693	29.841	30.185
Glass	Compression Benefit in %	-	34.73	34.73	34.73	34.69	34.38	33.78	32.84	30.07
	PSNR	37.248	33.404	33.404	33.404	33.404	33.404	33.409	33.421	33.498
Leather2	Compression Benefit in %	-	21.46	21.46	21.46	21.43	21.27	20.38	18.57	15.66
	PSNR	31.422	28.473	28.473	28.473	28.473	28.478	28.523	28.651	29.016
Man	Compression Benefit in %	-	22.74	22.74	22.74	22.52	22.07	20.69	18.16	13.62
	PSNR	34.13	31.158	31.158	31.158	31.158	31.17	31.214	31.359	31.771
Metal grates	Compression Benefit in %	-	25.012	25.012	25.012	24.92	24.29	22.65	17.56	11.39
	PSNR	33.378	32.302	32.302	32.302	32.302	32.311	32.765	32.424	32.644
Plastic bubbles2	Compression Benefit in %	-	23.29	23.29	23.29	23.24	22.91	21.36	18.53	13.57
	PSNR	32.289	30.573	30.573	30.573	30.575	30.583	30.635	30.749	31.035
Roof2	Compression Benefit in %	-	29.65	29.65	29.65	29.46	28.53	24.92	20.36	14.35
	PSNR	33.368	31.262	31.262	31.262	31.263	31.268	31.286	31.353	31.62
Sand2	Compression Benefit in %	-	20.3	20.3	20.3	20.26	20	18.82	16.73	12.7
	PSNR	33.19	31.616	31.616	31.616	31.617	31.626	31.673	31.783	32.04
Sea	Compression Benefit in %	-	22.32	22.32	22.32	22.26	22.09	21.29	18.27	12.82
	PSNR	38.236	36.312	36.312	36.312	36.312	36.312	36.319	36.344	36.46
Straw2	Compression Benefit in %	-	18.27	18.27	18.27	18.25	18.09	17.31	15.65	12.43
	PSNR	32.7811	30.74	30.74	30.74	30.741	30.748	30.795	30.918	31.232
Weave2	Compression Benefit in %	-	24.5	24.5	24.5	24.47	24.28	23.18	20.91	16.39
	PSNR	28.9874	26.391	26.391	26.391	26.392	26.399	26.454	26.594	26.061
Wood fence	Compression Benefit in %	-	23.98	23.98	23.98	23.86	23.2	20.61	16.69	10.84
	PSNR	34.3204	32.761	32.761	32.761	32.762	32.77	32.805	32.891	33.161

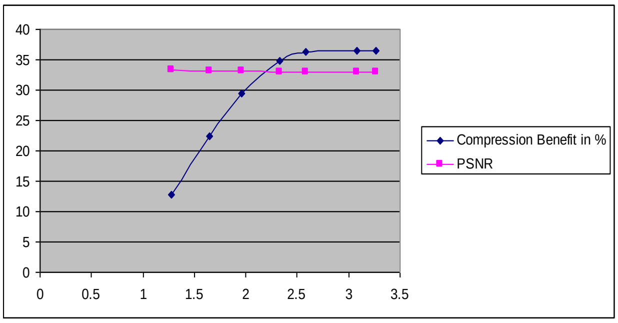

Fig. 4 : Critical Factor Vs Compression Benefit in % & Critical Factor Vs PSNR for Image "Gravel" with OutlierMeanDCT

Figure 4 shows As the C value increases, Compression Benefit increases and PSNR decreases. The variation in PSNR is very small as the C value increases. The PSNR values are very nearer to the PSNR values obtained by conventional JPEG coding.

Table 4 shows the Compression Benefit and PSNR values of MedianDCT algorithm Vs OutlierMedianDCT algorithm. With all the images it is found that MedianDCT and OutlierMedianDCT algorithms have better compression ratios as compared to conventional JPEG coding. The PSNR loss in MedianDCT and OutlierMedianDCT algorithms is negligible as compared to conventional JPEG coding. While comparing MedianDCT and the corresponding Outlier DCT, Compression Benefit in %s are observed to be MedianDCT>OutlierMedianDCT(for C=1.28 to 2.58). As the value of C increases in the Outlier, Compression Benefit increases. For C=3.08 to 3.27 Compression Benefit in MedianDCT and OutlierMedianDCT is same. PSNR in MedianDCT<OutlierMedianDCT(for C=1.28 to 2.58). As the value of C decreases in the Outlier, PSNR increases. For C=3.08 to 3.27 PSNR in MedianDCT and OutlierMedianDCT is Same.

Table 4 Compression Benefit and PSNR values of MedianDCT Vs OutlierMedianDCT

Image		Conventional	MedianDCT	Outlier Median DCT (C=3.27)	Outlier Median DCT (C=3.08)	Outlier Median DCT (C=2.58)	Outlier Median DCT (C=2.33)	Outlier Median DCT (C=1.96)	Outlier Median DCT (C=1.645	Outlier Median DCT (C=1.28)
Apc	Compression Benefit in %	-	27.58	27.58	27.58	26.9	25,57	22.14	17.58	10.65
	PSNR	34.594	32.29	32.29	32.29	30.304	33.342	33.468	33.66	34.04
Brickwall6	Compression Benefit in %	-	17.34	17.34	17.34	16.79	16.37	14.4	11.41	7.22
	PSNR	35.751	35.043	35.043	35.043	35.044	35.058	35.105	35.206	35.405
Car1	Compression Benefit in %	-	20.5	20.5	20.5	20.44	20.27	19.12	16.4	11.08
	PSNR	34.99	33.756	33.756	33.756	33.758	33.766	33.837	33.66	34.32
Grass3	Compression Benefit in %	-	32.59	32.59	32.59	32.38	31.24	27.09	20.48	11.42
	PSNR	33.839	33.022	33.022	33.022	33.037	33.052	33.13	33.269	33.5
Gravel	Compression Benefit in %	-	14.48	14.48	14.48	14.48	14.36	13.68	12.21	8.67
	PSNR	34.771	33.022	33.022	33.022	33.421	33.423	33.468	33.546	33.79
Lena	Compression Benefit in %	-	13.21	13.21	13.21	13.15	12.89	12	10.45	7.26
	PSNR	35.793	34.034	34.034	34.034	34.034	34.042	34.082	34.197	34.876
Peppers	Compression Benefit in %	-	12.82	12.82	12.82	12.66	12.25	10.71	8.61	5.4
	PSNR	34.7604	33.691	33.691	33.691	33.694	33.71	33.753	33.862	34.665
Raffia	Compression Benefit in %	-	32.98	32.98	32.98	32.38	31.24	27.09	20.48	11.42
	PSNR	32.839	33.122	33.122	33.122	33.027	33.052	33.13	32.269	33.5
Tank1	Compression Benefit in %	-	24.4	24.4	24.4	24,29	23.91	22.05	18.22	11.67
	PSNR	32.0536	30.405	30.405	30.405	30.41	30.428	30.522	30.73	31.162
Tank	Compression Benefit in %	-	25.78	25.78	25.78	25.64	25.12	22.8	18.78	11.47
	PSNR	33.578	31.98	31.98	31.98	31.986	32.003	32.096	32.291	32.78
Truck	Compression Benefit in %	-	10.15	10.15	10.15	10.13	10.12	9.96	9.44	7.69
	PSNR	37.428	36.597	36.597	36.597	36.6	36.602	36.611	36.655	36.808
Woolen	Compression Benefit in %	-	28.96	28.96	28.96	28.91	28.37	25.93	21.25	13.44
	PSNR	29.088	26.86	26.86	26.86	26.863	26.885	27.017	27.306	27.859
Airplane2	Compression Benefit in %	-	32.24	32.24	32.24	31.82	30.27	25.68	19.64	11.11
	PSNR	34.4	33.386	33.386	33.386	33.395	33.421	33.497	33.629	33.886
Airport	Compression Benefit in %	-	25.65	25.65	25.65	24.92	24.49	22.42	18.51	11.97
	PSNR	31.174	28.979	28.979	28.979	28.982	28.993	29.059	29.233	29.671
Bark2	Compression Benefit in %	-	16.89	16.89	16.89	16.87	16.69	15.72	13.83	10.01
	PSNR	31.7773	30.029	30.029	30.029	30.03	30.043	30.113	30.622	30.662
Glass	Compression Benefit in %	-	29.21	29.21	29.21	29.13	28.72	27.99	26.78	23.93
	PSNR	37.248	35.542	35.542	35.542	35.541	35.542	35.551	35.595	35.844
Leather2	Compression Benefit in %	-	16.05	16.05	16.05	16.01	15.86	15.09	13.4	10.04
	PSNR	31.422	29.35	29.35	29.35	29.353	29.364	29.426	29.583	29.965
Man	Compression Benefit in %	-	17.26	17.26	17.26	17.04	16.63	15.32	13.01	8.77
	PSNR	34.13	31.905	31.905	31.905	31.919	31.937	32.025	32.239	32.821
Metalgrates	Compression Benefit in %	-	20.97	20.97	20.97	20.38	19.9	17.65	13.84	8.23
	PSNR	33.378	32.418	32.418	32.418	32.421	32.44	32.508	32.628	32.932
Plastic bubbles2	Compression Benefit in %	-	17.59	17.59	17.59	17.54	17.25	15.93	13.42	8.94
	PSNR	32.289	31.009	31.009	31.009	31.012	31.025	31.093	31.228	31.53
Roof2	Compression Benefit in %	-	21.99	21.99	21.99	21.6	20.9	18.12	14.1	8.49
	PSNR	33.368	32.123	32.123	32.123	32.127	32.142	32.188	32.302	32.719
Sand2	Compression Benefit in %	-	15.56	15.56	15.56	15.53	15.29	14.23	12.24	8.63
	PSNR	33.19	31.947	31.947	31.947	31.949	31.962	32.019	32.145	32.395
Sea	Compression Benefit in %	-	17.73	17.73	17.73	17.61	17.45	16.82	14.18	9.15
	PSNR	38.236	37.256	37.256	37.256	37.257	37.259	37.276	37.358	37.551
Straw2	Compression Benefit in %	-	11.95	11.95	11.95	11.93	11.8	11.17	9.79	7.1
	PSNR	32.7811	31.592	31.592	31.592	31.593	31.604	31.664	31.792	32.069
Weave2	Compression Benefit in %	-	18.08	18.08	18.08	18.06	17.92	17.01	15.1	11.26
	PSNR	28.9874	26.841	26.841	26.841	26,842	26.854	26.93	27.101	27.489
Wood fence	Compression Benefit in %	-	20.43	20.43	20.43	20.03	19.5	17.4	13.89	8.31
	PSNR	34.3204	33.518	33.518	33.518	33.245	33.346	33.318	33.439	33.853

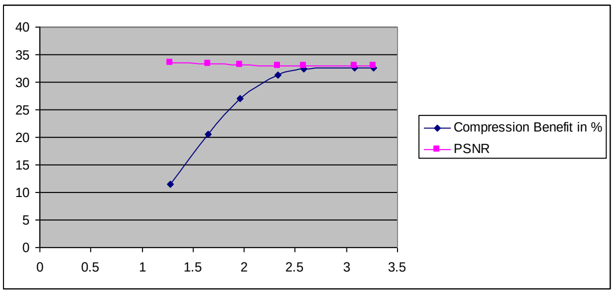

Fig. 5 : Critical Factor Vs Compression Benefit in % & Critical Factor Vs PSNR for Image "Gravel" with OutlierMedianDCT

Figure 5 shows As the C value increases, Compression Benefit increases and PSNR decreases. The variation in PSNR is very small as the C value increases. The PSNR values are very nearer to the PSNR values obtained by conventional JPEG coding.

In a nutshell, the experiments indicated the following,

1. Compression Benefit of algorithms are observed to be MeanDCT>MedianDCT> ConventionalDCT
2. PSNR of algorithms are observed to be MeanDCT<MedianDCT <ConventionalDCT
3. While comparing MeanDCT and the corresponding OutlierDCT, Compression Benefit are observed to be MeanDCT>OutlierMeanDCT (for C=1.28 to 2.58). As the value of C decreases in the Outlier, Compression Benefit decreases.For C=3.08 to 3.27 Compression Benefit in MeanDCT and OutlierMeanDCT is same.
4. While comparing MeanDCT and the corresponding OutlierDCT, PSNR is observed to be Mean-DCT<OutlierMeanDCT. (for C=1.28 to 2.56) As the value of C decreases in the Outlier, PSNR increases. For C=3.08 to 3.27 PSNR in MeanDCT and OutlierMeanDCT is same.
5. While comparing MedianDCT and the corresponding OutlierDCT, Compression Benefit are observed to be MedianDCT>OutlierMedianDCT (for C=1.28 to 2.58). As the value of C decreases in the Outlier, Compression Benefit decreases. For C=3.08 to 3.27 Compression Benefit in MedianDCT and OutlierMedianDCT is same.
6. While comparing MedianDCT and the corresponding OutlierDCT, PSNR is observed to be Median-DCT<OutlierMedianDCT (for C=1.28 to 2.56) as the value of C decreases in the Outlier, PSNR increases. For C=3.08 to 3.27 PSNR in MedianDCT and OutlierMedianDCT is same.
7. All the retrieved images based on Conventional JPEG system and Mean, Median & Outlier based JPEG system are almost same for visual appearance.
8. All the error images based on Conventional JPEG system and Mean ,Median & Outlier based JPEG system are negligible

In the recent years, value added multi-media services are gaining importance. Here, the consumer will be billed in accordance with the quality of service he has enjoyed. All of the algorithms are best suitable at this junction as they have freedom to control the quality with decreasing C.

5. CONCLUSIONS

In this paper, new MeanDCT, MedianDCT, OutlierMeanDCT & OutlierMedianDCT based JPEG compression algorithms are proposed. The authors have compared these MeanDCT, MedianDCT, OutlierMeanDCT & OutlierMedianDCT based JPEG compression algorithms with Conventional JPEG compression. From these experiments it is evident that these approaches gives better compression ratios compared to conventional JPEG. The PSNR resulting from the approach is slightly less than Conventional approach. The PSNR resulting from OutlierMedianDCT with lowest critical factor is almost same as conventional approach. Highest Compression Benefit is achieved from OutlierMeanDCT with highest critical factor. However, all the decoded images resulting from this approach and original images are almost the same in human perception point of view.

6. REFERENCES

[1] Muhammad F.Sabir, Hamid Rahim Sheikh, Robert W.Heath, Alan C.Bovik" A Joint Source-Channel Distortion Model for JPEG Compressed Images" IEEE Transictions on Image Processing Vol 15, No 6, pp1349-1364 June 2006

[2] Cung Nguyen "Detecting Computer –Induced Errors in Remote-Sensing JPEG Compression Algorithms" IEEE Transictions on Im age Processing Vol 15, No 7, pp1728-1739 July 2006

[3] R.C.Gonzalez and R.E.Woods "Digital Image Processing", 2nd Edition Addison Wesley, USA ISBN: 0-201-60078, 1993sz

[4] The USC–SIPI image database (http://sipi.usc.edu/database). Signal and image processing institute Ming Hgieh Department of Electrical Engineering.

[5] Andrew B.Watson "Image Compression using the discrete cosine transform" Mathematica Journal 4 (1), 1994, p-81-88

[6] Ken cabeen and peter gent," Image compression and the discrete cosine transform", Math 45 college of redwoods

[7] K. Kantapanit and W. Wiriyasuttiwong. "Face Recognition by Edge Detection of JPEG Compressed Images and Backpropagation Neural Network" The Engineering Journal of Siam University. Volume 3, Year 2 , July-December, 2000.

[8] "Mean filtering, Smoothing, Averaging, Box filtering",http://homepages.inf.ed.ac.uk/rbf/HIPR2/mean.htm

[9] "Median filtering, Rank filtering" http://homepages.inf.ed.ac.uk /rbf /HIPR2/median.htm

[10] "Cofidence Intervals",http://www.stat.yale.edu/courses/1997-98/101/confint.htm

[11] "Working with outliers", http://en.wikipedia.org/ wiki/ outlier

[12] "JPEG Artifacts ",http://graphicssoft.about.com/od/glossary/ g/jpegartifacts.htm

[13] "JPEG Artifacts", http://www.scantips.com/basics9jb.html