Scalable Quality Based Medical Image Compression

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Abstract:

In the present scenario the amount of medical image data being generated is enormous. Statistics say that the storage needs have increased by 25% accounting to petabytes of image data [1]. The major reasons for this increase in the imaging data is the growth in the aged population, awareness among people, increase in the size and resolution of the images and also due to retention policies and backup images [2]. Also the cost involved in per gigabytes data storage is very high. This has caused serious challenge in the storage and transmission of medical images. Though doctors are reluctant to use lossy compression, it is predominantly the solution that decreases the amount of storage. JPEG compression are widely used because of their advantage.

In this research an effort has been made to investigate, evaluate and analyse the effects of compression on the size and quality of the image using popular JPEG compression algorithms.

Hundreds of images from radiological modalities (CT, MRI and Digital X-Ray) were subjected to JPEG compression at varying qualities [100% to 5%]. Subjective validation was carried out with the help of Physicians by using side-by-side (or "flicker") comparison of original image and compressed image using 5 Point scoring scale. Quantitative assessment was accomplished by comparing MSE, PSNR, CR and BPP.

Keywords: **Medical images, JPEG compression, Scalability**

I INTRODUCTION:

The JPEG (Joint Photographic Experts Group) compression method although not designed for medical imagery is widely used because of its capability of compressing continuous- tone images of pixel depth of 6-24 bits with reasonable speed and efficiency [6]. It can produce high quality compressed images that are smaller in size compared to the original image.

In JPEG compression varying levels of compression and quality can be achieved by selecting specific quantization matrices. Quality levels range from 1 to 100. 1 gives poor quality image and highest compression whereas 100 gives best quality image and lowest compression. This selection of quality to compression helps to meet various needs [6].

II IMPLEMENTATION:

Hundreds of images from radiological modalities (CT, MRI and Digital X-Ray) were subjected to JPEG compression at varying qualities [100% to 5%]. If the image is compressed with 100% quality means, the reconstructed image after decompression is similar to the original. This is equivalent to lossless compression. If the image is compressed with 5% quality means, the image is totally distorted and is of no use. Therefore, a range of quality was observed for their diagnostic quality. The results were tabulated and the average values were calculated.

Subjective validation was carried out with the help of Physicians by using side-by-side (or "flicker") comparison of original image and compressed image using 5 Point scoring scale shown in Table1. With varying qualities, the images were classified as excellent, good, fair, mediocre and poor.

In order to find the optimum quality at which the images can be compressed, the physicians were shown both the original and compressed image side-by-side and their perception was recorded. Quantitative assessment is accomplished by comparing MSE, PSNR, CR and BPP. Subjective analysis is substantiated with the clinical validation reports.

Table 1. Five Point Scoring Scale

5	*Excellent*	*Optimum Image Quality*
4	*Good*	*Good image Quality*
3	*Fair*	*Satisfactory Visualization*
2	*Mediocre*	*Mediocre Quality*
1	*Poor*	*Not utilizable, image cannot be interpreted*

2.1 Subjective Evaluation:

A 512x512 CT image was compressed at various quality levels and their enlarged versions was shown to the physicians and were asked to record their perception as to find the optimum quality which can be accepted by the medical community. The following example explains one such validation report.

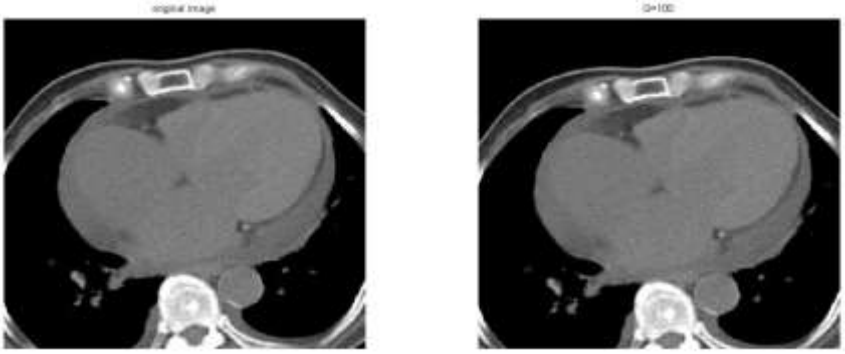

Fig 1.1 (a) Original image in comparison with compressed image at quality =100%

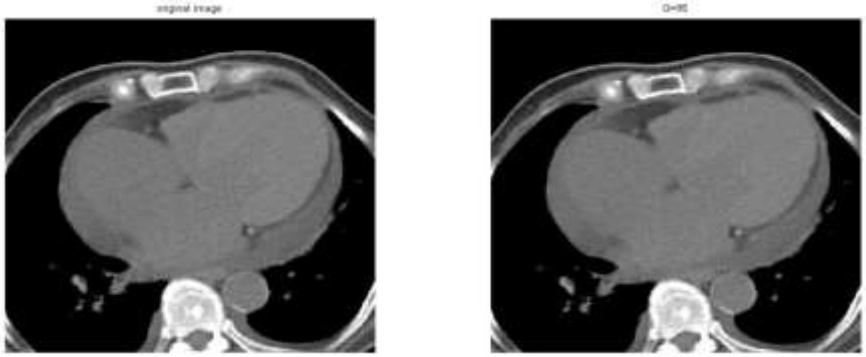

Fig 1.1(b) Original image in comparison with compressed image at quality =95%

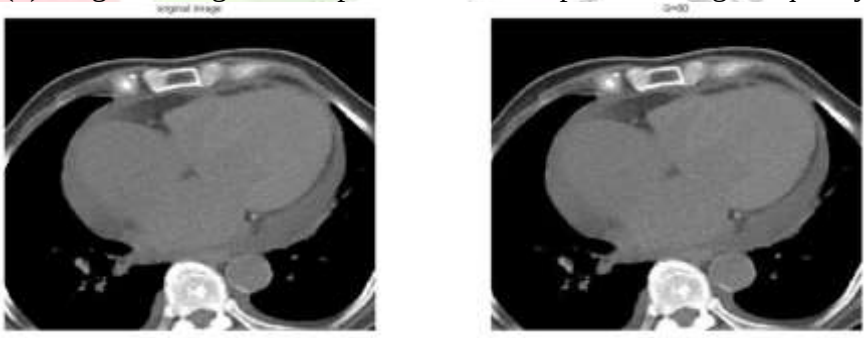

Fig 1.1 (c) Original image in comparison with compressed image at quality =80%

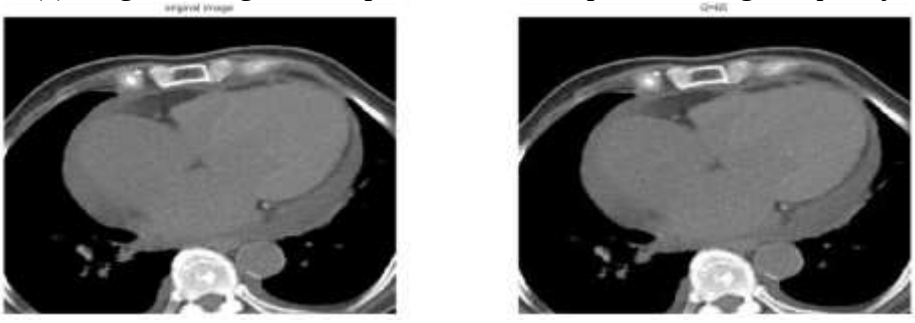

Fig 1.1 (d) Original image in comparison with compressed image at quality =65%

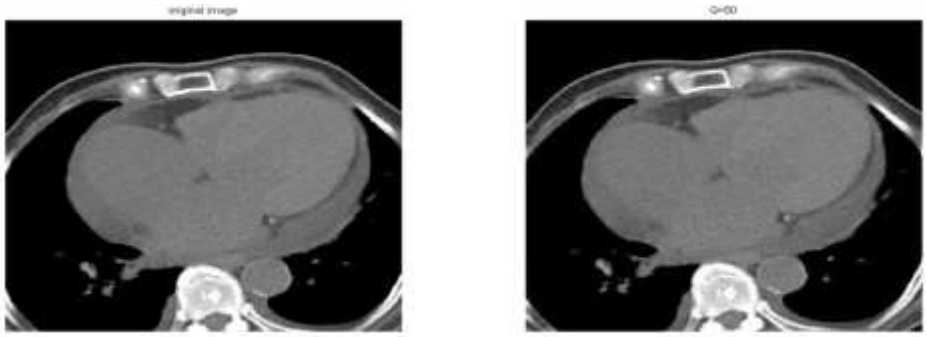

Fig 1.1 (e) Original image in comparison with compressed image at quality =50%

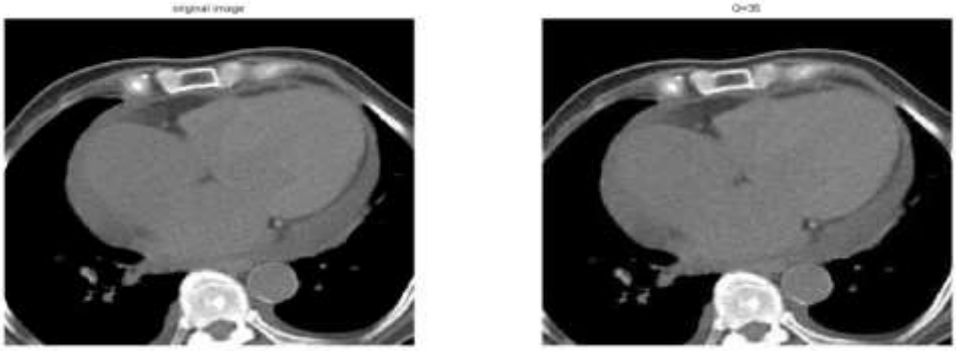

Fig 1.1 (f) Original image in comparison with compressed image at quality =35%

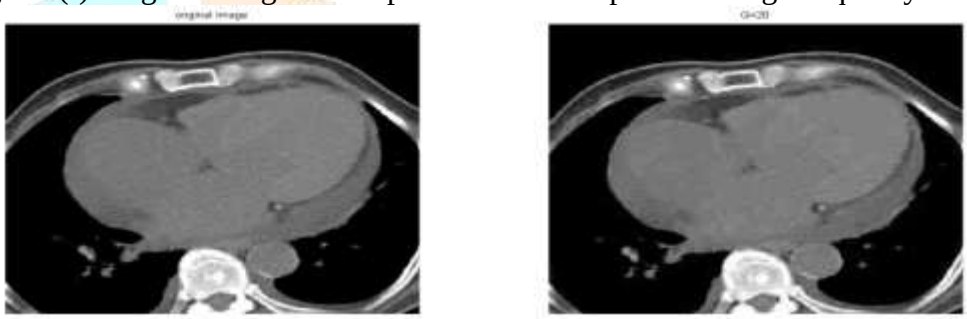

Fig 1.1 (g) Original image in comparison with compressed image at quality =20%

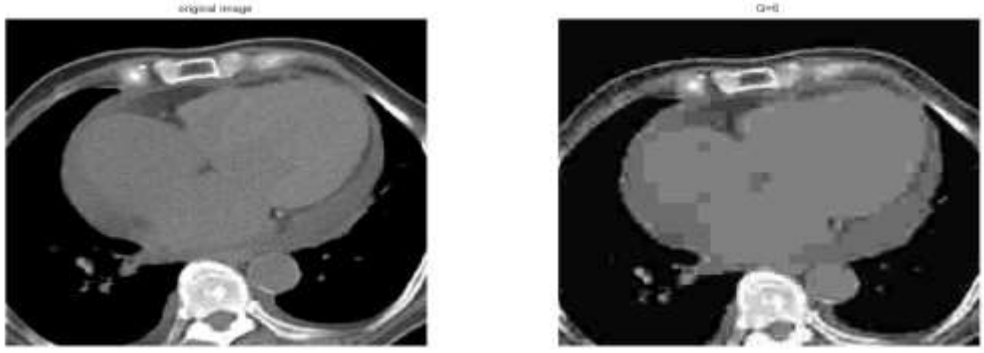

Fig 1.1 (h) Original image in comparison with compressed image at quality =5%

From the enlarged images Fig1.1 (a) - (h) it is visible that images compressed with 100%, 95% and 80% does not show much difference from the original image. Images with 65% and 50% quality do not exhibit much distortion whereas images with 20% and 5% quality are completely distorted.

2.2 Quantitative Evaluation:

CR and BPP are the quantitative measures that are commonly used as a performance indicator for the compression: Quantitative assessment is accomplished by comparing. CR (Compression Ratio) signifies that the compressed image is stored using only CR% of the original uncompressed image size. BPP (Bits Per Pixel) signifies the number of bits required to store one pixel of the image

2.3 Perceptual Quality Measures:

The commonly used measures for quantifying error between two images are Mean Square Error (MSE) and peak Signal to Noise Ratio (PSNR). MSE gives the cumulative squared error whereas PSNR is a measure of peak error between the original and compressed image.

Let A (i, j) be the original uncompressed image and B (i, j) the compressed image, both of the dimension MxN.

The MSE between two images A and B is defined by

$$MSE = \frac{1}{MN}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|A(i,j) - B(i,j)\|^2$$

The PSNR between two images A and B is defined by

$$PSNR = 20\log_{10}\left[\frac{MAX_i}{\sqrt{MSE}}\right]$$

Here, MAX_i is the maximum possible pixel value of the image and MAXi for an 8-bit gray scale image is 255.

Lower values of MSE indicates that the error between the compressed and the original image is low and higher values of PSNR is an indicator that the quality of the compressed or reconstructed image is better. From the observation made it is clear that typical values are between 30 and 50dB. If the PSNR value is greater than 40dB then we cannot distinguish between original and the compressed image. So it is always desired to have a compression method with high PSNR and lower MSE

Table 2(a), 2(b) and 2(c) represents the CR, PSNR, MSE obtained by compressing abdomen CT images at various quality levels. The abdominal images were randomly selected from the database of Clumax Imaging Centre, Bangalore.

Table 2 (a) CR obtained at different quality levels for CT abdomen image

Images/ Quality	**100**	**95**	**80**	**65**	**50**	**35**	**20**	**5**
Abct1*	7.12	10.64	19.16	24.87	29.62	34.73	44.93	81.0
Abct 2	5.02	7.51	13.97	18.51	22.3	26.93	36.6	73
Abct 3	6.08	9.14	16.8	22.1	26.8	32.2	43.2	80.05
Abct 4	7.6	11.2	19.9	25.9	30.5	35.7	46.1	80.4
Abct 5	5.8	8.9	15.9	21.3	25.6	30.2	39.7	73.3
Abct 6	6.3	9.3	17.2	22.6	27.2	32.4	43.3	77.1
Abct 7	8.3	12.1	21.2	27.1	31.9	36.9	46.9	79.6
Abct 8	7.9	11.7	20.67	26.7	31.5	36.9	47.3	80.6
Abct 9	8.88	13.2	23.6	30.8	36.6	42.6	54.7	89
Abct 10	8.36	12.3	21.85	28.03	33.07	38.5	49.1	82.05
Average	**6.29**	**10.6**	**19.05**	**24.8**	**29.5**	**34.7**	**45.2**	**79.6**

*** Abct – Abdomen CT images**

Table 2 (b) PSNR obtained at different quality levels for CT abdomen image

Images/ Quality	**100**	**95**	**80**	**65**	**50**	**35**	**20**	5
Abct1*	75.43	52.24	39.63	37.07	35.75	34.29	32.42	25.9
Abct 2	61.25	51.15	37.7	35.27	33.95	32.7	30.6	25.1
Abct 3	61.8	51.67	38.4	35.8	34.5	33.2	31.2	25.7
Abct 4	62.7	53.4	40.2	37.4	36.1	34.8	32.5	26.3
Abct 5	62.7	50.3	36.6	34	32.9	31.7	30	24
Abct 6	61.9	52.4	39.1	36.7	35.3	34.04	32	25.9
Abct 7	58.7	53.2	40.6	38	36.7	35.39	33	26.3
Abct 8	63.05	52.7	39.5	36.8	35.5	34.2	32.2	15.9
Abct 9	63.78	53.3	39.8	37.4	36.16	35	33	26.7
Abct 10	58.6	53.5	41.1	38.5	37.05	35.6	33.4	26.5
Average	**63**	**52.4**	**39.26**	**36.69**	**35.39**	**34.09**	**32.03**	**24.83**

Table 2 (c) MSE obtained at different quality levels for CT abdomen image

Images /Quality	100	95	80	65	50	35	20	5
Abct1*	0.01	0.38	7.07	12.75	17.26	23.29	37.24	164.5
Abct 2	0.048	0.49	10.83	19.34	26.2	34.8	56.2	202.8
Abct 3	0.04	0.44	9.4	17.1	23.2	31.02	41.1	175.3
Abct 4	0.03	0.3	6.3	11.9	16.1	21.5	36.7	152.8
Abct 5	0.03	0.6	14.1	25.6	33.6	43.6	64.8	220
Abct 6	0.04	0.37	7.9	39.9	19.01	25.6	41.0	165.7
Abct 7	0.08	0.3	5.6	10.1	13.8	18.8	31.6	152.4
Abct 8	0.03	0.34	7.2	13.4	18.4	24.6	39.3	163.87
Abct 9	0.03	0.3	6.8	11.9	15.8	20.6	32	139.7
Abct 10	0.09	0.29	5.04	9.11	12.8	17.7	29.8	143.74
Average	**0.04**	**0.38**	**8.02**	**17.1**	**19.6**	**26.1**	**40.9**	**168.081**

*** Abct – Abdomen CT images**

III RESULTS AND DISCUSSION:

The visual appearance of the images at 100% and 95% quality is excellent. From 80% to 50% it is good, at 35% the appearance of the image is satisfactory and when the images are compressed at 20% and 5%, there is lots of distortion seen and such images are to be discarded.

As the quality of the image decreases, there is an increase in CR and MSE and decrease in PSNR

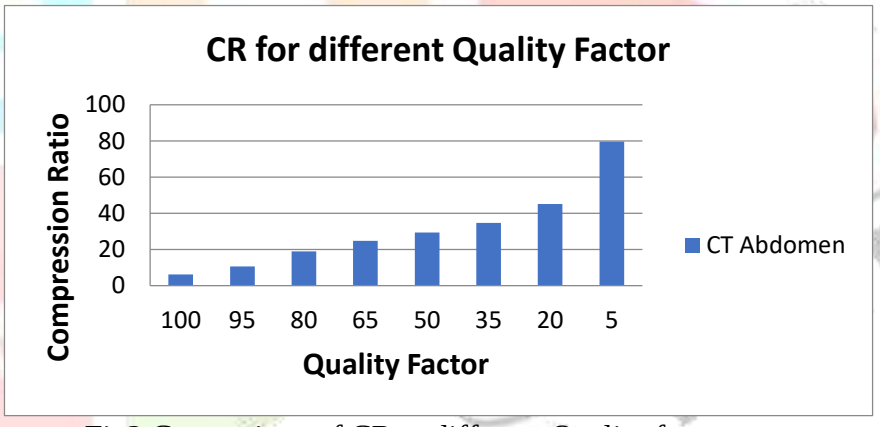

Fig2 Comparison of CR at different Quality factor

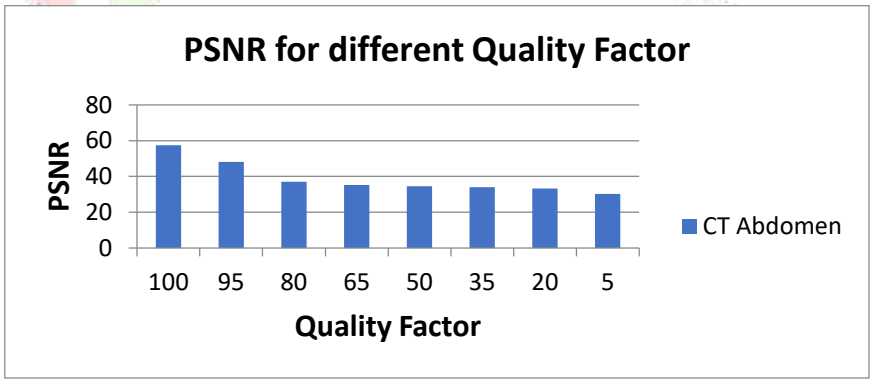

Fig3 Comparison of PSNR at different Quality factor

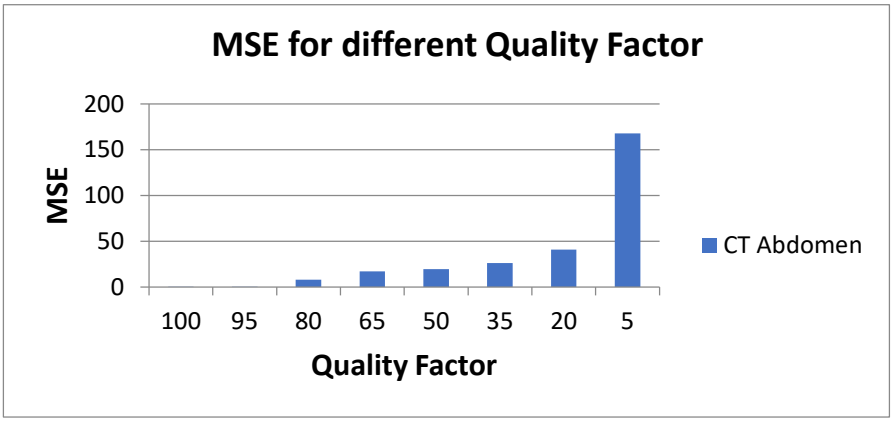

Fig4 Comparison of MSE at different Quality factor

The optimum quality factor at which the image can be compressed may be chosen as 50% where the Compression ratio is 30. If further increase in CR is required, then the image may be compressed at 35% quality and the CR achieved is around 35.
The achievable compression ratios at different quality using JPEG method is summarized in Table3.

Table3 Summary of CR achieved using JPEG method

Quality Factor	Compression achieved (%)
100	<10
95	10-15
80	15-20
65	20-25
50	25-30
35	35-40
20	40-50
5	>70

Storing DICOM images in JPEG format itself reduces the file size to a larger extent and compressing it at various quality levels will further reduce the file size. For example, when DICOM image is stored at 50% quality, 51.33% compression is achieved and the file size is 15KB which is very small size. Compression ratio achieved at various quality levels and their corresponding image sizes is shown in Table4.

Table4 Image file sizes after subjecting it to different levels of quality compression

Quality factor	Image file size in Kbytes	Compression ratio
Original DICOM image	770	
100%	60	12.83
95%	39	19.74
80%	22	35
65%	17	45.3
50%	15	51.33
35%	13	59.23
20%	10	77
5%	7	110

The quality at which the image needs to be stored is decided by the doctor.

IV CONCLUSION:

In order to combat with the ever increasing image data volume, lossy compression techniques can be adopted. Thereby the storage cost can be reduced to a larger extent and faster transmission of the images can be achieved largely benefiting the Healthcare Industry.

V REFERENCES:

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