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Comparative Study on MATLAB based Joint Photographic Experts Group Image Size Reduction Using Shearlet and Wavelet Packet Transform for X-ray Images with Potential Hospital Data Storage Applications

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Abstract

Aim: *Aim of this study is to compress X-ray images using wavelet packet transform and shearlet transform. These two transforms were compared for the better compression ratio to store large hospital data files in small memory space.* ***Materials and methods:*** *Sample X-ray images were, Wavelet packet (30) and Shearlet (30) for compression. Compression ratio was calculated. The significance of the data were calculated using SPSS software.* ***Results:*** *There was statistical significance between the wavelet packet and shearlet transform based compression ratio data ($p<0.05$, independent sample t- test).* ***Conclusion:*** *wavelet packet transform has a better compression ratio than shearlet transform. Wavelet packet transform appears to produce the most consistent results with higher standard deviation (3.3) when compared with shearlet transform which appears to produce lower results with lower standard deviation (0.8).*

Key-words: Shearlet Transform, X-ray Images, Novel Image Compression Technique, Artificial Intelligence.

1. Introduction

In the current study, we simulated on MATLAB© (2015), it helps to reduce the image size by using wavelet packet and shearlet transform for X-ray images. It stores the data in lower data bytes, hence less transition bandwidth consumed (Subramanian et al., 2010). Here the meaning of bandwidth is to transfer the maximum data across to the point. X-ray is a common imaging test for the doctors to view internal parts without having any incision on the patient's body. X-rays are passed through the patient's body to detect any tumor formation, bone fractures or any damaged part inside the body. By the compression of image size then it is capable of storing a large amount of files (Dong & Shi, 2008); (Sun Z. & Chang C. C., 2002). We evaluated the better compression ratio generated pertaining to X-ray images while comparing the transforms - wavelet packet transform with shearlet transform. The importance of this study in today’s world is to compress the image and reduce the redundancy (Meyer et al., 2000); (Wu & Liu, 2009). The existing experience in my research in MATLAB© coding. We worked on coding for wavelet packet and shearlet transform.

We worked out on the wavelet packet code and shearlet code then we got results as a compressed image. Wavelet packet transform output is sixteen levels of different compressed image formation. It has been reported that wavelet packet is very effective in image processing especially image compression. The shearlet transform output is about restoring the image and finally form it to the compressed size and finally applicable for the hospital data storage (Saleh & Rahman, 2010); (Ghodrati & Asadi, 2009). Large data files can be stored in a small data file due to the compression of the image. The main aim of this study is to compress X-ray using wavelet packet transform and shearlet transform and comparing the transform for better compression ratio (CR). Barro and team found that the use of the wavelet analysis reduced the spectral leakage due to the imperfect frequency response (Barros et al., 2012). Similarly, 24 subband wavelet packet trees approximated to the mean scale frequency division (Degaonkar & Apte, 2013). Hence, throwing light on the fact that the wavelet packet processes the image at a very lowestes level. It has also been reported that wavelet packet transform provided the same frequency bandwidth in each resolution for recording the feature (Bit rate -17.9) (Mudunuri & Savithri, 2011); (Chang et al., 2010).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Gheena & Ezhilarasan, 2019; Jose et al., 2020; Ke et al., 2019; Krishnaswamy et al., 2020; Malli Sureshbabu et al., 2019; Mehta et al., 2019; Muthukrishnan et al., 2020; M. S. Samuel et al., 2019; S. R. Samuel et al., 2020; Sathish & Karthick, 2020; Sharma et al., 2019; Varghese et al., 2019; Venu, Raju, et al., 2019; Venu, Subramani, et al., 2019; Vignesh et al., 2019; Vijayakumar Jain et al., 2019). Now the growing trend in this area motivated us to pursue this project.

So this motivated us to find a better transform based compression platform exclusively for X-rays as compression for the same has not been reported before. MATLAB© 15 was used to run the programs and get the ratios of compression for both our target transforms.

2. Materials and Methods

In this study, the number of groups were 2. Group 1 had 30 X-ray images compressed using wavelet packet transform. Group 2 had 30 X-ray images compressed using shearlet transform. For the statistical analysis we used SPSS (statistical package for the social sciences). The site for pre test power was calculated from clinical.com using base paper as cited (*Website*, n.d.); (Eben Sophia & Anitha, 2017). This process requires power for about 80% and the value of alpha was 0.05. There were no independent variables. The data collection was done from kaggle dataset [kaggle .com /paultomothymooney chest X-ray pneumonia] (*Kaggle: Your Machine Learning and Data Science Community*, n.d.).

Group 1 Sample images were resized to 512*512 dimension for wavelet packet transform. Basic code for wavelet packet transform that we used z= wprec2(wpdec2(y1,'db1'));. Similarly for shearlet the sample images were processed to the same dimensions with basic code being z= x_noisy=x+sigma.*radn(L,L);. The procedure to use transforming code based simulation with testing setup in MATLAB (2015) was opted in our study. In wavelet packet transform input images were decomposed later it was compressed to form the original image of reduced size. In the same way the shearlet transform directly compresses the original image to form a restored image. The data collection was done from kaggle dataset [kaggle .com /paultomothymooney chest X-ray pneumonia] (*Kaggle: Your Machine Learning and Data Science Community*, n.d.).

Statistical Analysis

SPSS was the statistical software used for analysis. The analysis was done by an independent t- test ($p<0.0001$). By comparing the output image size by input image size we got the compression ratio. The dependent variable in our study is the compression ratio generated for each image for the respective transforms. Later the ratios were compared.

3. Results

From Table 1, it was observed that the total size of sample for the study was 60. For Wavelet Packet, 30 images and Shearlet 30 were used for the compression process. The original image size ranges from 130 to 450 kb and for shearlet 130 to 198 kb. The compressed image sizes ranged from

26 to 33 kb with the compression ratio on an average of 6 - 12 for Wavelet packet. For Shearlet, the compressed image sizes ranged from 38 to 42 kb with the compression ratio - 3 to 5.5.

Table 1- Represents the Total Sample Size Used in the Compression Study

S. No	Wavelet packet X-ray original image size (kb)	Wavelet packet X-ray compression image size (kb)	Wavelet packet X-ray compression ratio	Shearlet X-ray original image size (kb)	Shearlet X- ray compression image size (kb)	Shearlet X-ray compression ratio
1	193	26	7.42	193	40	4.7
2	193	26.8	7.2	193	40.8	4.7
3	134	22.1	6.06	134	41.5	3.2
4	198	28.7	6.89	198	41	4.8
5	383	26	14.7	150	40.7	3.6
6	439	27.6	15.9	197	40	3.6
7	379	28.1	13.4	154	39.5	4.9
8	447	28.6	15.6	211	39.5	3.8
9	354	28.6	12.3	139	39	5.3
10	427	31.4	13.5	193	40.2	3.5
11	359	24.2	14.8	134	39.5	4.8
12	427	29.5	14.4	190	39.4	3.3
13	415	30.2	13.7	190	38.8	4.8
14	413	29.6	13.9	183	40.2	4.8
15	411	28.6	14.3	180	40.5	4.5
16	411	32.4	12.6	185	38.7	4.4
17	417	31.6	13.19	185	39.7	4.7
18	407	32.5	12.5	188	39.1	4.6
19	335	25	13.4	121	40.3	4.8
20	392	31.2	12.5	179	40.8	3
21	358	28.7	12.8	144	39	4.38
22	353	26.3	13.4	135	39	3.6
23	330	26.1	12.6	125	38.9	3.46
24	345	23.6	14.6	122	39.7	3.21
25	345	23.6	14.6	122	39.9	3.07
26	441	32.6	13.5	211	39.8	3.05
27	348	22.4	15.5	122	39.5	5.3
28	328	21.4	15.3	110	40.2	3
29	345	23.6	14.6	122	40.3	2.7
30	375	28.7	13	153	40.4	3

Fig. 1- Represents the Wavelet Packet Transform Compression of X- ray Images

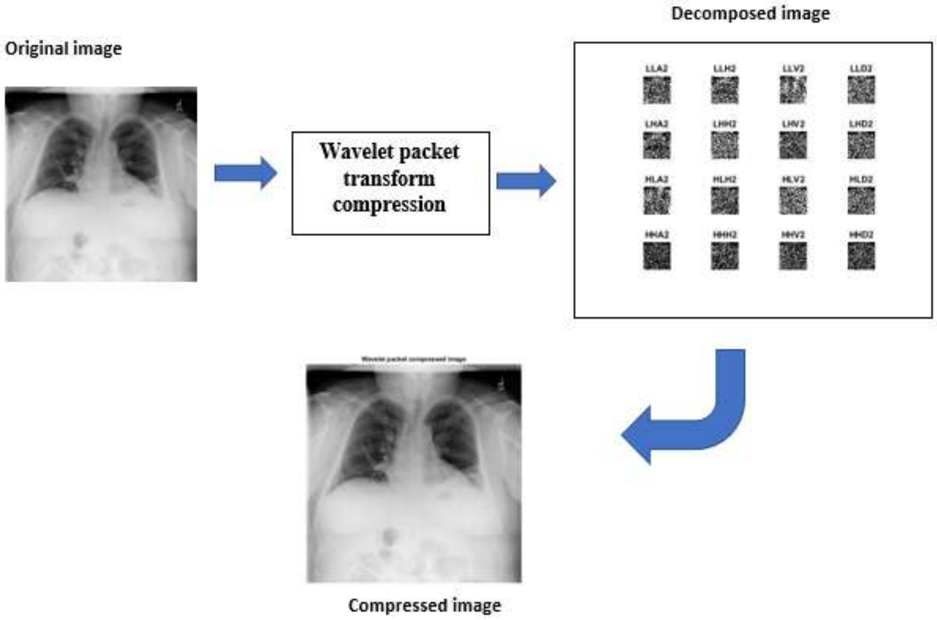


Figure 1 represents the wavelet packet transform compression of X-ray images. 30 images were compressed to obtain compression ratios. The transform decomposes the input image to 16 subsets to reduce noise and finally recontructs it while compressing simultaneously. Hence, images with reduced sizes are generated. Similarly, Fig. 2 represents the shearlet transform compression of X-ray images. X-ray images were pre-processed first for the bit rate of the images according to the code. They were directly compressed and later restored to have output images of reduced sizes. From Table 2, represents the group statistics data for this study. Wavelet packet based compression ratio was seen to be higher with mean value of 13.53, when compared to that of shearlet.

Fig. 2- Represents the Shearlet Transform Compression of X-ray Images

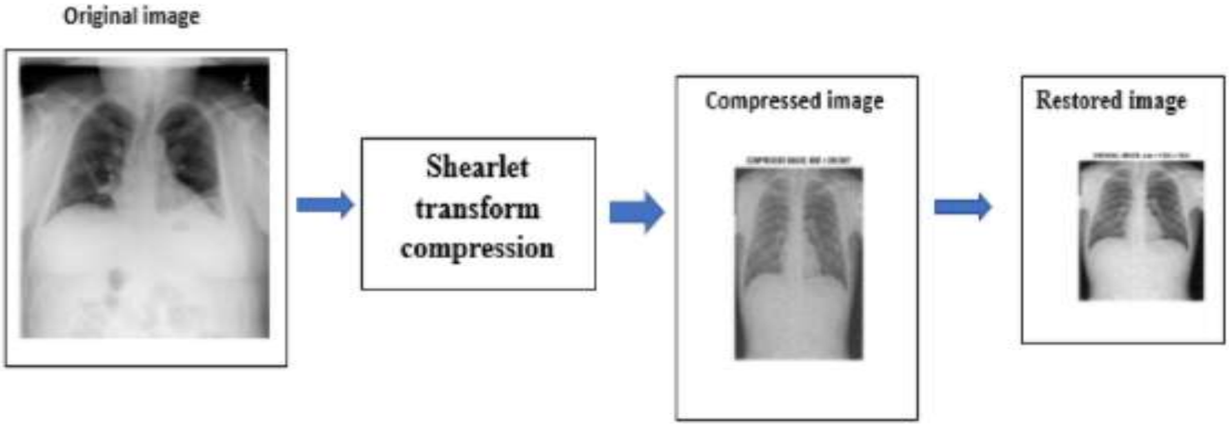


Table 2- Represents the Group Statistics Data for this Study. Wavelet Packet based Compression Ratio was seen to be Higher with Mean value of 13.53 when compared to that of Shearlet

	Group	N	Mean	Std. Deviation	Std. Error Mean
comp_ratio	**Wavelet Packet**	30	13.5377	3.35491	0.61252
	Shearlet	30	4.0257	0.8044	0.14686

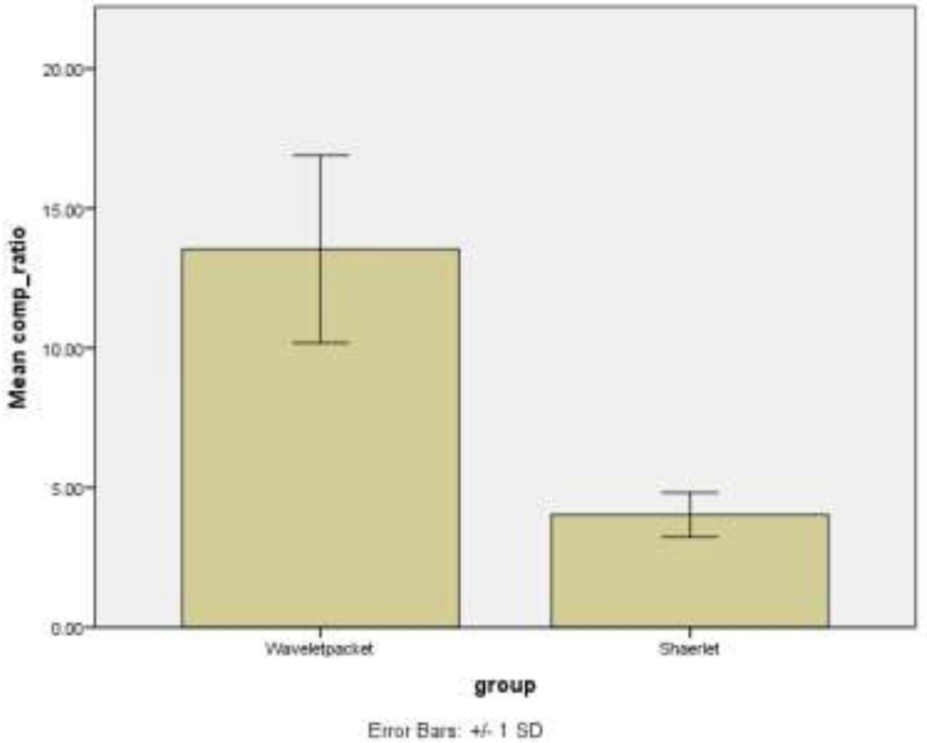
Table 3 depicts the comparison of wavelet packet based compression ratio with shearlet transform based compression ratio for 30 X-ray images. The wavelet packet transform had the highest compression ratio with the mean value of 13.53, when compared with the shearlet transform which had a lowest compression ratio with the mean value of 4.02. It was a statistically significant study with p value of 0.032. Hence supporting our hypothesis and our experimental results.

Table 3- Represents the Result of an Independent Sample t Test, for Wavelet Packet based Compression Ratio of Mammographic Image. There was a Statistical Significance between DCT and Shearlet Data (p=0.035) (p<0.05 Independent Sample t Test)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
comp_ratio	Equal variances assumed	4.8	0.032	15.1	58	0	9.512	0.62988	8.251	10.7728
	Equal variances not assumed			15.1	32.3	0	9.512	0.62988	8.229	10.7945

Figure 3 reports the comparison between wavelet packet and shearlet transform compression ratio for X-ray images. There was statistical significance between the data (p<0.05, independent sample t- test). Wavelet packet transform appears to produce the most consistent results with higher standard deviation (3.3) when compared with shearlet transform, which appears to produce lower results with lower standard deviation (0.8). Since the deviation is more for shearlet when compared to Wavelet Packet, the former has a prospects of upgrading its compression features if optimized aptly.

Fig. 3- Comparison between Wavelet Packet and Shearlet Transform Compression Ratio for x- ray Images. Wavelet Packet Transform appears to Produce the most Consistent Results with Higher Standard Deviation (3.3) when compared with Shearlet Transform which appears to Produce Lower Results with Lower Standard Deviation (0.8). X Axis: Wavelet packet vs Shearlet Transform Group. Y Axis: Mean Value of Compression Ratio +/- 1 SD



4. Discussion

Wavelet packet transform with higher standard deviation (3.3) has the potential for upgradation and enhancement of compression parameters ($p=0.032$, $p<0.05$ independent sample t test). CR for wavelet packet transform was seen to be higher (13.53) than its counterpart. Hence seems to be a better transform for compressing X-ray images. So the wavelet packet transform is better than shearlet transform for X-ray images.

Previously it has been suggested that wavelet packet is a novel algorithm for differential protection of three phase power transformers (Rahman & Al Mehedi Hasan, 2014). Similarly in 2017 scientists have reported that applications in X- ray using wireless technology was very predominant in the health industry (Al-Busaidi et al., 2017); (Subramanian et al., 2010). It has been suggested that secure and robust host, adapted color image watermarking using inter layered wavelet packets is very efficient (Meyer et al., 2000); (Al-Otum, 2019). As the efficiency of the transforms are good enough for most of the image formats, there were no negative reports that we could cite for the same. From the above reports, we inferred that various transforms are very frequently used in image compression but none of them have been compared based on their compression ratios and used exclusively for medical images. So our study helps to find out the most suitable transform with better compression ratio pertaining to X-ray images. The use of shearlet as a compression transform for X-ray images is the novelty of this study. Hence wavelet packet transform is suggested to be better than shearlet transform for X-ray images.

Our institution is passionate about high quality evidence based research and has excelled in various fields ((Ezhilarasan et al., 2019; Mathew et al., 2020; Pc et al., 2018; Ramadurai et al., 2019; Ramesh et al., 2018; Sridharan et al., 2019; Vijayashree Priyadharsini, 2019). We hope this study adds to this rich legacy.

Pre-processing of images before the compression (based on the code) is our major limitation. If the code is optimized to perform compression for every image regardless of size type and dimension (Subramanian et al., 2010) will be more effective.

The future prospect of this study is to come up with better code for better compression to store the large data files in a small file.

5. Conclusion

In this study, wavelet packet transform has a better compression ratio than shearlet transform. Wavelet packet transform appears to produce the most consistent results with higher standard deviation (3.3) when compared with shearlet transform which appears to produce lower results with lower standard deviation (0.8) when analysed using independent t test. The higher standard deviation gives wavelet packet transform more potential for upgradation and enhancement of compression parameters. Hence seems to be a better transform for compressing X- ray images.

Declarations

Conflict of Interests

No conflict of interest in this manuscript.

Authors Contributions

Author PH was involved in compression of images data analysis and manuscript writing, Author ND was involved in conceptualization, data validation and critical review of manuscript.

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