Comparative Study on MATLAB based JPEG Image Size Reduction Using Discrete Cosine Transform and Shearlet Transform for Mammogram Images with Potential Hospital Data Storage Applications

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Abstract

Aim: The aim of this study was to compare Discrete cosine transform and Shearlet transform for mammographic image compression and determine better transform among them.

Materials and methods: Sample mammographic images were collected- DCT (30) and Shearlet (30) for compression. Compression ratio was calculated by comparing the original and compressed image size. The significance of the data were calculated using SPSS software. Result: There was a statistical significance between DCT and shearlet based compression ratio data (p=0.035) deviation independent sample t test). Conclusion: DCT based compression ratio was higher (2.41) than the shearlet transforms (0.73). Hence, proving to be a better compression transform than its counterpart (shearlet).

Key-words: DCT, Shearlet, Novel Image Compression Technique, Image Compression, Artificial Intelligence.

1. Introduction

Image compression was normally done in many fields to have better usage of storage space. In the medical field, image compression has not yet been done effectively (Patel et al., 2016); (Chen, 2007). If compression is applied with the better transform, it will be a boon to the medical images storage and transmission. Mostly in diagnosis, medical images play a major role in the first step of
Image compression of mammographic images were performed in the current research study using DCT and shearlet. It aims to reduce the size of an image without reducing the size, quality and bit size of the image. Better image compression may lead to better utilization of storage space.

Till date, several articles related to our experimental study have been published in many databases. Researchers have performed a block transform which is inspired by DCT and performed image compression with higher efficiency (Bit rate-54.9) (Liu et al., 2018); (Jha & Kolekar, 2018). Few authors have developed some simple functions to compete with DCT and to compare images (Gupta, M., & Garg, A. K., n.d.); (Barbhuiya et al., 2014). Very recently, image compression based on ROI detection and shearlet transform were experimented and reported their feasibility as a compression tool (Saraswathy et al., 2013); (Katharotiya et al., 2011). Authors also have performed image compression using DCT and wavelet transforms by selecting proper threshold methods along with PSNR (Telagarapu et al., 2011); (Yuen & Wong, 2011). Most of the papers were done in fields other than the medical images let alone our target image type. DCT and Shearlet transforms were not used in medical image compression and comparison till date.

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.

After referring to recent research papers associated with image compression, we found that different transforms have not been used in mammographic image compression. And we proposed to use MATLAB® coding using different transforms for image compression as our potential scope in this current study. We planned to compress mammographic images using DCT and shearlet transforms. And then the compression ratio was determined to infer which of them is a better transform for compression ratio.

2. Materials and Methods

We took 2 groups of mammographic images, one was for DCT transform compression and another one was for shearlet transform. Sample sizes were calculated using clinical.com (Website,
n.d.) by having the base values from (Eben Sophia & Anitha, 2017). Then images were compressed. G power values of the sample size were calculated using clinical.com website, G power -80% and alpha value is 0.05 (Eben Sophia & Anitha, 2017). DCT (30) and shearlet (30) images were processed and compressed. So totally we took 60 samples for our study.

Before the compression process, the images were resized according to the need of code. DCT transform was mostly used in the image compression. Discrete cosine transforms split the images into small pixels. The code for DCT was Ycbr=rgb2Ycbr(I). Shearlet transforms are not yet used in any image compression. This is a very new transform for image compression. The images resized to 512X512 dimension before compression. The main code of this transform was X_noisy=X+_sigma.*randn(L,L). MATLAB©. 2015 version was used in our study, the code for DCT and shearlet transforms were optimized by trial-and-error method. For the sample image collection, we have used Kaggle dataset (Kaggle: Your Machine Learning and Data Science Community, n.d.). We downloaded the dataset and selected the image randomly for the compression process. JPEG image file format was preferred for compression in our code, so if the file was in a different extension, it was converted into JPEG format for further process. For DCT transform input images were pre-processed and then images were decomposed in the compression process. As the next step the images were compressed. For Shearlet transform also input images were pre-processed and then the compression was performed.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS 22) software was used for the statistical analysis (Independent sample t test). This test helps to find out the significance between the two groups. There was no independent variable and compression ratio was dependent variable.

3. Results

From Table 1, it was observed that the total size of sample under study was 60. 30 images for DCT and 30 images for shearlet were used for compression. The DCT original image size ranged from 13 kb to 30 kb and for shearlet 14 to 40 kb. The compressed images were generated in the range of 6 to 12 kb with compression ratio in an average of 2.2-2.6 for DCT. For Shearlet the compressed image sizes ranged from 34 to 37 kb with the compression ratios from 0.5 to 0.9.
Table 1 - Represents the Total Size of the Sample was 60- DCT (30) and Shearlet (30)

| S. No | Original Image size (KB) | DCT Compressed image size (KB) | DCT Compression ratio (KB) | Original Image size (KB) | Shearlet Compressed Image size (KB) | Shearlet Compression ratio (KB) |
|-------|--------------------------|-------------------------------|---------------------------|--------------------------|-----------------------------------|-------------------------------|
| 1     | 27.9                     | 10.8                          | 2.583333                  | 31.8                     | 37.3                              | 0.852547                      |
| 2     | 28.3                     | 11.1                          | 2.54955                   | 36.2                     | 37.8                              | 0.957672                      |
| 3     | 28.3                     | 10.6                          | 2.669811                  | 36.2                     | 37.7                              | 0.960212                      |
| 4     | 27                       | 11.1                          | 2.432432                  | 29.7                     | 36.8                              | 0.807065                      |
| 5     | 30.5                     | 11.9                          | 2.563025                  | 33.7                     | 37.4                              | 0.90107                       |
| 6     | 27.7                     | 11                            | 2.518182                  | 33.3                     | 36.3                              | 0.917355                      |
| 7     | 21.7                     | 8.45                          | 2.568047                  | 24.7                     | 36.3                              | 0.680441                      |
| 8     | 26.4                     | 10.5                          | 2.514286                  | 29.9                     | 36.8                              | 0.8125                        |
| 9     | 30.2                     | 12                            | 2.516667                  | 39                       | 39.2                              | 0.994898                      |
| 10    | 17.8                     | 7.5                           | 2.373333                  | 21.5                     | 34.9                              | 0.616046                      |
| 11    | 18.6                     | 7.86                          | 2.366412                  | 22.5                     | 34.3                              | 0.655977                      |
| 12    | 17.5                     | 7.56                          | 2.314815                  | 20.1                     | 36.4                              | 0.552198                      |
| 13    | 16.9                     | 7.29                          | 2.318244                  | 19.5                     | 37.1                              | 0.525606                      |
| 14    | 17.1                     | 7.83                          | 2.183908                  | 17.2                     | 35.3                              | 0.487252                      |
| 15    | 13.7                     | 6.5                           | 2.107692                  | 14.2                     | 35.5                              | 0.4                           |
| 16    | 23.3                     | 9.7                           | 2.402062                  | 27.8                     | 37                                | 0.751351                      |
| 17    | 24.5                     | 9.98                          | 2.45491                   | 30.2                     | 37.6                              | 0.803191                      |
| 18    | 17.7                     | 7.58                          | 2.335092                  | 20.4                     | 38.1                              | 0.535433                      |
| 19    | 19.3                     | 8.23                          | 2.345079                  | 22.1                     | 36.4                              | 0.607143                      |
| 20    | 24.4                     | 10                            | 2.44                      | 29.2                     | 36.3                              | 0.804408                      |
| 21    | 28.9                     | 12.2                          | 2.368852                  | 34.3                     | 37                                | 0.927027                      |
| 22    | 26.6                     | 10.8                          | 2.462963                  | 31.2                     | 36.9                              | 0.845528                      |
| 23    | 17.2                     | 7.58                          | 2.269129                  | 18.4                     | 36.5                              | 0.50411                       |
| 24    | 16.7                     | 7.36                          | 2.269022                  | 18.7                     | 37                                | 0.505405                      |
| 25    | 26.5                     | 10.5                          | 2.52381                   | 30                       | 36.8                              | 0.815217                      |
| 26    | 29.6                     | 11.4                          | 2.596491                  | 34                       | 37.9                              | 0.897098                      |
| 27    | 23.7                     | 10.1                          | 2.346535                  | 25.2                     | 37                                | 0.681081                      |
| 28    | 20.8                     | 8.58                          | 2.424242                  | 24.2                     | 35.9                              | 0.674095                      |
| 29    | 24.7                     | 10.4                          | 2.375                     | 30.3                     | 36.8                              | 0.82337                       |
| 30    | 24.5                     | 10.2                          | 2.401961                  | 30.5                     | 36.8                              | 0.828804                      |

Fig. 1 - Represent the DCT Compression of the Mammographic Images. 30 Images were Compressed to obtain 30 Compression Ratios
Figure 1 represents the DCT compression of the mammographic images. The input image was decomposed by the transform, then compressed to get an output image of reduced size. Similarly, Fig. 2 represents the shearlet transform compression of the mammographic images. Input images were pre-processed first for the bit rate of the image according to the code and compressed to get restored images.

Table 2- Represents the Statistical Analysis between the CR Generated by DCT and Shearlet Transform. DCT based Compression Ratio was higher (2.41) than the Shearlet Transforms (0.73). Hence, Proving to be a better Compression Transform than its Counterpart (Shearlet)

| Group    | N  | Mean   | Std. Deviation | Std. Error Mean |
|----------|----|--------|----------------|-----------------|
| DCT      | 30 | 2.4198 | 0.12734        | 0.02325         |
| Shearlet | 30 | 0.7374 | 0.16664        | 0.03042         |

Fig. 2- Represents the Shearlet Transform Compression of the Mammographic Images. 30 Compression Ratios were obtained for the given Transform

From Table 2, it was observed that the statistical analysis between the CR generated by DCT and shearlet transform. DCT based compression ratio was higher (2.41) than the shearlet transforms (0.73). Hence, proving to be a better potential compression transform than its counterpart. Table 3 depicts the result of an Independent sample t test, for DCT 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). Hence the DCT transform was inferred to be better than shearlet transform for mammographic images. Both the transforms have the same mean difference value (1.682).

From Fig. 3, represents the comparison between DCT and Shearlet transform compression ratio for mammographic images. There was a statistical significance between the DCT and shearlet transform data (p<0.05, Independent sample t test). DCT transform appears to produce the most consistent results with lower standard deviation (0.12), when compared with shearlet transform which
appears to produce lower results with higher standard deviation (0.16). Since the deviation is more for shearlet compared to DCT, the former has a better potential to enhance its compression features if optimized suitably.

Table 3- Represents the Result of an Independent Sample T Test, for DCT 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). Hence the DCT Transform was Inferred to be better than Shearlet Transform for MAMMOGRAPHIC IMAGES

| Independent Samples 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 |
| Comp_rat                 | Equal variances assumed | 4.656 | .035 | 43.93 | 58.000 | 1.68240 | .03829 | 1.6057 | 1.7590 |
|                          | Equal variances not assumed | 43.93 | 54.256 | .000 | 1.6840 | .03829 | 1.6056 | 1.7591 |

Fig. 3- Comparison between DCT and Shearlet Transform Compression Ratio for Mammographic Images. DCT Transform Appears to Produce the most Consistent Results with Lower Standard Deviation (0.12), when compared with Shearlet Transform which appears to produce Lower Results with Higher Standard Deviation (0.16). X Axis: DCT vs Shearlet Transform Group Y Axis: Mean Value of Compression Ratio +/- 1 SD
4. Discussion

In this study we observed that DCT transform seems to have a better compression ratio than Shearlet transform (P=0.035, P<0.05 Independent sample t test) as depicted in table 2 and figure 3. They were statistically significant, hence assuring the data sets have a deviation in them based on compression ratio (table 2). Most of the researchers have used different transforms like DCT, DWT, DOCM, DWT for image compression. But the image compression is calculated based on PSNR values in most of the cases (Hashim, A.T., & Ali, S.A., n.d.); (Saraswathy et al., 2013). In another research, authors have performed image compression using spectrum PSF (Point spread function) determined using spectrum (Kumar et al., 2017); (Chen, 2007). Using a particular integer approximation of DCT, image compression was performed just to check their efficiency as a compression platform (Nabila brahm et.al, 2020). Transforms have been reported to enhance the quality of the image in most of the reports, hence we were unable to point any negative reports or articles on the same the above stated literature mostly tried to perform compression or processing in basic images only. If the image compression tools were used in the medical images, it would be far far better improvement in the storage utilization. Although these transforms are used in image compression previously, none of them have been compared to the compression ratio exclusively, let alone for mammographic images. The use of shearlet as a compression tool for mammographic images is the novelty of this study.

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.

The main and only limitation of this study was pre-processing demanded by every image before the compressing process. If the code is optimized, to perform compression for every image regardless of size, type and dimension, the compression would be more effective.

The future of this research would be to come up with a better code for better compression. If that is possible in the upcoming research, the utilization of storage space will be more efficient for hospitals.
5. Conclusion

Within the limits of this study, DCT transform, has a significantly greater compression ratio (2.41 Mean) than Shearlet transform (0.734 Mean). Even though the shearlet transform was a newer alternative, it performed somewhat lower than DCT in image compression. We observed that the compression ratio was better in DCT transform especially for mammographic images. But the standard deviation was promising for shearlet, hence holds a potential as a prospective compression tool if the code is enhanced in the future.

Declarations

Conflict of Interests

No conflict of interest in this manuscript.

Authors Contribution

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

Acknowledgements

The authors would like to express their gratitude towards Saveetha school of engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding

We thank the following organizations for providing financial support that enabled us to complete the study.

1. Sri chakra consultants.
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

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