www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC Gestão, Inovação e Tecnologias

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

Naveen Srinivasan[1]; Dr. Nibedita Dey[2*]

[1]Research Scholar, Department of Biomedical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India.

[1]naveen6052530@gamil.com

[2*]Assistant Professor, Project Guide, Department of Biotechnology, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India.

[2*]nibeditadey.sse@saveetha.com

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

treatment and detection (Oliveira et al., 2019). 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 Ycbcr= rgb2Ycbcr(I). Shearlet transforms are not yet used in any image compression. This is a very new transform for image compression. The images resized to 512X 512 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

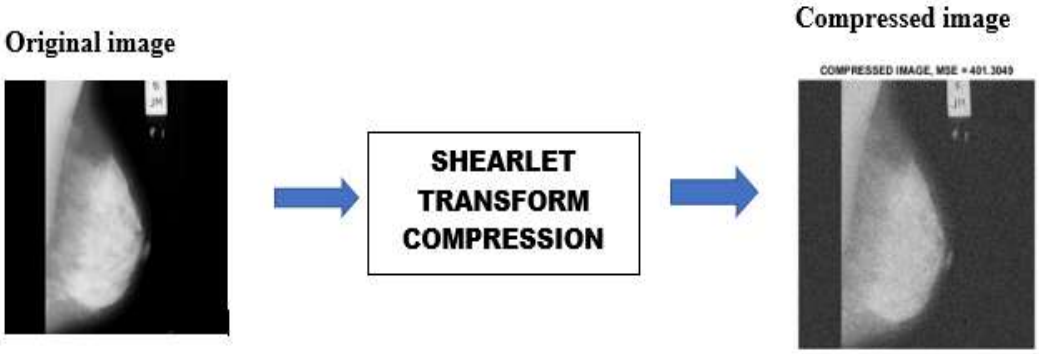
Fig. 1- Represent the DCT Compression of the Mammographic Images. 30 Images were Compressed to obtain 30 Compression Ratios

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
Comp_rat	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).

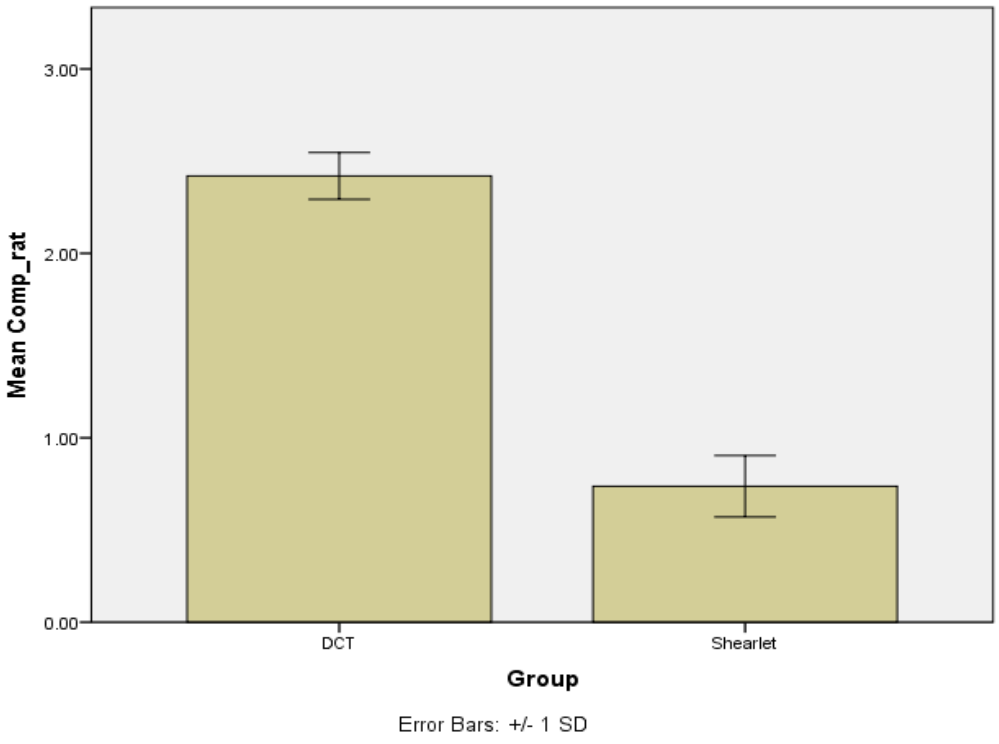
From Fig. 3, represents the comparison between DCT and Shearlet transform compression ratio for mammographic images. There was a statistical significance between the DCT and shearlet transform data ($p<0.05$, Independent sample t test). DCT transform appears to produce the most consistent results with 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**	
									Lower	**Upper**
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.

References

Barbhuiya, A.J.I., Laskar, T.A., & Hemachandran, K. (2014). An approach for color image compression of JPEG and PNG images using DCT and DWT. *In 2014 International Conference on Computational Intelligence and Communication Networks,* 129-133.

Chen, Y.Y. (2007). Medical image compression using DCT-based subband decomposition and modified SPIHT data organization. *International Journal of Medical Informatics*, *76*(10), 717–725.

Eben Sophia, P., & Anitha, J. (2017). Contextual Medical Image Compression using Normalized Wavelet-Transform Coefficients and Prediction. *IETE Journal of Research*, *63*(5), 671–683.

Ezhilarasan, D., Apoorva, V.S., & Ashok Vardhan, N. (2019). Syzygium cumini extract induced reactive oxygen species-mediated apoptosis in human oral squamous carcinoma cells. *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology*, *48*(2), 115–121.

Gheena, S., & Ezhilarasan, D. (2019). Syringic acid triggers reactive oxygen species-mediated cytotoxicity in HepG2 cells. *Human & Experimental Toxicology*, *38*(6), 694–702.

Kaushik, A., & Gupta, M. (2012). Analysis of image compression algorithms. *International journal of engineering research and application, 515-521*.

Hashim, A.T., & Ali, S.A. (2016). Color Image Compression Using DPCM with DCT, DWT and Quadtree Coding Scheme. *Engineering and Technology Journal, 34*(4 Part (B) Scientific), 585-97.

Jha, C.K., & Kolekar, M.H. (2018). Electrocardiogram data compression using DCT based discrete orthogonal Stockwell transform. *Biomedical Signal Processing and Control*, *46*, 174–181.

Jose, J., Ajitha, & Subbaiyan, H. (2020). Different treatment modalities followed by dental practitioners for Ellis class 2 fracture – A questionnaire-based survey. *The Open Dentistry Journal*, *14*(1), 59–65.

Kaggle: Your Machine Learning and Data Science Community. (n.d.). Retrieved March 17, 2021, from https://www.kaggle.com/

Katharotiya, A., Patel, S., & Goyani, M. (2011). Comparative analysis between DCT & DWT techniques of image compression. *Journal of Information Engineering and Applications*, *1*(2), 9–17.

Ke, Y., Al Aboody, M.S., Alturaiki, W., Alsagaby, S.A., Alfaiz, F.A., Veeraraghavan, V.P., & Mickymaray, S. (2019). Photosynthesized gold nanoparticles from Catharanthus roseus induces caspase-mediated apoptosis in cervical cancer cells (HeLa). *Artificial Cells, Nanomedicine, and Biotechnology*, *47*(1), 1938–1946.

Krishnaswamy, H., Muthukrishnan, S., Thanikodi, S., Arockiaraj, G., Antony, & Venkatraman, V. (2020). Investigation of air conditioning temperature variation by modifying the structure of passenger car using computational fluid dynamics. *Thermal Science*, *24*(1 Part B), 495–498.

Kumar, H., Gupta, S., & Venkatesh, K.S. (2017). A novel method for image compression using spectrum. *2017 Ninth International Conference on Advances in Pattern Recognition (ICAPR)*. 2017

Ninth International Conference on Advances in Pattern Recognition (ICAPR), Bangalore, India. https://doi.org/10.1109/icapr.2017.8593179

Liu, D., Ma, H., Xiong, Z., & Wu, F. (2018). CNN-Based DCT-Like Transform for Image Compression. In *MultiMedia Modeling*, 61–72. https://doi.org/10.1007/978-3-319-73600-6_6

Malli Sureshbabu, N., Selvarasu, K., Nandakumar, M., & Selvam, D. (2019). Concentrated growth factors as an ingenious biomaterial in regeneration of bony defects after periapical surgery: A report of two cases. *Case reports in dentistry*, 7046203.

Mathew, M.G., Samuel, S.R., Soni, A.J., & Roopa, K.B. (2020). Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: Randomized controlled trial. *Clinical oral investigations, 24*(9), 3275-3280. https://link.springer.com/article/10.1007/s00784-020-03204-9

Mehta, M., Tewari, D., Gupta, G., Awasthi, R., Singh, H., Pandey, P., & Satija, S. (2019). Oligonucleotide therapy: an emerging focus area for drug delivery in chronic inflammatory respiratory diseases. *Chemico-biological interactions, 308*, 206-215.

Muthukrishnan, S., Krishnaswamy, H., Thanikodi, S., Sundaresan, D., & Venkatraman, V. (2020). Support vector machine for modelling and simulation of heat exchangers. *Thermal Science*, *24* (1 Part B), 499–503.

Oliveira, R.S., Cintra, R.J., Bayer, F.M., Da Silveira, T.L.T., Madanayake, A., & Leite, A. (2019). Low-complexity 8-point DCT approximation based on angle similarity for image and video coding. *Multidimensional Systems and Signal Processing*, *30*(3), 1363–1394.

Patel, R., Katiyar, S., & Arora, K. (2016). An Improved Image Compression Technique Using Huffman Coding and FFT. *Smart Trends in Information Technology and Computer Communications*, 54–61.

PC, J., Marimuthu, T., Devadoss, P., & Kumar, S.M. (2018). Prevalence and measurement of anterior loop of the mandibular canal using CBCT: A cross sectional study. *Clinical implant dentistry and related research, 20*(4), 531-534. https://europepmc.org/article/med/29624863

Ramadurai, N., Gurunathan, D., Samuel, A.V., Subramanian, E., & Rodrigues, S.J.L. (2019). Effectiveness of 2% Articaine as an anesthetic agent in children: randomized controlled trial. *Clinical Oral Investigations*, *23*(9), 3543–3550.

Ramesh, A., Varghese, S., Jayakumar, N.D., & Malaiappan, S. (2018). Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study. *Journal of Periodontology*, *89*(10), 1241–1248.

Samuel, M.S., Bhattacharya, J., Raj, S., Santhanam, N., Singh, H., & Pradeep Singh, N.D. (2019). Efficient removal of Chromium (VI) from aqueous solution using chitosan grafted graphene oxide (CS-GO) nanocomposite. *International Journal of Biological Macromolecules*, *121*, 285–292.

Samuel, S.R., Acharya, S., & Rao, J.C. (2020). School Interventions-based Prevention of Early-Childhood Caries among 3-5-year-old children from very low socioeconomic status: Two-year randomized trial. *Journal of Public Health Dentistry*, *80*(1), 51–60.

Saraswathy, K., Vaithiyanathan, D., & Seshasayanan, R. (2013). Notice of Violation of IEEE Publication Principles: A DCT approximation with low complexity for image compression. *2013 International Conference on Communication and Signal Processing*, 465–468.

Sathish, T., & Karthick, S. (2020). Wear behaviour analysis on aluminium alloy 7050 with reinforced SiC through taguchi approach. *Journal of Japan Research Institute for Advanced Copper-Base Materials and Technologies*, *9*(3), 3481–3487.

Sharma, P., Mehta, M., Dhanjal, D.S., Kaur, S., Gupta, G., Singh, H., Thangavelu, L., Rajeshkumar, S., Tambuwala, M., Bakshi, H.A., Chellappan, D.K., Dua, K., & Satija, S. (2019). Emerging trends in the novel drug delivery approaches for the treatment of lung cancer. *Chemico-Biological Interactions*, *309*, 108720.

Sridharan, G., Ramani, P., Patankar, S., & Vijayaraghavan, R. (2019). Evaluation of salivary metabolomics in oral leukoplakia and oral squamous cell carcinoma. *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology*, *48*(4), 299–306.

Telagarapu, P., Naveen, V.J., Prasanthi, A.L., & Santhi, G.V. (2011). Image compression using DCT and wavelet transformations. *International Journal of Signal Processing, Image Processing and Pattern Recognition*, *4*(3), 61–74.

Varghese, S.S., Ramesh, A., & Veeraiyan, D.N. (2019). Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students. *Journal of Dental Education*, *83*(4), 445–450.

Venu, H., Raju, V.D., & Subramani, L. (2019). Combined effect of influence of nano additives, combustion chamber geometry and injection timing in a DI diesel engine fuelled with ternary (diesel-biodiesel-ethanol) blends. *Energy*, *174*, 386–406.

Venu, H., Subramani, L., & Raju, V.D. (2019). Emission reduction in a DI diesel engine using exhaust gas recirculation (EGR) of palm biodiesel blended with TiO2 nano additives. *Renewable Energy*, *140*, 245–263.

Vignesh, R., Sharmin, D., Rekha, C.V., Annamalai, S., & Baghkomeh, P.N. (2019). Management of Complicated Crown-Root Fracture by Extra-Oral Fragment Reattachment and Intentional Reimplantation with 2 Years Review. *Contemporary Clinical Dentistry*, *10*(2), 397–401.

Vijayakumar Jain, S., Muthusekhar, M.R., Baig, M.F., Senthilnathan, P., Loganathan, S., Abdul Wahab, P. U., Madhulakshmi, M., & Vohra, Y. (2019). Evaluation of Three-Dimensional Changes in Pharyngeal Airway Following Isolated Lefort One Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study. *Journal of Maxillofacial and Oral Surgery*, *18*(1), 139–146.

Vijayashree Priyadharsini, J. (2019). In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. *Journal of Periodontology*, *90*(12), 1441–1448.

Yuen, C.H., & Wong, K.W. (2011). A chaos-based joint image compression and encryption scheme using DCT and SHA-1. *Applied Soft Computing*, *11*(8), 5092–5098.