ORIGINAL RESEARCH

Submitted: 20.09.2022; Accepted: 8.10.2022; Published online: 25.12.2022

Analysis and Comparison of Image Enhancement Technique for Improving PSNR of Lung Images by Linear Contrast Enhancement Technique over Histogram Equalization Technique

Sabarish Raja T, Ramadevi R

Department of Biomedical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu. India. Pincode:602105.

Abstract

Aim: The aim of this study is to compare and analyze linear contrast enhancement algorithm for lung image enhancement over novel histogram equalization technique. **Material and Methods:** In this research, different sources of lung images collected from the kaggle website were used. Samples were considered as (N=30) for linear contrast filter and (N=30) for novel histogram equalization technique with total sample size calculated using clinical.com. As a result the total number of samples was calculated to be 60. Using SPSS Software and a standard data set, the PSNR was obtained. Both linear contrast filter and novel histogram equalization technique image enhancement were implemented on lung images through Matlab coding and also PSNR values of each image were extracted. Then through SPSS software comparison and analysis has been made. **Result:** In the final output of image enhancement, novel histogram equalization technique shows better performance in improving PSNR of lung images than linear contrast filter. Comparison of PSNR values are done by independent sample test using IBM-SPSS software. There is a statistical difference between histogram technique and linear contrast filter. The novel histogram equalization technique showed higher results of PSNR (65.9197dB) with (p=0.04) in comparison with linear contrast filter (36.1190dB). **Conclusion:** Within this research study the histogram equalization image enhancement technique has greater PSNR value of lung images than in linear contrast enhancement technique.

Keywords

Image Enhancement, Filtering Technique, Linear Contrast Enhancement, Peak Signal to Noise Ratio (PSNR), Novel Histogram Equalization Technique, Image Processing.

Imprint

Sabarish Raja T, Ramadevi R. Analysis and Comparison of Image Enhancement Technique for Improving PSNR of Lung Images by Linear Contrast Enhancement Technique over Histogram Equalization Technique. Cardiometry; Special issue No. 25; December 2022; p. 838-844; DOI: 10.18137/cardiometry.2022.25.838844; Available from: http://www.cardiometry.net/issues/no25-december-2022/linear-contrast-enhancement-technique

Introduction

Image enhancement is mainly used to obtain a high quality image after improving the characteristics of the input image (Senthilkumaran and Thimmiaraja 2014). Image enhancement helps doctors accurately interpret medical images as crucial information for better diagnosis and treatment for lung disorders in the medical field applications (Kaur, Girdhar, and Kanwal 2016). In linear contrast enhancement, also referred as a contrast stretching, linearly expands the original digital values of the remotely sensed data into a new distribution (Padmavathy and Priya 2019). By expanding the original input values of the image, the total range of sensitivity of the display device can be utilized (Suralkar and Rajput 2020). Linear contrast enhancement makes subtle variations within the data more obvious in image. Contrast enhancement techniques are used in images to enhance the visibility quality of internal human body texture in magnetic resonance imaging (MRI). Histogram equalization is mainly used in image enhancement and divides the original image into several non overlapping sub images. In medical image applications novel histogram equalization is used for obtaining details in an image with clear relative to background by enhancing the image contrast and suppressing the noise (Kalyani and Chakraborty 2020). There are 180 research articles published on image enhancement in sciencedirect and 350 papers on Google Scholar and 73 research articles were published in IEEE xplore for image enhancement of lung images.

Linear contrast enhancement technique is compared with histogram equalization technique by removing noise and blur images and improves good quality richness of image as performance enhancement (Vartak and Mankar 2015). It also preserves the richness of details and sharpness of edge detection in

an image compared to linear contrast enhancement technique. It takes less computational time in contrast to histogram equalization algorithm and it calculates histogram of the whole image and then the image gets clipped according to threshold value. Histogram equalization technique and contrast-limited adaptive histogram equalization is applied in order to improve the contrast of MRI medical images. Experimental results showed good efficiency by improving the contrast of MRI medical images with very high quality. Comparison of various image quality measures like MSE, PSNR are taken into account for evaluation of the quality of enhanced MRI medical images (Tom and Wolfe 1983).Our team has extensive knowledge and research experience that has translate into high quality publications (Chellapa et al. 2020; Lavanya, Kannan, and Arivalagan 2021; Raj R, D, and S 2020; Shilpa-Jain et al. 2021; S, R, and P 2021; Ramadoss, Padmanaban, and Subramanian 2022; Wu et al. 2020; Kalidoss, Umapathy, and Rani Thirunavukkarasu 2021; Kaja et al. 2020; Antink et al. 2020; Paul et al. 2020; Malaikolundhan et al. 2020)

The research gap identified from the survey is that there are many methods proposed for image enhancement of medical images but most of the methods have less PSNR. Hence the major objective of this study is to enhance lung images using novel histogram equalization techniques and linear contrast enhancement and compare both performances based on PSNR values to identify better enhancement techniques.

Materials and methods

The research work was carried out at the department of Biomedical Engineering, Saveetha School of Engineering. The number of groups identified for the study are two. Group 1 is given as a novel histogram equalization technique and group 2 is given as a linear contrast enhancement algorithm. Sample size for each group was calculated by using previous study results in clinical.com by keeping g power as 80%, threshold 0.05 and confidence interval as 95% (Zipporah and Sharmila 2018). According to that, the sample size of histogram technique (N=30) and linear contrast enhancement technique (N=30) were calculated. The study uses CT, X-ray, MRI lung images downloaded from kaggle website. In sample preparation, for Group1 the number of lung image samples collected from CT Scan images is 10, X-rays scan images is 10 and MRI scan images is 10. The collected image samples are used for PSNR based image enhancement using linear contrast enhancement technique. For Group 2 sample Preparation, 10 lung images were collected each from X-ray, MRI and CT Scan. Testing setup is done by installing the Matlab R2018a software. After preparation a Matlab code was implemented for both histogram equalization and linear contrast enhancement methods. The performance of both algorithms was measured using the PSNR parameter. This parameter was calculated and evaluated to assess the method's efficacy and comparison of results was done for both methods to find which algorithm performed significantly better results for enhancing images.

Statistical analysis

The SPSS statistical software was used in the research for statistical analysis. Group statistics and independent sample t-tests were performed on the experimental results and the graph was built for two groups with one parameter under study ((Unal and Akoglu 2016). The independent variable is noise which affects the quality of an image and the dependent variable is PSNR.

Results

Table 1 shows PSNR (dB) values of 30 lung images obtained using histogram equalization and linear contrast filter. The mean value of PSNR (dB) of the histogram equalization filter is 65.9197dB and for the linear contrast enhancement technique is 36.1190dB.

Table 1

Comparison of histogram equalization and linear contrast enhancement technique with improved PSNR of lung images. The mean value of PSNR (dB) of the histogram equalization filter is 65.9197dB and for linear contrast enhancement technique is 36.1190dB

Images	PSNR (dB) of Histogram Equalization	PSNR (dB) of Linear Contrast Filter
Image1	37.59	35.66
Image 2	36.96	36.17
Image 3	36.45	33.45
Image 4	36.32	36.66
Image 5	34.60	36.04
Image 6	42.31	36.10
Image 7	41.39	39.12
Image 8	40.55	40.91
Image 9	42.97	43.57
Image 10	42.47	42.17
Image 11	42.74	43.65

Images	PSNR (dB) of Histogram Equalization	PSNR (dB) of Linear Contrast Filter
Image 12	57.54	55.75
Image 13	54.86	56.78
Image 14	59.75	62.31
Image 15	64.24	64.53
Image 16	66.34	69.76
Image 17	69.67	70.24
Image 18	73.33	70.19
Image 19	75.34	72.56
Image 20	77.10	74.34
Image 21	77.18	74.16
Image 22	77.22	75.64
Image 23	77.27	75.65
Image 24	78.43	76.48
Image 25	78.44	76.65
Image 26	78.87	77.42
Image 27	79.38	78.53
Image 28	79.76	78.59
Image 29	79.38	79.26
Image 30	79.54	79.34

Table 2 represents group statistics that shows comparison of histogram equalization of image enhancement with linear contrast enhancement method based on PSNR values. Mean value of PSNR is high (65.9197dB) for histogram equalizer and low (36.1190dB) for linear contrast enhancement technique. Standard deviation of PSNR is low (3.15003) for linear contrast enhancement technique and high (12.89324) for histogram equalizer.

Table 2

Group statistics comparison of Histogram equalization of image enhancement algorithm using PSNR and Linear Contrast Enhancement methods.Histogram Equalization is having high mean (65.9197dB) and Linear contrast enhancement technique of PSNR is having low mean (36.1190dB).Histogram equalizer of PSNR is having high standard deviation (12.89324) and Linear contrast enhancement technique of PSNR is having low standard deviation (3.15003).

	Group	N	Mean	Std Deviation	Std. Error Mean
PSNR	Linear Contrast Enhancement Technique	30	36.1190	3.15003	0.57511
PSNR	Histogram Equalization Technique	30	65.9197	12.89324	2.35397

Table 3 represents an independent sample test of PSNR based image enhancement using histogram equalizer and linear contrast algorithms. The two tailed significance p-value is 0.04 and standard mean difference is -29.80067 with a standard error difference of 2.42321. In the test confidence interval, the lower value is (-34.65125) and the upper value is (-24.95008). Based on independent sample T test results, histogram equalization based image enhancement method performed better than linear contrast filtering method with 95% confidence interval.

Discussion

Figure 1 represents simulation results of the linear contrast enhancement technique and histogram equalization algorithm. (a) Input image (X-ray chest), (b) Histogram equalization restored X- ray image, (c) Linear contrast enhancement on X-ray lung image and (d) Intensities analysis of linear contrast enhancement technique over histogram equalization (X-ray lung image).

Figure 2 shows bar chart comparison of mean PSNR (+/-1 SD) of histogram equalization and linear contrast enhancement methods. X-Axis represents the histogram equalization vs linear contrast technique,Y-Axis represents mean PSNR (+/- 1 SD).

Image enhancement is a vital step of medical image analysis and image recognition. X-ray and ultrasound imaging are the most preferred medical imaging technologies which are important for diagnosis of disease. But the edges and borders on the image are not as clear as expected due to interference and low intensity in images especially in the case of medical images (Kanwal, Girdhar, and Gupta 2011). Using image enhancement, it is possible to get the details which are kept hidden as well as to improve the image contrast in the case of analyzing an image, the commencing part is that of the edge of an image. This developed method is tested on low contrast medical images and by observing the results it can be said that the applied method performs well for enhancing medical images ((Zeng et al. 2012).

In image enhancement technique, histogram equalization is applied in order to improve the contrast of MRI medical images (Boccignone and Picariello, n.d.). The experiments was conducted on standard images and low contrast images and the results evaluated using quality metrics with relative contrast error, relative mean brightness error, relative structural similarity, relative entropy error, Peak signal to noise ratio (PSNR) and global contrast factor (Beghdadi and

Table 3

Independent sample t-test providing mean difference, significance value (2-tailed), standard error difference and 95% confidence interval of the difference in both lower and upper level for PSNR at equal variances assumed and not assumed.

		Levene's test for Equality of variance		T-Test for equality of mean						
		F	Sig	t	df	Sig (2 -tailed)	Mean difference	Std.Error Difference	95% confidence of Difference	
									Lower	Upper
PSNR	Equal variances assumed	34.503	0.02	-12.298	58	0.04	-29.80067	2.42321	-34.65125	-24.95008
	Equal Variances not assumed			-12.298	32.450	0.04	-29.43321	2.42321	-34.73390	-24.86743

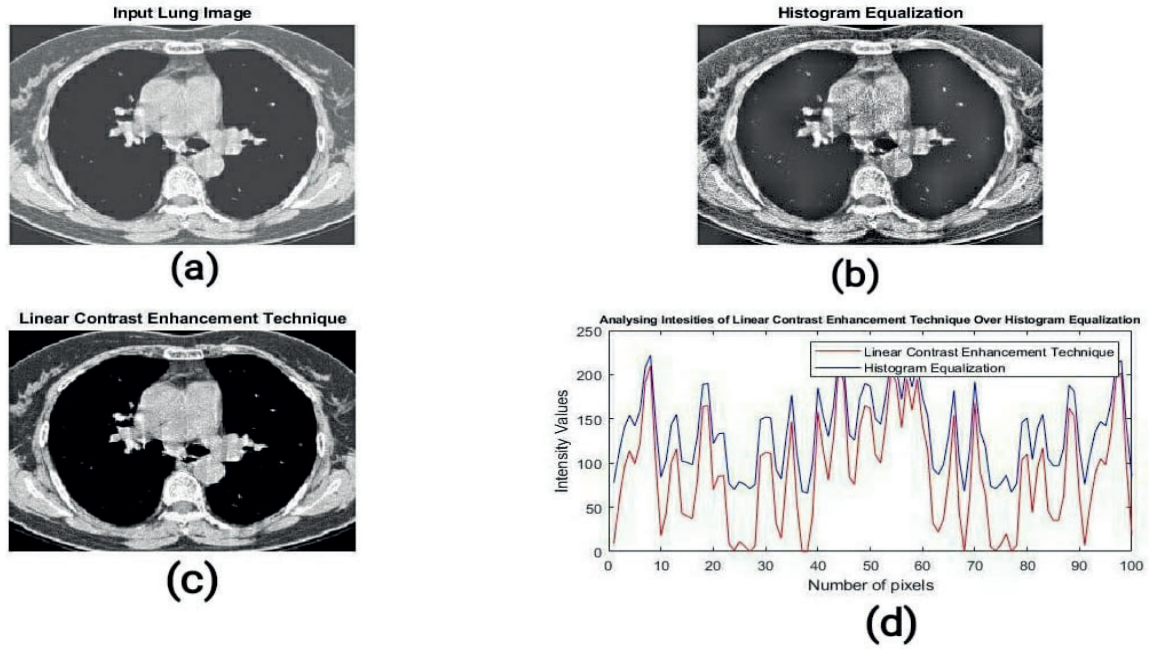

Fig. 1. Simulation results of linear contrast enhancement technique and histogram equalization algorithm. (a) Input image (X-ray chest) (b) Histogram equalization restored image, (c) linear contrast enhancement on X-ray image and (d) Intensities analysis of linear contrast enhancement technique over histogram equalization (X-ray image)

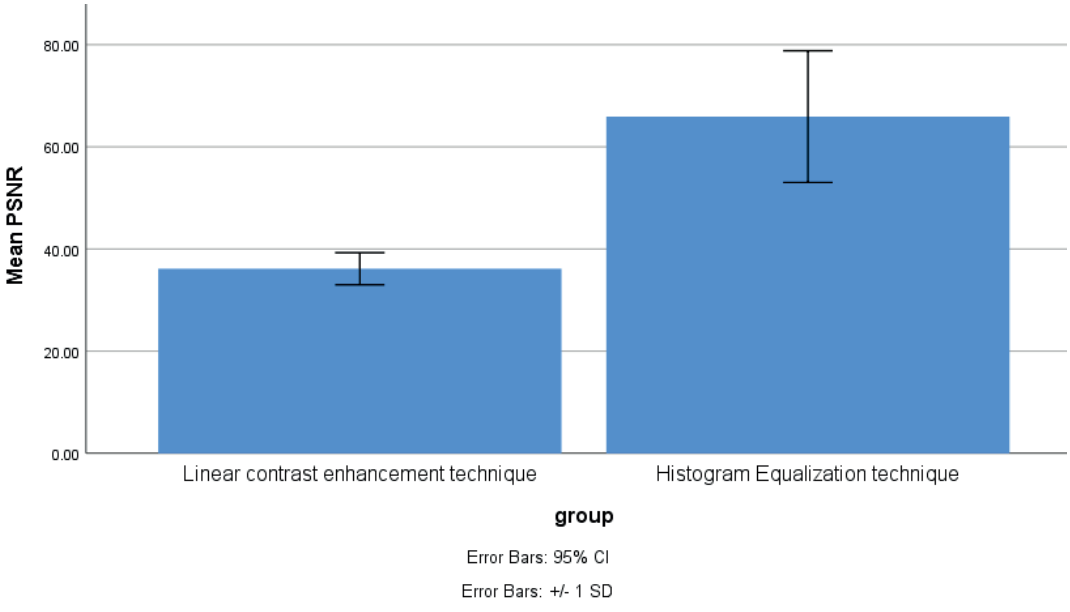

Fig. 2. Bar chart representing the comparison of mean PSNR (+/-1SD) of histogram equalization and linear contrast enhancement methods. X-Axis represents the histogram equalization vs linear contrast enhancement,Y-Axis represents mean PSNR (+/-1SD).

le Negrate 1989). Global contrast factor measures the contrast at various resolutions and the original image is completely recovered after the secret data is extracted. Contrast enhancement techniques are used widely in image processing (Stark 2000). Histogram equalization overcomes this drawback by generating the mapping for each pixel from the histogram in a surrounding window. Novel histogram equalization does not allow the degree of contrast enhancement to be regulated. Linear contrast enhancement is achieved by means of a local histogram equalization which preserves the level sets of the image (Caselles et al. 1999). This technique is based on equalizing the histogram in all connected components of the image, which are defined based both on gray level values and spatial resolutions between pixels in the image.

In linear contrast enhancement technique specification which requires more input than previous transformation. Therefore, the work performance given by histogram technique has better PSNR and also less mean error than the linear contrast enhancement algorithm. It would be better if the mean error can be reduced to a considerable extent. In future, feature selection algorithms can be used to reduce the computation time and improve the PSNR of medical image enhancement.

Conclusion

The results show that the proposed histogram equalization performs better than linear contrast enhancement technique in terms of PSNR. The Proposed histogram equalization proved with better PSNR (65.9197dB) when compared with linear contrast enhancement technique (36.1190dB).

Declarations

Conflict of Interest

The authors declare no potential conflict of interest.

Authors Contribution

Author TS was involved in data collection, data analysis, manuscript writing. Author RR was involved in conceptualization, data validation, and critical review of manuscript.

Acknowledgement

The authors would like to thank the Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (formerly known as Saveetha University) management for providing us all the necessary facilities to complete this project successfully.

Funding:

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

1. Healthminds Pvt, Ltd, Bangalore.
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

References

5. Antink, Christoph Hoog, Joana Carlos Mesquita Ferreira, Michael Paul, Simon Lyra, Konrad Heimann, Srinivasa Karthik, Jayaraj Joseph, et al. 2020. "Fast Body Part Segmentation and Tracking of Neonatal Video Data Using Deep Learning." Medical & Biological Engineering & Computing 58 (12): 3049–61.
6. Beghdadi, Azeddine, and Alain le Negrate. 1989. "Contrast Enhancement Technique Based on Local Detection of Edges." Computer Vision, Graphics, and Image Processing. https://doi.org/10.1016/0734-189x(89) 90093-5.
7. Boccignone, G., and A. Picariello. n.d. "Multiscale Contrast Enhancement of Medical Images." 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing. https://doi.org/10.1109/icassp.1997.595368.
8. Caselles, V., J. L. Lisani, J. M. Morel, and G. Sapiro. 1999. "Shape Preserving Local Histogram Modification." IEEE Transactions on Image Processing: A Publication of the IEEE Signal Processing Society 8 (2): 220–30.
9. Chellapa, L. R., S. Rajeshkumar, M. I. Arumugham, and S. R. Samuel. 2020. "Biogenic Nanoselenium Synthesis and Evaluation of Its Antimicrobial, Antioxidant Activity and Toxicity." Bioinspired Biomimetic and Nanobiomaterials, July, 1–6.
10. Kaja, Rekha, Anandh Vaiyapuri, Mohamed Sherif Sirajudeen, Hariraja Muthusamy, Radhakrishnan Unnikrishnan, Mohamed Waly, Samuel Sundar Doss Devaraj, Mohamed Kotb Seyam, and Gopal Nambi S. 2020. "Biofeedback Flutter Device for Managing the Symptoms of Patients with COPD." Technology and Health Care: Official Journal of the European Society for Engineering and Medicine 28 (5): 477–85.

11. Kalidoss, Ramji, Snekhalatha Umapathy, and Usha Rani Thirunavukkarasu. 2021. "A Breathalyzer for the Assessment of Chronic Kidney Disease Patients' Breathprint: Breath Flow Dynamic Simulation on the Measurement Chamber and Experimental Investigation." Biomedical Signal Processing and Control 70 (September): 103060.
12. Kalyani, Jagriti, and Monisha Chakraborty. 2020. "Contrast Enhancement of MRI Images Using Histogram Equalization Techniques." 2020 International Conference on Computer, Electrical & Communication Engineering (ICCECE). https://doi.org/10.1109/iccece48148.2020.9223088.
13. Kanwal, Navdeep, Akshay Girdhar, and Savita Gupta. 2011. "Region Based Adaptive Contrast Enhancement of Medical X-Ray Images." 2011 5th International Conference on Bioinformatics and Biomedical Engineering. https://doi.org/10.1109/icbbe.2011.5780221.
14. Kaur, Anureet, Akshay Girdhar, and Navdeep Kanwal. 2016. "Region of Interest Based Contrast Enhancement Techniques for CT Images." 2016 Second International Conference on Computational Intelligence & Communication Technology (CICT). https://doi.org/10.1109/cict.2016.21.
15. Lavanya, M., P. Muthu Kannan, and M. Arivalagan. 2021. "Lung Cancer Diagnosis and Staging Using Firefly Algorithm Fuzzy C-Means Segmentation and Support Vector Machine Classification of Lung Nodules." International Journal of Biomedical Engineering and Technology 37 (2): 185.
16. Malaikolundhan, Harikrishna, Gowsik Mookkan, Gunasekaran Krishnamoorthi, Nirosha Matheswaran, Murad Alsawalha, Vishnu Priya Veeraraghavan, Surapaneni Krishna Mohan, and Aiting Di. 2020. "Anticarcinogenic Effect of Gold Nanoparticles Synthesized from Albizia Lebbeck on HCT-116 Colon Cancer Cell Lines." Artificial Cells, Nanomedicine, and Biotechnology 48 (1): 1206–13.
17. Padmavathy, V. S., and R. Priya. 2019. "Study on Contrast Enhancement Techniques for High Contrast and Low Contrast Images." Journal of Advanced Research in Dynamical and Control Systems. https://doi.org/10.5373/jardcs/v11sp10/20192885.
18. Paul, M., S. Karthik, J. Joseph, M. Sivaprakasam, J. Kumutha, S. Leonhardt, and C. Hoog Antink. 2020. "Non-Contact Sensing of Neonatal Pulse Rate Using Camera-Based Imaging: A Clinical Feasibility Study." Physiological Measurement 41 (2): 024001.
19. Raj R, Kathiswar, Ezhilarasan D, and Rajeshkumar S. 2020. "β-Sitosterol-Assisted Silver Nanoparticles Activates Nrf2 and Triggers Mitochondrial Apoptosis via Oxidative Stress in Human Hepatocellular Cancer Cell Line." Journal of Biomedical Materials Research. Part A 108 (9): 1899–1908.
20. Ramadoss, Ramya, Rajashree Padmanaban, and Balakumar Subramanian. 2022. "Role of Bioglass in Enamel Remineralization: Existing Strategies and Future Prospects-A Narrative Review." Journal of Biomedical Materials Research. Part B, Applied Biomaterials 110 (1): 45–66.
21. Senthilkumaran, N., and J. Thimmiaraja. 2014. "Histogram Equalization for Image Enhancement Using MRI Brain Images." In 2014 World Congress on Computing and Communication Technologies. IEEE. https://doi.org/10.1109/wccct.2014.45.
22. Shilpa-Jain, D. P., Jogikalmat Krithikadatta, Dinesh Kowsky, and Velmurugan Natanasabapathy. 2021. "Effect of Cervical Lesion Centered Access Cavity Restored with Short Glass Fibre Reinforced Resin Composites on Fracture Resistance in Human Mandibular Premolars- an in Vitro Study." Journal of the Mechanical Behavior of Biomedical Materials 122 (October): 104654.
23. S, Sudha, Kalpana R, and Soundararajan P. 2021. "Quantification of Sweat Urea in Diabetes Using Electro-Optical Technique." Physiological Measurement 42 (9). https://doi.org/10.1088/1361-6579/ac1d3a.
24. Stark, J. A. 2000. "Adaptive Image Contrast Enhancement Using Generalizations of Histogram Equalization." IEEE Transactions on Image Processing: A Publication of the IEEE Signal Processing Society 9 (5): 889–96.
25. Suralkar, S. R., and Seema Rajput. 2020. "Enhancement of Images Using Contrast Image Enhancement Techniques." International Journal Of Recent Advances in Engineering & Technology. https://doi.org/10.46564/ijraet.2020.v08i03.004.
26. Tom, Victor T., and Gregory J. Wolfe. 1983. "Adaptive Histogram Equalization And Its Applications." Applications of Digital Image Processing IV. https://doi.org/10.1117/12.965966.
27. Unal, Burak, and Ali Akoglu. 2016. "Resource Efficient Real-Time Processing of Contrast Limited Adaptive Histogram Equalization." 2016 26th International Conference on Field Programmable Logic and Applications (FPL). https://doi.org/10.1109/fpl.2016.7577362.

28. Vartak, Akshay, and Vijay Mankar. 2015. "Image Processing Techniques for Contrast Enhancement with Poor Lighting on Social and Medical Images." International Journal of Computer Applications. https://doi.org/10.5120/ijca2015905643.
29. Wu, Shuang, Shanmugam Rajeshkumar, Malini Madasamy, and Vanaja Mahendran. 2020. "Green Synthesis of Copper Nanoparticles Using Cissus Vitiginea and Its Antioxidant and Antibacterial Activity against Urinary Tract Infection Pathogens." Artificial Cells, Nanomedicine, and Biotechnology 48 (1): 1153–58.
30. Zeng, Ming, Youfu Li, Qinghao Meng, Ting Yang, and Jian Liu. 2012. "Improving Histogram-Based Image Contrast Enhancement Using Gray-Level Information Histogram with Application to X-Ray Images." Optik. https://doi.org/10.1016/j.ijleo.2011.05.017.
31. Zipporah, Miriam, and Banu N. Sharmila. 2018. "Mincut Algorithm and Adaptive Histogram Equalization (AHE) for Segmentation of Retinal Layer in OCT Images with Choroidal Neovascularization." The SIJ Transactions on Computer Science Engineering & Its Applications (CSEA). https://doi.org/10.9756/sijcsea/v6i5/06050100101.