ORIGINAL RESEARCH

Submitted: 18.09.2022; Accepted: 8.10.2022; Published online: 25.12.2022

Analysis and Comparison of Image Enhancement Technique for Improving PSNR of Lung Images by Wiener Filtering 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, Tamilnadu. India. Pincode:602105.

Abstract

Aim: The aim of this study is to compare and analyze wiener filter algorithm for lung image enhancement over novel histogram equalization technique. **Materials and Methods:**In this research, different sources of lung images collected from the kaggle website were used. Samples were considered as (N=30) for median filtering 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 median filter and novel histogram equalization technique image enhancement were implemented on lung images through Matlab coding and also extracting PSNR values of each image. Then through SPSS software comparison and analysis has been made. **Result:**. The novel histogram equalization technique showed higher results of PSNR (67.2076dB) in comparison with wiener filtering (37.1558dB). It is observed that histogram algorithm performed better than the Wiener filter (p=0.04) by performing an independent sample t-test. **Conclusion:** Within this research study the histogram equalization image enhancement technique has greater PSNR value of lung images than in wiener filtering technique.

Keywords

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

Imprint

Sabarish Raja T, Ramadevi R. Analysis and Comparison of Image Enhancement Technique for Improving PSNR of Lung Images by Wiener Filtering over Histogram Equalization Technique. Cardiometry; Special issue No. 25; December 2022; p. 832-837; DOI: 10.18137/cardiometry.2022.25.832837; Available from: http://www.cardiometry.net/issues/no25-december-2022/wiener-filtering-histogram

Introduction

Noise adaptive filtering technique containing additive white Gaussian noise was presented in the research which utilizes the wiener filter (Wang, Zhou, and Yan 2018). It uses preliminary estimation of the noise variance from unknown set of input images and relies on statistical analysis of the relatively homogenous areas in them. Its application may turn useful for multispectral analysis of CT, MRI and other types of images. In medical image processing the wiener filter has an essential role as image enhancement technique for detection and diagnosis of respiratory disorders.

There are 180 research articles published on the image enhancement to compare with different algorithms and the storage location in sciencedirect and 500 articles on Google Scholar and 60 research articles were found in IEEE xplore. Accurate detection of disorders and image enhancement of lung images leads to exact classification in CT Scan and X-ray images for medical field applications (Dougherty 2009). Histogram equalization tends to introduce some annoying artifacts and unnatural enhancement (Yang and Wu 2010). To overcome these drawbacks different brightness preserving techniques are used. Some of them are wiener filter, linear contrast enhancement technique and unsharp mask filter. Subjective parameters are visual quality and objective parameters are peak signal to noise ratio (PSNR). Wiener filtering technique is used in image restoration and assumes that if noise is present in the system, then it is considered to be additive white gaussian noise. Wiener filtering normally, requires a prior knowledge of the power spectra of the noise and the original image. Wiener filter is also optimal for enhancement of image from the noise and motion blur (Biswas, Sarkar, and Mynuddin 2015). This technique is creating an image that is less noisy than the original image. The greatest mechanization for elimination of blur in images consequent to unfocussed optics blur or linear motion is the wiener filter. Wiener filters are out of the way, the most common deblurring method used because it mathematically finds the best output. Nowadays the quality of digital medical images has become an important issue. To achieve the best diagnosis it is important that medical images should be sharp, clear, and noise free. Removal of noise is effective in medical imaging applications in order to enhance and recover very minute details which may be hidden in the data (Koundal, Gupta, and Singh, n.d.). The wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing (Zhang, Nosratinia, and Wells, n.d.) by removing the additive noise and inverts the blurring simultaneously. Wiener filter is a linear filter that provides linear estimation of a desired signal sequence from another related sequence (Cohen and Dinstein 1999). 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 which are proposed have less PSNR. The main aim of this study is to enhance lung images using novel histogram equalization technique and wiener filter algorithm to attain better PSNR.

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 wiener filter 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% (Zhou and Shui 2011). According to that, the sample size of histogram technique (N=30) and wiener filter (N=30) were calculated.

The study uses CT, X-ray, MRI lung images downloaded from kaggle. 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 lung image enhancement using wiener filtering 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 wiener filtering 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 (Shui 2005). 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 wiener filter. The mean value of PSNR (dB) of the histogram equalization is 67.2076dB and for the wiener filter is 37.1558 dB.

Table 1

Comparison of histogram equalization and wiener filter with improved PSNR of lung images. The mean value PSNR (dB) of the histogram equalization filter is 67.2076dB and for wiener filter 37.1558dB

Images	PSNR (dB) of Histogram Equalization	PSNR (dB) of Wiener filter
Image1	37.59	32.24
Image 2	36.96	35.32
Image 3	36.45	35.54
Image 4	36.32	36.26
Image 5	34.60	36.34
Image 6	42.31	36.40
Image 7	41.39	37.52
Image 8	40.55	37.60
Image 9	42.97	42.97
Image 10	42.47	41.68
Image 11	42.74	42.47
Image 12	57.54	43.62
Image 13	54.86	43.74
Image 14	59.75	45.21
Image 15	64.24	45.53

Images	PSNR (dB) of Histogram Equalization	PSNR (dB) of Wiener filter
Image 16	66.34	51.26
Image 17	69.67	52.34
Image 18	73.33	60.19
Image 19	75.34	62.56
Image 20	77.10	62.74
Image 21	77.18	65.26
Image 22	77.22	65.42
Image 23	77.27	70.58
Image 24	78.43	70.42
Image 25	78.44	72.65
Image 26	78.87	72.64
Image 27	79.38	77.35
Image 28	79.76	78.16
Image 29	79.38	78.41
Image 30	79.54	79.34

Table 2 represents group statistics that shows comparison of histogram equalization techniques of image enhancement algorithms with a wiener filter based on PSNR values. Mean value of PSNR is high (67.2076dB) for histogram equalizer and low (37.1558dB) for wiener filter. Standard deviation of PSNR is low (0.20680) for wiener filter and high (13.03304) for histogram equalizer.

Table 2

Group statistics comparison of histogram equalization of image enhancement algorithm using PSNR and wiener filter methods. Histogram equalization has a higher mean of 67.2076dB than wiener filter mean 37.1558dB. Histogram equalization has higher standard deviation 13.03304 than wiener filter 0.20680.

	Groups	N	Mean	Standard Deviation	Standard Error Mean
PSNR	Histogram Equalization	30	67.2076	13.03304	0.3776
	Wiener filter	30	37.1558	0.20680	0.3783

Table 3 represents an independent sample test of PSNR based image enhancement using histogram equalizer and wiener filter algorithms.The two tailed significance p-value is 0.04 and standard mean difference is 30.05177 with a standard error difference of 2.14296. In the test confidence interval, the lower value is (29.94479) and the upper value is (-7.11280). Based on independent sample T test results, histogram equalization based image enhancement technique performed better than wiener filtering with 95% confidence interval.

Discussion

Figure 1 represents simulation results of the wiener filter and histogram equalization algorithm. (a) Input image (X-ray chest), (b) X-ray lung image with histogram equalization restored X- ray image, (c) Wiener filter on X-ray lung image and (d) Intensities analysis of wiener filter over histogram equalization (X-ray lung image).

Figure 2 shows bar chart comparison of mean PSNR (+/-2 SD) of histogram equalization and wiener filter methods. X-Axis represents the histogram equalization vs wiener filter,Y-Axis represents Mean (+/- 2 SD).

The Wiener filtering is a linear estimation of the original image. It removes the additive noise and inverts the blurring simultaneously. The Wiener filtering is optimal in terms of the mean square error (A.Gajdhane et al. 2014). In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing (Saluja and Boyat 2015). Wiener filtering is a commonly used algorithm for recovering degraded images. It is also the earliest and most well-known linear image restoration method. The design idea of this method is to multiply the input signal by the output after the response, and the mean squared error of the desired output is minimum (Fan, Xiao, and Xiao 2019). Wiener filter is favored as it has the lowest noise related peak signal and is mainly used in the development of digital images (Petkova and Draganov 2020). It is often used by linear invariant methodology in the deconvolution method to reduce noise. This tests the stationary signal, spectrum of sound, and noise additives which are identified and eliminated (Vidhyalakshmi and Priya 2020). The iterative wiener filter, to update the covariance estimates, is investigated. The convergence properties of this iterative filter are analyzed. It has been shown that this iterative process converges to a signal which does not correspond to the minimum mean-squared-error solution (Hillery and Chin 1991).

In the wiener filter, it is very difficult to estimate the power spectra and also to obtain perfect restoration for the random nature of noise. Therefore, the work performance given by histogram technique has better PSNR and also less mean error than the wiener filter 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.

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 (dB)	Equal variances assumed	0.137	0.02	562.302	58	0.04	30.05177	2.14296	29.94479	-7.11280
	Equal Variances not assumed			562.302	58.00	0.04	30.05177	2.14296	29.94479	-6.93559

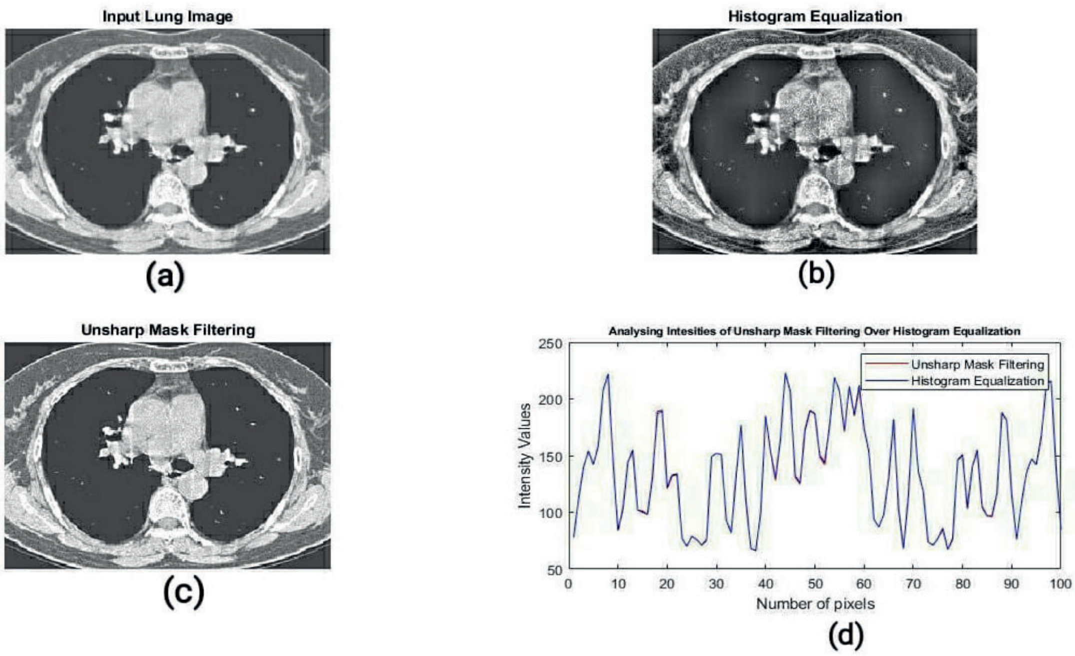

Fig. 1. Simulation results of wiener filter and histogram equalization algorithm. (a) Input image (X-ray chest), (b) Histogram equalization restored image, (c) Wiener filter on X-ray image and (d) Intensities analysis of wiener filter over histogram equalization (X-ray image)

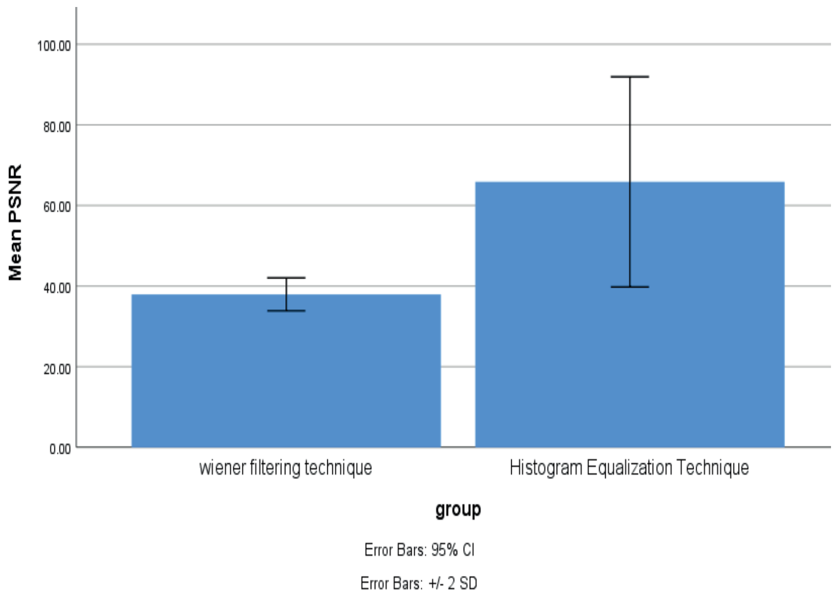

Fig. 2. Bar chart representing the comparison of mean PSNR (+/-2 SD) of histogram equalization and wiener filter methods. X-Axis represents the histogram equalization vs wiener filter, Y-Axis represents mean PSNR (+/-2 SD).

Conclusion

The results show that the proposed novel histogram equalization method performs better than wiener filter in terms of PSNR. The Proposed histogram equalization proved with better PSNR (67.2076dB) when compared with wiener filtering (37.1558dB).

Declaration

Conflict of interests

No conflict of interest in this manuscript.

Authors Contributions

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

Acknowledgments

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

References

1. A.Gajdhane, Mr Vijay, Mr Vijay A. Gajdhane, Dept. of Electronics and Tele-communication Engineering, TPCT's College of Engineering, Osmanabad, Maharashtra, India, and L. M. Deshpande. 2014. "Detection of Lung Cancer Stages on CT Scan Images by Using Various Image Processing Techniques." IOSR Journal of Computer Engineering. https://doi.org/10.9790/0661-16532835.
2. 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.
3. Biswas, Prodip, Abu Sufian Sarkar, and Mohammed Mynuddin. 2015. "Deblurring Images Using a Wiener Filter." International Journal of Computer Applications. https://doi.org/10.5120/19203-0846.
4. 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.
5. Cohen, Beny, and Its 'hak Dinstein. 1999. "Image-Resolution Enhancement by Polyphase FIR Wiener Filtering." Applications of Digital Image Processing XXII. https://doi.org/10.1117/12.365862.
6. Dougherty, Geoff. 2009. Digital Image Processing for Medical Applications. Cambridge University Press.
7. Fan, Wen-quan, Wen-shu Xiao, and Wen-shu Xiao. 2019. "Image Denoising Based on Wavelet Thresholding and Wiener Filtering in the Wavelet Domain." The Journal of Engineering. https://doi.org/10.1049/joe.2019.0194.
8. Hillery, A. D., and R. T. Chin. 1991. "Iterative Wiener Filters for Image Restoration." IEEE Transactions on Signal Processing: A Publication of the IEEE Signal Processing Society 39 (8): 1892–99.
9. 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.
10. 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.
11. Koundal, Deepika, Savita Gupta, and Sukhwinder Singh. n.d. Applications of Neutrosophic Sets in Medical Image Denoising and Segmentation. Infinite Study.
12. 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.

13. 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.
14. 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.
15. Petkova, Lora, and Ivo Draganov. 2020. "Noise Adaptive Wiener Filtering of Images." 2020 55th International Scientific Conference on Information, Communication and Energy Systems and Technologies (ICEST). https://doi.org/10.1109/icest49890.2020.9232887.
16. 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.
17. 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.
18. Saluja, Rubi, and Ajay Boyat. 2015. "Wavelet Based Image Denoising Using Weighted Highpass Filtering Coefficients and Adaptive Wiener Filter." 2015 International Conference on Computer, Communication and Control (IC4). https://doi.org/10.1109/ic4.2015.7375588.
19. 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.
20. Shui, Peng-Lang. 2005. "Image Denoising Algorithm via Doubly Local Wiener Filtering with Directional Windows in Wavelet Domain." IEEE Signal Processing Letters. https://doi.org/10.1109/lsp.2005.855555.
21. 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.
22. Vidhyalakshmi, A., and C. Priya. 2020. "Image Enhancement of Metastasis and Acrometastasis Images Using Clahe with Weiner Filter." In 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA). IEEE. https://doi.org/10.1109/iccsea49143.2020.9132947.
23. Wang, Min, Shudao Zhou, and Wei Yan. 2018. "Blurred Image Restoration Using Knife-Edge Function and Optimal Window Wiener Filtering." PloS One 13 (1): e0191833.
24. 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.
25. Yang, Fan, and Jin Wu. 2010. "An Improved Image Contrast Enhancement in Multiple-Peak Images Based on Histogram Equalization." 2010 International Conference On Computer Design and Applications. https://doi.org/10.1109/iccda.2010.5540857.
26. Zhang, H., A. Nosratinia, and R. O. Wells. n.d. "Image Denoising via Wavelet-Domain Spatially Adaptive FIR Wiener Filtering." 2000 IEEE International Conference on Acoustics, Speech, and Signal Processing. Proceedings (Cat. No.00CH37100). https://doi.org/10.1109/icassp.2000.859269.
27. Zhou, Zuo-Feng, and Peng-Lang Shui. 2011. "Wavelet-Based Image Denoising via Doubly Local Wiener Filtering Using Directional Windows and Mathematical Morphology." Journal of Electronics & Information Technology. https://doi.org/10.3724/sp.j.1146.2006.01453.