Dithering techniques and segmentation analysis on a mammogram breast cancer image

Saravanan S. [1], Aravind Britto K. R.[2], Sandeep Kumar M.[3], Prabhu J.[3] and Sathishkumar V. E.[4]

[1]Department of CSE, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai.
[2]Department of ECE, PSNA College of Engineering and Technology, Dindigul.
[3]School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India.
[4]Department of Industrial Engineering, Hanyang University, Seoul, 04763, South Korea.

sathishkumar@hanyang.ac.kr

Abstract. The objective of the publishing industry is to minimize the number of colors in an image for printing. Also, to retain the better quality from the picture, some useful techniques are needed with the aid of only a few colors. The contouring consequences occur when an image quantized bluntly regardless of the quantization, either uniform or non-uniform. To alleviate the issues of contouring, a slight amount of random noise is added (dithered) to the original image, followed by the quantization method. The methods such as dithering and half toning are extensively used strategies in acquiring texts and pictures in books, newspapers, magazines, computer monitors, and LCDs. This article investigates the dithering technique on a mammogram image with different procedures, such as dithering followed by quantization and dithering, quantization followed by filtering are detailed with Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) results. For better visualization, segmentation techniques are applied to the dithering technique.

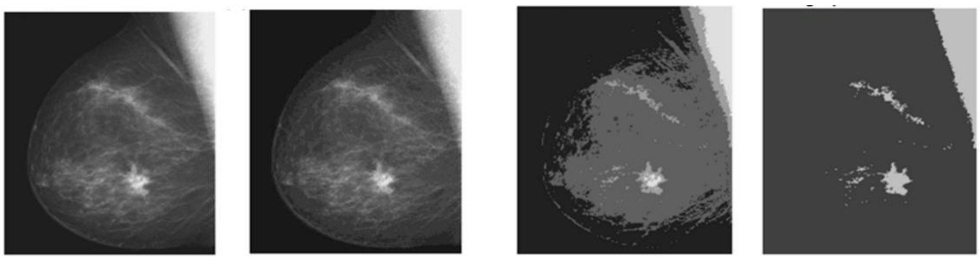
Keywords: dithering, filtering, mammogram, Matlab, MSE, PSNR, segmentation.

1. Introduction

At present, digital image processing (DSP) turns into an indispensable technology in almost all critical biomedical science and engineering era [1]. Likewise, the mix, such as signal, image, and video processing methods, are broadly exploited in all fields of science and engineering. Mainly, techniques such as data compression, digital filtering, enhancement, segmentation, fast Fourier transform, discrete cosine transform, restoration, convolution, and pattern recognition techniques are predominantly applied in facets of the biomedical engineering domain [2]. Nowadays, images appear routinely in everyday printed items such as books, magazines, newspapers, fax documents, printer outputs, computer monitor outputs, and LCDs. Likewise, in the current Internet generation, the images do repeatedly arise over web pages and multimedia forms [3]. Besides the Internet, digital storage media such as DVD and CD-ROM do usually accommodate images, pictures, video frames in different

© 2023 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

formats [4]. Digital image half toning is a broadly ratified method in numerous realistic applications. However, acquiring high fidelity tone reproduction and underlying storage with fewer computing resources and lesser time undergo a difficult problem [5]. This study mainly focuses on the dithering technique x-ray image of the breast, which is so-called "mammogram". Images from x-rays can be obtained using the following methods [6]: Computed radiography, plain (film-screen) radiography, Computed tomography, Mammography, Fluoroscopy and digital subtraction angiography. Generally, the process of reducing the total number of colors in an image refers to dithering. This study dealt with only the grayscale dithering to improve the appearance of an accomplished grayscale image. Dithering is unavoidable occasionally for display if the picture must be presented with a limited number of colors on equipment. Particularly, newspapers do contain only black (considering 0) and white (considering 1) colors to display an image, which is so-called "half toning" [7]. As a real-time example, in cell phones, the actual 24-bit RGB color image is reduced to an 8-bit RGB format. In dithering, by adding noise, the undesirable bands can be discarded [8]. To preserve the most information, for better results, the most natural noise such as Gaussian noise can be added due to random samples, seek the normal distribution. As a result of quantization, during the storage of data, the image intensities occur as contours both in 1-D and 2-D signals. For instance, the false contouring would rise in 2-D images, as shown in Figure 1.



(a) (b) (c) (d)

Figure 1. (a) quantized to 8 bits; (b) quantized to 4 bits; (c) quantized to 2 bits; (d) quantized to 1 bit

Digital half-toning and dithering techniques are fruitful in day-to-day applications like animations, video games, computer graphics, print productions (from the publishing industry), etc. For instance, animations are considerably fewer demanding resources than videos [9]. With the aid of half toning, the black and white images can be produced quickly from continuous tone images [10]. The applications of half toning are outlined as follows: (a) Laser/ink-jet printers (images/text), (b) Low-cost LCDs (images/videos), (c) Image and video compression. The rest of the paper is formulated as follows: Section 2 contains the materials and methods involved in quantization, dithering (with/without subtraction) followed by filtering (lowpass/highpass), patterned dithering, and error diffusion methods on a mammogram image. Simulation results (MSE, PSNR) and discussion are obtained in Section 3. The conclusions are described finally in Section 4.

2. Materials and methods

The introduction to dithering technique followed by the implementation of different dithering techniques is detailed in this section. All the examples with interpretations on digital image dithering are drawn in this section.

2.1. Dithering

Every pixel in a digital image adds a quantization error. To improve the quality of such a digital image, the quantized error can be scattered, which can be achieved by adding random noise before quantization. The local quantization errors can be reduced by the dithering, which is common in both the analog and digital domains. In signal, image, and video processing and control systems, dithering techniques are extensively implemented to alleviate the following issues [11]: (a) Nonlinearity, (b) Static rasping, (c) Hysteresis, (d) Quantization and (e) Gear fallout.

2.2. *Implementation of different dithering methods*

2.2.1. Quantized and Lowpass filtered. Since the performance metric results such as the mean-square error (MSE) and a peak signal-to-noise ratio (PSNR) of the quantized image have poor values, and the filtering technique is applied to enhance the performance. As illustrated in Figure 2, the input image is quantized before lowpass filtering. The lowpass filtering kernel used here is:

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix} \tag{1}$$

The results of quantized (4-bits, 2-bits, and 1-bit) and lowpass filtered images are shown in Figure 3. The lowpass filter is applied here to retain the overall information of the picture.

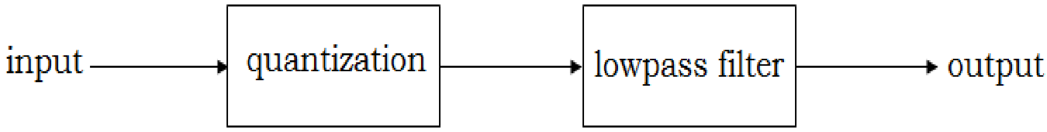


Figure 2. The schematic on: quantized, and lowpass filtering.

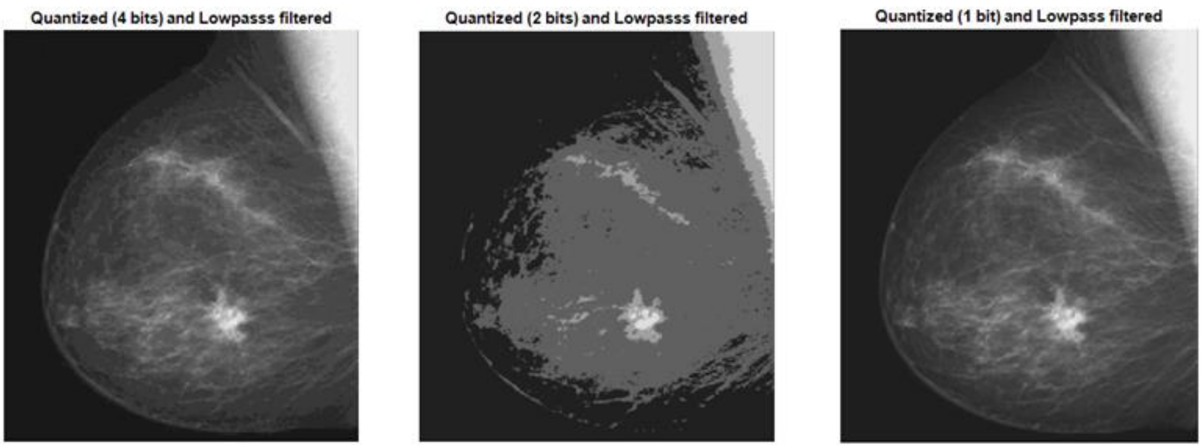


Figure 3. Results of quantized, lowpass filtered images.

2.2.2. Quantized and Highpass filtered. Similarly, the high-pass filtering is applied after quantization, and the results of quantized (4-bits, 2-bits, and 1-bit) and highpass filtered images are obtained from equation 2[12]. The highpass filter is applied here to retain the details (edges) of the picture. The highpass filtering kernel used here is:

$$\left(\frac{1}{10}\right) * \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix} \tag{2}$$

2.2.3. Dithered and quantized. The pseudo-noise is added to the input image prior to quantization. The pseudo-noise can be subtracted from the dithered, quantized output to enhance the resulting previous result. The results of dithered and quantized (4-bits, 2-bits, and 1-bit) images are shown in Figure 4.

DOI: 10.54254/2755-2721/6/20230536

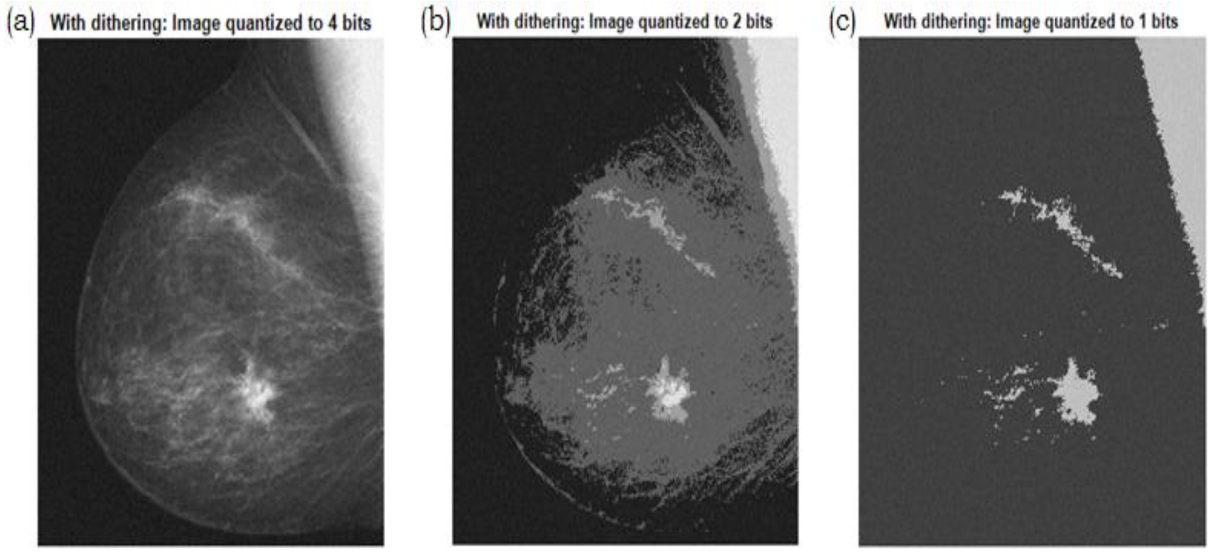


Figure 4. Results of dithered, quantized images.

3. Results and discussion

3.1. Results on quantization; dithered and quantized output

The PSNR values (MSE) are higher (lower) for higher bits quantization; an identical movement appears in the course of dithered and quantized action (with the inclusion of subtraction) (refer Table 1). It is noticeable from the tables that modest growths (superior metrics) are built with dithering and quantization with subtraction included. For example, with 8-bits, the quantized image offers a PSNR value of 25.9784 dB, whereas the dithered, quantized (with subtraction) offers a PSNR value of 31.7848.

Table 1. Simulation results on dithered and quantized method.

Bits of Quantization	subtraction		no subtraction	
	MSE	PSNR (dB)	MSE	PSNR (dB)
8 bits	0.1639	31.7848	21.73	10.6261
7 bits	0.4006	27.9137	21.7109	10.6126
6 bits	1.3970	22.4252	23.2537	10.2971
5 bits	5.3748	16.6449	27.0244	9.6792
4 bits	21.3297	10.7005	48.3443	7.0835
3 bits	99.5213	3.9478	140.9065	2.4377
2 bits	287.6002	–0.6609	303.4564	–0.8940
1 bit	748.3916	–4.8143	733.0750	–4.7245

3.2. Simulation results on quantized and lowpass/high pass filtered method

The MSE and PSNR results of the quantized, lowpass filtered and the quantized, highpass filtered (see Table 2) are drawn here. A similar trend appears here too, i.e., better (poor) results are obtained for lower (higher) bits quantization.

Table 2. Quantized and lowpass and highpass filtered results.

Bits of Quantization	MSE		PSNR (dB)	
	Lowpass	Highpass	Lowpass	Highpass
8 bits	10.3706	1431.9	13.7689	–0.0118
7 bits	10.8413	1441.7	13.5762	–0.0416
6 bits	10.8223	1487.1	13.5838	–0.1944
5 bits	12.7499	1662.9	12.8719	–0.7164
4 bits	25.8278	2278.5	9.8061	–2.1589
3 bits	90.7024	3727	4.3508	–4.1481
2 bits	213.4867	6689.3	0.6333	–6.9893
1 bit	675.5848	5182.7	–4.3698	–6.1007

3.3. Experimental results on dithered, quantized, and low pass/high pass filtered method

It is noticeable from the experimental results (see Table 3) that improved performance metric results are produced with the inclusion of the dithering technique. Due to the behavior of a highpass filter (allowing noisy components), the dithered, high-pass filtered images obtain poor PSNR values. Obviously, results are better (lower) for lower (higher) bit quantization. For example, with 4-bits quantization, dithering, lowpass filtered (no dithering, lowpass filtered) output produces a better (poor) MSE value of 13.3629 (25.8278).

Table 3. Results on dithered, quantized, and lowpass and highpass filtered method.

Bits of Quan-tization	MSE (subtraction)		PSNR (db)		MSE (no-subtraction)		PSNR (db)	
	Low	High	Low	High	Low	High	Low	High
8 bits	10.4057	1446.5	13.7543	–0.0402	13.423	3324.1	12.6485	–3.7613
7 bits	10.5014	1460.3	13.7145	–0.0710	13.4643	3353.4	12.6351	–3.7364
6 bits	10.6267	1550.8	13.663	–0.3190	13.6813	3404.3	12.5657	–3.8490
5 bits	11.1796	1905.3	13.4427	–1.1493	14.1734	3789.4	12.4122	–4.0092
4 bits	13.3629	3335.1	12.668	–3.7272	17.1491	4735.8	11.5846	–5.1174
3 bits	31.8562	9344.5	8.895	–8.3475	37.4289	9480.3	8.1949	–8.1953
2 bits	159.3668	14909	1.903	–10.4243	161.3248	17378	1.85	–11.0217
1 bit	668.4554	9836.6	–4.3238	–8.8732	665.3605	15179	–4.3036	–10.7943

4. Conclusion

The sole motive of this article is to aid in diagnosing breast cancer in a better way for the clinicians. The elaborative techniques on dithering followed by a segmentation technique would help a lot on biomedical images, by considering reasonably fewer resources to retain the details of the information (due to dithering). As a future work, instead of a pseudo-noise, even the quantization noise in appropriate resolution stages can be added for better results. Also, this work can further be encouraged in all other disciplines of science and engineering.

5. Future scope

As we know that when an image is quantized then the image contains some blocking artifacts that are introduced after the quantization process. So, the dithering technique helps to remove the effects after

DOI: 10.54254/2755-2721/6/20230536

the quantization process. Since the noise is added, there will be a poor performance with the higher MSE. Hence, for better performance, we will keep a filter at the end. So, by this, the PSNR metric can be improved. This can be further extended for the color images. This work can be further extended to other domains such as brain signal processing and analysis, automatic detection and diagnosis of neurological diseases, pattern recognition, machine learning.

References

[1] Alan C. Bovik, 2009. The Essential Guide to Image Processing. Academic Press.
[2] Alasdair McAndrew, 2015. A Computational Introduction to Digital Image Processing. Second Edition, CRC Press.
[3] Arpitam Chatterjee, Bipan Tudu, and Kanai Ch. Paul, 2011. Binary genetic algorithm-based pattern LUT for grayscale digital half-toning. Signal, Image and Video Processing, 7: 377–388.
[4] Bernard Widrow and Istvan Kollar, 2008. Quantization Noise: Roundoff Error in Digital Computation, Signal Processing, Control, and Communications. Cambridge University Press.
[5] Fan Zhang and Xinhong Zhang, 2019. Image inverse halftoning and descreening: a review. Multimedia Tools and Applications, 15: 21021–21039.
[6] Easwaramoorthy, S., Moorthy, U., Kumar, C. A., Bhushan, S. B., & Sadagopan, V. (2017, January). Content based image retrieval with enhanced privacy in cloud using apache spark. In International Conference on Data Science Analytics and Applications (pp. 114-128). Springer, Singapore.
[7] L. Yue, P. Ganesan, B.S. Sathish, C. Manikandan, A. Niranjan, V. Elamaran, and A.F. Hussein, 2019. The importance of dithering technique revisited with biomedical images-A survey. IEEE Access, 7: 3627–3634.
[8] Ling-yue Liu, Wei Chen, Tien-tsin Wong, Wen-ting Zheng, and Wei-dong Geng, 2013. An improvement parallel contrast-aware halftoning. Journal of Zhejang University - Science C (Computers & Electronics), 14: 918–929.
[9] Easwaramoorthy, S., Sophia, F., & Prathik, A. (2016, February). Biometric Authentication using finger nails. In 2016 international conference on emerging trends in engineering, technology and science (ICETETS) (pp. 1-6). IEEE.
[10] Ming Sun Fu and Oscar C. Au, 2001. Data hiding in ordered dithered halftone images. Circuits Systems Signal Processing, 20: 209–232.
[11] Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, 2004. Digital Image Processing Using MATLAB. Prentice Hall, Upper Saddle River, New Jersey.
[12] Sathishkumar, V. E., Park, J., & Cho, Y. (2020). Using data mining techniques for bike sharing demand prediction in metropolitan city. Computer Communications, 153, 353-366.