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Enhancing Mammographic Imaging: A Novel Multiscale Morphological Approach

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Accurate interpretation of mammographic images is crucial for the early detection and diagnosis of breast cancer. Unfortunately, the quality of these images is often compromised by noise, low resolution, and insufficient contrast, hindering the identification of key features such as microcalcifications and increasing the risk of misdiagnosis or the need for repeat examinations. This work introduces an innovative approach for the enhancement of mammographic images through the Multiscale Top-Hat Transform by Reconstruction (MTHR), a multiscale morphological method that significantly improves clarity, contrast, and visibility of important structures while maintaining the integrity of essential information. Unlike existing techniques such as [2], MTHR extracts and maximizes multiple features, using top-hat transform by reconstruction to add bright areas and subtract dark zones to enhance contrast and fine details. The results obtained surpass several state-of-the-art contrast enhancement algorithms, demonstrating significant improvements in clarity and visibility of key structures.

For the evaluation of our Multiscale Top-Hat Transform by Reconstruction (MTHR) method, we conducted tests with 24 mammographic images from a public database [1]. MTHR was compared against a range of established algorithms: MSTH [2], Quadri-histogram equalization using cutoff limits based on the size of each histogram with preservation of average brightness (QHELC), CLAHE, HE, and MMBEBHE. We utilized four objective image processing metrics for a comprehensive evaluation. These metrics, applied to the enhanced images, include Peak Signal-to-Noise Ratio (PSNR) for assessing image quality, Entropy (E) for the amount of information, Absolute Mean Brightness Error (AMBE) for changes in brightness, and Contrast Enhancement Coefficient (REC) for contrast improvement.

The average results for each algorithm are shown in Table 1, with the top two highlighted in bold. The MTHR algorithm demonstrates strong performance in PSNR, E, and AMBE metrics, enhancing image quality, contrast, and brightness. The QHELC algorithm excels in PSNR, while CLAHE performs well on the E metric. Overall, except for HE, all algorithms improve contrast based on the REC metric. Unlike the compared methods, this method is competitive across all metrics, not just some, as state-of-the-art methods typically are.

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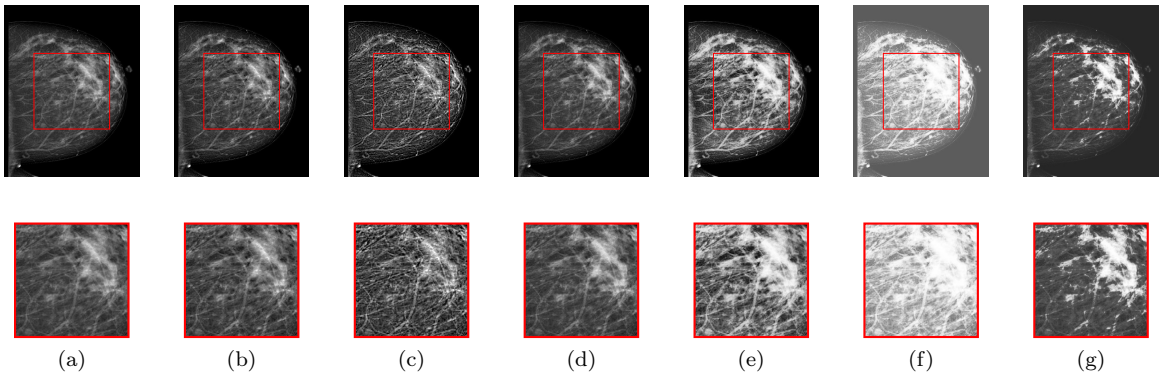
Table 1: Average results obtained by the algorithms.

Algorithms	PSNR	E	AMBE	REC
MTHR	**37,74161**	**4,66137**	**0,15048**	1,00551
MSTH	25,07077	4,64947	1,41399	1,02825
QHELC	**37,85387**	4,63960	**0,87624**	1,01209
CLAHE	18,77954	**5,01097**	16,23378	**1,10462**
HE	6,82707	4,42640	118,73309	0,96936
MMBEBHE	16,74060	4,39742	24,65631	**1,06071**

Additionally, representative images are included in the Figure 1, showing the original image and the enhancements achieved with each of the analyzed algorithms. These visual comparisons highlight the improvements in clarity, contrast, and visibility of key structures in mammographic images, underscoring the efficacy of MTHR compared to existing methods.



(a) (b) (c) (d) (e) (f) (g)

Figure 1: (a) Original Image [1], (b) MTHR, (c) MSTH, (d) QHELC, (e) CLAHE, (f) HE, (g) MMBEBHE.

Through these numerical results and visual comparisons, we demonstrate the effectiveness of MTHR in enhancing the quality of mammographic images compared to existing methods, establishing a new standard for image enhancement in this critical field.

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