Abstract — Breast cancer is a dangerous disease for women worldwide. X-ray mammograms are typically used by radiologists for diagnosis of early-stage breast cancer to reduce the risk of mortality. In many cases they are not easy to be analyzed because mammograms are low contrast and very noisy. This paper proposes improved contrast enhancement and adaptive denoising in mammograms. First, mammograms are decomposed using discrete wavelet transform. Detail subbands are then boosted to increase a global contrast. However it makes noisy mammograms though the contrast improved. The difference between the original mammograms and noisy mammograms is used to identify spatial noise location in the detail subbands. The localized noises are finally suppressed adaptively. The experimental results show higher PSNR than the conventional method while keeping high contrast.

Index Terms — Contrast Enhancement, Image Denoising, Wavelet Transform, Mammograms.

I. INTRODUCTION

Breast cancer is top cancer in women worldwide and is increasing in developed and developing countries. In the united state, breast cancer is the second cause of death. The National Cancer Institute [1] estimates about 12% of women in united state will develop invasive breast cancer in their lives and about 3% of women’s death by breast cancer. Currently, there are survivors of breast cancer as a result of the early detection and improved treatment. Screening mammography is costly and effective for the early-state detection. Thus, the early detection of breast cancer is essential to reduce the risk of mortality of breast-cancer patients. In many cases, however, they are not easy to be diagnosed because digitized mammograms are low contrast and noisy that may be a cause of diagnosis error. Improvement of contrast in mammograms is important to reduce the error rates from radiologists and to make the patients treated correctly.

Digital image processing is useful techniques to solve low contrast problem in mammograms. There are several methods in digital image processing that are used to improve the contrast in mammograms, for example, direct contrast enhancement and indirect contrast enhancement. In this paper, we investigate direct contrast enhancement technique which is based on discrete wavelet transform to enhance contrast and suppress noises in mammograms.

In the previous works, Panetta et al. [2] proposed nonlinear unsharp masking for mammogram enhancement. The unsharp masking has a good performance in enhancement of mammographic details included with noises. The performance of linear unsharp masking (NLUM) to enhance mammograms was improved by combination of the nonlinear filtering and unsharp masking techniques. The NLUM can enhance the contrast of specific regions, objects and details. Wu et al. [3] developed unsharp masking method based on an improved high-pass filter which the filter is improved using a new convolution template. This method can enhance image edges by using low enhancement factor and can reduce noises appearing in image background.

Furthermore, Singh [4] proposed retrieval technique for image enhancement analysis and classification of mammograms using histogram, statistical, wavelet coefficients and spectral feature. The efficiency of this technique is increased by using suspicious regions’ shape classification. Sarge et al. [5] developed histogram technique to modified contrast limited adaptive histogram equalization (HMCLAHE) to adjust the level of contrast which give higher contrast and preserve more local information of the original image than classic histogram equalization method. Zhang et al. [6] proposed adaptive bilateral filter (ABF) which can be able to smooth noises, while enhance edges and textures in the image.

Recently, Bouyahia et al. [7] proposed enhancement methods for mammograms by using wavelet transform and wavelet packets. The wavelet packets transform can detect