Development of techniques and methods for evaluation of quality of scanned image in mammography

Priscila do Carmo Santana, Maria S. Nogueira∗

Development Centre for Nuclear Technology (CDTN / CNEN - MG), Rua Mário Werneck, s/n, Cidade Universitária- Pampulha, Belo Horizonte, Brazil.

Abstract. Cancer is the second cause of death in the Brazilian female population and breast cancer is the most frequent neoplasm amongst women. Mammography is an essential tool for diagnosis and early detection of this disease. In order to be effective, the mammography must be of good quality. The Brazilian College of Radiology (CBR), the National Agency for Health Surveillance (ANVISA) and international bodies recommend standards of practice for mammography. Due to the risk of ionizing radiation, techniques that minimize dose and optimize image quality are essential to ensure that all women are submitted to mammography procedures of high quality for the detection of breast cancer. In this research were analyzed components of the image treatment via digital and developed methods and techniques of analysis aiming the detection of structures for medical diagnosis, decreasing variations due to subjectivity. It used free software Image J, to make the evaluations of the information contained in the scanned images. We use the scanned images of calibration of a simulated breast to calibrate the program Image J. Thus, it was able to correctly convert the values of the scale of shades of gray in optical density values of presenting the standard deviation for each measure held. Applying the test t-student noticed that the values obtained with the digital system to the level of contrast and spatial resolution are consistent with the results obtained so subjective, since there was no significant difference (p <0.05) for all comparisons evaluated. Since then, this methodology is recommended in routine evaluations of services of mammography.

KEYWORDS: mammography, image in mammography, spatial resolution.

1. Introduction

Cancer is the second cause of death in the Brazilian female population and breast cancer is the most frequent neoplasm amongst women. Mammography is an essential tool for diagnosis and early detection of breast cancer if it is provided as a very good quality service. [1]

The Brazilian College of Radiology (CBR), the National Agency for Health Surveillance (ANVISA) and international bodies recommend standards of practice for mammography [2]. Due to the risk of ionizing radiation, techniques that minimize absorbed dose and optimize the quality of the diagnostic image are essential to ensure that all women are submitted to high quality mammography procedures for the detection of breast cancer. It is unacceptable that a small curable cancer would not be identified due to the low quality of a mammographic exam. [3]

A good quality mammography service cannot be considered as one if it is not able to register with high definition and contrast the normal and abnormal breast structure details. The performance of the equipment, the radiographic techniques (including breast positioning and compression) and the film processing have direct influence on image quality in mammography. Minas Gerais state has about 1,460,000 women among the population; it is estimated that 47% of those women are undergone to routine mammography. [4]

• Presenting author, E-mail: mnogue@cdtn.br
The Sanitary Vigilance of Minas Gerais (VISA/MG) and the Development Centre for Nuclear Technology (CDTN) have established and maintained a jointly program for evaluating the quality of mammographic services in Minas Gerais state. Image quality evaluations are performed by adopting the Brazilian Radiology Council (CBR) protocol and a physical breast phantom with specific objects like fibers, masses and details for low and high contrast (Fig. 1).

**Figure 1:** Details of the physical breast phantom used in VISA/MG-CDTN Mammography Program. [5].

The breast phantom consists of three Plexiglas plates of 10x120x160 mm³ and one Plexiglas plate of 20x120x160 mm³ that contains a 5x70x140 mm³ inserted wax and a stepwedge that produces five optical densities to assess image contrast. The inserted wax embeds the following structures: four brass meshes of 4, 6, 8 and 12 lp/mm to evaluate spatial resolution; five groups of Al₂O₃ specks of 0.45, 0.35, 0.30,0.25 and 0.18 mm grain sizes to simulate microcalcifications; eight polyester discs of 6 mm diameter and 0.1 to 0.8 mm thickness range to simulate low contrast areas; six nylon fibers of 1 cm length and 1.4, 1.2, 0.8, 0.7, 0.6 and 0.4 mm diameters to simulate fibrils; and five nylon spherical caps of 2.00, 1.5, 1.0, 0.75 and 0.50 mm heights to simulate tumor-like masses (Fig. 1). The limiting values to the visualization of these structures are: the mesh of 12 lp/mm, the Al₂O₃ speck group of 0.25 mm grain size, the 0.2 mm thickness polyester disc (1.5% contrast), the nylon fiber of 0.7 mm diameter and the 0.75 mm height tumor-like mass. Each limiting value achieved in the phantom image received one point in the final quality score.[5] Absorbed doses were determined by calibrated thermoluminescent dosimeters on the phantom during radiation exposures; the phantom and an example of the obtained image is shown in Fig.2.

**Figure 2.** Details of the dosimetric card (left) and phantom (right) used in the tests.
The aim of this work was to develop a technique to evaluate the image quality parameters by means of the ImageJ free software. Evaluation results were compared to the routine procedure adopted by the VISA/MG-CDTN program.

2. Methodology

In this work, 126 images from the 134 and 469 breast phantoms were digitalized by a very reproducible Scanion Express A3 USB scanner in the transmission mode with 90 dpi resolution. Images were analyzed by a ImageJ free-software with the FFT tools to evaluate the amount of visible grids and with Calibrate tool to measure the grayscale of the contrast index.

The grayscale values were exactly converted to uncalibrated optical densities by means of the uncalibrated OD ImageJ function with the following equation: Uncalibrated OD = log10(255/PixelValue).

Image definition was analyzed by means of the Fourier transform -FFT ImageJ tool that applies the Fourier transform to deconvulate the signal into its frequency and amplitude components. The result of the FFT application is a deconvulated image without values which it requires a subjective analysis.

The VISA/MG-CDTN program often gets the contrast index by means of a densitometer that measures the density of phantom image films from the inspected services; image resolution is assessed by means of a lens to identify the grids for 4 image definition standards. Image definition is evaluated in a subjective way.

Results of both the VISA/MG-CDTN program and our work were compared.

3. Results and Discussion

Density curves that were obtained by ImageJ (our work) and the densitometer (VISA/MG-CDTN program) were different; a calibration curve (Fig. 3) between both results was plotted for comparison purpose. Fluctuation in the results of the index contrast calibration curve is shown in Figure 4.

Results in Figures 3 and 4 showed that for optical densities higher than 2 the scanner has high fluctuations that make the results unreliable.

Figure 3. Values of the index contrast of the scanned images using as reference values of the reading with densitometer.

\[ y = -0.34475 \times \tanh\left(\frac{0.27253-x}{0.26349}\right)+0.86428 \times (x)+0.95157 \]
4. Conclusion

Results of the contrast index evaluation suggested that it is advisable that the methodology should be improved in order to reduce the associated uncertainty; the influence of the film type and manufacturer may be investigated, for example, during the digitalization process.
Concerning the identification of the amount of visible grids, it was concluded that it is needed to achieve values of the Fourier transform that establish actual limits and, consequently, reliable results.

The work is to be continued by evaluating the breast phantom objects like masses, fibers and microcalcifications. A plug-in is also expected to be developed in the software in order to get values related to the image resolution which they would enable limits to be established.

5. References


