A COMPARATIVE STUDY OF COMPUTER ASSISTED ASSESSMENT OF IMAGE QUALITY INDEX FOR MAMMOGRAPHIC PHANTOM IMAGES

P. Mayo*, F. Rodenas**, G. Verdú*, J. I. Villaescusa***, J. M. Campayo****

* Chemical and Nuclear Engineering Department, Polytechnic Univ. of Valencia, Camino de Vera s/n 46022-Valencia, Spain

** Applied Mathematics Department, Polytechnic University of Valencia, Camino de Vera s/n 46022-Valencia, Spain

*** Radiological Protection Unit, Hospital Universitario La Fe, Avenida Campanar 21, 46009-Valencia, Spain

**** Radiophysical and Radiological Protection Unit, Hospital Clinico, Avenida Blasco Ibañez 17, 46010-Valencia, Spain

Abstract- Mammographic phantom images are usually used to study the quality of images obtained by a determined mammographic equipment. The digital image treatment techniques allow carrying out an automatic analysis of the phantom image. In this work we apply some techniques of digital image processing to compute a specific image quality index (IQI) for a mammographic phantom, namely the CIRS model 11A version SP01. The designed algorithm analyses the phantom image by means of an automatic detection of the number of microcalcifications and the image resolution as the number of line pairs per millimetre, then the IQI is calculated from a scoring system. We also study the manner in which the functioning conditions (KV and mAs) of the mammographic equipment and the preprocessing denoising method of the digital image affect the results for the IQI.

INTRODUCTION

The image quality assessment of a mammographic phantom of reference image is one of the fundamental points in a complete quality control programme of a mammographic equipment. The good functioning result of all the process must be a mammographic image with an appropriate quality to carry out a suitable diagnostic using the smallest radiation dose as possible [1-3].

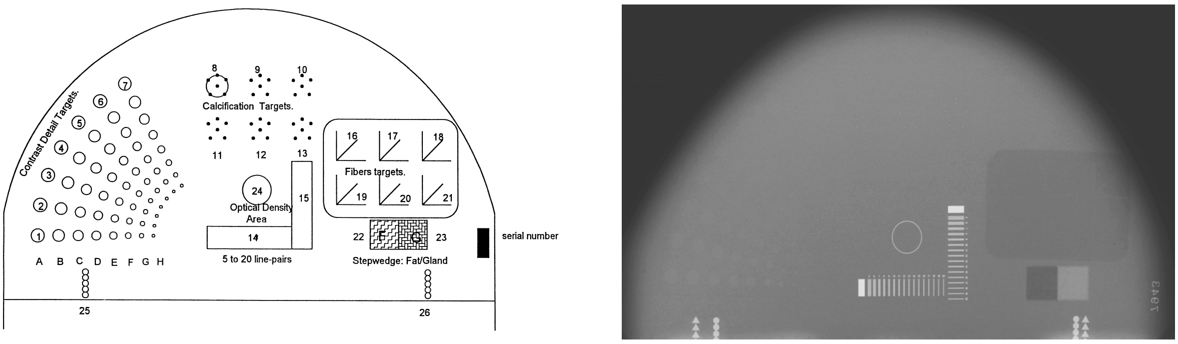
We are developing the analysis of the mammographic phantom image quality by means of automatic process techniques**.** The digital image analysis provides information about the phantom test objects as the size, the exact position, the shape, the orientation, the contrast, etc, useful to characterize the phantom image obtained [4]. These values can be used like parameters in order to determine the image quality in an objective way.

The presence of noise in the digital image might difficult the detection of the phantom test objects. In this sense, an important item for the automatic assessment of the phantom image quality is the preprocessing step reducing the noise of the image, and so, improving the detection of mammographic phantom feautures. Classically, denoising methods have been based on apply linear filters as the Wiener filter to the image, however, linear methods tend to blur the edge structure of the image. To avoid this problem, several denoising methods based on nonlinear filters have been introduced. For this reason, we will compare the effect of different denoising filters on the results of the IQI. In particular, we have compared the IQI results obtained without filtering the image and by using an adaptative Wiener filter and a wavelet based filter.

DIGITISATION

The mammographic equipments under observation do not supply the digital image directly. The mammographic image is formed in an x-ray film, which after developing it is fixed in a transparent plate. Computer image analysis requires the digitisation of the phantom radiographic image. The mammographic images of the CIRS phantom model 11A, SP01 version, have been digitised with a slide scanner AGFA Duoscan f40. It is a charge coupled device (CCD) flatbed scanners. The random noise inherent to all CCD scanners is automatically reduced since each line is scanned several times and the results are averaged.

The images have been obtained under different functioning conditions of kV and mAs by the mammographic equipment. The resolution used for film digitisation is 1200 dpi, in grey scale at 8 bits/pixel, so the grey range is formed by 256 values, which are between black, whose value is 0, and white that corresponds to the value 255.



(a) (b)

Figure 1. (a) Sketch of the mammographic phantom model 11-A, version SP01, by CIRS. (b) Image plate of the mammographic phantom obtained at 28 kV, 42 mAs and digitised at 1200 dpi, 8 bits/pixel.

IMAGE QUALITY INDEX

Nowadays, the mammographic image quality is determined in Spain by an expert radiographer or by a radiologist evaluating visually a reference phantom image. He classifies the test objects in three categories: visible, partially visible and not visible and according to these results, he scores the image according to a scale that determines its quality. It is obvious that this method of evaluating the image quality depends on the human factor, so it makes this subjective determination has certain variability.

It is important the definition of a parameter which characterize in an objective way the mammographic phantom image quality, that is the image quality index (IQI). There are different ways to define the IQI of the phantom image [5,6]. Our definition of IQI is based on a scoring scheme that uses the number of the microcalcifications detected and the resolution measured as the number of line pairs per millimetre (lp/mm) obtained by the application of automatic algorithms to the digitised mammographic phantom images. The scoring system proposed is given in the Table 1. The score of the microcalcification zone is based on the number of the microcalcifications detected in each group and it is inspired by the 3-2-1-0 scoring scheme used in [6,7]. The resolution zone is punctuated obtaining the last group detected in the horizontal and vertical resolution.

Table 1: Scores of the groups of the microcalcifications and resolution zones to determine the image quality index (IQI).

No. of microCa detected by group	6	4-5	3-2	1-0
Score	3	2	1	0

Line Pairs per Millimetre		5-8	9	10	11	12	13	14	15	16	17	18	19	20
Score	***Horizontal Resolution***	0	0	0.5	1	2	4	8	12	16	20	24	28	32
	Vertical Resolution	0	0.5	1	2	4	8	12	16	20	24	28	32	36

Other scoring systems include more phantom regions as low contrast zone or fiber zones. Now, we are developing the automatic phantom analysis algorithms to include the masses and fibres zones in the definition of a new IQI, probably more complete, although this affirmation is under study.

METHODOLOGY

Each phantom area requires a specific treatment. We have considered subimages of the initial mammographic phantom image, of each microcalcifications group, of the area with the line pairs per millimetre horizontal and vertical, of the low contrast zone and of the reference densities zones, although for the IQI calculation we have focused our attention on the microcalcification group number and the image resolution. The techniques used for digital phantom image processing are described in more detail in [5], including techniques as the image thresholding to detect objects, regional growing by pixels attachment, morphological operators application, etc. All the algorithms have been implemented in Matlab 6.5 and they have been applied to images of the mammographic phantom model 11A version SP01, obtained under different clinical functioning conditions of kv and mAs of mammographic equipments.

As it was said at the introduction, an important point for the automatic assessment image quality is the preprocessing filtered to reduce the noise of the image. So we have carried out the comparison between two different denoising filters and the values of the IQI obtained.

In order to observe better the effects of the denoising filters, we have added a gaussian white noise to the original mammographic phantom images. The standard deviation of the noise is of 10% of the deviation of the original images. These noisy images have been preprocessed by two different ways and after that, we have applied our automatic analysis programme to calculate the IQI for each one of them. The first preprocessing method consists in applying a local Wiener filter on a neighbourhood of 3x3 pixels blocks of the image, and the second preprocessing technique is the application to the images of the denoising method of Donoho [8] based on the minimax thresholding strategy, roughly speaking, based on a soft thresholding of the wavelet transformed coefficients of the image. The coifflet 10 family wavelet at level one has been chosen because of its efficient energy compactness preserving the essential information of the image. We have compared the results obtained using these two filters with the results obtained without applying any preprocessing method.

RESULTS

We have considered five different mammographic phantom images obtained under different mammographic equipment functioning conditions, these images have been corrupted with a gaussian white noise. The following tables contain the results for the number of microcalcifications detected in each phantom image group (see Fig.1(a)), the horizontal and vertical resolution in lp/mm and the IQI calculated in accordance with the scoring system given in the Table1.

Table 2: Results obtained without any denoising technique.

Images	*KV & mAs*	*No. microCa detected*				*Resolution (lp/mm)*		**IQI**
		Group 10	*Group 9*	*Group 8*	*Group 13*	*Horizontal*	*Vertical*	
1	23kv136mAs	3	1	2	2	14	14	23
2	26kv65mAs	3	3	1	1	14	13	18
3	28kv42mAs	5	1	2	2	13	12	12
4	30kv30mAs	3	3	4	1	14	13	20
5	33kv20mAs	3	2	3	2	14	13	20

Table 3: Results obtained using a Wiener filter preprocessing of the images.

Images	*KV & mAs*	*No. microCa detected*				*Resolution (lp/mm)*		IQI
		Group 10	*Group 9*	*Group 8*	*Group 13*	*Horizontal*	*Vertical*	
1	23kv136mAs	6	5	5	5	12	12	15
2	26kv65mAs	6	6	6	5	12	11	15
3	28kv42mAs	6	6	6	3	13	12	18
4	30kv30mAs	6	5	6	3	12	12	15
5	33kv20mAs	5	5	5	4	13	13	20

Table 4: Results obtained using a wavelet (coiflet 10) filter preprocessing of the images.

Images	*KV & mAs*	*No. microCa detected*					*Resolution (lp/mm)*		IQI
		Group 10	*Group 9*	*Group 8*	*Group 13*	*Group 12*	*Horizontal*	*Vertical*	
1	23kv136mAs	6	6	6	6	3	14	14	33
2	26kv65mAs	6	6	6	6	3	13	12	21
3	28kv42mAs	6	6	6	5	2	13	12	20
4	30kv30mAs	6	6	6	5	2	14	13	28
5	33kv20mAs	6	6	6	6	3	13	13	25

CONCLUSIONS

The application of the denoising filters to the images improve the number of microcalcifications detected by the algorithm, however, this is not the case for the image resolution. The Wiener filter tends to blur slightly the image edges, then the resolution measured after applying this filter is generally worst than the results for the wavelet filter and even worst than the results for the nonfiltered case. The image resolution results obtained after wavelet filter application are similar to the resolution values obtained for the nonfiltered images.

As a result, comparing the IQI values given at the tables above, we conclude that the application of the wavelet based denoising filter improves the image quality, whereas the Wiener filter application do not produce any global increase of the image quality.

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