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Study of digital mammographic equipments by phantom image quality

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bstract*— Nowadays, the digital radiographic equipments are replacing the traditional film-screen equipments and it is necessary to update the parameters to guarantee the quality of the process. Contrast-detail phantoms are applied to digital radiography to study the threshold contrast-detail sensitivity at operation conditions of the equipment. The phantom that is studied in this work is CDMAM 3.4. One of the most extended indexes to measure the image quality in an objective way is the *Image Quality Figure (IQF).

The aim of this work is to study the image quality of different images contrast-detail phantom CDMAM 3.4, carrying out the automatic detection of the contrast-detail combination and to establish a parameter which characterize in an objective way the mammographic image quality. This is useful to compare images obtained at different digital mammographic equipments to study the functioning of the equipments that facilitates the evaluation of image contrast and detail resolution.

I. Introduction

In a quality control of the radiographic equipment, the quality of the obtained image is very useful to characterize the physical properties of the imaging chain. In the radiographic technique it is necessary that objects with low contrast and diameter could be distinguish of its background, to carry out a suitable diagnosis [1-2]. The use of digital systems allows the automatic analysis of the obtained radiographic images, increasing the objectivity in the evaluation of the image.

The phantom used in this work is the *CDMAM* 3.4 [3] which consists of an aluminium base with gold disks of various thickness and diameters, which is attached to a plexiglas cover. The gold disks range in diameter from 0.06 to 2.0 mm and in thickness from 0.03 to 2.0 μm, resulting in a radiation contrast range of 0.5-30% at standard mammography exposure conditions. The phantom is used with 4 plexiglass plates, each with a thickness of 10 mm. The dimensions of the phantom and plexiglass plates match the standard mammography film size, which is 180 mm x 240 mm. The disks are located in a matrix of 16 rows and 16 columns. The matrix is rotated forty-five degrees to minimize influences of the heel effect that causes optical density variations.

Within a row the disk diameter is constant with exponentially increasing thickness from 0.03 to 2.00 μm and within a column the disk thickness is constant, with exponentially increasing diameter from 0.06 to 2.0 mm. The phantom, at the first rows has only central disk, while in the other rows there are two identical disks, one in the centre and one in a random chosen corner as it is shown in Figure 1.

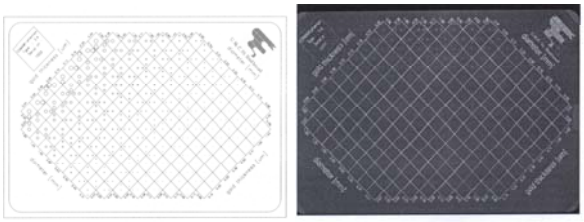

Fig. 1. (a) Sketch of the phantom CDMAM 3.4 (b) Radiographic image of the CDMAM3.4

II. I MAGE QUALITY

A. Image quality index

There are various parameters to measure the quality of the radiographic image. One of the most extended to measure the quality in an objective way is the *Image Quality Figure (IQF),* that is defined in that way:

$$IQF = \sum_{i=1}^{n^{o}cols} C_i \cdot D_{i,\min} \quad (1)$$

where $D_{i,th}$ is the threshold diameter in the contrast column i and C_i is the value of the thickness of the holes of the column. The sum is extended for all columns of different thickness.

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In addition two rules are applied, when one column is completely invisible, it is punctuated with a diameter $D_{i,th}$ of 2.5 mm (for a gold disk thickness between 0.03 and 0.25 µm). And when one column is completely visible, it is punctuated with a diameter $D_{i,th}$ of 0.06 mm (for a gold disk thickness between 0.16 and 2.00 µm.)

Because the image quality increases when the correctly identified contrast-detail combination has a smaller depth and diameter, it is defined IQF_{inv} that gives an increasing value for increasing image quality.

$$IQF_{inv} = \frac{1}{\sum_{i=1}^{n^{o}cols} C_i \cdot D_{i,\min}} \cdot 100 = \frac{100}{IQF} \quad (2)$$

B. *Contrast detail curve*

The contrast-detail curve is a graphical representation in which the hole thickness and diameter are plotted for each contrast-detail combination detected in the radiographic image of the phantom.

It is useful for the comparison of the functioning of different radiographic image systems, for phantom images under the same exposition conditions. The better image system produces images that allow the detection of lower contrasts and details.

III. METHODOLOGY

In this work, we have used the software *CDCOM* [4], developed by the Radiology Department of the *University Medical Centre Nijmegen* to automatically evaluate the images of the CDMAM 3.4 phantom.

The evaluation of the radiographic image quality is carrying out in the following way: The algorithm determines the border of the phantom, resolve the position and centre of its contrast-detail combinations by the Hough transform. Then, it is determined the mean and standard deviation of the background and the mean and standard deviation of each contrast detail combination. The program tests with a statistical method, if the average contrast-detail is greater than the average background, to consider the combination as detected. Then, it is applied a score correction taking into account the nearest neighbours of the combination under evaluation. Finally, the IQF_{inv} is calculated and the contrast-detail curve obtained, as an example in Figure 2.

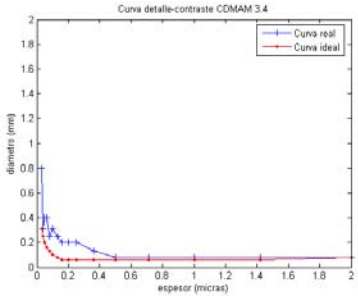

Fig. 2. Contrast-detail curve for a radiographic image of the CDMAM3.4 obtained at 28kv, CAE:+0, 55mAs.

We have obtained some radiographic images, at two different technology mammographic systems. Two of them are computed radiography and the other two are direct radiographic digital of some units of the Valencian Breast Cancer Screening Programme. This programme has recently have incorporated digital mammographic equipments of computerised radiography and direct radiography.

The mammograhic digital image acquisition is in dicom format 3.0, which is the format that is actually implemented in medical image communication [5].

The phantom has been studied with two plexiglass tablets above and under of it, to simulate the breast typical thickness. The acquisition of the images are carried out in different conditions for each unit and varying the functioning parameters of the mammographic equipment of kv, mAs and AEC.

The images have been obtained without preprocessing with thick size of the focus, anti scatter grid and compression plate. After that, the image is evaluated with the programme *CDCOM* and the quality of the image obtained with the contrast detail curve and the image quality figure.

The mammography equipments used are the following:

Computed radiography (CR):
Unit 1: Senographe DMR, anode of Mo with filter of Mo 30µm; Fuji Profet CS
Unit 2: MammoDiagnostic UC Philips, anode of Mo with filter Mo 30µm; Agfa CR 75.0

Direct radiography (DR)
Unit 3: Mammomat Novation Siemens DR, anode of Mo with filter Mo 30µm
Unit 4: DM 1000 (Agfa) DR, anode of Mo with filter Mo/Rh 30µm.

IV. RESULTS

The results of the image analysis obtained of the computerized and direct mammography equipments under study are the following

Images			IQI_{inv}
kV	*CAE*	*mAs*	
26	+0	101	126.10
28	-2	40	105.28
28	+0	55	127.70
28	+2	75	138.22
30	+0	32	116.14

Table 1: Results of the IQI_{inv} for the images in different conditions for Unit1.

Images			IQI_{inv}
kV	*CAE*	*mAs*	
26	+0	117	110.49
28	-2	54	91.26
28	+0	76	108.09
28	+2	104	105.69
30	+0	47	95.16

Table 2: Results of the IQI_{inv} for the images in different conditions for Unit2.

Images			IQI_{inv}
kV	*CAE*	*mAs*	
26	+0	139	121.82
28	-2	71	135.14
28	+0	91	139.26
28	+2	110	147.17
30	+0	58	106.76

Table 3: Results of the IQI_{inv} for the images in different conditions for Unit3.

Images			IQI_{inv}
kV	*CAE*	*mAs*	
26	+0	142.9	149.72
28	-2	62.8	140.73
28	+0	86.5	156.13
28	+2	109	160.41
30	+0	56.8	143.04

Table 4: Results of the IQI_{inv} for the images in different conditions for Unit4.

V. CONCLUSIONS

From the results we can see that the image parameters, as the contrast detail curves of the DICOM images of the CDMAM 3.4 phantom and the Image Quality Figure (*IQF*), show that that the direct digital mammographic equipments have bigger indexes that indirect digital equipments. It indicates that the image quality obtained with direct equipments is better than in the computed radiography.

Comparing indirect mammographic equipments, Unit 1 has better image quality than Unit 2, for similar radiographic techniques. Comparing direct mammographic equipments the image quality parameters are bigger for Unit 4. These results have to be considered joined to the analysis of the dose. We are working to study some correlations between them.

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REFERENCES

[1] *Protocolo Español de Control de Calidad en Radiodiagnóstico*. Revisión 1 (Aspectos Técnicos) ISBN:84-87450-70-9, 2002

[2] Working Party of Radiologists, Quality Assurance Coordinating Group, *Computer aided detection in mammography*, NHSBSP Publication nº 48, 2001.

[3] Artinis Medical Systems B.V, *User Manual CDMAM 3.4*, 2002.

[4] Department of Radiology, University Medical Centre Nijmegen, *CDCOM Manual:software for automated readout of CDMAM 3.4 images*, 2004

[5] National Electrical Manufacturers Association, *Digital Imaging and Communications in Medicine (DICOM),*2003.