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Automatic Programs for Image Quality Control in Radiodiagnostics

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Abstract

The objective of this work is to develop image quality control programs with M software that allow the automation of image analysis in radiodiagnostic areas, including computed tomography (CT), conventional X-ray and mammography images. For each of these imaging equipment, automatic image analysis software was designed. This allowed the creation of a simple and robust interface, capable of speeding up measurement times and ensuring repeatability of the tests.

Keywords: Radiodiagnostics; medical physics; quality control; medical informatics

Introduction

During the first years of quality control in radiodiagnosis, image quality analysis was performed in freely available software such as ImageJ, where the analysis of each image was performed through the creation of ROIs and manual calculations, which resulted in the evaluation of subjective parameters and consumed a lot of clinical work time.

In view of this problem, it was proposed to develop programs where the analysis of the images would be automatic, with the creation of ROIs in specific regions of the image, calculations that would allow the acquisition of parameters and function graphs. As well as to evaluate the variation of the parameters with the KV, mA and filters of large sets of images.

These programs were developed as graphical user interfaces (GUI) in Matlab software, with the possibility of loading the sets, handling them with different tools and thus obtaining parameters that allow evaluating the quality of the images.

Materials and Methods

Image acquisition in each modality

A set up procedure was established for the phantoms for the different diagnostic modalities, so that the images are obtained in the same way each time quality control is performed. Images are obtained in DICOM format.

DICOM image import

In the programs the images are imported. The program shows information of interest such as KV, mA, filters, etc.

This information is automatically loaded in the final report in each equipment.

Software tools

It presents useful tools for measurements, image window level, zoom, pan, ROI manipulation, the latter being very important since it allows moving them and correcting their location if necessary.

Acquisition of interest parameters

For each modality, metrics such as uniformity, noise, spatial and low contrast resolution, MTF, among others, were evaluated. As an example, we detail how uniformity and noise are calculated in a CT image.

To evaluate uniformity, Eq. 1, five ROIs were performed, one in the center and the remaining ones in the periphery, in the uniformity module of the phantom, Fig. 1.

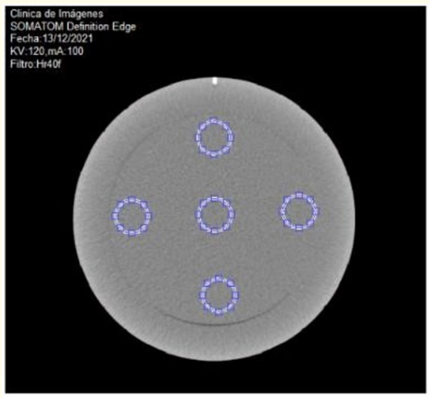


Figure 1: Uniformity ROIs.

The mean pixel value (MPV) of each ROI was determined and the difference between the values of each peripheral ROI with respect to the central ROI was calculated. The maximum difference between the peripheral ROI 's and the central ROI was recorded [1, 2].

$$Uniformidad = \max\,(MPVi - MPVc) \quad (1)$$

To evaluate noise, an ROI was performed in the center of the image in three slices, in the phantom noise module, Fig. 2.

The standard deviation of the pixel values of the ROI's was determined, Eq. 2 [1, 2].

$$Noise = \text{media}\,(\sigma ROI's) \quad (2)$$

In this way, each of the tests recommended in the international protocols is obtained automatically.

The programs perform graphs of interest that complement the results obtained, Fig. 3 shows as an example the accuracy curve of the TC number values for different materials.

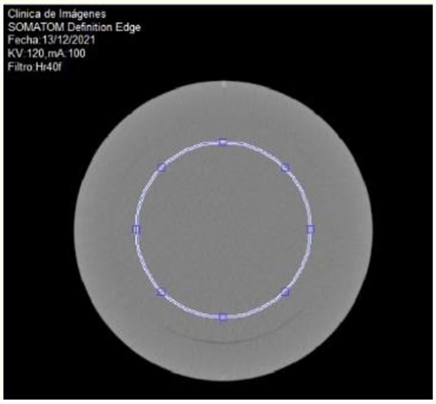


Figure 2: ROI noise.

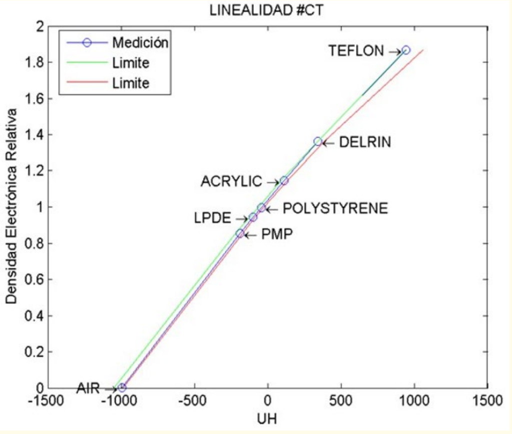


Figure 3: Accuracy curve of TC number values for different materials.

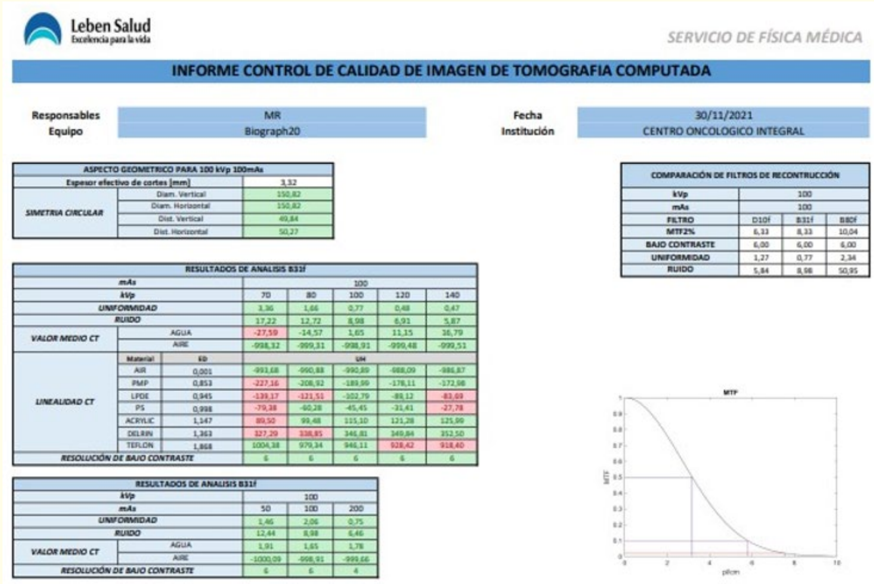
Reports and results

At the end of each of the tests, the program automatically stores the data in an Excel file, which allows obtaining a report with the results obtained, Fig. 4.

Finally, this is loaded into the online quality control registration system, Track it of PTW, which allows the comparison and evaluation of the repeatability of the controls.

Graphical program interface

To simplify the use, an interface was created, Fig. 5, which guides the user to load the images in DICOM format, to perform each of the controls and to obtain the results in the corresponding reports.



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INFORME CONTROL DE CALIDAD DE IMAGEN DE TOMOGRAFIA COMPUTADA

Responsables	MR	Fecha	30/11/2021
Equipo	Biograph20	Institución	CENTRO ONCOLOGICO INTEGRAL

ASPECTO GEOMETRICO PARA 100 kVp 100mAs		
Espesor efectivo de cortes [mm]		3,32
SIMETRIA CIRCULAR	Diam. Vertical	150,82
	Diam. Horizontal	150,82
	Dist. Vertical	49,84
	Dist. Horizontal	50,27

RESULTADOS DE ANALISIS B31f							
mAs			100				
kVp			70	80	100	120	140
UNIFORMIDAD			3,36	1,66	0,77	0,48	0,47
RUIDO			17,22	12,72	8,98	6,91	5,87
VALOR MEDIO CT	AGUA		-27,59	-14,57	1,65	11,15	16,79
	AIRE		-998,32	-999,31	-998,91	-999,48	-999,51
LINEALIDAD CT	Material	ED	UH				
	AIR	0,001	-991,68	-990,88	-990,89	-988,09	-986,87
	PMP	0,853	-227,16	-208,92	-189,99	-178,11	-172,98
	LPDE	0,945	-139,17	-121,51	-102,79	-89,12	-83,69
	PS	0,998	-79,38	-60,28	-45,45	-31,41	-27,78
	ACRYLIC	1,147	89,50	99,48	115,10	121,28	125,99
	DELRIN	1,363	327,29	338,85	346,81	349,84	352,50
	TEFLON	1,868	1004,38	979,34	946,11	928,42	918,40
RESOLUCIÓN DE BAJO CONTRASTE			6	6	6	6	6

RESULTADOS DE ANALISIS B31f				
kVp		100		
mAs		50	100	200
UNIFORMIDAD		1,46	2,06	0,75
RUIDO		12,44	8,98	6,46
VALOR MEDIO CT	AGUA	1,91	1,65	1,78
	AIRE	-1000,09	-998,91	-999,66
RESOLUCIÓN DE BAJO CONTRASTE		6	6	4

COMPARACIÓN DE FILTROS DE RECONTRUCCIÓN			
kVp	100		
mAs	100		
FILTRO	D10f	B31f	B80f
MTF2%	6,33	8,33	10,04
BAJO CONTRASTE	6,00	6,00	6,00
UNIFORMIDAD	1,27	0,77	2,34
RUIDO	5,84	8,98	50,95

Figure 4: Report of results.

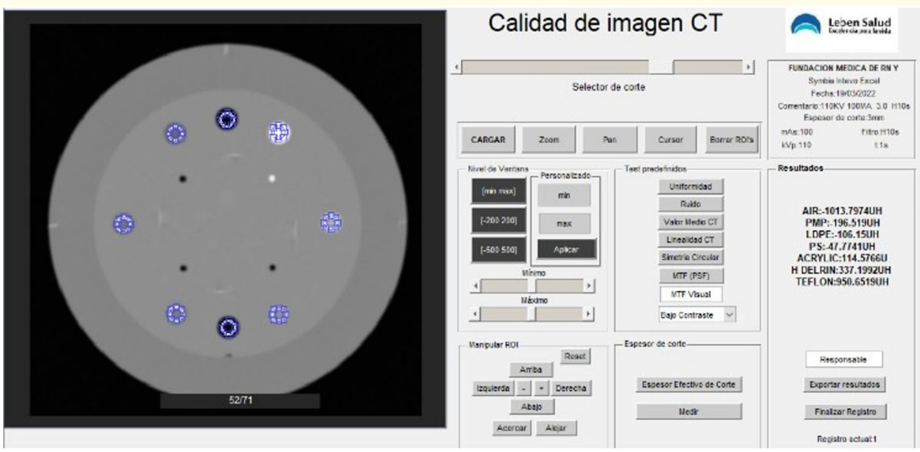

Figure 5: Graphical interface.

A similar interface was created for each of the modalities, considering their particularities.

Results

A set of image quality control software was designed for all the previously mentioned modalities. These results were compared with the Image J program, which are shown in Table 1:

Parameters	Program develop	Image J	Deviation
Uniformity	0,96 UH	0,98 UH	2 %
Noise	9,90 UH	10,10 UH	1,98 %

Table 1: Comparison of program with image J.

It is observed that the results obtained show a discrepancy of only 2%, allowing its validation.

This allowed the image quality control of seven CT scanners, six X-ray machines, four mammographs, three of which with tomosynthesis. It was possible to evaluate that the tests were in tolerance, as well as their repeatability, allowing to evaluate the constancy from year to year.

Discussion

This work presents the development of a software that allows the medical physicist to speed up image quality controls in radiodiagnosis.

This allowed reducing image processing times by 90%, thus optimizing the use of human resources. The professional no longer has to perform manual ROIs or calculations to obtain the parameters or excel to save the results and make reports, which takes approximately 15 minutes per series of images (one KV, one mA and one type of filter). In other words, thanks to automation, this time was reduced to 2 minutes. This allowed large sets of image series to be analyzed, evaluating the variation of the parameters with the modification of the KV, mAs and filters.

This leads to a single medical physicist (reality of many centers) being able to perform the quality control of large amounts of equipment, investing the rest of the working hours in other areas.

In addition, it is noted that being an open source, it allows to visualize and solve possible problems in the analysis, with future modifications by the staff.

It is a simple and intuitive tool, which in addition to the advantages already mentioned, allows faster data processing and automatic reporting for each of the diagnostic equipment.

Conclusions

The implementation of automatic image quality control programs in a clinic with a large number of radiodiagnostic equipment is essential to comply with a quality assurance program.

The programs developed made it possible to reduce the time invested in this type of controls and, therefore, the human resources required to perform these tasks. In turn, the automation of the controls made it possible to guarantee the reproducibility of the tests, since they are not user-dependent.

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