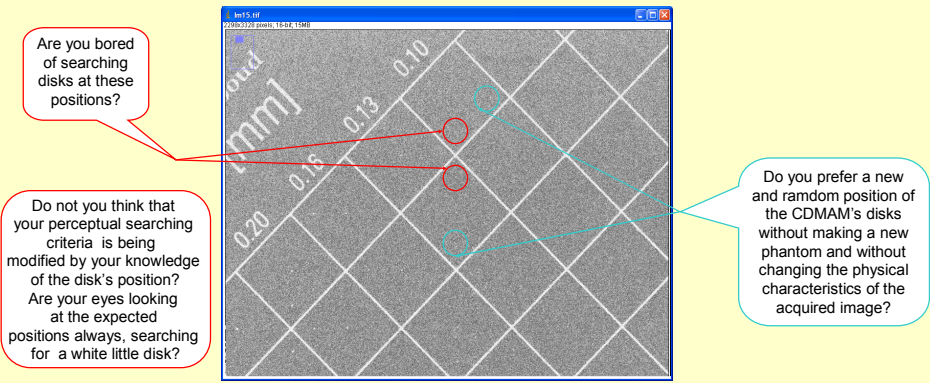# MANIPULATION OF CDMAM IMAGES :
A CDMAM image phantom software improvement for human observer assessment

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Are you bored of searching disks at these positions?

Do not you think that your perceptual searching criteria is being modified by your knowledge of the disk's position? Are your eyes looking at the expected positions always, searching for a white little disk?

Do you prefer a new and ramdom position of the CDMAM's disks without making a new phantom and without changing the physical characteristics of the acquired image?
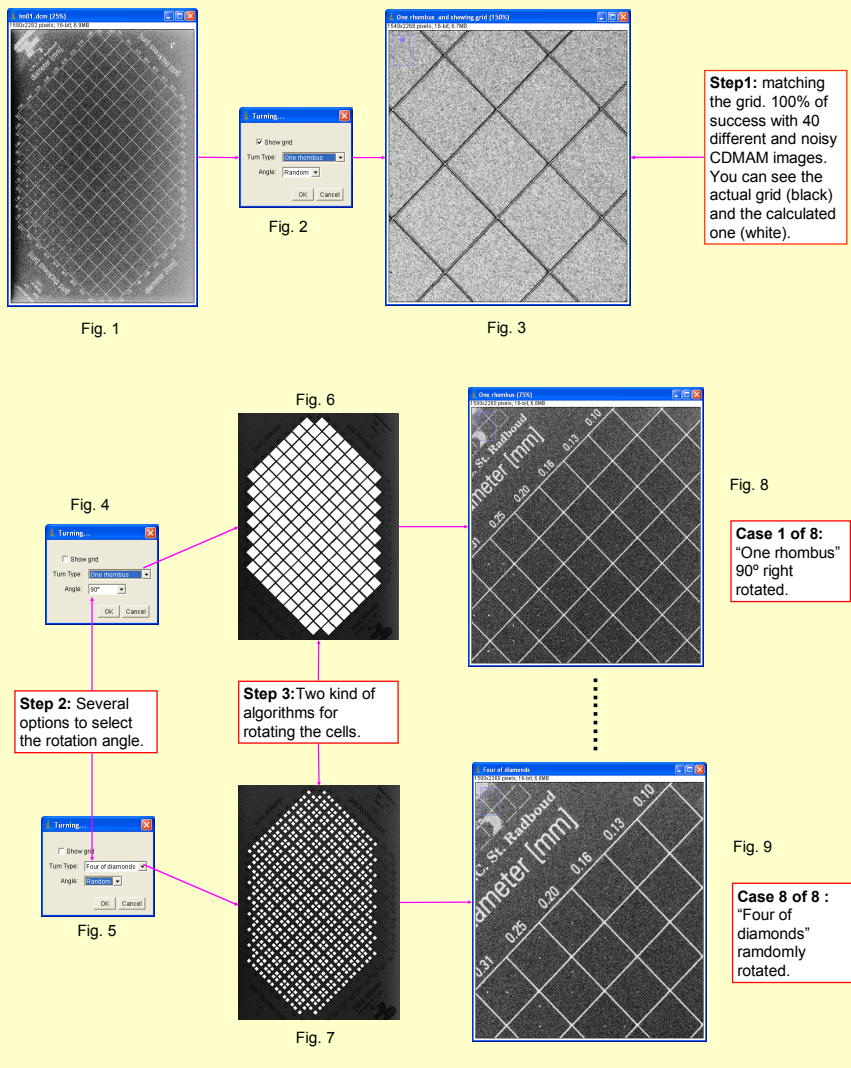
ABSTRACT

A software tool is presented to improve the features of CDMAM image phantom by University Hospital Nijmegen. This software tool ensures that the 4-alternative forced choice method of CDMAM is actually kept, even when is being scored by highly expertise observers familiar on the test object pattern. For digital images, the developed software tool automatically changes the image position of the four corners. It can be selected a fixed rotation angle or a random one, so making impossible that any observer is able to remember the exact corner position of the target disc inside any cell. Two alternative successful algorithms have been tested. ROC curve analysis obtained by 36 observers shows that both original and computer-modified images are indistinguishable. The ROC area was 0.507±0.024 for first algorithm and 0.522±0.026 for the second one, indicating that there was no statistical difference between real and computer-modified images for both of them.

MATERIAL AND METHOD

We have developed our algorithms as a plugin inside ImageJ, the image manipulation program developed by Wayne Rasband. The plugin uses three steps illustrated in the following figures. First (Fig. 1, 2 and 3), we find the position of the phantom grid where gold discs are inserted. Our algorithm is very heuristic, because of the big amount of information we have about the geometry of the grid. We select a fixed ROI around the centre of the image with side dimensions of one third of the dimensions of the CDMAM. Inside this area, we scan all pixels in the first and last columns. For each pixel we consider a fan of straight lines with origin at this pixel and ending on the other side of the ROI, within a narrow angle. For each of these straight lines we calculate the addition of the pixel values. Maximum values of these additions indicate where the grid lines lie and which one is their angle. We extrapolate these lines to the edges of the grid. The main properties of this algorithm are: a) Low computational consumption. b) No need of any kind of pre-processing, even for very noisy images c) Robustness of the algorithm under very different conditions.

To avoid the memory effect of the expert observer, we have moved the corner disks in some cells. We have used two different algorithms, very well illustrated in Fig. 6 and 7. The first algorithm ("One rhombus") rotates each cell in steps of 90° around its centre. In the second algorithm ("Four of diamonds"), we define four little rhombuses inside each cell, centred each one at the four possible centres of the CDMAM's disks and then we interchange these rhombuses (in steps of 90° around its centre) between them inside the same cell.

A ROC experiment has been developed to evaluate both algorithms. We arranged two set of images. Set #1 contained 8 different CDMAM images acquired under different radiological conditions. We obtained 8 modified images by applying algorithm "Rhombus" to each image. The complete set was formed with modified and non modified images randomly ordered. Set #2 was formed with the same 8 original CDMAM images and 8 modified images obtained by applying the algorithm "Four of diamonds". The complete set was randomly ordered. The two sets of images were presented to two different groups of observers. The first one was composed by 27 medical physicists with an experience between 2 – 10 years in quality control. The second group was composed by 9 students of a Medical Physics Master, with no experience in diagnostic radiology neither quality control. Each observer had to answer to the question "Do you think this image has been computer modified in any form?" The test was run in different displays and the observers could use any tool of the ImageJ viewer with no time limits. The answer included a confidence level, from 0 to 4.

Fig. 1

Fig. 2

Fig. 3

Step1: matching the grid. 100% of success with 40 different and noisy CDMAM images. You can see the actual grid (black) and the calculated one (white).

Fig. 6

Fig. 4

Fig. 8

Case 1 of 8: "One rhombus" 90° right rotated.

Step 2: Several options to select the rotation angle.

Step 3: Two kind of algorithms for rotating the cells.

Fig. 5

Fig. 7

Fig. 9

Case 8 of 8 : "Four of diamonds" ramdomly rotated.

RESULTS

As it can be seen from ROC curves in Table 1, the computer-modification of images was indistinguishable for both groups and for both algorithms. Result may show a light significance in test #1 analyzed for students, but the significance is at the limit of random choice. Combining expert and non-expert observers, the ROC area was 0.507±0.024 for first algorithm (significance level P=0.7724 for area 0.5) and 0.522±0.026 (significance level P=0.4003 for area 0.5) for the second one, indicating that there was no statistical difference between real and computer-modified images for both of algorithms presented.

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CONCLUSIONS

1) Both algorithms can be used to manipulate CDMAM images.
2) They can be useful in those cases in which a researcher suspects that the observer is memorizing the position of some disks, mainly the critical ones around the middle section of the CDMAM.
3) They can be used to investigate and quantify the memory effect in the radiologist community. We have made a preliminary test with students, trying to train them to memorize the position of the disks, not for explicit methods, but for indirect ones.

Our software developments will be periodically updated at http://www.ucm.es/info/fismed/CDMAM/CDMAM.htm and as a link in the ImageJ website http://rsb.info.nih.gov/ij/plugins/index.html, including object code, instructions of use and several test images.

	Experts's group	Students's group	Addng groups
Exp. #1			
Exp. #2			

Table 1