NOISE REDUCTION ON MAMMOGRAPHIC PHANTOM IMAGES

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Breast Cancer

Nowadays 1 woman out of 10 is affected

In a near future 1 woman out of 8 will be affected

Extensive means devoted to tackling this flail were unsuccessful

↓

Early detection

Mammography

High quality mammograms is required

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Quality control of mammographic facilities

Quality control in mammography

A phantom is used for that purpose

Object with the same anatomic shape and radiological response of an average dense fleshed breast → Embedded targets: microcalcifications, masses, fibres

Quality control of mammographic films needs to be done periodically

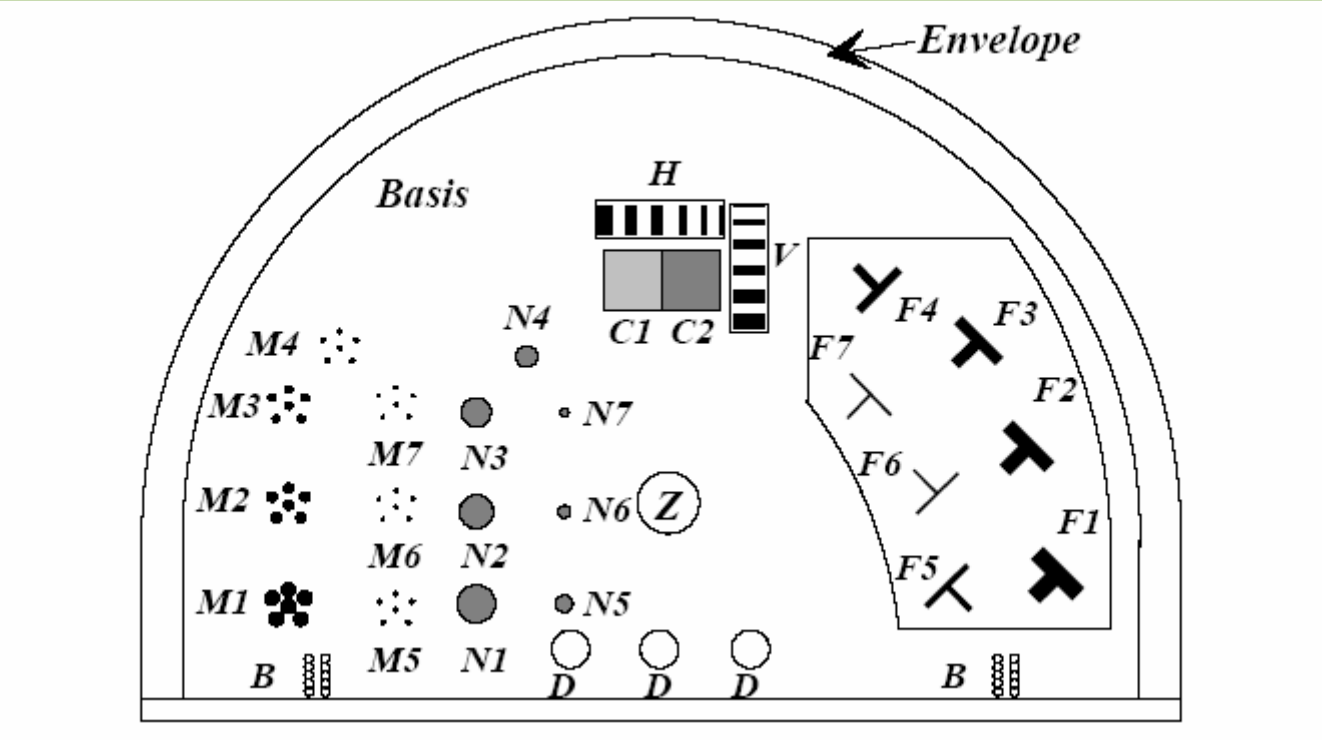
Standard method

Scoring phantom film by visual observation

Proposed method

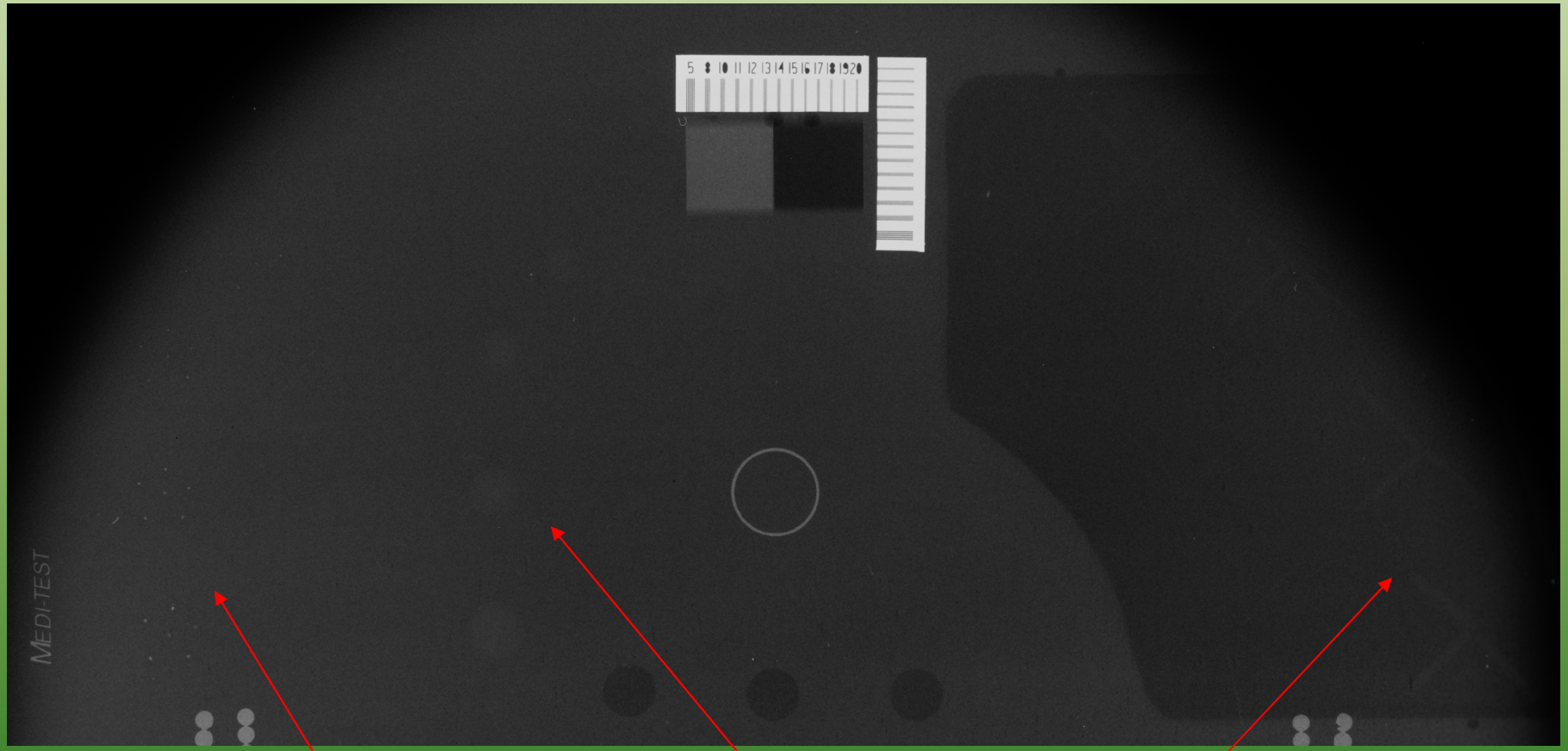
Automating phantom score using image processing on digitized phantom films

Description of the studied phantom

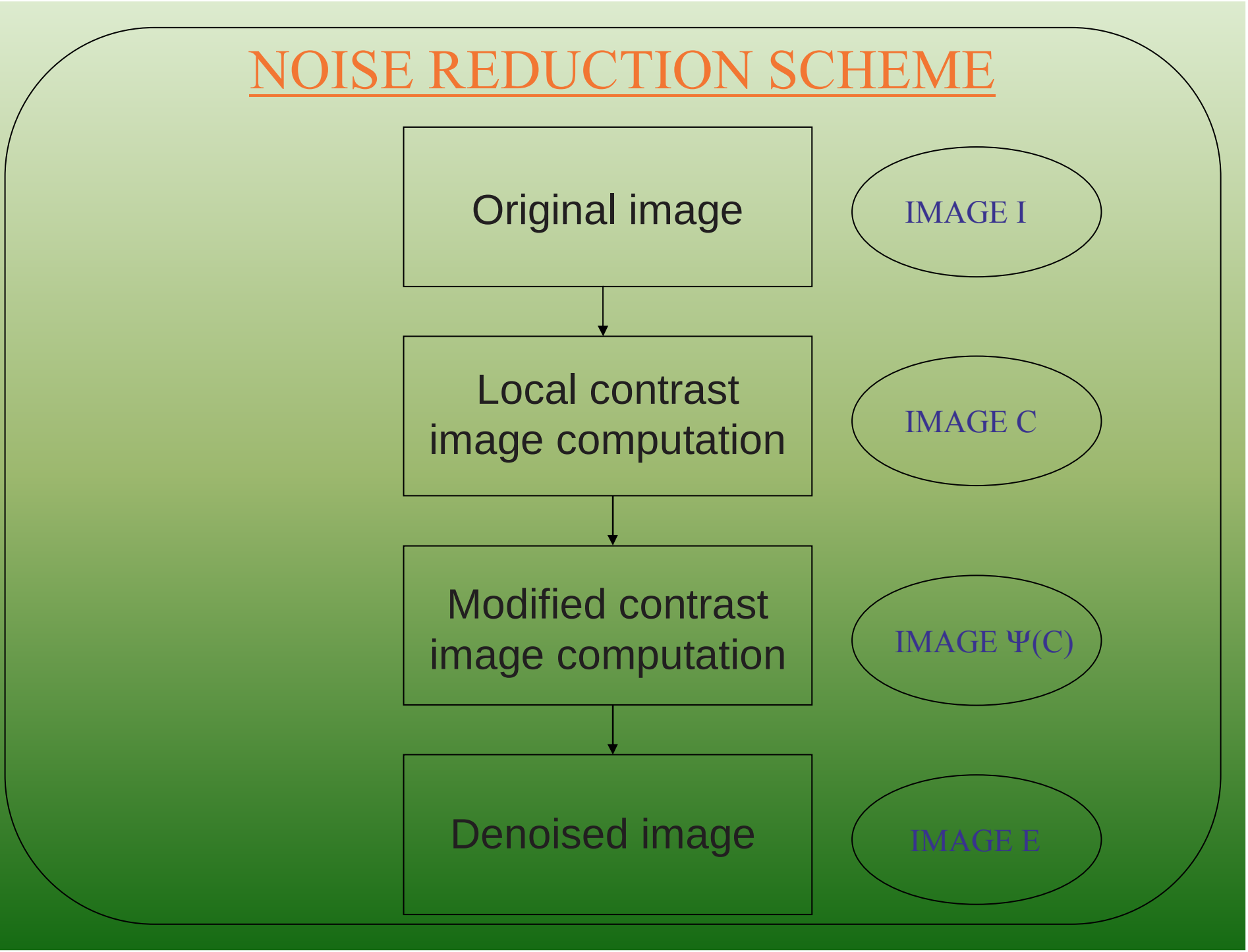


- M_i : microcalcification groups
- N_i : masses
- F_i : fibres
- B : balls for X-ray alignment control
- C_1, C_2 : contrast areas
- H : horizontal spatial resolution scales
- V : vertical spatial resolution scales
- Z : reference optical density measurement area

Digitized image of the studied phantom

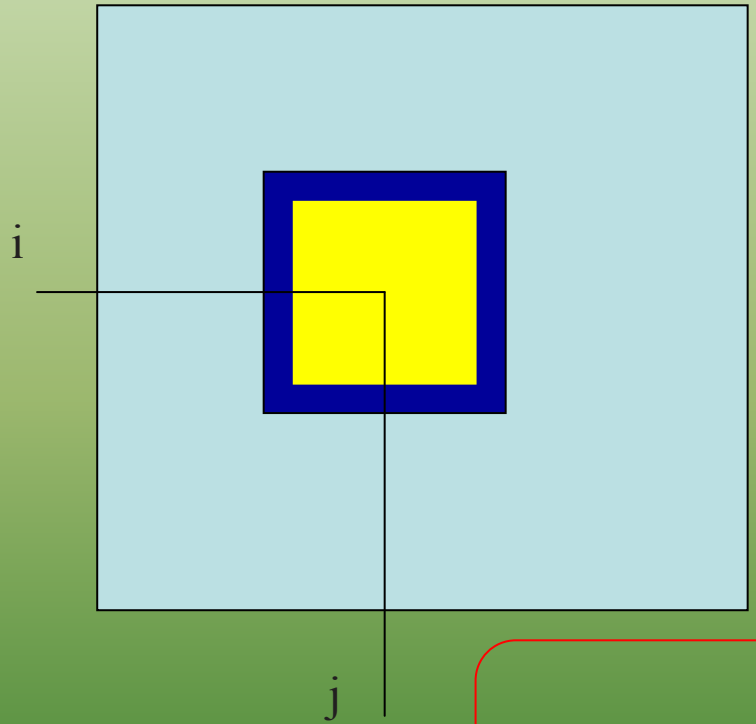


NOISE REDUCTION SCHEME

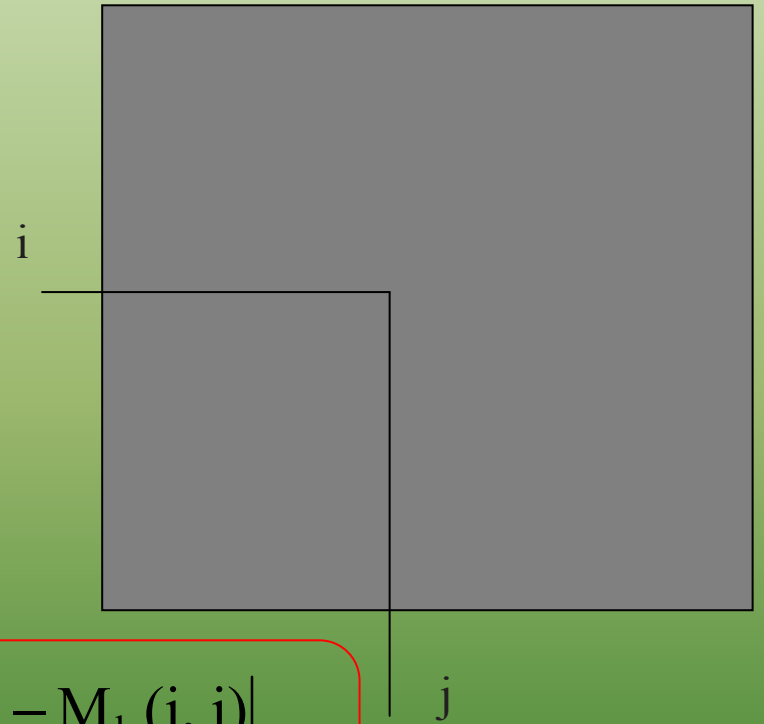


LOCAL CONTRAST IMAGE COMPUTATION

Original Image I



Local contrast image C

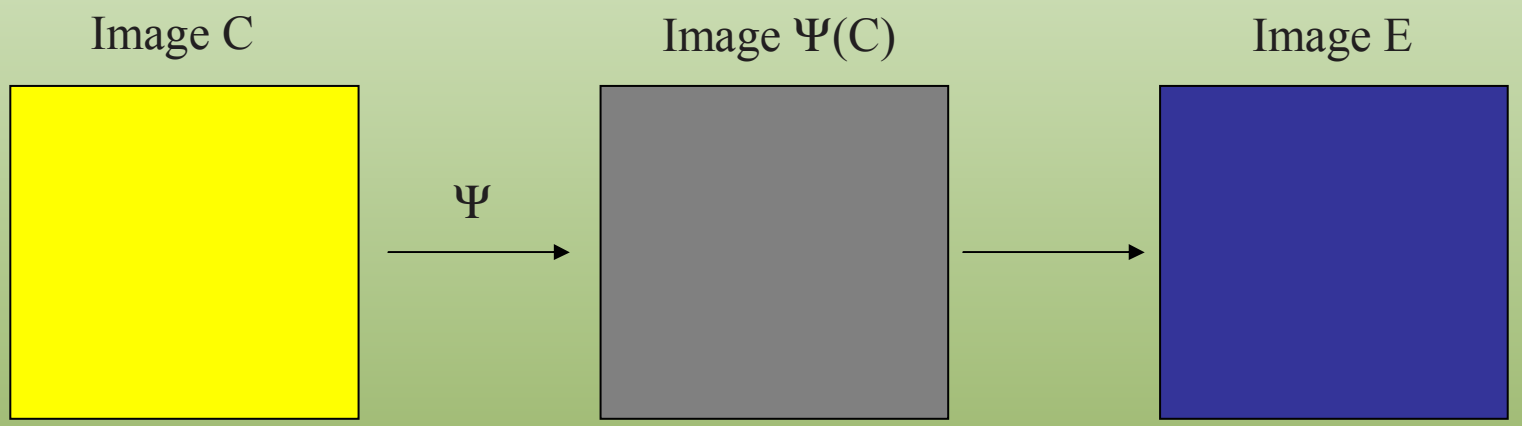


$$C(i,j) = \frac{\left|M_c(i,j) - M_b(i,j)\right|}{\max(M_c(i,j), M_b(i,j))}$$

M_c : mean value of pixels in the center area : yellow pixels

M_b : mean value of pixels in the background area : blue pixels

CONTRAST MODIFICATION FUNCTION Ψ



$\Psi : [0,1] \rightarrow [0,1]$

$$E(i,j) = M_b(i,j)(1-\Psi(C(i,j))) \quad \text{if} \quad M_b(i,j) > M_c(i,j)$$

$$E(i,j) = \frac{M_b(i,j)}{1-\Psi(C(i,j))} \quad \text{if } M_b(i,j) \le M_c(i,j)$$

CONTRAST MODIFCATION FUNCTION CHOICE

Considering mammographic noise as signal-dependent and assuming an additif model

$$I(i,j) = F(i,j) + W(i,j) \qquad \text{with} \qquad W(i,j) = \sqrt{F(i,j)}\,U(i,j)$$

I is the NxN pixels original image

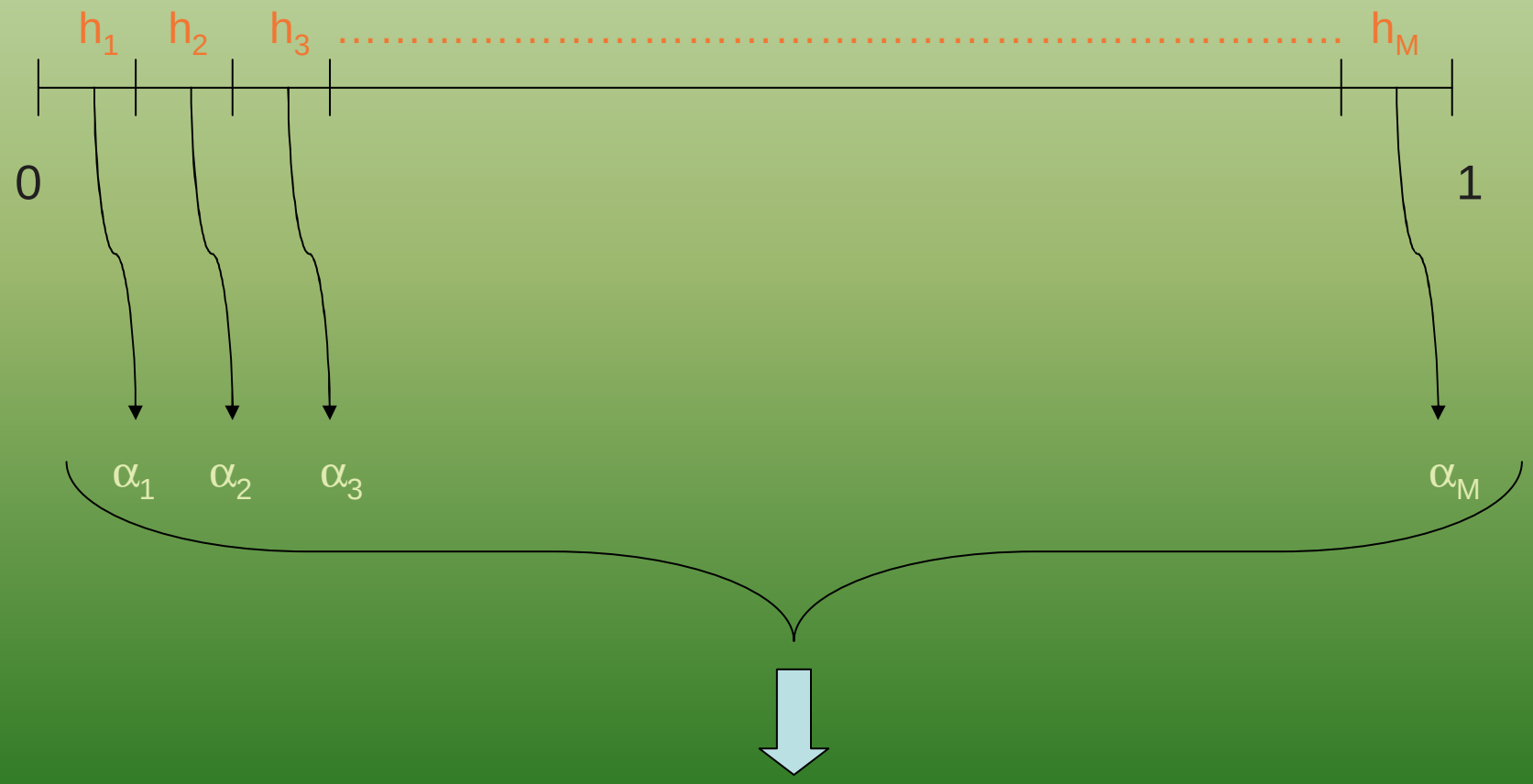
U is a zero mean Gaussian noise with standard deviation σ

Function Ψ is chosen to minimize the MSE defined as follows :

$$MSE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N}\left(F(i,j) - E(i,j)\right)^2}{N^2} = \frac{\sum_{(i,j)\in I}\left(F(i,j) - E(i,j)\right)^2}{N^2}$$

CONTRAST MODIFCATION FUNCTION CHOICE

Case of a piecewise linear in the range [0,1]
$\Psi(x)=\alpha_i$ if x is in the interval h_i



Function Ψ

CONTRAST MODIFCATION FUNCTION CHOICE

Minimizing MSE

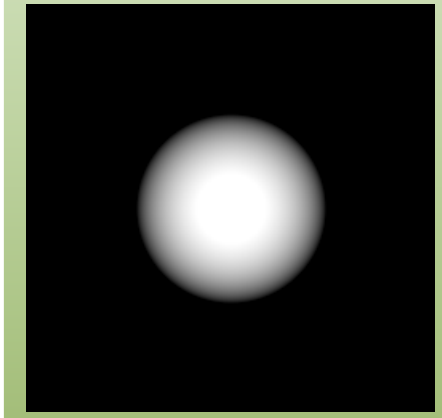
$$\left(\sum_{(i,j)\in L_k} M_b(i,j)^2\right)\beta_k^4 - \left(\sum_{(i,j)\in L_k} M_b(i,j)F(i,j)\right)\beta_k^3 + \left(\sum_{(i,j)\in H_k} M_b(i,j)F(i,j)\right)\beta_k - \sum_{(i,j)\in H_k} M_b(i,j)^2 = 0$$

where

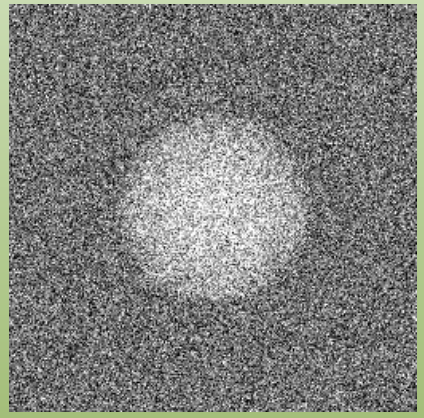
$\beta_k = 1-\alpha_k$

$H_k=\{(i,j)\in I \,/\, Mc(i,j)\geq Mb(i,j) \text{ and } C(i,j)\in h_k\}$ $\quad$ $L_k=\{(i,j)\in I \,/\, Mc(i,j)<Mb(i,j) \text{ and } C(i,j)\in hk\}$

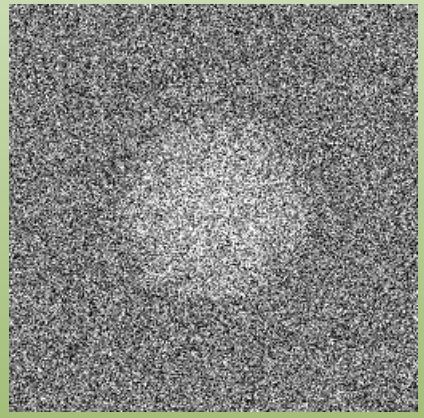
COMPUTER SIMULATED IMAGES



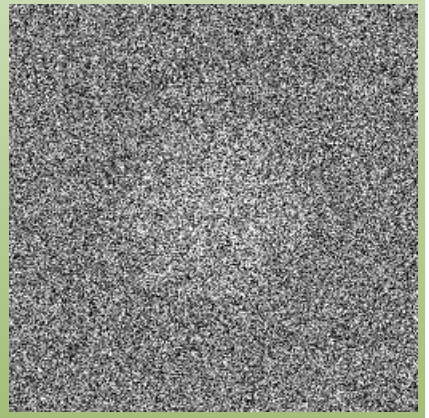
Mass noise-free image F



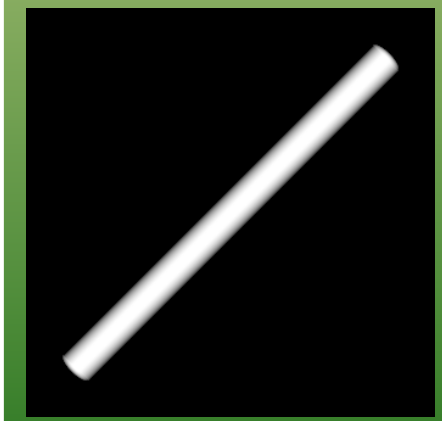
(a) Mass noisy image I with SNR=21 dB



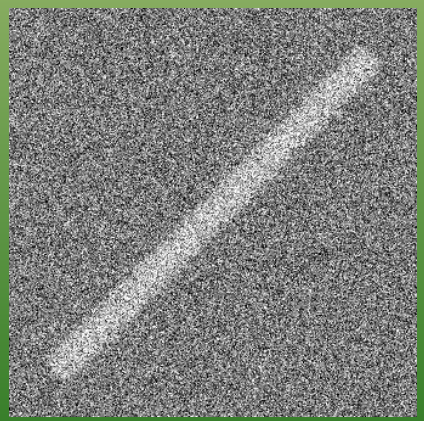
(b) Mass noisy image I with SNR=15 dB



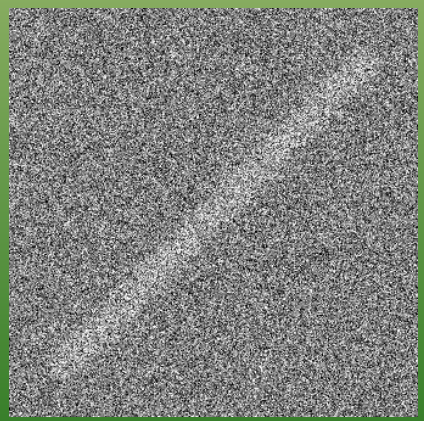
(c) Mass noisy image I with SNR=9 dB



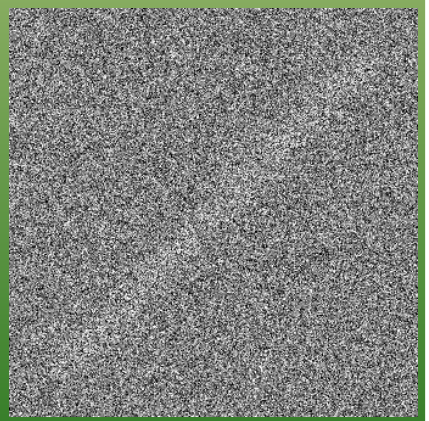
Fibre noise-free image F



(d) Fibre noisy image I with SNR=21 dB

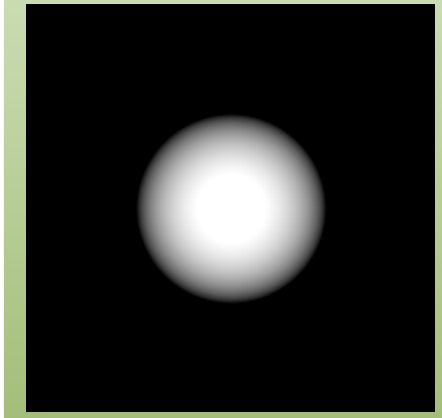


(e) Fibre noisy image I with SNR=15 dB

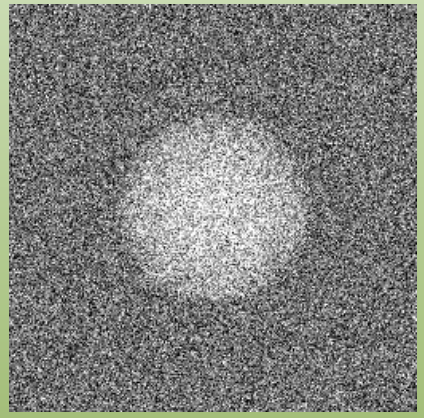


(f) Fibre noisy image I with SNR=9 dB

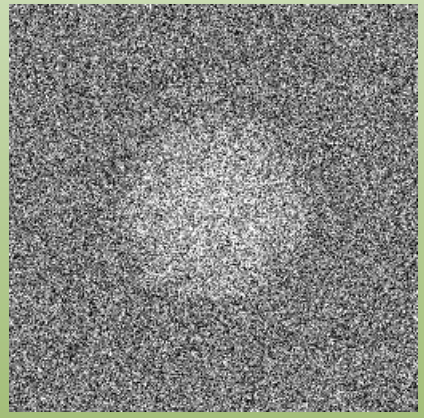
RESULTS ON COMPUTER SIMULATED IMAGES



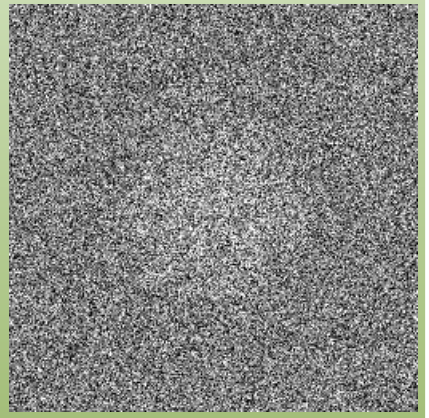
Mass noise-free
image F



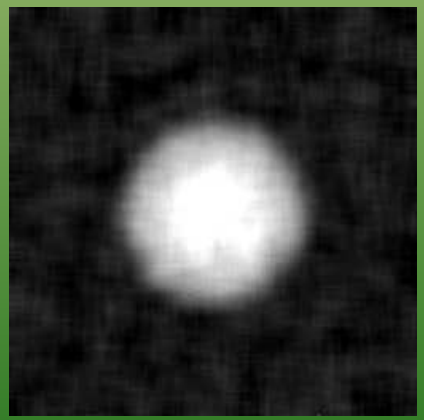
(a)
Noisy image I
with SNR=21 dB



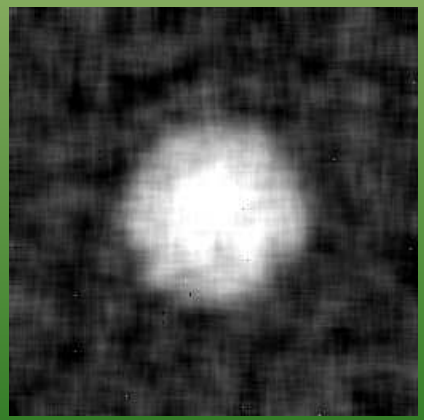
(b)
Noisy image I
with SNR=15 dB



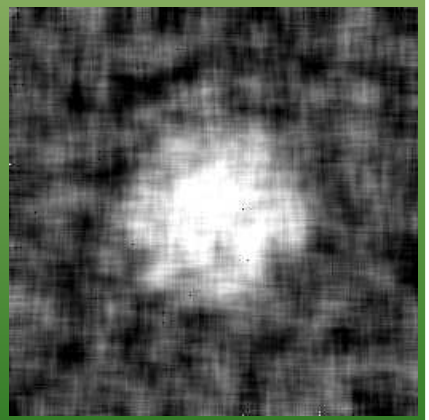
(c)
Noisy image I
with SNR=9 dB



Noise reduction result
on image (a)

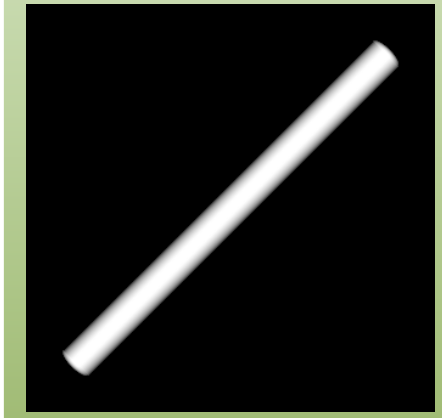


Noise reduction result
on image (b)

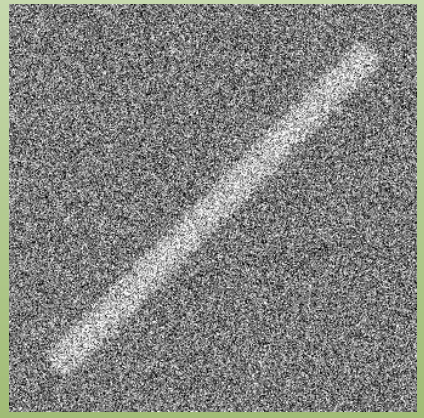


Noise reduction result
on image (c)

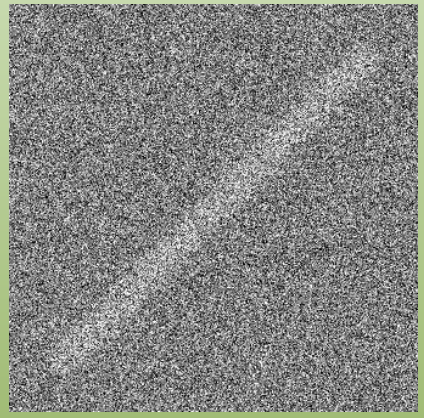
RESULTS ON COMPUTER SIMULATED IMAGES



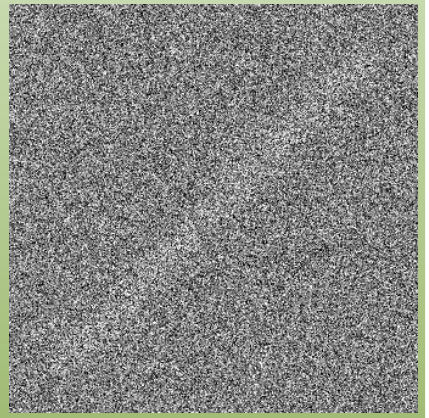
Fibre noise-free image F



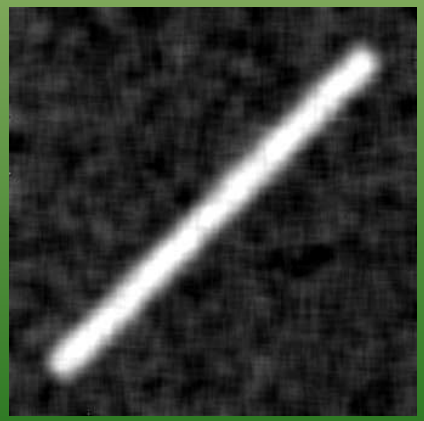
(d)
Fibre noisy image I with SNR=21 dB



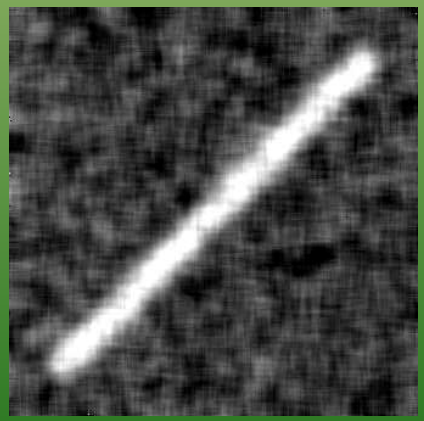
(e)
Fibre noisy image I with SNR=15 dB



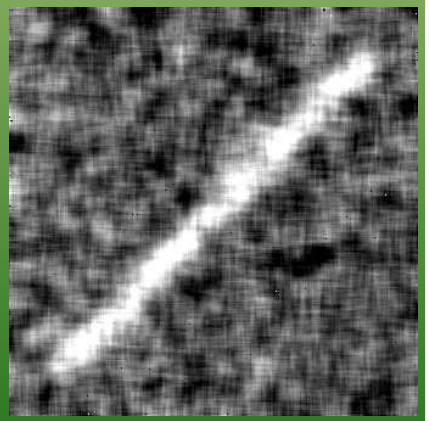
(f)
Fibre noisy image I with SNR=9 dB



Noise reduction result on image (d)

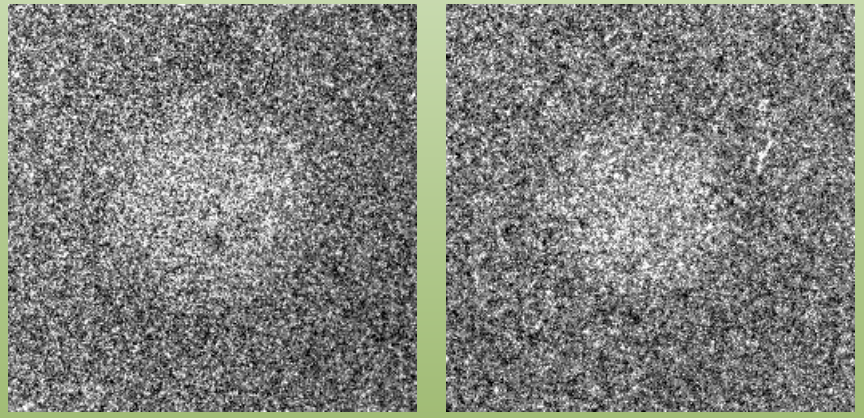


Noise reduction result on image (e)

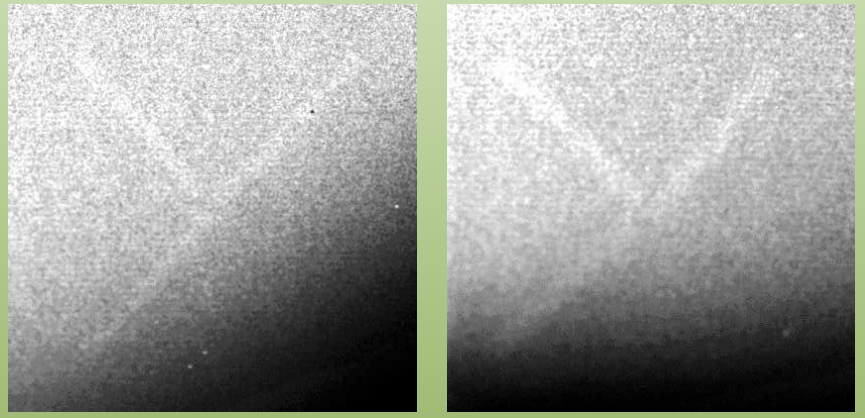


Noise reduction result on image (f)

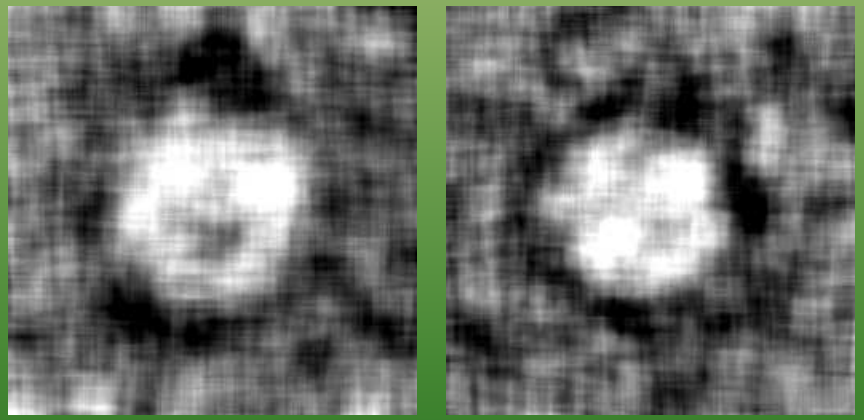
RESULTS ON REAL PHANTOM IMAGES



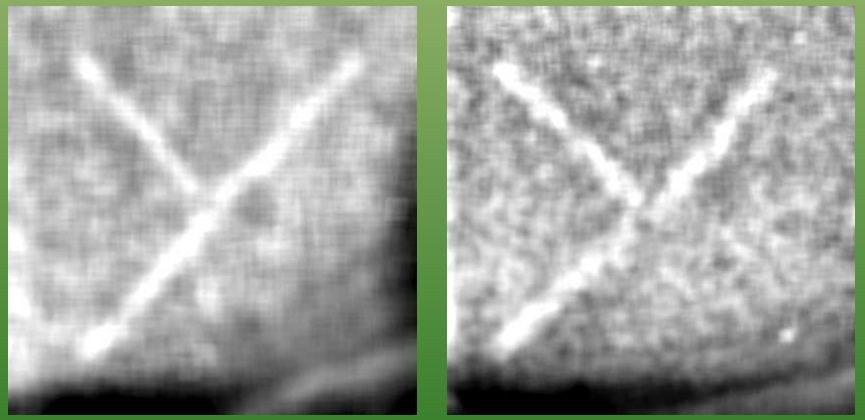
Real mass images



Real fibre images



Resulting denoised images



Resulting denoised images

CONCLUSIONS

- Function Ψ is found to be linear.

- Good results are obtained on both mass and fiber images.

- This method appears to be a good image preprocessing for automating quality control in mammographic facilities.