A New Approach of Anisotropic Diffusion: Medical Image Application

Y. TOUFIQUE*, L.MASMOUDI*, R.CHERKAOUI EL MOURSLI*, M. CHERKAOUI MALKI**.

*Université Mohammed V –Agdal, Faculté des Sciences de Rabat, Maroc
**L' Hôpital Internationale CHU Cheik Zaïd, Rabat, Maroc

The aim

✓Image data pre-processing

➡ Correcting some degradation on the image or enhancing some image features necessary for further processing and analysis.

✓A new implementation of the anisotropic diffusion technique, based on Perona-Malik (P-M) equation,

➡ Better noise reduction and preserving small structures and discontinuities between different regions on the images.

✓Experimental results on real medical scanner(CT) images.

Anisotropic Diffusion Algorithm

Matrice image

12	14	38
23	40	19
22	30	13

In practice, this amounts to calculating a "weighted average" of the neighboring around the central pixel. The weights reflect the difference in intensity with the central pixel.

Malik and Perona proposed the following functions to calculate the weights:

$$f(x) = \frac{1}{1 + \left({}^{x}/_{k}\right)^{2}}$$

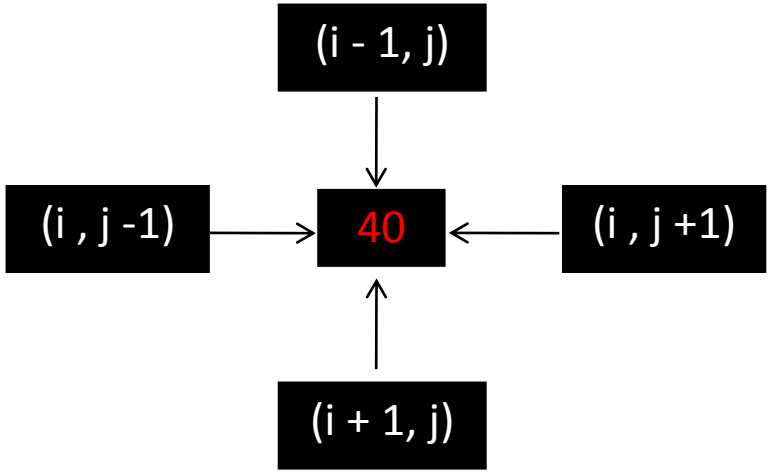
$$f(x) = e^{-\left({}^{x}/_{k}\right)^{2}}$$

Where K is a parameter to be chosen adequately

$$I^{t+1}(i,j) = im^{t}(i,j)+delta*[f[im(i,j)-im(i,j-1)]+ f[im(i,j)-im(i,j+1)]+ \ldots.\ ]$$

The factor "delta" is used to control the spread of the force, thus to avoid saturating the new value.

In practice, we use a low value of "delta" (about 0.1) and multiple iterations are performed.



Adaptive edge magnitude parameter

We propose to adjust the parameter K according to the local intensity variance V(i,j).

$k_{i,j}$ should increase when the variance V(i,j) decreases and should decrease when V(i,j) increases.

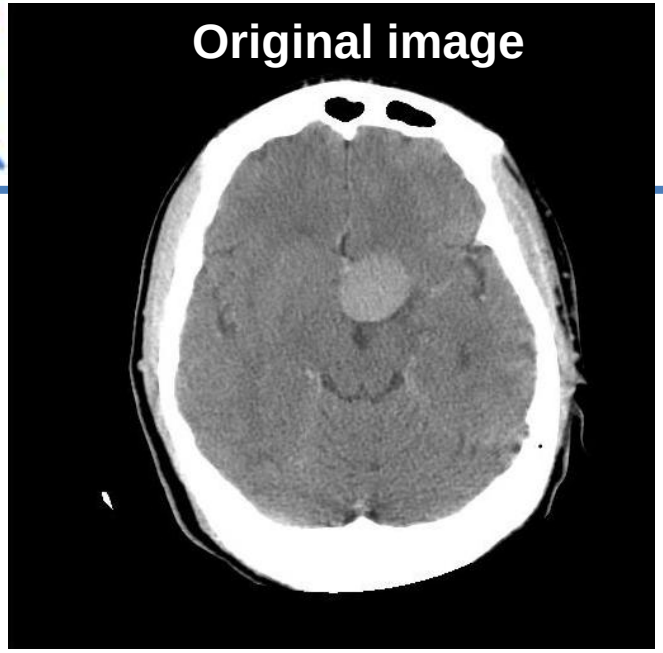
Moreover, $k_{i,j}$ should be between k_{max} and k_{min}.

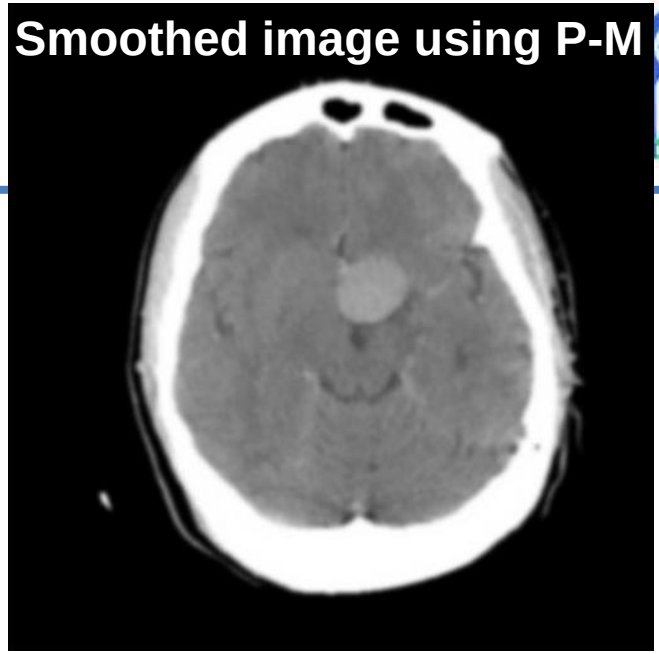
The adaptive procedure can be formulated as follow :

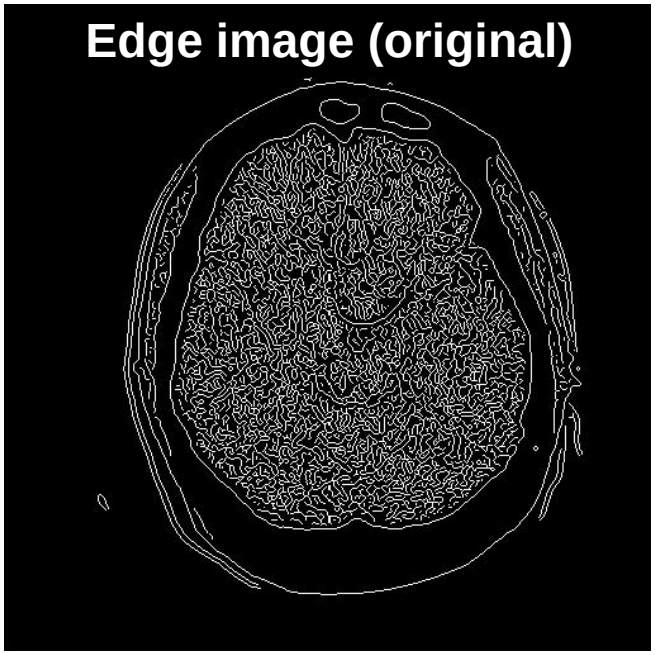
$$k_{i,j} = k_{\max} - \left(V(i,j) \times \frac{k_{\max} - k_{\min}}{V_{\max}} \right)$$

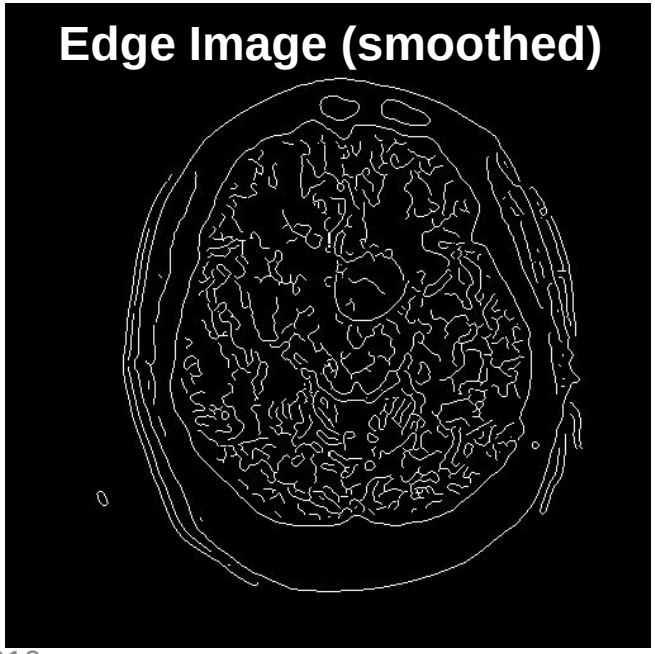
With k_{max}=100 and k_{min}=10

Medical Image Application



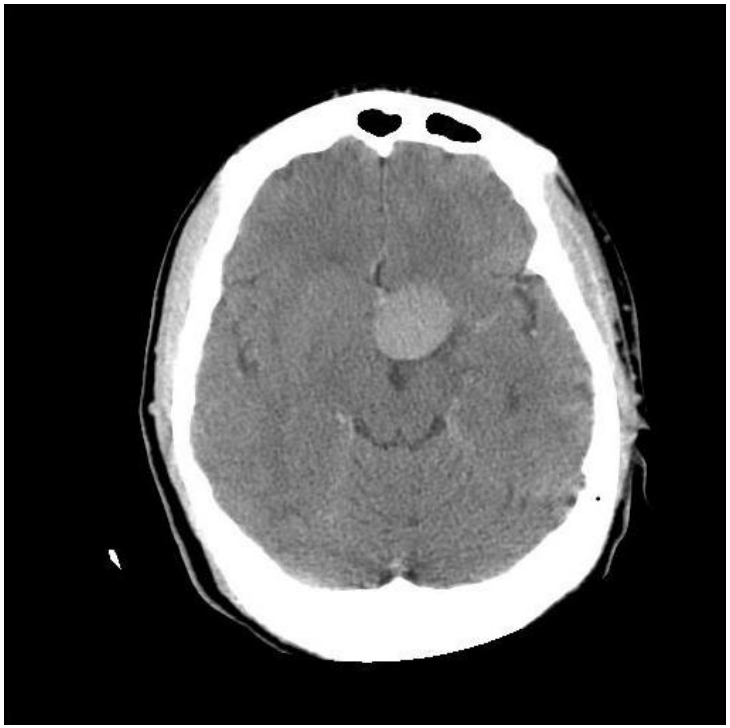


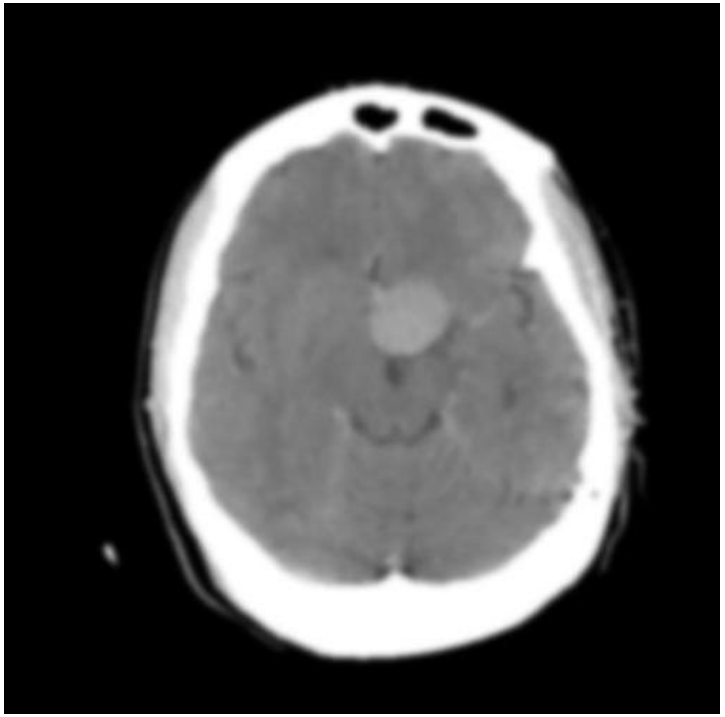




For k = 5 and number of iterations =15

With the new approach by using the formula mentioned before, we have value ki,j for each pixel (i,j). Hence we have local variation of k parameter.

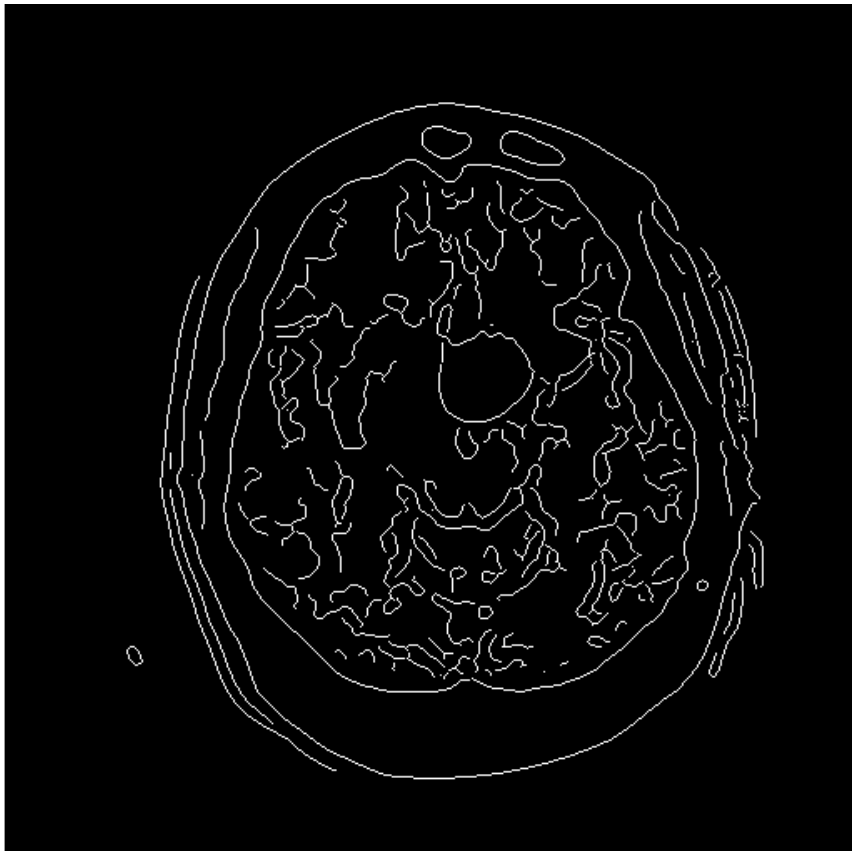




With the new approach

The comparison is much clearer on the edge images
The edge images show the contours and the change of image noise

k = 5 and number of iterations =15



New adaptive

Stop iterations

As the quality of smoothing also depends of iterations' number, the main problem of the algorithm is how to stop these iterations at the right moment?

We introduce the Entropy information to determine the optimal number of iteration required for each image.

The processing of diffusion is being stopped when the entropy value became approximately constant.

The Shannon entropy

The quality of filtered image depends on number of iteration.

We will stop the iterations when the entropy becomes stable.

$I(i, j)$ is the initial noisy image at (i,j)th pixel

$\tilde{I}(i, j)$ is the filtered image at at (i,j)th pixel

$e(i, j)$ is filtering error defined by:

$$e(i, j) = I(i, j) - \tilde{I}(i, j)$$

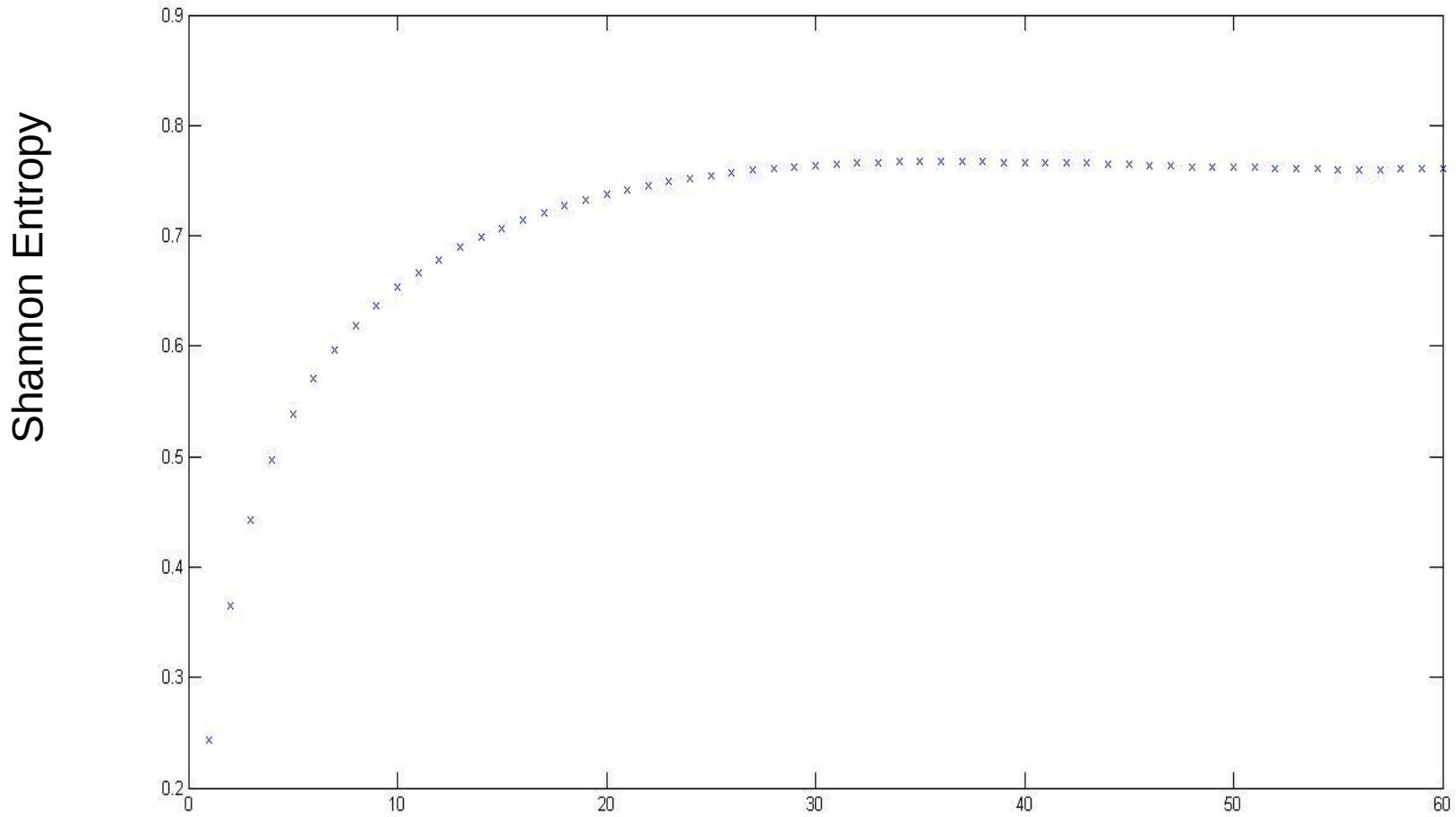
The Shannon entropy

$$g(i,j) = \frac{e(i,j)}{\sum_{i=1}^{N}\sum_{j=1}^{N} e(i,j)}$$

The Shannon entropy for each g is defined in this case as:

$$E(g) = -\sum_{i=1}^{N}\sum_{j=1}^{N} g(i,j)\log\left(g(i,j)\right)$$

The processing of diffusion is being stopped when the entropy value became approximately constant.

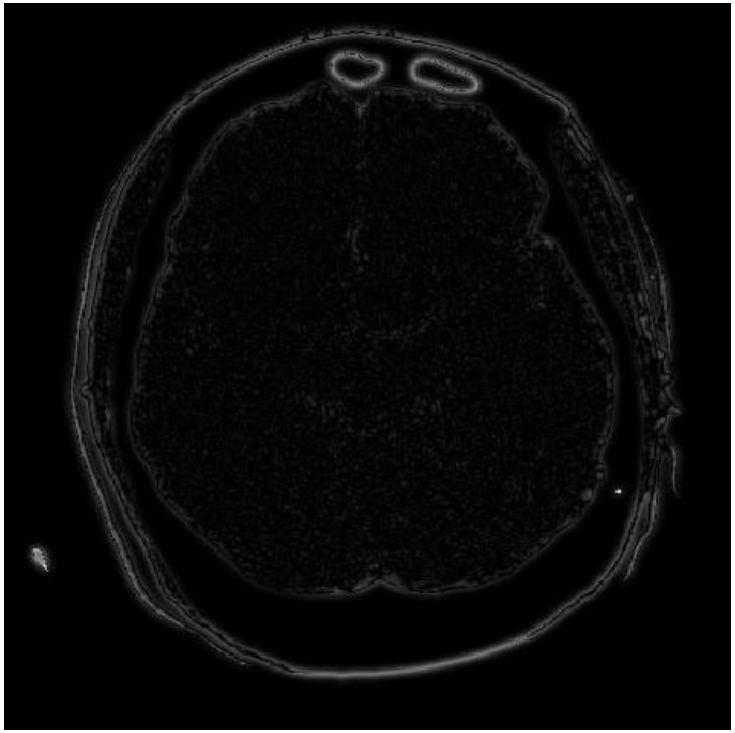


from the graph we observe that from the 35th iteration error image remains stable

Experimentation results

image "error" only gives information on the change of the image
(the difference between the image and the filtered image by setting "K")
versus the number of iterations

Original image



Error image after 20 iterations and k=15

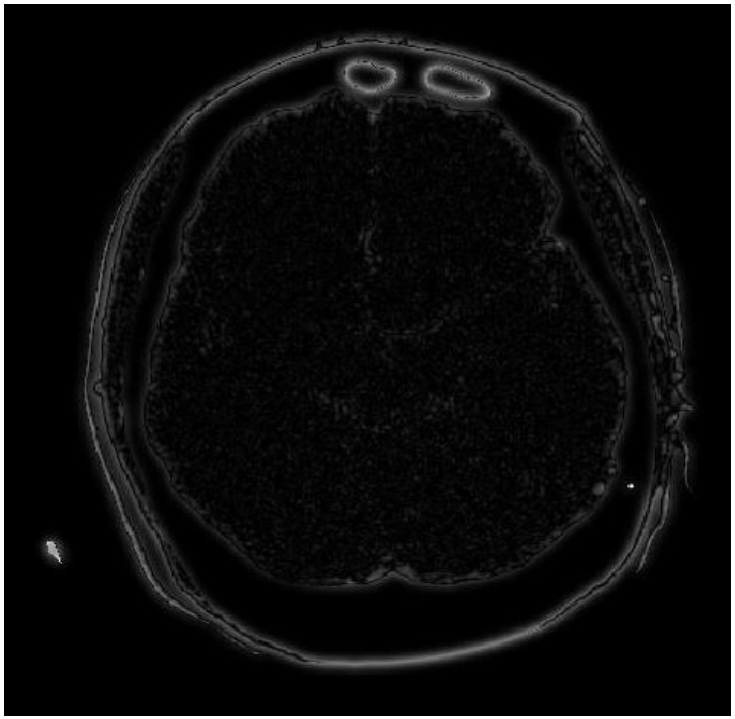


Fig. 1 (a) : Error image after 35 iterations and k=15

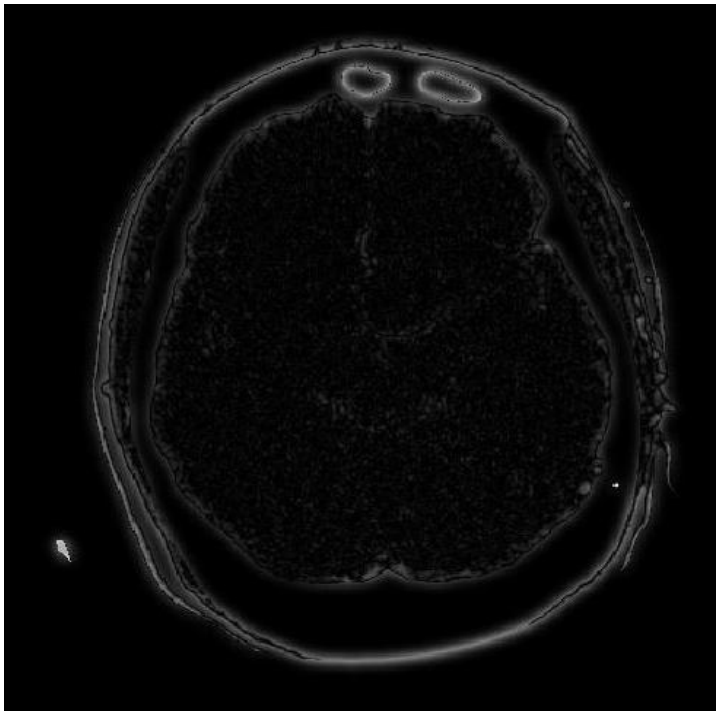


Fig. 1 (a) : Error image after 45 iterations and k=15

Conclusion

✓The proposed approach, based on P-M technique, reduces noise and irrelevant details while preserving sharper boundaries.

✓The stop criterion is based on the entropy principal to limit the number of iterations and to improve the quality of filtering.

✓Extension of this technique to others modalities (RMN, PET, Echography, Doppler …) and/or to 3D medical images can be considered.

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Thank you