

# Fuzzy Edge Detection In Computed Tomography Through Particle Swarm Optimization

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**Keywords** : Computed Tomography; Non Destructive Testing; Bayesian Inference; Fuzzy Inference; particle swarm Optimization.

## 1 Introduction

The ill posedness problem of image reconstruction as we have seen in our last work [1] needs powerful tools for the inference system and the optimization process. So the problems must be regularized, usually, a penalty is imposed on the solution. The difficulty is to avoid the smoothing of edges, which are very important attributes of the image. In this paper, we first introduce a fuzzy inference model for such edge-preserving regularization. Under these conditions, we show that it is possible to found the global best solution of the problem by introducing The particle swarm optimization (PSO).

## 2 Proposed method

Image reconstruction in x-ray tomography [2] consists in determining an object  $f(i, j)$  from its data measures called projections  $p$  [1] expressed by:

$$p(r, \theta) = \int_{L_{r,\theta}} f(x, y) dl \quad (1)$$

For the ill-posed problem  $f = \underset{f}{\operatorname{argmin}}(J(f))$  is the quasi solution with minimization of the criteria  $J(f)$  chosen to be a likelihood function in the probabilistic estimation. If we add constraints to the criteria as the smoothing, we introduce the constraint violation as a heavy penalization in the criteria [2]:

$$J(f) = L(f) + P(f) \quad (2)$$

Where  $L(f)$  is a likelihood function  $l(f)$  [4].  $P(f)$  is the priori information.

$$l(f) = \sum_{i=1}^n \left( - \sum_{j=1}^m a_{ij} f_j + p_i \ln \left( \sum_{j=1}^m a_{ij} f_j \right) - \ln(p_i!) \right) \quad (3)$$

$a_{ij}$  a weighting factor representing the contribution of pixel  $j$  to the number of counts detected in bin  $i$ . Our contribution takes the prior information as fuzzy penalty and optimizes the new criteria with PSO. The most used prior is GIBBS prior defined by [3]:

$$P(f) = Ce^{-\beta U(f)} \quad (4)$$

Where  $U(f)$  is the potential function defined in the Markov field,  $\beta$  and  $C$  chosen to modulate the

importance of the prior value  $U(f) = |f - f_0| \Rightarrow \frac{\partial}{\partial f_j^k} U(f_j^k) = \sum_{b \in N} w_{jb} (f_j^k - f_b^k)$  (5)

$k$  iteration number,  $w_{jb}$  weight of pixel  $j \in N$  the nearest neighbor set of the pixel,  $f_0$  the information image.

The derivative of  $J(f)$  is taken equal to zero to find the image  $f$  (from green formulation) [3]:

$$f_j^{k+1} = \frac{f_j^k}{\sum_{i=1}^n r_{ij} + \beta \frac{\partial}{\partial f_j} U(f_j^k)} \sum_{i=1}^n \frac{p_i}{\sum_{j=1}^m r_{ij} f_j^k} r_{ij} \quad (6)$$

The correction value of the prior term in the denominator of MAP makes difference with the ML EM [1] we will with fuzzy model in our method FP EM (fuzzy penalty expectation maximization)[1]. If we take  $J(f)$  as a fitness function to optimize by the PSO we will express the Value of the prior term in MAP criteria with fuzzy model in our method FP PSO (fuzzy penalty particle swarm optimization).

$$J(f) = \sum_{i=1}^n (-\sum_{j=1}^m a_{ij} f_j + p_i \ln(\sum_{j=1}^m a_{ij} f_j) - \ln(p_i!)) - \beta U(f) + k \quad (7)$$

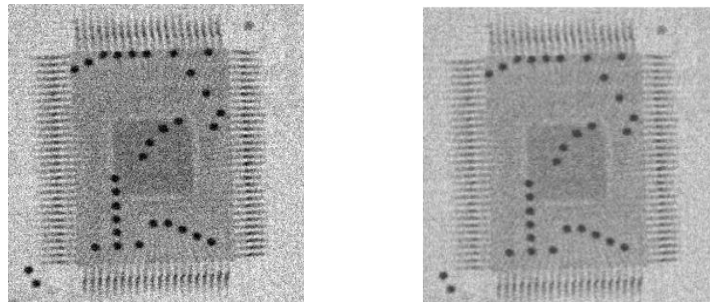


Figure-Original and reconstructed Gaussian noisy Image with PSO algorithm.

## References

- [1] A.M.T. Gouicem, K. Benmahammed, R. Draï, M. Yahi and A.Taleb-Ahmed, "Multi-objective G-A Optimization of Fuzzy Penalty for Image Reconstruction from Projections in X-Ray Tomography", Digital Signal Processing Elsevier, vol 22 No 3 pp 486-596, 2012.
- [2] A.M.T. Gouicem, " G-A Optimization of Fuzzy Penalty for Image Reconstruction from Projections in X-Ray Tomography", these PHD, University of Batna, Mars 2013.
- [3] A.M. Djafari, " Inverse problem in vision and 3D Tomography", Wiley, 2010.