Improving Reconstructed Images using Hybridization between *Local Search* and *Harmony Search* Meta-heuristics

Ahlem Ouaddah and Dalila Boughaci
University of Science and Technology Houari Boumediene USTHB
Electrical Engineering and Computer Science Department
El-Alia BP 32 Bab-Ezzouar
16111 Algiers, Algeria
aouaddah@usthb.dz,dboughaci@usthb.dz

ABSTRACT

Image reconstruction from projections in tomography is an ill-posed, inverse problem. This problem is always a challenge because there are no standard methods which give satisfactory results. In this paper we propose hybridization between Local Search (LS) and Harmony Search (HS) meta-heuristics to improve quality of reconstructed images. The proposed method is implemented, tested on some images and compared to LS and Filtered backprojection (FBP) methods. The preliminary results are promising and prove the efficiency of our method.

Categories and Subject Descriptors

G.1.6 [**Mathematics of Computing**]: Optimization—*Stochastic programming, Linear programming, Global optimization*; I.4.5 [**IMAGE PROCESSING AND COMPUTER VISION**]: Reconstruction—*Transform methods*

Keywords

image reconstruction in tomography; Harmony search meta-heuristic; Local search meta-heuristic ;

1. INTRODUCTION

Image reconstruction in tomography from projections is an inverse problem, ill posed: from a set of measures (projections), we have to find the object which produces these measures. It is also an ill-posed problem: the solution could exist or not and could be not unique. Several methods are proposed for tomographic reconstruction, the most used method in clinical routine is the FBP method [1]. Meta-heuristics have been used successfully in various optimization fields such as industry, scheduling and medical imaging. However in tomography reconstruction, there is only a few research dealing with meta-heuristics for tomographic images reconstruction as [3, 5]. In [4], we showed that a Local Search algorithm could be used for tomographic reconstruction in case of same concentration of physical parameter, the evaluation function was based only on a local distance of each point. In this paper, we propose an hybridization between Harmony Search (HS)[2] algorithm, which was never proposed for this problem and Local Search (LS) meta-heuristic [4] to improve more quality of reconstructed images. We demonstrate that hybridization between Harmony Search and Local Search meta-heuristics can be used to reconstruct and improve more the quality of images from its projections.

GECCO'14, July 12–16, 2014, Vancouver, BC, Canada.
ACM 978-1-4503-2881-4/14/07.
http://dx.doi.org/10.1145/2598394.2602283.

2. THE PROPOSED METHOD

2.1 Harmony Search algorithm (HS)

As following, the principles steps of HS method :

Step 1. Initialize the problem and algorithm parameters: After initialization of the problem, we specify the algorithm parameters as follows:

- **Harmony memory size (HMS)**: corresponds to the number of harmonies (solutions) in the harmony memory (HM).
- **Harmony Memory Considering Rate (HMCR)**: $HMCR \in [0, 1]$
- **Pitch Adjusting Rate (PAR)**:$PAR \in [0, 1]$
- **Number of improvisations (NI)**: corresponds to the stopping criterion.

Step 2. Initialize the Harmony Memory (HM): HM is a vector which contains all the solutions, the HM could be filled with randomly generated solutions.

Step 3. Improvise a new harmony from the HM: A new HM vector is estimated using three parameters: (1) memory consideration, (2) random selection and (3) pitch adjustment.

Step 4. Update the HM: The new harmony is added in the HM only if its evaluated as better than the worst solution of HM which will be removed and replace by the new harmony.

Step 5. Repeat Steps 3 and 4 until satisfaction of stopping criterion.

3. HS METHOD FOR THE PROBLEM

The problem consists to find the reconstructed image which has the minimum of distance between estimated and measured projections.

3.1 Initialization

3.1.1 Initialize population called HM

Initial solution corresponds to the reconstructed image by FBP method.

3.1.2 Parameters Initialization

1. **HMS**: $HMS \in [1, 4]$
2. **HMCR**: $HMCR \in [0, 1]$
3. **PAR**: $PAR \in [0, 1]$
4. **NI**: $NI = 300$

3.1.3 New harmony

For each iteration, we produce two new solutions:

1. If $rand < HMCR$ we produce a new solution from the HM, and choose randomly a value x_{k_t} from HM.
2. If $rand < PAR$, we produce from the current harmony, one new neighbors solution.

3.1.4 Update HM

Using the objective function for the two new solutions, we choose and add the best one which has the minimum value of distance in the HM and remove the historical solution which has the maximum value of distance.

3.1.5 Objective function

The Objective function corresponds to the distance between all measured projections (sinogram) and the estimated one. City block distance [7], is used because it's given a high quality of precision and it's a fast method.

We supposed that the projection is recorded into sinogram $H(s,\theta)$. We compute the sum of the distance (D) between each estimated projection of changed point that recorded into sinogram $H_c(s,\theta)$ and each measured projection for the same angle θ of the same point recorded into sinogram $H_m(s,\theta)$, such (1):

$$D = \sum_{s,\theta} |H_c(s,\theta) - H_m(s,\theta)| \quad (1)$$

3.2 Hybridization between LS and HS

The basic principle is presented as follows:

1. Apply LS algorithm
2. compute rate of reconstructed image by step(1)
3. if $rate < value\ V$ Apply HS algorithm.

3.3 Results

To assess and validate our method in the simplest case, we have developed synthetic images. We compared our tested images with those of FBP method and the comparison as shown in Figure 1.

Also, we estimate the gap (the difference between the reconstructed image and the original one) and the NMP (number of misplaced pixels) for reconstructed image.
The values of reconstructed image are by: FBP method: $gap = 0.11$ and $NMP = 88.89\%$, LS algorithm: $gap = 0.2$ and $NMP = 2.77\%$ and HS algorithm: $gap = 0$ and $NMP = 0\%$. As we see HS improves quality of reconstruction comparing to FBP method.
However the gap of LS is $gap = 0.2$, the NMP proves that LS is better than FBP. After applying HS, the gap became $gap = 0$, therefore HS improves more the quality of reconstructed image.

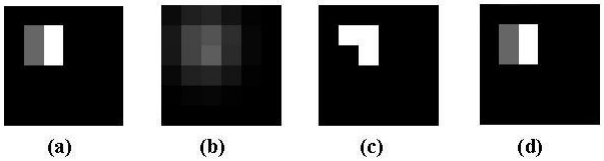

Figure 1: Reconstruction results for image (a). Reconstructed image: by FBP in (b), by LS method in (c), by HS method in (d)

4. CONCLUSION

In this paper we proposed hybridization between Local Search and Harmony Search algorithms for grayscale images reconstruction in tomography. We also compared our method with FBP and LS methods. The numerical results show the effectiveness of our method for grayscale images reconstruction in tomography. Further work will include parallel programming and a comparison with MLEM method.

5. REFERENCES

[1] Fessler,J.: Analytical Tomographic Image Reconstruction Methods., Chapter 3, November 19 (2009).

[2] Geem ZW., Kim, JH. and Loganathan, GV.: A new heuristic optimization algorithm: Harmony search. Simulation, 76:60-68.(2001).

[3] Mou,C., Pen,L.,Yao,D., Xiao,D.:Image Reconstruction Using a Genetic Algorithm for Electrical Capacitance Tomography, Tsinghua science and technology, ISSN 1007-0214 12/20, vol 10 No 5, 587-592 October (2005).

[4] Ouaddah,A. and Boughaci,D.: Local Search Method for Image Reconstruction with Same Concentration in Tomography, Advances in Intelligent and Soft Computing Springer Series, SIRS (2014).

[5] Qureshi,S. A., Mirza,S. M. and Arif, M.: A Hybrid Continuous Genetic Algorithm for Parallelray Transmission Tomography Image Reconstruction, Journal of Biomedical Informatics, in Process (2006).

[6] Radon J. On the determination of functions from their integrals along certain manifolds [in German]. Math Phys Klass.69:262-277 (1917).

[7] Vadivel, A., Majumdar, A.K. and Sural,S.: Performance Comparison of Distance Metrics in Content-based Image Retrieval Applications., International Conference on Information Technology (CIT), Bhubaneswar, India, 159-164 (2003).