INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS

ISSN 2320-7345

MIXED NOISE DENOISING USING NEURO FUZZY AND MEMETIC ALGORITHM

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Abstract: - This paper proposes denoised images from mixed noise of type Gaussian with Salt and Pepper. These noises are denoised by using hybrid filters. These hybrid filters come from join neuro fuzzy system (which also hybrid system join fuzzy system with neural network) with famous image filter which is mean filter. Memetic algorithms be accustomed to determine the best parameters for neuro fuzzy system that is the suitable numbers of fuzzy set for every input and also the advisable input and output weights of neuro fuzzy system. For evaluating the performance of hybrid filter, PSNR (peak signal to noise ratio) are used and all the results of hybrid filters will be compared with the famous image filters that are mean and median filters. The empirical results show that hybrid filters deliver the best results even the density of both (Gaussian and Salt & Pepper) noise is high.

Keywords: Image denoising, Neuro fuzzy system, Hybrid filter, Local search, and Memetic algorithm**.**

1. Introduction

The interests in digital image processing stem from the pictorial information improving for human explanation and the processing of scene data for autonomous machine comprehension [1]. Data sets collected by image sensors are usually contaminated by noise. Defective instruments, problems with the data acquisition process, and meddlesome natural phenomena can all degrade the data of interesting. Furthermore, noise can be introduced by transmission errors and compression. Image Denoising is one of the mainly significant operations used in image processing. Denoising is often a necessary and the first step to be taken before the images data is analyzed where it is not only practice to enhance image quality but is also used as a preprocessing before most image processing operations such as encoding, recognition, compression, tracking and etc. In other words, with none this preprocessing, the other processing would have unsuitable or even false results and it is indispensable to apply an effective denoising technique to compensate for similar data corruption [2, 3]. Techniques that used for Image denoising are:

- *Frequency domain techniques:* in this techniques Fourier transform and Wavelet transforms are useable to improve image.
- *Spatial domain techniques:* The spatial domain direct attention to the aggregate of pixels composing an image, and the spatial domain processing include operations that implement directly on these pixels [1].

Images in this technique are filtering direct the use of "sliding neighborhood processing", where a" mask" is slid across the input image and at every point; an output pixel is computed using some formula that join the pixels inside the prevalent neighborhood. The center pixel is the current pixel in the input image being processed. Filters in this technique possibly linear like mean filter or nonlinear like median filter [4, 5]. In this paper a hybrid filter will be formed by integrate NF with *Spatial domain* filter which is intend filter and then memetic algorithm are used to find that is most desirable weights and the lower number of fuzzy set for every input of NF.

2. Image noise

Noise presence is manifested by undesirable information, not related to the scene under study, which perturbs the information relative to the form observable in the image. It is translated to more or less severe values, which are added or subtracted to the original values on a number of pixels [6].Noise is any undesired information that contaminates an image. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. Presence of noise is manifested by undesirable information which is not at all related to the image under study, but in turn disturbs theoretic indices introduce in the image where it is translated into values, who are getting added or deduct to the true gray level values on a gray level pixel [7, 8]. Noise [9, 10] possibly supplement, supplement noise such as Gaussian can be expressed as:

$$g(x,y) = f(x, y) + n(x,y), \qquad (1)$$

Where $f(x, y)$ is the original 2D signal (image), n is the noise contribution, and $g(x,y)$ is the spoiled image. Gaussian noise is characterized by adding to each image pixel a value from Gaussian distribution. Gaussian distribution explain as follows:

$$p(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, for -\infty \leq x \geq \infty, (2)$$

Where **μ** is the mean and σ is the standard deviation of the distribution. Such noise is usually introduced during image acquisition.

Image noise can be also Impulse. Impulse noise is characterized by replacing a portion of an image's pixel values with other values, leaving the remainder unchanged. The image model containing impulse noise can be described as follows:

$$g(x,y) = \begin{cases} N(x,y), \text{with probability } p \\ f(x,y), \text{with probability } 1 - p \end{cases}, \qquad (3)$$

This classify of noise can be induced by dead pixels, analog to digital converter errors, bit errors in transmission.

Mixed Noise

Mixed noise occurs when images are corrupted by two or more noise as in the case where an image is by together Gaussian and impulse noise. Similar mixed noise be entitled happen when an image which has previously been contaminated by Gaussian noise in the procedure of image acquisition with faulty equipment suffers impulsive corruption during its transmission over noisy channels successively [11].

3. Fuzzy logic and Neural networks as a Hybrid system

Fuzzy logic and artificial neural networks are perfecting technologies. The combination of these two technologies into an integrated system seem to be a promising path toward the development of intelligent systems competent of capturing qualities characterizing the human brain [12].

Integrating these two methodologies can lead to better technologies that take advantage of the strengths of each methodology and at the same time overcome some of the limitations of the individual techniques. For instance , Fuzzy Inference System (FIS) can use human expertise by storing its essentials components in a rule base, and perform fuzzy reasoning to infer the overall output value. Usually it is very difficult to transform human knowledge and experience into a rule base of fuzzy logic system.

Moreover there is a need for developing efficient methods to tune membership functions i.e., to obtain optimal shapes, ranges and number of member functions etc. On the other hand, although ANN provides learning capability and this learning mechanism does not rely on human expertise, it not good at explaining how they reach their conclusions where it is difficult to extract structured knowledge from either the weights or the configuration of the ANN [13, 14, and 15].

The architecture of the NF network based on Takaj fuzzy inference system [16] consists of three layers; they consist of an input layer, fuzzification and rule layer, and output layer correspondingly. Figure (1) explain the structure of NF network.

In order to derive a learning algorithm for a NF network with a gradient descent technique, the inference rule must use differentiable membership function type, for example in this paper the Gaussian membership function will be used.

The adapted parameters in the NF network can be segmented into two parts based on *if* (antecedent) part and *then* (consequent) part of the fuzzy rules. For example in the preceding part, the mean and variance are fine-tuned, whereas in the consequent part, the adapted parameters are the importance weights. The gradient descent based on BP algorithm is employed to adjust the parameters in NF network.
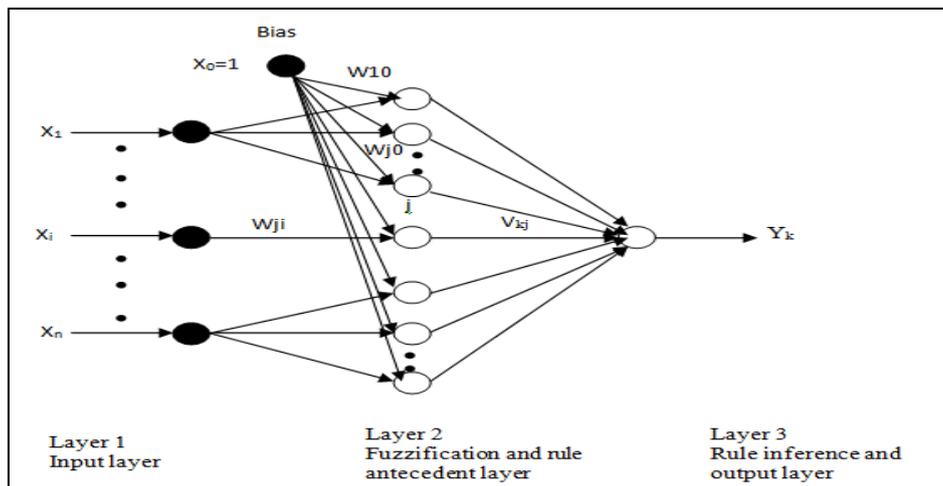

Figure (1): Structure of Neuro Fuzzy Network.

To use neuro fuzzy system as denoise filter we have to solve some problems probably how many number of fuzzy set (rules) should be used for every input and the appropriate weights for training the NF system to receive best result. So we used Memetic algorithm to solve these problems.

Memetic Algorithms (MAs)

Memetic Algorithms (MAs) are a class of stochastic global search heuristics in to what developmental algorithms-based approaches are combined with problem-specific solvers. The later might be executed as local search heuristics techniques [17]. MA starts with various alternative solutions to the optimization problem that are considered as individuals in a population. The population is initialized at random or using a heuristic. To form a new population for the next generation, higher quality individuals are selected. The selection phase is identical in form to that used in the classical GA selection phase. Local search is performed to individuals to select the best chromosome from the pool of available chromosomes. Individuals are subjected to crossover and mutation to generate new individuals [18]. In MAs, GA is used to perform global exploration among a population while heuristic methods are used to perform local exploitation around the chromosomes to get best solution [19].

4. Local search

Local search can be thought of as the process of an individual improving its idea of the solution. Local search algorithms try to find high-quality solutions by searching through the solution space. A local search algorithm starts with an initial solution and then iteratively generates a new solution that is in some sense near to it. The Hill climbing search algorithm is a local search algorithm that iteratively performs a neighborhood search to pick best chromosome from a pool of available chromosomes. When the termination criterion is met, the search algorithm terminates and returns the best solution [17, 18]. In the following we describe the algorithm steps that we use:

a. Encoding and initial population

Each chromosome consists from number of inputs and outputs of NF network. Each input consists of the number of fuzzy rules for this input and the input weights which consist of the mean and variance of membership function for promising part. Each output part of chromosome contains the output weights of consequent part for that input. The number of fuzzy rules will be encoded using integer value whiles the input and output weights will be represented using real value.

b. Fitness function

Fitness value will be computed as follows:

$$fitness = \beta_{e} + \alpha \left(\frac{\sum_{i=1}^{k} fset_i}{max * k} \right) , \qquad (4)$$

Where α, β are a constant in the range **[0..1]**, e is the output error, k is the number of inputs, *fseti* is the number of fuzzy set assign for input i and max is a constant value equal to **7**. The fitness function minimizes the BP error and also minimizes the number of fuzzy set that used. This means that high fitness value has less error and/or less rules.

c. Selection

We use the tournament choice for crossover and substitution. Where for crossover we chosen three different randomly then two of them that would prefer fitness value will be choice. For substitution we also select three different randomly and the worst of them will be replaced with the new different if the new different has better fitness value.

d. Local search

We use hill-climbing as local search strategy (operator) to refine the individual.

e. Crossover

Uniform crossover will be used to recombine the parents and to produce two chilled.

f. Mutation

We used uniform mutation where a mask of "0" and "1" will be generated randomly and if the mask value=1 then perform mutation else do not perform.

g. Stopping criteria

MA will be stopped if the number of cycle reaches the maximum which is equal to 20.

5. Experiment Results and Discussion

In this paper a hybrid filter of combining NF with mean filter will be used for denoising mixed noise (Gaussian with Salt and Pepper) and memetic algorithm are used to find the best weights and the lower number of fuzzy set for each input of NF. The training patterns of neuro fuzzy system consist of six inputs. Five inputs generated from the pixel value that processed and the values of its 4-neighbors; the sixth input is the mean value.

In testing the same inputs for training pattern (the pixel and its 4- neighbors with the mean value) will be passed through the trained NF network. Lena is used as training data and For testing four images will be used two of them are grayscale image and the other are true color image (RGB image).these image will be passed through hybrid neuro fuzzy filter and then the PSNR value will be computed for each image and compared with mean and median filters. PSNR is the ratio between the reference signal and the distorted signal in an image, given in decibels and it is defined as:

$$PSNR(db) = 10 * \log_{10}\left(255^2 / MSE\right) \quad (5)$$

MSE (mean square error) is the average squared distinction betwixt an original image and the restored images and is defined as:

$$MSE = \frac{1}{m*n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}(y(i,j) - d(i,j))^2, \quad (6)$$

Where d and y are the original and the restored images correspondingly, m and n are the number of pixels in both images (dimensions of the images). The higher the PSNR in the reconstruct image, the better is its quality. Table1, 2, and 3 show the results of passing testing image direct the proposed method and mean and median filter. Also Figure 2 and 3 show some images that result from hybrid filters.

Noise ratio	10%				20%				30%			
Image name	Camera man	Pepper	Barbara	Parrot	Camera man	Pepper	Barbara	Parrot	Camera man	Pepper	Barbara	Parrot
Proposed method	30.1	27.05	31.72	28.47	29.52	26.54	30.88	27.69	28.36	25.84	29.85	26.23
Mean filter	21.25	22.25	22.88	22.12	19	19.91	20.13	19.16	17.2	18.1	18.26	17.24
Median filter	25.34	28.3	28.22	28.53	23.47	25.73	25.69	25.36	20.3	21.56	22.25	21.75

Table (1): PSNR values of testing images that corrupted by Gaussian noise of zero mean and σ=10 and Salt and Pepper noise of different ratio and denoised by Proposed method and also by mean and median filter.

Noise ratio	10%				20%				30%			
Image name	Camera man	Pepper	Barbara	Parrot	Camera man	Pepper	Barbara	Parrot	Camera man	Pepper	Barbara	Parrot
Proposed method	26.69	25.19	27.59	25.97	26.21	24.84	27.06	25.34	25.45	24.21	26.39	24.6
Mean filter	20.86	21.99	22.48	21.73	18.83	19.73	19.92	19.04	17.11	17.95	18.03	17.08
Median filter	23.88	25.72	25.78	25.93	22.35	23.75	23.89	23.84	19.72	20.68	20.85	20.44

Table (2): PSNR values of testing images that corrupted by Gaussian noise of zero mean and σ=20 and Salt and Pepper noise of different ratio and denoised by Proposed method and also by mean and median filter.

Noise ratio	10%				20%				30%			
Image name	Camera man	Pepper	Barbara	Parrot	Camera man	Pepper	Barbara	Parrot	Camera man	Pepper	Barbara	Parrot
Proposed method	23.99	23.16	24.81	23.75	23.51	22.85	24.27	23.15	22.92	22.39	23.6	22.48
Mean filter	20.46	21.44	21.98	21.09	18.49	19.33	19.61	18.69	16.87	17.84	17.85	16.84
Median filter	22.36	23.66	23.58	23.72	20.83	21.7	22.03	21.93	18.77	19.5	19.54	19.46

Table (3): PSNR values of testing images that corrupted by Gaussian noise of zero mean and $\sigma = 30$ and Salt and Pepper noise of different ratio and denoised by Proposed method and also by mean and median filter.
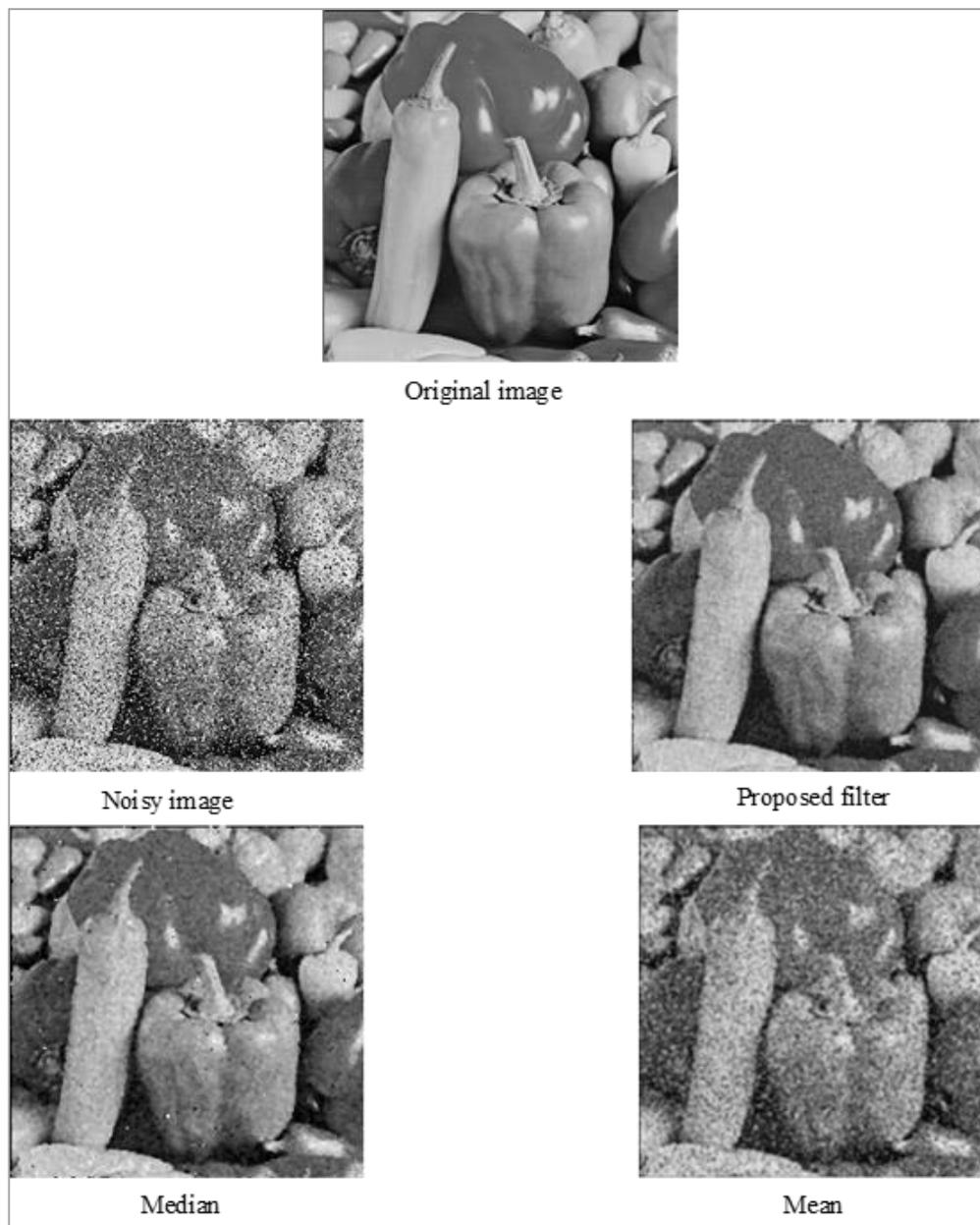

Figure (2): The result of passing Pepper image that corrupted by Gaussian noise of $\sigma = 20$ and salt and pepper noise with 20% through the proposed filter with the result of mean and median filter.
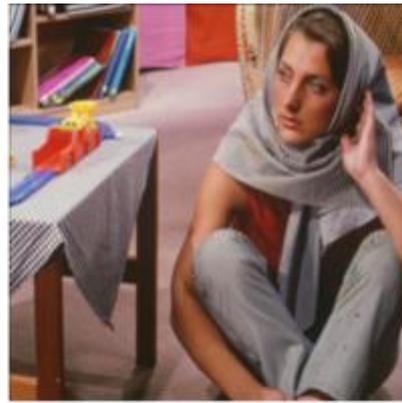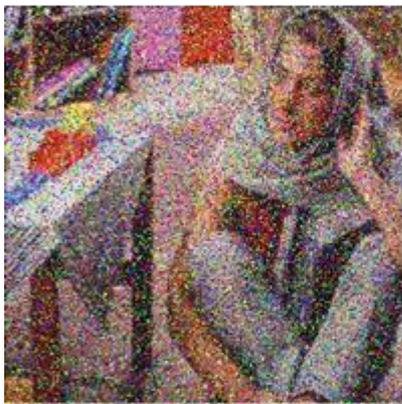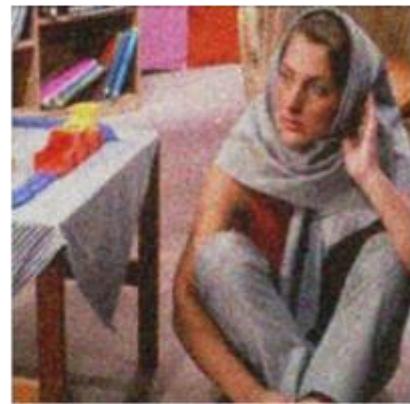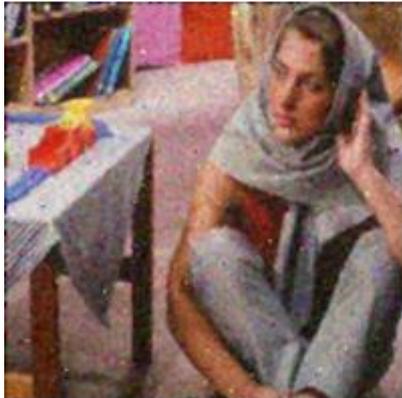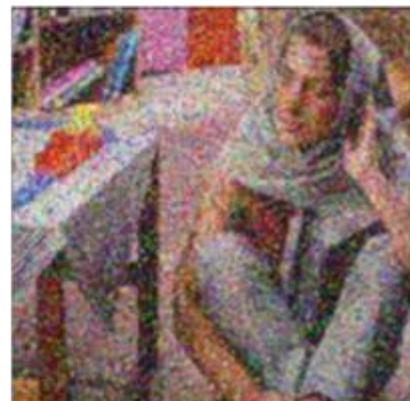
Figure (3): The result of passing Barbra image that corrupted by Gaussian noise of $\sigma = 20$ and salt and pepper noise with 20% through the proposed filter with the result of mean and median filter.

6. Conclusion

In this paper, mixed noise are removed using hybrid filters this hybrid filters consist from combining NF system mean filter and memetic algorithm is used to obtained best weights and architecture. Experimental results show that the proposed filter is more effective in denoising mixed noise even if the density of noise is high and also give best result in PSNR with better visual quality.

REFERENCES

[1] F. Y. Shih, "**Image Processing and Pattern Recognition**", John Wiley & Sons, 2010.

[2] Sh. kala and R. k. sahu, "ICA based Image denoising for Single-Sensor Digital Cameras," IOSR Journal of Engineering, Vol.2, pp: 446-450, 2012.

[3] M. Saeidi, M. H. Moradi, "Mixed Noise Reduction in Image Sequences Using a new Fuzzy Method", In 14th Iranian Conference on Electric Engineering (ICEE) , 2006.

[4] S. Qureshi, "Embedded Image Processing on the TMS320C6000™ DSP", Springer Science+Business Media, Inc.2005.

[5] Y. A. Al-Sbou, "Artificial Neural Networks Evaluation as an Image Denoising Tool", World Applied Sciences Journal, Vol.17, pp. 218-227, 2012.

[6] C. Khare and K. K. Nagwanshi, "Image Restoration in Non-Linear Filtering Domain using MDB approach", World Academy of Science, Engineering and Technology, Vol.37, pp. 761-765, 2010.

[7] S. Lakshmiprabha, "A New Method of Image Denoising Based on Fuzzy Logic", Signal &International Journal of Soft Computing, Vol.3, pp. 74-77, 2008.

[8] C. Khare and K. K. Nagwanshi, "Image Restoration Technique with Non Linear Filter", International Journal of Advanced Science and Technology, Vol.39, pp. 67-74, 2012.

[9] P. C. Khanzode and S. A. Ladhake, "Two Stage Impulse Noise Removal Technique based on Neural Network and Fuzzy Decisions", 2nd National Conference on Information and Communication Technology (NCICT), 2011.

[10] A. Bovik, "Hand Book of Image and Video Processing", Academic Press, 2000.

[11] J. Zhang, R. Xiong, C. Zhao, S. Ma and D. Zhao, "Exploiting Image Local And Nonlocal Consistency For Mixed Gaussian-Impulse Noise Removal", IEEE International Conference on Multimedia & Expo (ICME), pp. 592–597, Melbourne, Australia, Jul. 2012.

[12] N. T. Makhsoos, R. Ebrahimpour and A. Hajiany, "Face Recognition Based on Neuro-Fuzzy System", IJCSNS International Journal of Computer Science and Network Security, Vol. 9, pp. 319-326, April 2009.

[13] M. Kumar and D. P. Garg, "Intelligent Learning of Fuzzy Logic Controllers via Neural Network and Genetic Algorithm", In Proceedings of Japan – USA Symposium on Flexible Automation, Denver, Colorado, July 19-21, 2004.

[14] H. T. Nguyen, N. R. Prasad, C. L. Walker and E. A. Walker, "A First Course in Fuzzy and Neural Control", Chapman & Hall/CRC, 2003.

[15] J. A. B. Vieira, F. M. Diasand and A. M. Mota, "Comparison between Artificial Neural Networks and Neuro-Fuzzy Systems in Modelling and Control: A Case Study", In Proceedings of 5th IFAC International Symposium on Intelligent Components and Instruments for Control Applications, Aveiro, Portugal, 2003.

[16] [16] Martin S. Thomas S. , "Hybrid System : Genetic Algorithms, Neural Network, and Fuzzy Logic", Denmark, 1996.

[17] E. Alba and R. Marti, "Metaheuristic Procedures for Training Neural Networks", Springer Science+Business Media, 2006.

[18] S. Padmavathi, S. M. Shalinie and R. Abhilaash, "A Memetic Algorithm Based Task Scheduling considering Communication Cost on Cluster of Workstations", International Journal of Advances in Soft Computing and Its Applications , Vol. 2, pp. 174-190, July 2010.

[19] H. A. Sanusi, A. Zubair and R. O. Oladele, "Comparative Assessment of Genetic and Memetic Algorithms", Journal of Emerging Trends in Computing and Information Sciences, Vol. 2, pp. 498-508, October 2011.