

A Hybrid Image Contrast Enhancement Approach Using Genetic Algorithm and Neural Network

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Abstract- Contrast Enhancement is one of most important issues in Image Processing. The process of image contrast enhancement improves the contrast of an image and brings out the hidden details which leads to improved visual appearance without addition of unwanted noise. There exist numerous choices for improving the quality of image but the method used for Enhancement is problem dependent. This paper provides a hybrid technique that combines Genetic Algorithm and Neural Network for Contrast Enhancement. The method is applied on the original image and the evaluation parameters are calculated which show that proposed work gives better performance.

Keywords— Histogram Equalization, Genetic Algorithm, Neural Network.

INTRODUCTION

Image Enhancement is a method to improve the quality of a blurred image. Image gets distorted during the process of acquisition because of light intensity, angle of capture and shortcomings of sensing device. Enhancement provides better input for automated image processing. A lot of efforts have been made to enhance low contrast images by improving various factors, such as enhancement of contrast, sharpening, denoising and improving the color accuracy [1]. Image enhancement techniques are characterized by the fact so that both its inputs and outputs are images [2]. Two main categories of Image contrast enhancement are Spatial domain and Frequency Domain [3].

Spatial Domain methods deal with direct manipulation of pixels and thus improve the overall contrast of image while Frequency Domain methods work on Fourier transform of an image [4]. Major Spatial Domain methods include Intensity Transformation and Filtering. Intensity transformation consists of brightness control, stretching the contrast and histogram equalization, Histogram Equalization (HE) stretches the contrast by redistributing the gray level values. Subcategories of HE are BBHE, DSIHE, MMBEHE, RMSHE, MBPHE, DHE, BPDHE [5]. Each of the subcategories have their own advantages and are applied as per the problem. These techniques break the histogram into and then perform equalization. Filters are linear and non linear. Linear filters are low pass filter, sharpening filter, Laplacian filter, High boost filter Median, Min and Max Filters [6].

Genetic Algorithm's [7] are a relatively new paradigm for search. GA's have been proven to be the most powerful optimization technique even when the search space is large

[8]. This explains the ongoing popularity of GA in image processing [7] and other fields [9, 10]. Genetic Algorithms are based on the methodology of natural selection [11]. Natural selection of fittest individuals is used as optimization problem solver. Natural exchange of genetic material between parents will then take place which will lead to optimization. Children are produced from parent genes. Fitness value of offsprings is then calculated. The fittest individuals survive [12] and are allowed to breed. The individuals then produce offsprings using crossover operation. Some of the individuals are mutated randomly. Neural Network play an important role in image contrast enhancement while preserving the original brightness of image. The basic structure consists of many inputs corresponding to one output.

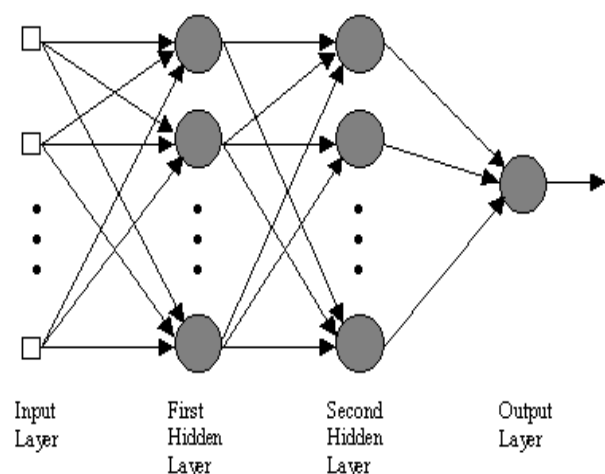


Fig1. A Neural Network

ANN consists of large number of processing elements which are interconnected with each other [13,14]. A neural network is a set of nodes and a set of links [15]. Nodes represent neurons and connections are represented by links quantified by weights. There are two modes of Neuron: Training mode and Using mode. In the training mode the neuron is trained to fire on seeing the particular input pattern. In the using mode the rule is fired on detecting the taught input pattern.

This paper proposes a hybrid technique that uses Genetic Algorithm for optimization. GA will find out the chromosome with maximum fitness and containing alpha values for each object. Neural network will be trained by

taking as input the alpha values contained in the chromosome and the pixel values of the original image and target of Neural Network will give new values to the pixels. As a result of which enhanced image will be obtained. The motivation of this paper is to enhance the image to its correct extent other than over or under enhancement. Section II describes about the proposed work. Experimental results of the work are discussed in Section III. Section IV gives the conclusion and the future scope.

PROPOSED WORK

In [16] fuzzy set theory was used for contrast enhancement. The major shortcoming of the above technique is that it led to under enhancement i.e. enhanced image becomes darker than the original image. To overcome the under enhancement a new algorithm is proposed. The steps of proposed work are represented in Fig 2.

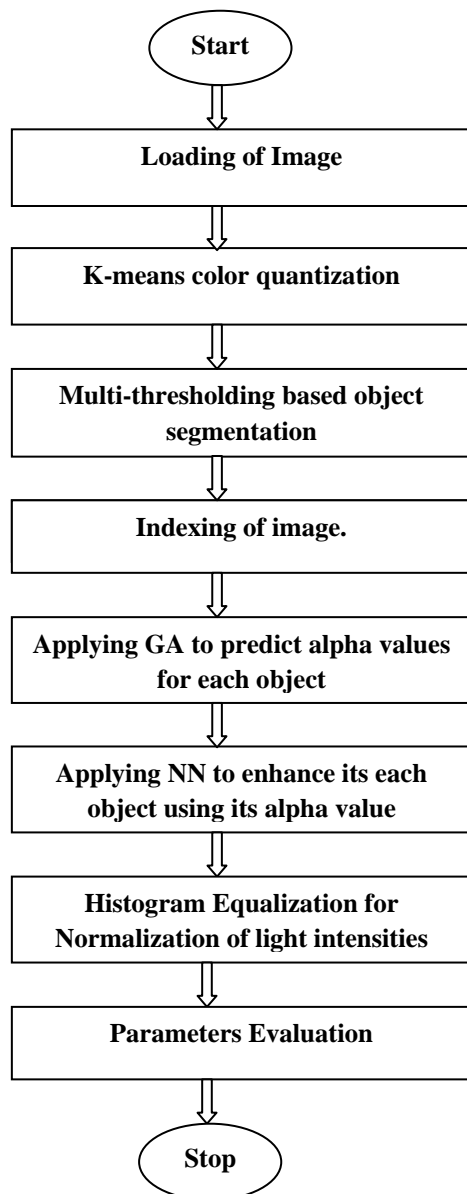


Fig..2 Flowchart of the proposed method

A. In the very first step the image on which we are going to implement the algorithm is loaded into MATLAB workspace and necessary modifications are made.

B. In this step K-means color quantization is done. The main purpose is to reduce the number of distinct colors used in an image. The image obtained will be visually similar to the original image. Here the number of distinct colors is ten.

C. In the next step objects were segmented using multi-threshold segmentation techniques. This technique works on gray level images. Multiple threshold values are chosen based on which multiple objects are segmented.

D. In the Indexing process, MATLAB function ‘bwlabel’ used to label the objects in the image and displays the results as an indexed image. Also from this image the connected components which have fewer than p pixels are removed as these objects do not form the Region of Interest.

E. In the next step GA is applied as follows :
A genetic algorithm simulates the natural evolution process. Basically genetic algorithm is characterized by parameters namely population size, no of generations, selection, crossover and mutation.

1) Initialization of GA:

First of all we have to initialize the value of number of chromosomes ‘C’ and number of generations ‘N’. The algorithm will be applied on ‘C’ chromosomes for ‘N’ number of times. Accuracy will depend on number if generations. After initialization of the parameters GA is then applied.

GA starts with random generated population .This population is selected to breed a new generation which we say as Child chromosomes. The Genetic operators are Mutation and Crossover.

Mutation: In the mutation process child chromosomes are generated from the parent chromosomes by changing one of the values among each chromosome with a defined step size. Child chromosomes thus produced will be equal in number to the parent chromosomes and share characteristics.

For Example if Parent is- 1101111010000110 then child chromosome- 1100111010000110 i.e. mutation changes the value randomly.

Crossover: In crossover child chromosome is produced from more than one parent chromosome. The new chromosome will have some properties from first parent and some from second parent. The child chromosome may be better than both of the parents if it takes the best characteristics from each of the parents. In this any one of the value of any of the chromosomes crosses over with the value of some other chromosome.

For Example if parent1 is 11001011 and parent2 is 11011110 then the child chromosome will contain some part of parent 1 and other from parent 2 i.e.

$$11001010 + 11011111 = 11011111$$

2) *Fitness Value Evaluation:* Fitness function is used to find the fitness value of each chromosome. The chromosome which gives the maximum value of fitness value will be considered as best chromosome and can be used further. The fitness function is defined using the weighted sum method where the fitness value is generated keeping in mind all the evaluation parameters. The weight sum method assigns equal weight for each parameter used in fitness function.

The pseudo code for calculation of fitness function is as follows:

$$\text{Fitness value} = (w1*f) + (w2*f2) + (w3*f3) + (w4*f4) + (w5*f5) + (w6*f6) + (w7*f7) + (w8*f8) + (w9*f9) + (w10*f10).$$

Where,

- f1=EMEE f6=CD
- f2=ME f7=SD
- f3=MII f8=MCI
- f4=MLI f9=MSD
- f5=CII f10=PEOIR

These parameters are discussed later in this paper.

Where w1, w2, w3 w10 are the respective weights for features and f1, f2, f3..... f10 are the features taken for fitness function.

3) *Selection:* The selection process includes selecting the best fitness value that in turn gives best chromosome. Only chromosomes that pass the fitness test are kept. The chromosomes with least fitness value are then replaced with the one having maximum fitness value. This step will go on for 'C' chromosomes for 'N' number of times. Suppose initially we had ten chromosomes then after mutation ten child chromosomes are produced then one among child and parent chromosomes is kept based on their fitness value. As a result of which we will get ten chromosomes. Then these 10 chromosomes will fight among themselves and only the fittest individuals will survive.

4) *Termination :* After getting the chromosome with maximum fitness value the algorithm is terminated.

The pseudo code for GA applied is as follows:

```

1. for g=1 to g=gen
2.   for i=1 to i=n
3.     Cpi= R[ss]
4.   end for
5.   for i=1 to i=n
6.     fpi=fitfn(i)
7.   end for
8.   for i=1 to i=n
9.     Cci=Cpi+ RR[ss]
10.    fci= fitfn(i)
11.  end for
    
```

```

12.  for i=1 to i=n
13.    if fci> fpi
14.      Cpi= Cci
15.      fpi=fci
16.    end if
17.  end for
18. end for
    
```

Where,

C_i stands for ith parent chromosome. R[ss] is a random function to generate random alpha values within the search limit [ss]. f_{pi} stands for fitness value of ith chromosome, gen is the number of generations.

C_{ci} is the ith child chromosome. RR[ss] is the random mutation limit. f_{ci} is the fitness value of ith child chromosome.

In this way we are left with one chromosome in the end containing alpha values of for each object.

F. Neural network training is done in order to get the desired results. Neural network makes use of Levenberg-Marquardt Backpropagation algorithm. There are two inputs to neural network-alpha values of objects obtained using GA and pixel values for each object. The number of hidden layers is ten. The target will give new pixel values to the objects resulting in enhancement.

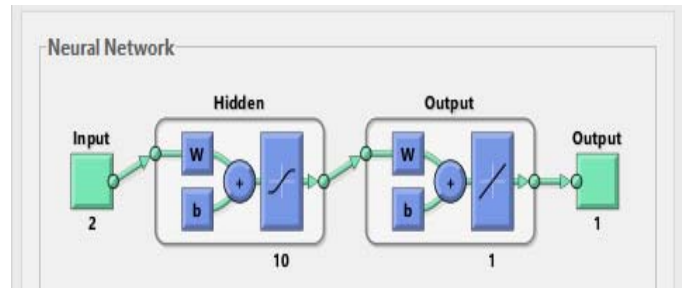


Fig.3 A Neural Network for the proposed approach

G. The usable data of the image is represented by close contrast values. Thus Histogram Equalization is used in order to better distribute the intensities on the histogram. Thus the final enhanced image is obtained.

H. In the end parameters are evaluated and final results are compared. The following Evaluation parameter are used :

1) *Measure of Enhancement of Entropy (EMEE):*

$$EMEE = \frac{1}{mn} \ln((I_{max} / I_{min})) (I_{emax} / I_{emin}) \tag{1}$$

It is the calculated by taking the average of ratio of max to min pixel intensity of enhanced image to that of original image.[16]For a high quality image it should have high value.

2) *Measure Of Entropy (ME):*

$$ME = \sum_{i=1}^m \sum_{j=1}^n p(i, j) \log_2(p(i, j)) \tag{2}$$

It is a measure of randomness [16].For a high contrast image it should be high.

3) *Measure Of Luminance Index(MLI):*

It is the ratio of mean of enhanced image to that of original image [16].

$$MLI = MI(I_e) / MI(I_o) \tag{3}$$

Where

$$MI = \frac{1}{mn} \sum_{i=1}^m \sum_{j=1}^n I(i, j) \tag{4}$$

MLI should be high for a good quality image.

4) *Measure of Contrast Improvement Index(CII):*

It is the ratio of enhanced contrast to that of original contrast [16].

It should have high value.

$$CII = C_{enhanced} / C_{original} \tag{5}$$

$$C = (r-b) / (r+b) \tag{6}$$

r is mean gray level value of foreground

b mean gray level value for background.

5) *Contrast Difference(CD):*

$$CD = I_{max} - I_{min} \tag{7}$$

Where I_{max} and I_{min} are the max and min pixel intensities[16]

CD should have high value.

6) *Measure of Contrast Index (MCI):*

It is the ratio of Standard Deviation of enhanced to that of original image. Standard deviation is defined by [16]:

$$I = \sqrt{\frac{1}{mn-1} \sum_{i=1}^m \sum_{j=1}^n (I(i, j) - MI(I))^2} \tag{8}$$

$$MCI = \sigma I_e / \sigma I_o \tag{9}$$

MCI must have high value

7) *Mean Square Difference (MSD):*

$$MSD = \frac{1}{mn} \sum_{i=1}^m \sum_{j=1}^n (I_e - I_o)^2 \tag{10}$$

I_e and I_o is intensity of enhanced image and original image respectively [16].]It should have low value for a good quality image

8) *Peak Enhanced to Original Image (PEOIR)[16]*

$$PEOIR = 10 \log_{10}(I_{max}^2 / MSD) \tag{11}$$

PEOIR should have high Value for a good quality image.

EXPERIMENTAL RESULTS

The performance of proposed method is discussed here. The evaluation parameters are evaluated. The Diagrams shown below are the original image, Image obtained with fuzzy method [16] and the image obtained with the proposed method.



Fig.4 Original Image



Fig.5 Enhanced Image (fuzzy technique)



Fig.6 Enhanced Image (Proposed Method)

TABLE-I
EVALUATION RESULTS

Parameters	Original Image	Fuzzy method	Proposed Method
ME	5.7599	5.4472	3.9325
MI	110.3037	121.9249	93.3339
CD	150	255	255
EMEE	3	233	255
CII	0.55	1.9807	2.2052
MLI	1	1.1054	1.1819
MCI	1	1.0896	1.6662
SD	9.733	10.6055	56.788
MSD	0	124.06	3.8072
PEOIR	Inf	11.371	42.3247

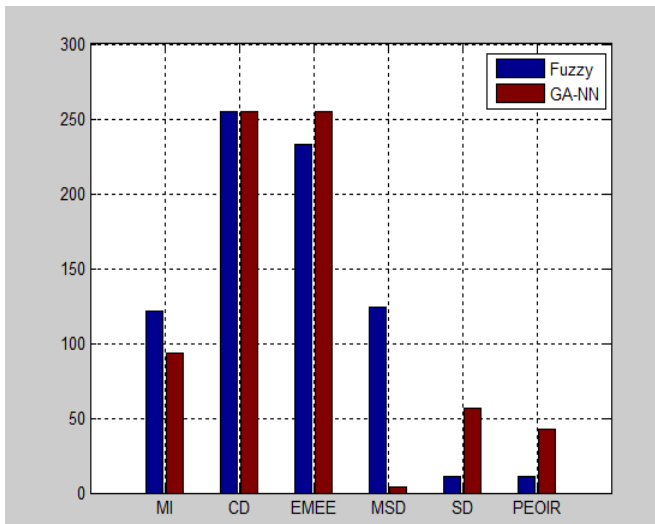
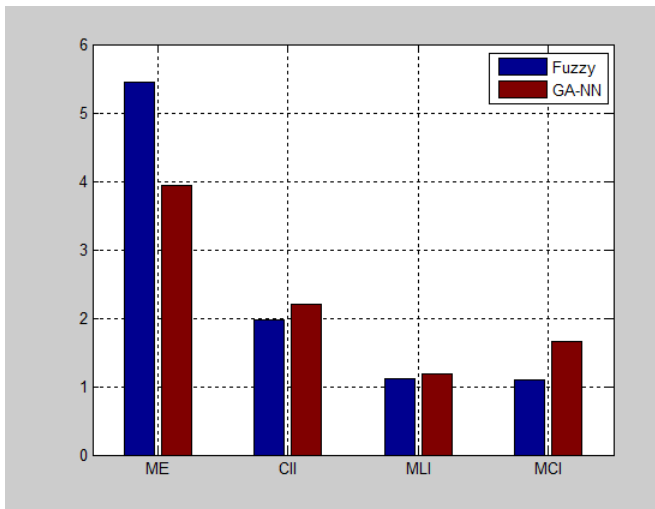


Fig. 7 Comparison Of Evaluation parameters

The above diagram shows the comparison of Fuzzy and the proposed method based on the values of evaluation parameters.

CONCLUSION

A unique algorithm for Contrast Enhancement has been proposed. It overcomes the major shortcoming of under enhancement and enhances the image to correct extent. Experimental results show that it works better than the fuzzy method. All the parameters other than ME, MI have been improved with this method. Introduction of errors have been avoided. The future work will be to improve the values of ME and MI also.

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REFERENCES

- [1] C. Lee, Y. Lee, and C. Kim, "Power-constrained contrast enhancement for emissive displays based on histogram equalization," *Image Processing, IEEE Transactions on*, no. 99, pp. 1-1, 2011.
- [2] R. Gonzalez, R. Woods, and B. Masters, "Digital image processing," *Journal of Biomedical Optics*, vol. 14, p029901, 2009.
- [3] Cheenu Sharm, Manshi Shukla , "Methods for Image Enhancement: A review", *International Journal of Computer Science and Mobile Computing*, ISSN 2320-088X, Vol. 3, Issue. 8, August 2014, pg.602 - 606.
- [4] S.S. Bedi , Rati Khandelwal," Various Image Enhancement Techniques- A Critical Review", *International Journal of Advanced Research in Computer and Communication Engineering* Vol. 2, Issue 3, March 2013.
- [5] Mandeep Kaur, Kiran Jain, Virender Lather," Study of Image Enhancement Techniques: A Review", *International Journal of Advanced Research in Computer Science and Software Engineering*, Volume 3, Issue 4, April 2013 ISSN: 2277 128X.
- [6] Nirmala S. O ,T. D. Dongale ,R. K. Kamat, "Review on Image Enhancement Techniques: FPGA Implementation perspective", *International Journal of Electronics Communication and Computer Technology (IJECCT)* Volume 2 Issue 6 (November 2012).
- [7] J. Holland,"Adoption in natural and artificial systems",The MIT press, 1975, 211.
- [8] P. W. M. Tsang, A.T.S. Au,"A genetic algorithm for projective invariant object recognition" *Conference proceedings, 1996 IEEE.TENCON: Digital Signal Processing Applications*, 1996, 58 - 63.
- [9] S.E. Papadakis, P. Tzionas, V.G. Kaburlasos, J.B. Theocharis,"A genetic based approach to the type I structure identification", *Informatica*, 2005, Vol.16, No. 3, 365 - 382.
- [10] A. Misevicius," Experiments with hybrid genetic algo-rithm for the grey pattern problem", *Informatica*, 2005, Vol.17, No.2, 237 - 258.
- [11] H.P Schwefel, G. Rudolph," Contemporary evolution strategies", *Advances in artificial life*, 1995, 893 - 907.
- [12] Mantas Paulinas, Andrius Ušinskas ,"A Survey of Genetic Algorithms Applications for Image Enhancement and Segmentation ", *ISSN 1392 - 124X Information technology And Control*, 2007, Vol.36, No.3 .
- [13] Eldon Y. Li, "Artificial Neural Networks and their Business Applications", Taiwan, 1994.
- [14] Christos Stergiou and Dimitrios Siganos, "Neural Networks".
- [15] ESANN'2003 proceedings - European Symposium on Artificial Neural Networks Bruges (Belgium), 23-25 April 2003, d-side publi., ISBN 2-930307-03-X,pp.349-354.
- [16] Reshmalakshmi C.,Sasikumar M. ,"Image Contrast Enhancement using Fuzzy Technique", *International Conference on Circuits, Power and computing Technologies [ICCPCT-2013]*.