Alpha-rooting Image Enhancement Using a traditional Algorithm and Genetic Algorithm

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***Abstract* — The application of soft computing in image/signal enhancement and comparing it with traditional methods will be discussed in this paper. This study presents two optimization methods for α-rooting image enhancement which is a transform based method. The first method is a derivative-based optimization and the second one is Genetic Algorithm optimization. The parameter will be driven through optimization of measure of enhancement (EME) function. The results from simulation show both methods are reliable; however, the first method has more computing cost.**

Keywords: sotf computing, genetic algorithm, alpha-rooting

1. Introduction

Soft computing has been used to solve complex tasks such as pattern recognition, anomalies recognition and forecasting. The classical problem solving methods have been replaced with these new algorithms rapidly over the past decades. Artificial Neural Networks (ANN), Fuzzy Logic and Genetic Algorithms (GA) are the most popular methods in soft computing working based on human mind and genetic evolution [1]. Image enhancement composed of several techniques applied images to modify image perception.

There are two general methods for image enhancement; the first method is spatial domain image enhancement which directly manipulates the pixels of the images. Second is Frequency Domain Methods. This method deals with the images in frequency domain; images are transferred into frequency domain then a function is applied to modify their magnitudes and finally the results convert to time domain. In [2], Maini has proposed several image enhancement algorithms in spatial domain. Logarithmic transformations are applies in image enhancement when images are gray scale and there are large range of values, the lower values are mapped into wider range in Logarithmic transformation methods. Powers-Law Transformations (gamma Correction) is defined by $s = cr^{\gamma}$. This method is used for various values of γ in order to find the best performance. Histogram Processing is the most common spatial domain methods which improve image performance by spreading out higher bin intensity in the histogram.

It was proved that genetic algorithms are the most powerful unbiased optimization techniques for sampling a large solution space. Because of unbiased stochastic sampling, they were quickly adapted in image processing. They were applied for the image enhancement, segmentation, feature extraction and classification as well as the image generation. Genetic Algorithm is a heuristic that is routinely used to generate useful solutions to optimization and search problems [3]. Since in the α-rooting method the objective is to find the best parameter α which maximizes the EME function, this problem is considered an optimization problem and therefore Genetic Algorithm has been used as a solution. We will describe both methods in the following sections.

1.1 A-ROOTING IMAGE ENHANCEMENT

α-rooting filter is a Fourier based image enhancement method. The basic idea of using α-rooting enhancement is that working in frequency domain is much easier. The procedure of transform based image enhancement has the following steps [4]:

- Transfer to frequency domain (DFT)
- Perform a function which modifies the magnitude (M)
- Transfer to the time domain

These steps are represented in figure 1.

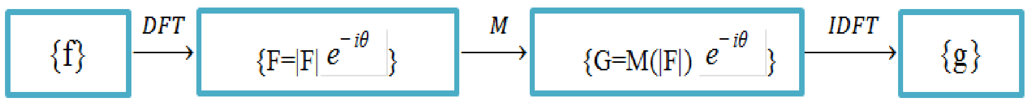

Fig 1. Flowchart of the steps for image enhancement by α-rooting

Where f is the original image, M is a function which multiplies the transformed coefficients α, and g in the enhanced image. In this case M is define as

$$M(|F|) = |F|^{\propto}, \tag{1}$$

where the coefficient ∝ is in the range of [0, 1].

For measuring image enhancement we used the following equation which is explained in [2] :

$$EME_{\propto,k_1,k_2} = \frac{1}{k_1k_2}\sum_{l=1}^{k_1}\sum_{k=1}^{k_2} 20\log\left(\frac{I^w_{max,k,l}}{I^w_{min,k,l}}\right) \tag{2}$$

where each image f(n,m) is divided to $k_1 \times k_2$ blocks w(n,m), α is the enhancement parameter, $I^w_{min,k,l}$ and , $I^w_{max,k,l}$ are the minimum and maximum intensity of each block. In this project, $k_1$and k_2 are constant and the objective is to find α that maximizes equation (2).

$$EME = \max(EME_{\propto,k_1,k_2}) \tag{3}$$

1.2 Genetic Algorithm

In this study, we mostly focus on image (contrast) enhancement of gray-scale images applying new technology versus the classic one; the objective of this paper is to optimize α-rooting parameter which is a frequency based image enhancement method [4],[5]. Genetic Algorithm has been applied to calculate the required parameter. The proposed methodology has been implemented with MATLAB and MATLAB’s GA toolbox has been used.

The rest of the paper is organized as follows. First the paper describes the α-rooting algorithm in details which is a useful method in image enhancement. Then, the genetic algorithm algorithm used for enhancing the image will be explained. In the third section, the results acquired from both algorithms will be presented and compared. In the final section, we show our conclusion and make some discussions.

2. METHODS

Genetic Algorithm is an artificial intelligence approach that is used to solve optimization problems. It mimics the metaphor evolution of genes in the form of biological generation. The same as the evolutions of genes in nature, this process is not a directed, purposive process in this machine learning technique. The individual parameters that are to optimized will be presented as a vector of random values at the beginning of the algorithm which are similar to the base-4 chromosomes seen in living organisms' DNA. Each base of these chromosomes will then evolve to its final value through a random process.

Fig 2. shows the process of evolution in a simple GA optimization. It can be seen from the flowchart that this process contains the following steps [6]:

1. Start with generating random population of N chromosomes, which N represents the number of parameters or chromosomes to be optimized
2. Evaluate the fitness function $\phi(x)$ for each chromosome X in the population.
3. If the generated population does not satisfy the condition of fitness function, in reproduction parts, two parents (chromosomes) should be selected. The probability of selection of the parents increases for those chromosomes that have higher values for the fitness function
4. Cross over the parents to produce new children
5. Mutate new offspring at position in chromosome
6. Replace newly generated population with old the one
7. The new chromosome is generated now, the algorithm goes back to step 2
8. When the created population satisfies the condition the algorithm stops, will replace the new population as the output of the optimization
9. If the end condition is satisfied, then stop.

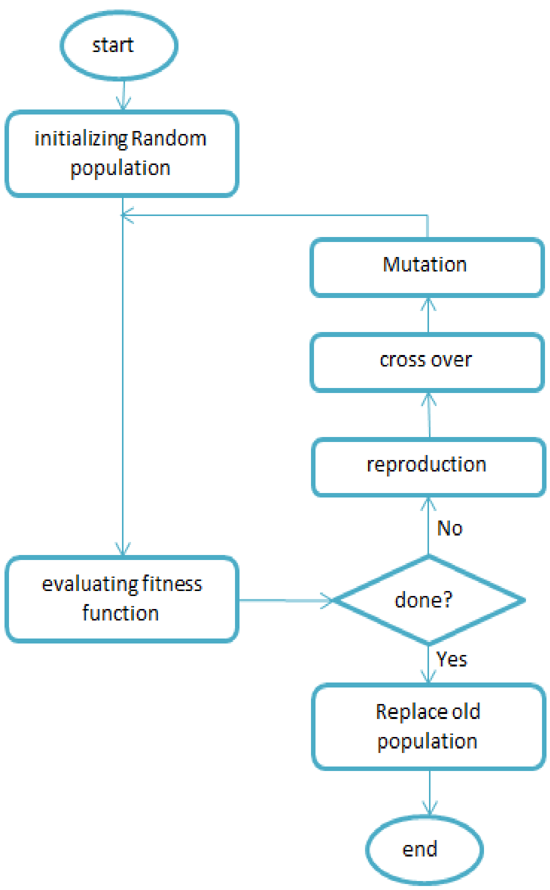

Fig 2. Genetic algorithm flowchart

As mentioned earlier, α-rooting algorithm finds the value of alpha that maximizes the value of EME. However, the algorithm must go through all the values of alpha to find this optimized value of α. In this this research, GA is used to improve gray-scale image contrast by optimizing the parameter α. Therefore the fitness functions for the chromosome in GA (as alpha in only one parameter to be optimized) using the measure of enhancement as a fitness function.

3. Implementation And Results

In this part, we used the classical algorithm of α-rooting and GA to find α which satisfied equations (2) and (3. The classical algorithm is based on sequence of points calculated by a deterministic computation. In each iteration the algorithm generates a single point [7]. The first method is using a sequence of points for α starting at 0.01 which increases at increments of 0.01. EME should be calculated for 100 iterations per image. In the second method, we use GA to optimize EME. α has been selected as a GA parameter and inverse of EME is the fitness function. GA algorithm may find the best solution after a few generations.

Four black and white images were adopted from [8]. Both algorithms were used to find the parameter α. The Matlab GA toolbox was used to simulate the genetic algorithm. The images size varies between 359×460 to 1095×1692. The values of $k_1$and k_2 are 16 pixels. We padded zeros to both sides of the images equally such that the image's pixels are divisible to $k_1$and k_2. Table 1 compares the results acquired from both models. It shows that both methods have achieved acceptable results while GA methods requires fewer iteration to find the optimum α. This is equivalent to the fewer computation time which shows GA has performed the task with less computation time.

Table 1. shows optimized parameter for both classical and GA algorithms. It also shows the number of iteration required by each method.

Methods	α	# of iterations
Classical algorithm (1st image)	0.7900	100
GA (1st image)	0.78199	37
Classical algorithm (2nd image)	0.7700	100
GA (2nd image)	0.77589	3
Classical algorithm (3rd image)	0.8600	100
GA (3rd image)	0.88204	4
Classical algorithm (4th image)	0.8800	100
GA (4th image)	0.93216	1

Fig 3. is a graphical representation of the value that maximizes the EME function. We used these values and those of found by GA algorithm to the images and represented the enhanced images by both methods. The results show that both methods perform well on the black and white images. However, it is worth mentioning that the genetic algorithm required fewer iterations for finding the optimum value of α. For most of the images, the algorithm found the best value of α. With less than 5 iterations while the classical α-routing algorithm should compute all the values in the range of α.

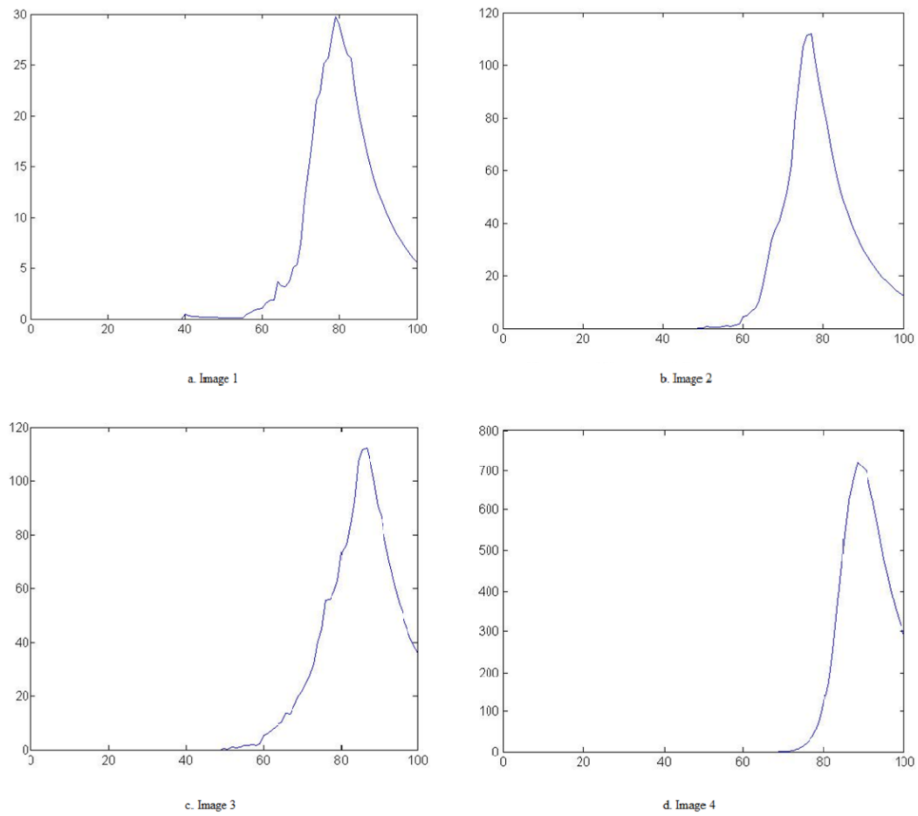

Fig 3. The EME vs. α graph for 4 images

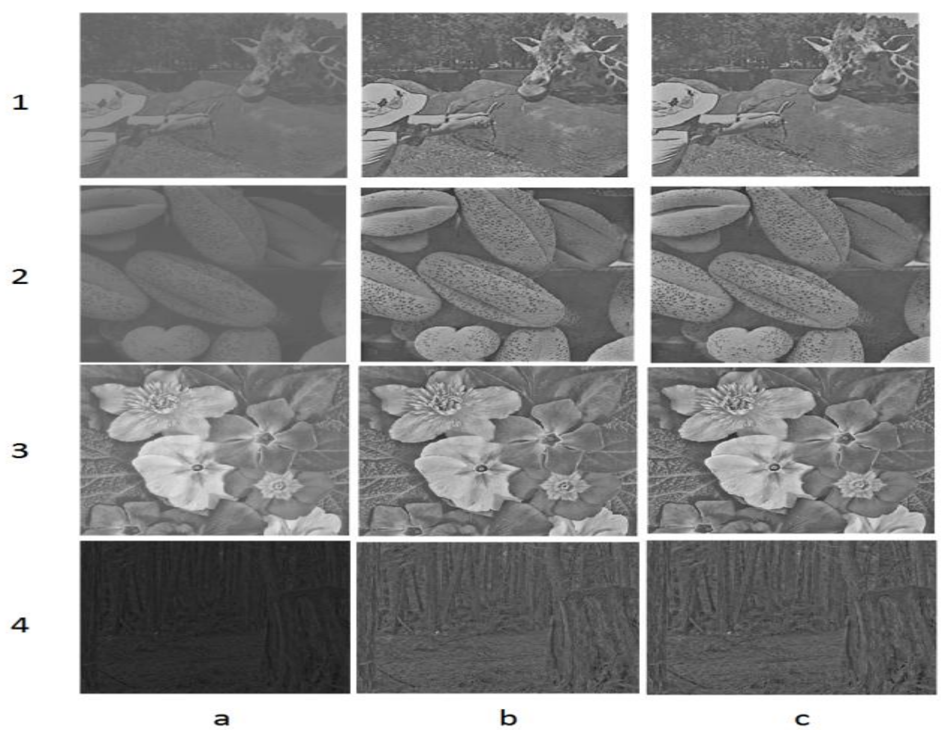

Fig 3- a) Original image b) α-rooting enhanced image using GA c) α-rooting enhanced image using classical algorithm

4. CONCLUSION

In this paper, two methods have been used for contrast enhancement of gray-scale images using α-rooting. The first method is using an algorithm which increases α in increments of 0.01 (starting at α = 0.01) for 100 iterations per image to find the best α that maximizes the EME measure. And the second method is using Matlab's GA toolbox to find the best α that minimizes the inverse of the EME measure. By comparing the results for 4 images we can see that both methods greatly improved the contrast of the images, but there is not a significant difference between the results generated by both methods. However by using GA toolbox we get faster results as it generates good results after a few generations whereas the algorithm terminates after 100 iterations and then compares the results.

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