Transmutations of Images – By Genetic Algorithms

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Abstract: Genetic algorithm (GA) is the type of Soft Computing or Artificial Intelligence method. The GA is a representation of machine learning which grows its behaviour from an image of the processes of evolution in nature. The objective here is to improve the quality of the image, mutating the image to other image and to convert the image into segments to get more meaningful image and it will be easy to analyze the image using genetic algorithm. In order to use a genetic algorithm to solve a problem, a function is needed of converting a string of numbers (or symbols) into possible solutions to the problem. This permits solutions to be mutated by changing symbols at random or by changing the elements of three-dimensional array representing RGB pixels. Mainly, every possible string of symbols must generate a valid solution. It is also required a way of measuring the fitness of a solution - how close is it to solving the problem from tip to toe. Comparison of two potential solutions is allowed to select the better solution. Genetic algorithm is the fair-minded optimization technique. It is useful in image mutation, enhancement and segmentation. GA is proven in many research works as the most powerful optimization technique in a large solution space. This is the reason for increasing popularity of GAs applications in image processing and other fields.

A simple genetic algorithm works in the following way:

1. Produce a random genome (the mother's genome)
2. Measure the fitness of the solution prearranged by the mother's genome (the mother's fitness)
3. Arbitrarily mutate/inherit the mother's genome to a daughter's genome
4. Compute the fitness of the solution encoded by the daughter's genome (the daughter's fitness)
5. If the daughter's fitness is greater than the mother's, then overwrite the mother's genome with the daughter's
6. Go to step 3

This paper gives an analytical overview of the genetic algorithm to review the tasks of image processing with mutation through RGB pixels, enhancement & segmentation of images.

Keywords: Genetic Algorithms, RGB pixels, Mutating/Evolving Images, Fitness measure, Mutation, Image Segmentation, Cross over

I. INTRODUCTION

The term Genetic Algorithm was used by John Holland at very first[3]. Genetic Algorithms (GAs) are basically the natural selection process invented by Charles Darwin where it takes input and computes an output where multiple solutions might be taken. The GAs is designed to simulate processes in natural system necessary for evolution. GA performs efficient search in global spaces to get an optimal solution. GA is more effective in the contrast enhancement and produce image with natural contrast. A Genetic Algorithm provides the systematic random search. Genetic Algorithms provide a simple and almost generic method to solve complex optimization problems. A genetic algorithm is a derivative-free and stochastic optimization method. A Genetic Algorithm needs less prior information about the problems to be solved than the conventional optimization schemes, such as the steepest descent method, which often require the derivative of the objective functions. Based on individual fitness value, genetic algorithm uses the operators such as reproduction, crossover and mutation to get the next generation that may contain chromosomes providing better fitnesses [2]. Basically in Genetic Algorithm the new child or chromosome obtained is made up of combination of features of their parents. So genetic algorithm is applied on any image to get the new enhanced image which is much better than the original one that contains features of parents. Image enhancement techniques are used to improve image quality or extract the fine details in the degraded images. Most existing color image enhancement techniques usually have three weaknesses:

(1) color image enhancement applied in the RGB (red, green, blue) color space is inappropriate for the human visual system;
(2) the uniform distribution constraint employed is not suitable for human visual perception;
(3) they are not robust, i.e., one technique is usually suitable for one type of degradations only.

According to [1] GA has the ability to determine optimal number of regions of a segmentation result or to choose some features such as the size of the analysis window or some heuristic thresholds. Genetic Algorithm works well for many practical problems. However, in complex design, simple GA may converge extremely slowly or it may fail, due to convergence to an unacceptable local optimum. Considerable research efforts have been made to improve GA. Some of these improvements are mentioned in [4]. The two parameters of genetic algorithm are crossover and mutation.

Crossover: Crossover is a genetic parameter which will combines two chromosomes (can also be called as parents) to produce a new chromosome (also called as offspring). The result of crossover will give the new chromosome may be better than both of the parents if it takes the best characteristics from each of the parents. Crossover occurs during evolution according to a user-definable crossover probability. The new offspring will have some properties from one parent and some properties from other parent.

Example, suppose parent1 is **11**0010**11** and parent2 is 11**0111**11 and after performing the crossover we will get the output which contains some part of parent1 and other from parent2 i.e. **11011111.**
110010**11** + 11**0111**11 = **11011111**

Mutation: Mutation can be takes place after the crossover got performed. This is to prevent falling all solutions in population into a local optimum of solved problem. The mutation depends on the encoding as well as the crossover. For example when we are encoding permutations, mutation could be exchanging two genes. Mutation changes the new offspring randomly. For binary encoding we can switch a few randomly chosen bits from 1 to 0 or from 0 to 1. Mutation can then be following:

Original offspring 1- 110**1**111010011110
Mutated offspring 1- 110**0**111010011110

Original offspring 2- 1101100100110110
Mutated offspring 2- 1101101100110110

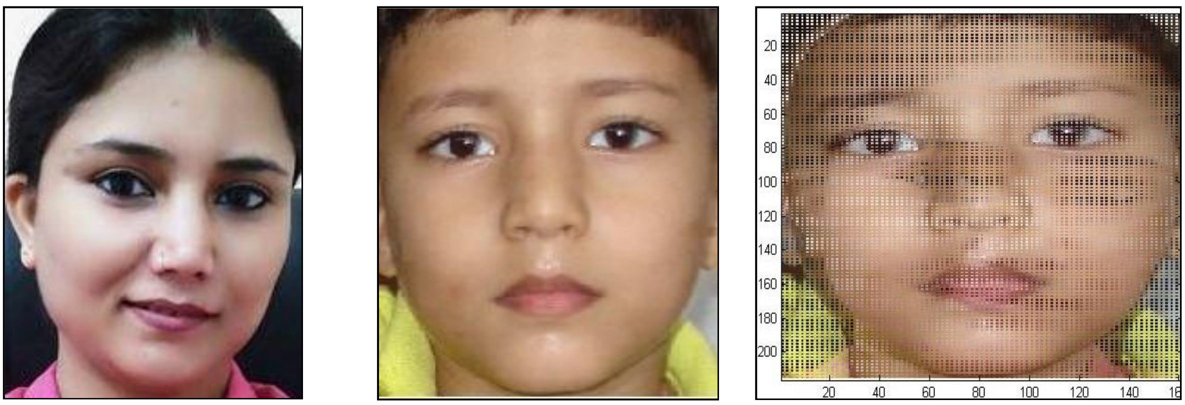
Following is the Simple Genetic Algorithm which includes GA operators as suggested by [5].

```
function GeneticAlgo()
{
   Initialize population;
   Calculate fitness function;
   While(fitness value != termination criteria)
   {
      Selection;
      Crossover;
      Mutation;
      Calculate fitness function;
   }
}
```

Here it is proposed that pixels of colour RGB are captured in a 3-D array from source images of a mother and her son and related row & column (of x and y axes) pixels of son image are replaced by the corresponding pixels of mother image. The result is shown in mutated image [Figure 1].

```
i1=imread('d:\yash2.jpg');
i2=imread('d:\seema2.jpg');
% image(i1);
%image(i2);
for x = 1:2:216
   for y=1:2:161
      for z=1:3
         i1([x],[y],[z])=i2([x],[y],[z]);
      end
   end
end
image(i1);
```

The fitness is measured by comparing each pixel of the generated image with the corresponding pixel in the target image.



: Mother's Image Son's Image Mutating Image

Figure 1

II. IMAGE ENHANCEMENT

Image Enhancement technique is use to convert the original image into the better image without losing its original good properties. The main purpose of image enhancement is to modify various image attributes to make the original image more suitable for any given task and for a specific observer. For this to achieve we can modify one or more attributes of the particular image. The attributes that are selected and are modified are specific to a given task. Edges are basic features of an image, which carry valuable information, useful in image analysis object classification. And requirement for user interaction, as each image, treated as an individual in the population, should be rated subjectively by a human interpreter [12]. Figure 3 shows that the original image can be converted into the better image using the image enhancement technique. Image enhancement techniques can be divided into two broad categories:

A. Spatial Domain Method.

Spatial domain methods directly operate on pixels .These techniques are based on gray level mappings, and the type of mapping used for these techniques are depends on the criterion chosen for enhancement. For example consider the problem of enhancing the contrast of an image. Let r denotes gray level in the original image and s denotes gray level in enhanced image. Suppose that for every pixel with level r in original image we create a pixel in the enhanced image with level

$$s=T(r) \qquad \text{………………………(1)}$$

where *T* denotes the gray level transformation function.

T(r) produces a 2-level (binary) image. This is also referred to as image thresholding. Many powerful enhancement processing techniques can be formulated in the spatial domain of an image. The value of a pixel with coordinates (x,y) in the enhanced image F is the result of performing some operation on the pixels in the neighbourhood of (x,y) in the input image, F. The Neighbourhoods can be of any shape, but normally they are rectangular in shape. T is a transformation that maps a pixel value r into a pixel value s. The results of this transformation are mapped into the grey scale range as we are dealing here only with grey scale digital images. So, the results are mapped back into the range [0,L-1], where L=2k, k being the number of bits in the image being considered. So, for instance, for an 8-bit image the range of pixel values will be [0, 255].[11]

B. Frequency Domain Method.

Frequency domain method operates on the Fourier transform of an image. Image enhancement in the frequency domain is straightforward. We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter (rather than convolve in the spatial domain), and take the inverse transform to produce the enhanced image.
Let g(x,y) be an image formed by the convolution of an image f(x,y) and a position invariant operator h(x,y) i.e.

$$g(x,y) = h(x,y) * f(x,y) \qquad \text{…………………………..2}$$

In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values[11].

III. IMAGE ENHANCEMENT USING GENETIC ALGORITHM

The function GeneticAlgo () can be applied to work on the image for enhancement. The main steps in solving a problem using GAs are [6]:

1. Initializing the population of possible solutions .
2. Calculation of an evaluation i.e. fitness function that plays the role of the environment,
3. Rating solution in terms of their `fitness' .
4. Definition of genetic operators (selection, crossover, mutation) that alter the composition of children during reproduction.
5. Establishing values for the parameters (population size, probabilities of applying genetic operators) that the genetic algorithm uses . The genetic algorithm includes following parameters.

A. Initial Population.

Usually in GAs, the initial population consists of entirely random strings (chromosomes). However, random binary strings, each of length pq (q bits for each of the parameters) can be considered as chromosomes for individuals of the initial population .

B. Fitness Function.

Reproduction is a process in which individual strings are copied according to their objective function values, F, called the fitness function. The fitness function is fully objective, no human subjective term being required. An individual fitness is measured by the sum of intensities of edges in an enhanced image, because a gray image with a visual good contrast includes many intensive edges [7].

C. Genetic Operators.

Genetic algorithm uses the principle of selection to produce solutions at each generation. Matting of parents is represented by cross-over and mutation operations. Selection is used to select the individuals for next generation. The crossover is used to recombine the information.

D. Domains of Parameters.

The parameters needed in defining a Genetic Algorithm for a specific problem are:
(i) the population size, i.e., the number of chromosomes in each generation that means Population size provides how many chromosomes are in population (in one generation).
(ii) the number of generations to be generated .
(iii) the probability of mutation i.e. mutation rate.
Mutation rate is the probability of adding new information randomly. Mutation may be the chromosomes of individuals to be different from their parent individuals. Figure 2 shows the maping curve for enhanced image.

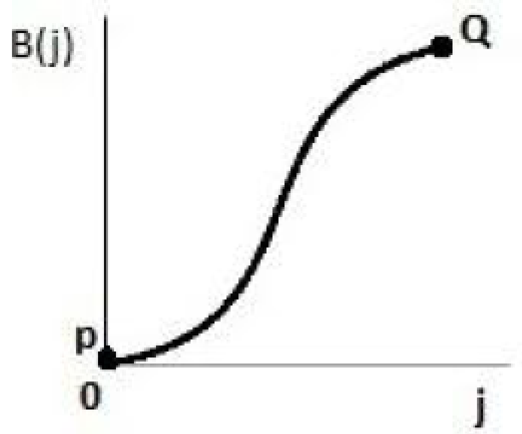
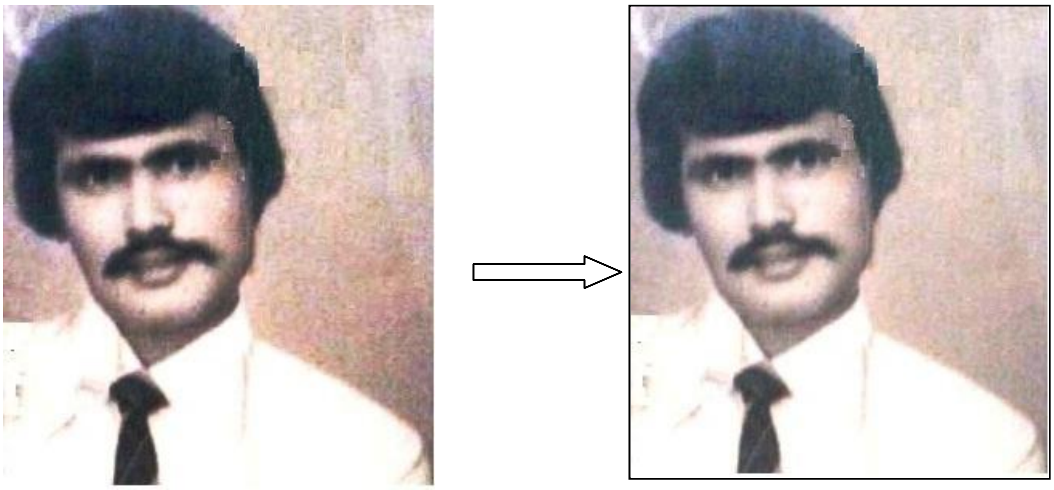


Figure 2: mapping Curve for enhanced image

The result is shown in the enhanced image of original image in Figure 3. It clearly shows the difference between the original image and the enhanced image. Enhancement of image is very useful in positive sense for investigation of crimes. As enhancement will improve the clarity of the original image by removing the noise. so that it will be more easier to analyze any image.



Original Image Enhanced Image

Figure 3: Enhancing Image

IV. IMAGE SEGMENTATION FOR BLURRING IMAGE

In Image Segmentation the original image is partitioned into different pieces for better analysis. The goal of image segmentation is to cluster pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Image segmentations are based on different types are:

1) Segmentation based on greyscale
2) Segmentation based on texture
3) Segmentation based on motion
4) Segmentation based on depth

The image segmentation algorithms are divided into three major categories[10][9]:

1. Edge Based Techniques: Edges are basic features of an image, which carry valuable information, useful in image analysis object classification. Edge detection includes the detection of boundaries between different regions of the image. Due to these boundaries discontinuities occurs between the pixels of the chosen feature such as color, texture and intensity.

2. Region Based Techniques: Region splitting is an image segmentation method in which pixels are classified into regions. Any particular image contains various regions. The image can be segmented by considering the different regions of the image. Each region has a range of feature values, with thresholds being delimiters. It is very important to choose these thresholds, as it greatly affects the quality of the segmentation. This tends to excessively split regions, resulting in over segmentation.

3. Clustering Based Techniques Clustering separates the image into various classes which does not require any prior information. In this the data which belong to same class should be as similar as possible and the data which belongs to different class should be as different as possible.

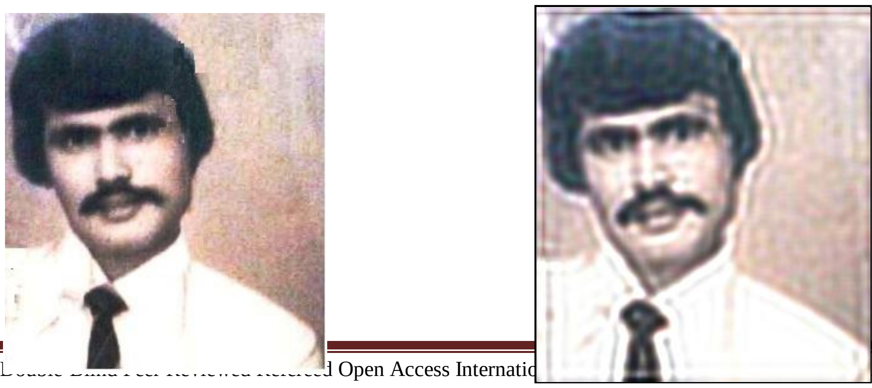


Fig4. Result of image segmentation.

V. CONCLUSION: IMAGE PROCESSING & GENETIC ALGORITHMS

The image segmentation using genetic algorithm can be done using Parameter selection and pixel level segmentation, where parameter selection includes the genetic algorithms which are used to modify the parameters of an existing image segmentation method to improve its output. and Pixel-level segmentation includes genetic algorithms are used to perform region labeling. In most image segmentation methods, the first method is used more often The adaptive image segmentation consists following steps[10]:

1. Compute image statistics;
2. Generate an initial population;
3. Segment the image using initial parameters;
4. Compute the segmentation quality measures;
5. While not (stopping conditions) Do
6. {
    i. select individuals using the reproduction operator
    ii. generate new population using the crossover and mutation operators
    iii. segment the image using new parameters
    iv. compute the segmentation quality measures
7. }
8. Update the knowledge base using the new knowledge structures.

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