Implementation of Bacteria Foraging Optimization for Color Image Quantization and its Evaluation for Various File Formats

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Abstract: Bacterial Foraging Optimization (BFO) is optimization technique to tackle complex search problems of the real world. Bacterial Foraging Optimization is a burgeoning nature inspired technique to find the optimal solution of the problem. A Color images Quantization is necessary if the display on which a specific image is presented works with less colors than the original image. The research work suggests that images quantized with Bacteria Foraging Optimization technique gives good results. This paper explains the Bacteria Foraging Optimization for Color Image Quantization and Presents the evaluation for various file formats.

Keywords: Bacteria Forgaging Optimization, Image Quantization, PNG, BMP, JPEG

1. Introduction

Bacterial foraging behaviours are used as a source of engineering applications and computational model. A few models have been developed to bacterial foraging behaviours and been applied for solving practical problems. Among them, Bacterial Foraging Optimization (BFO) is a population-based numerical optimization algorithm. Until date, BFO has been applied successfully to some engineering problems, such as optimal control, harmonic estimation, transmission loss reduction and machine learning.

Color image quantization is an important process of representing true color images using a small number of colors. With a good color quantization algorithm and some lossy compression algorithms (such as ones used by .jpg formats), the same image quality (at least visually) can mostly be restored from a much smaller file. The color image quantization can reduce not only storage requirement but also the transfer time of the image. These reductions are quite important for multimedia applications in the Internet where the communication delays are very concerned. Moreover, the color image quantization can be implemented as a preprocessing step for image compression algorithm.

2. Bacteria Foraging Optimization for Image Quantization

In this research each Pixel of the image is considered as bacteria and the color of the pixel is considered as bacteria food. The aim of the proposed algorithm is to minimize the food sources i.e. to reduce the number of colors in the image. In this research, all the pixels initially have some color and the purpose of this research is to optimize the number of colors in the image. All the colors in the image are evaluated as the number of pixels having that color. This evaluation defines the health status of all the colors present in the image. Depending upon the health status of the colors, all the colors in the image are divided into two categories popular colors and unpopular colors. If the health status of the color is high i.e. the color is present on too many pixels then that color is considered as popular color and all other colors whose health status is poor are considered unpopular colors. All the pixels in the image are compared with every other pixel in the image to find the most similar color to be eliminated. The fitness function is taken as Euclidean distance to find out the distance between two food sources i.e. colors. Based on the value of euclidean distance between similar colors elimination of one of the colors is done. After this elimination process the health status of all the colors is evaluated again because after elimination the health status of colors may change. After the elimination process, the unpopular colors are compared based on euclidean distance values to combine colors to produce a new color. This process of producing the new color is called as reproduction. The colors from which the new color is produced are killed.

3. Algorithm for BFO-CIQ

Step 1: Compute Chemo-taxis

The motion patterns that the bacteria will generate in the presence of chemical attractants and repellents are called chemo-taxis. In this research, each bacteria takes a unit step of size one in the same direction to find its nutrient i.e. each pixel takes a unit step of size one to find the most similar color. If the pixel find the most similar color after a unit walk fulfilling the fitness function then it is called as swim where the pixel color is replaced with the color of that next pixel.

Step 2: Elimination

Primary Elimination: In primary elimination if a pixel in the image found similar color following the fitness function then one of them becomes candidate pixel for the elimination.

Secondary Elimination: In secondary elimination firstly the health status is of all the colors in the image is evaluated. Then based on the health status the colors are divided into two categories surviving i.e. popular and the un-surviving i.e. unpopular colors. The un-surviving colors following the fitness function become candidate for the elimination. In this research, after comparing the colors of all the pixels in the image the elimination of colors in this step is based on the primary elimination.

Step 3: Reproduction

If the health status of the color is high then that pixel is considered as surviving color and all other colors whose health status is poor are considered un-surviving colors. The unpopular colors are compared and if the Euclidean distance between two unpopular colors is found less than threshold value then those two colors are combined to produce a new color.

Step 4: Dispersal

The un-surviving colors from which the new color is produced are eliminated. Elimination in this step is performed according to the secondary elimination. This new color is now dispersed i.e. allocated to the parents of new color.

4. Evaluation Of Image Quality

For comparing original image with quantized image requires a measure of image quality, commonly used measures are Mean-Squared Error, Peak Signal-to-Noise Ratio [3] and histogram.

A. Mean-Squared Error

The mean-squared error (MSE) between two images is:

$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M * N} \quad ....(Eq.\ 4.1)$$

M and *N* are the number of rows and columns in the input images, respectively. Mean-squared error depends strongly on the image intensity scaling. A mean-squared error of 100.0 for an 8-bit image (with pixel values in the range 0-255) looks dreadful; but a MSE of 100.0 for a 10- bit image (pixel values in [0,1023]) is barely noticeable.

B. Peak Signal-to-Noise Ratio

Peak Signal-to-Noise Ratio (PSNR) avoids this problem by scaling the MSE according to the image range

$$PSNR = 10\ log_{10}\left(\frac{R^2}{MSE}\right) \quad ....(Eq.\ 4.2)$$

PSNR is measured in decibels (dB). PSNR is a good measure for comparing restoration results for the same image, but between-image comparisons of PSNR are meaningless.

4. Experimented Results

A. BFO-CIQ in BMP

The BMP file format also called bitmap or DIB file format (for *device-independent bitmap*), is an image file format used to store bitmap digital images.

Fig 4.1: *Scene.bmp*

Fig 4.2: *Sparrow.bmp*

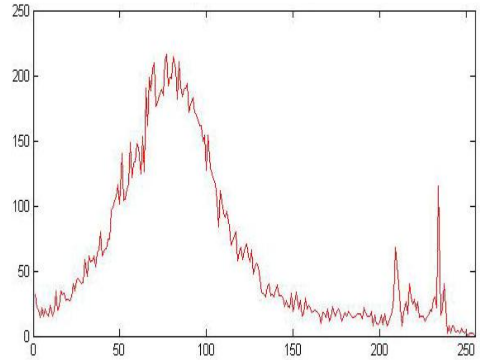
Table 4.1 Computational Result based on MSE, PSNR

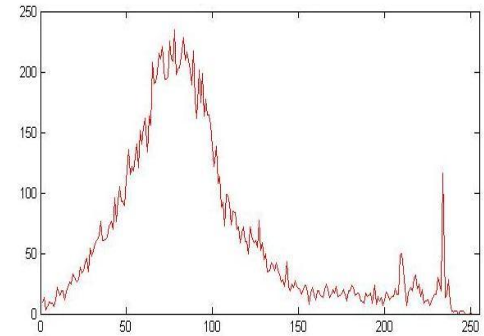
File Name	MSE	PSNR
Scene.bmp	297.3768	23.3977
Sparrow.bmp	371.5434	22.4307

Table 4.2 : Histogram Analysis for BFO-CIQ in *Scene.bmp*

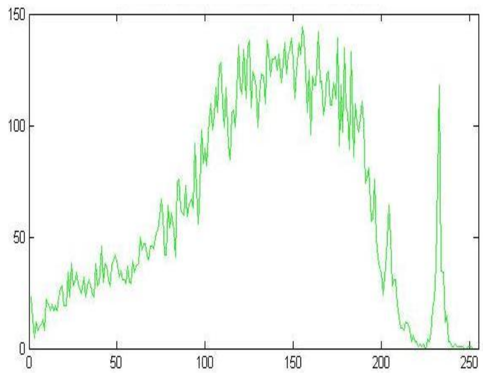
Original Image	Quantized Image

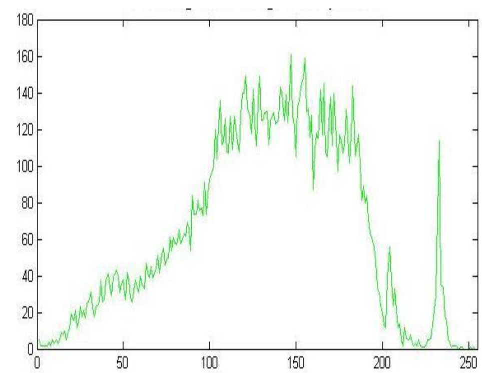
Histogram of R Component



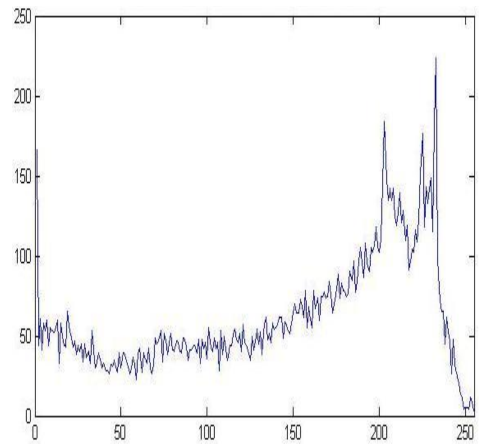


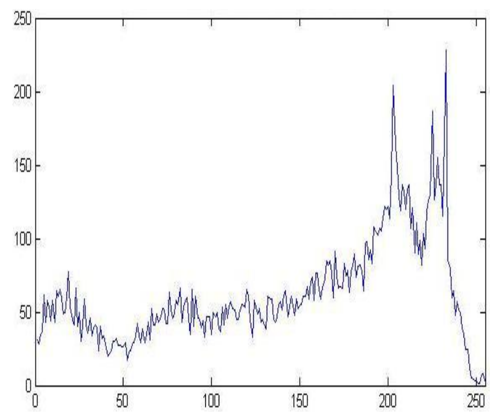
Histogram of G Component





Histogram of B Component





Bit-mapped images (also known as raster images) make use of pixels, or picture elements, to define an image as a matrix made up of rows and columns of pixels. The advantage of using bitmapped images in digital teaching files is that they are specifically designed to handle computed tomography, magnetic resonance, and photographic images. The disadvantage of using Bit-mapped images is that they are resolution dependent, so that overall image quality is degraded if resolution is altered. Bit-mapped images with higher resolution contain more pixels and more detail but are consequently large files that move slowly in the electronic environment.

A. BFO-CIQ in PNG

Portable Network Graphics (PNG) is a bitmapped image format that employs lossless data compression. PNG was created to improve upon and replace GIF. The PNG file format was created in 1995 in response to the GIF proprietary transition. The PNG file format is by design free of the patent issues that have hindered further GIF development. PNG are important for developing digital teaching files and lossless compression make PNG an attractive alternative for multimedia projects.

Fig 4.3: *Technology.png*

Fig 4.4: *Flower.png*

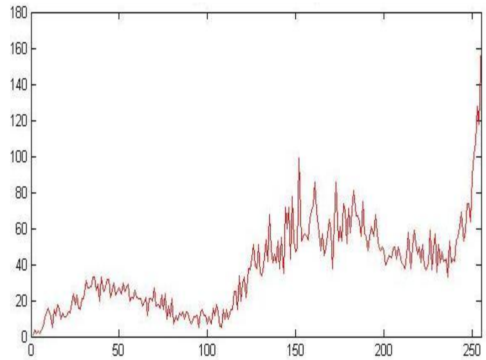
Table 4.3 Computational Result based on MSE, PSNR

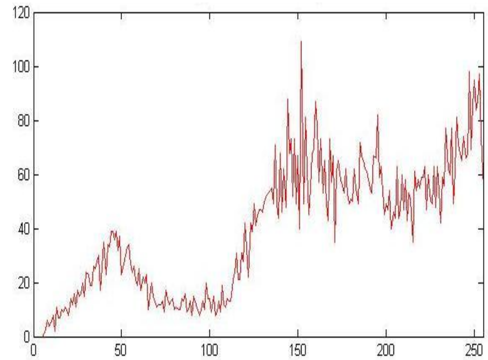
File Name	MSE	PSNR
Technology.png	271.9284	23.7863
Flower.png	283.5304	23.6048

Table 4.4 : Histogram Analysis for BFO-CIQ in Flower.png

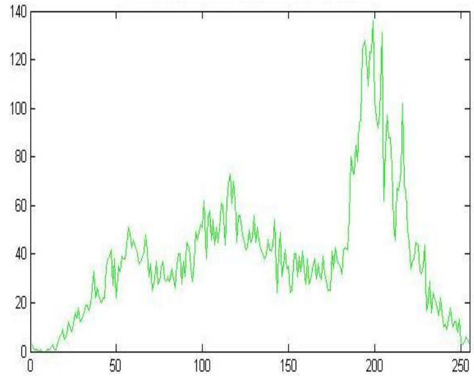
Original Image	Quantized Image

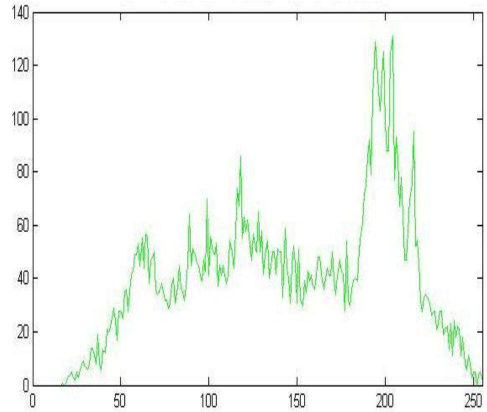
Histogram of R Component



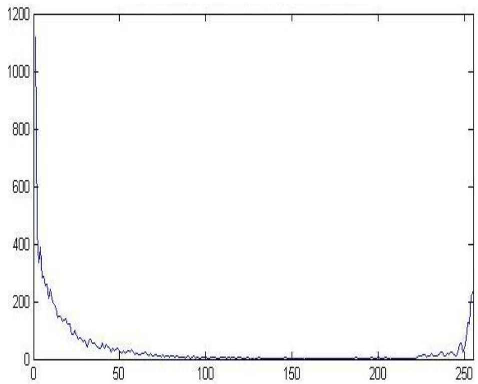


Histogram of G Component





Histogram of B Component



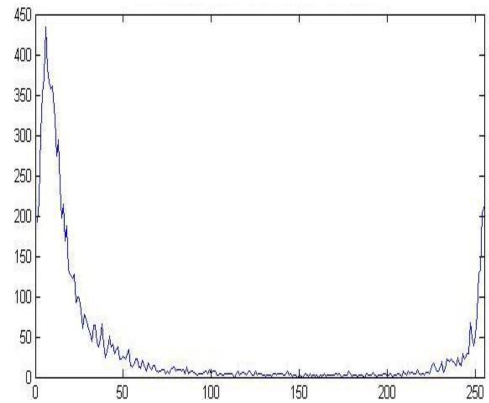


Fig 4.5: *Parrots.jpg*

The PNG image files are usually 20%– 30% smaller than similar bitmapped files. PNG is better suited to computer-generated graphics (eg, in digital radiographic studies). The ability to open, edit, and save files repeatedly with PNG without data loss makes this a preferable format in multimedia projects. The PNG file format provides a network-friendly, patent-free, lossless compression scheme that is truly cross-platform and has many new features that are useful for multimedia and Web-based radiologic teaching.

C. BFO-CIQ in JPG

The JPG file type is primarily associated with 'JPEG/JIFF Image'. A lossy bitmap image format used by digital cameras and to display photographs on the Web (along with many other like uses).

Fig 4.6: *Phantom.jpg*

Table 4.5 Computational Result based on MSE, PSNR

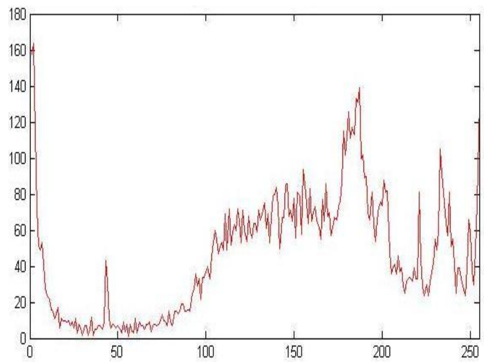
File Name	MSE	PSNR
Parrots.jpg	105.2100	27.9102

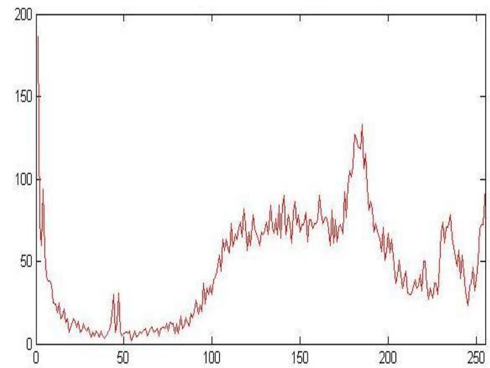
Phantom.jpg	141.8328	26.6130

Table 4.6 : Histogram Analysis for BFO-CIQ in Flower.png

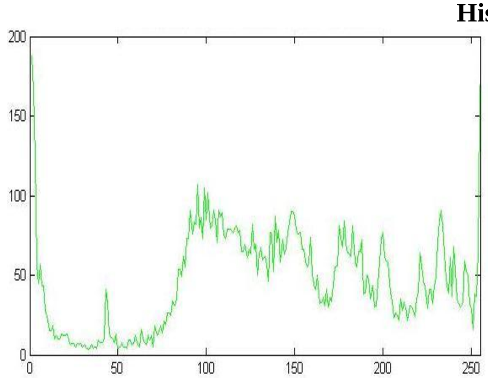
Original Image	Quantized Image

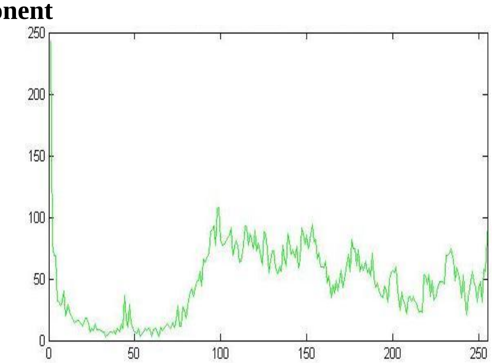
Histogram of R Component



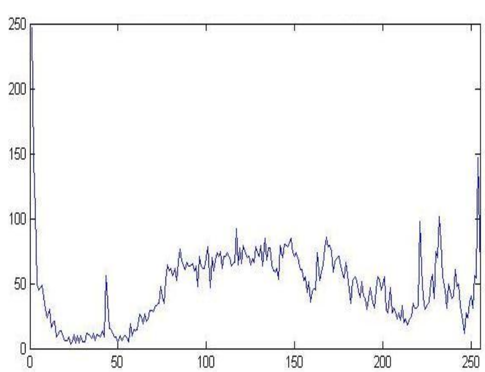


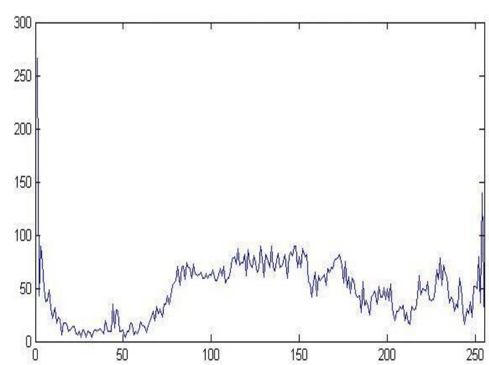
Histogram of G Component





Histogram of B Component





The strength of the JPEG format is its capacity to significantly compress larger image files, allowing faster movement in the electronic environment. The primary weakness of JPEG is that it is a lossy compression technique that results in a loss of data with each compression, which may translate into image degradation.

5. Evaluation Of Different Techniques

Table 5.1: Comparison of BFO-CIQ for various file formats

Parameters	BMP	PNG	JPG
Percentage Distortion less resultant image	Medium	Lower than *bmp*	Lowest
Image manipulation	Low	Greater than *bmp*	High
Percentage no. of colors reduced	Low	Greater than *bmp*	High
Mean Squared Error	High	Medium	Low
Compression	Low	Medium	High

By applying Bacteria Foraging Optimization to Color Image Quantization to file types *bmp, png, jpg,* it has been observed that image distortion is lowest in files of type *jpg.* Since the purpose image quantization is to reduce colors by preserving image quality, maximum colors were found reduced in *jpg* files. Similarly a low value of Mean Squared Error as compared to other files types indicate the prefernce of *jpg* file types over other image formats. Also the file size after quantization is found reduced more as compared to other when Bacteria Foraging Optimization is applied.

6. Conclusion

By applying Bacteria Foraging Optimization to olor Image Quantization to file types *bmp, png, jpg,* the superiority of *jpg* over other files types is revealed. The reason behind this is JPG was created specifically for the storage and transmission of photographic images. Image compression to as little as 1/20 of the original file size can be achieved. Such compressed images can obviously be moved considerably faster in the electronic environment and require significantly less storage space per image. Therefore the application of quantization on *jpg* file formats by using swarm intelligence technique of Bacteria Foraging Optimization is well suited to transmission of images with good quality and lesser sotorage over networks.

7. References

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