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Color Quantization Based Artificial Bee Colony and Training Tools

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Abstract: Color quantization addressed as a useful method to help with limited disk capacity, network bandwidth, monitors true resolution. It works in reducing the true colors to the colors that the human eyes can detect and don't change the scene. In this paper a new method for color image quantization is proposed that depends on hybrid artificial tools. It consists of three main steps, the first is creating K colors to depend on them in quantizing the required colors in this step k-means algorithm is used starting from N colors. Then Artificial Bee Colony algorithm is used to improve the center of each cluster (color) which is combined to k-means algorithm as part of its optimization. Finally, the proposed color palette is used to quantize the image depending on the result of hybrid approach and apply to k-means. Two metrics are used to optimized the method (MSE, PSNR), both of them show good results for the quality of quantized images, as well as good human perception and good running time.

Keywords: Swarm Algorithms, Color Quantization (CQ), K-means Algorithm, Artificial Bee Colony.

1. INTRODUCTION

Currently, photos are highly essential components of daily communication. Several images need to be processed, submitted, and displayed on social media, websites, records, or electronic files. Current devices with multiple colors can view high-quality images [1]. The quality of the picture is nevertheless a drawback when processed and transmitted because more colors mean higher quality and thus more storage space and a lower transmission speed[2].

Color quantization is a technique for image processing that is intended to achieve a new image of fewer Color spaces with a good quality of picture which is less than the quality of the original picture with minimum distortion[3]. This is shortening the storage and transmission requirements for color images while preserving a reasonable degree of image fidelity[4]. It is considered one of the most effective lossy compression methods for finding an acceptable set of color palettes to represent original colors[5].

CQ includes two stages, The first stage (palette design) is to create a group of representative colors (generally 8-256) to take out the color palette (CP)[6]. The next stage (pixel mapping) is to assign every pixel in the color image to a specific color in the CP[7].

The consistency of the palette design depends on how accurately the colors are chosen from the input image to produce a quantized image similar to the original image. An ideal board minimizes the scale of the error, such as the mean square error[8]. There are several well-known palette design algorithms including fuzzy c-means, self-organizing map (SOM), k-means, competitive learning, and others[9].

Color quantization carrying out an important role in color image segmentation, image and video compression, color texture analysis, etc., given the characteristics of the human visual system (HVS), color quantization techniques require attention to the impacts of minimal variation[10]. In another context, at reducing the image colors, it is not possible to fully preserve every detail of the image, as a result of the use of a little number of pixels to create the output image, this may lead to a loss of part of the details thus reducing size[11].

When more detailed information is saved, this means an increase in the number of colors, which means more transmission time and storage[12]. It can be concluded that number of founded colors and the quantity of detailed

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information represent an ambivalence, which leads to a difficult problem in NP for color quantification[13].

Since the last decade Optimization algorithms was used in many research using different techniques and studying their performance in color quantization[14].

ABC divides worker bees into three groups: employed, Onlooker, and scouts bees. Bees that are employed have the task of finding food sources in the hive[15]. If a bee becomes aware of a good food source, the bees must go back to the hive and exchange information on what was discovered[16]. The types of dance characters that bees make and the duration of their dances are influenced by the food source traits that draw more people to watch. The Onlooker bees monitor the user bees (employed) and choose many other sources of food to consume or discover another new location that contains food next to them as the employed bees do[17].

The phase of selecting food sources is one of the most excellent stages of searching for food, although the onlooker bees test the bees employed differently in the dance area, they are qualified to select the sources that are also brought to the hive[18].

Some of the current techniques can produce good-quality quantized pictures. The disadvantage of these techniques is their high computational costs. To extract quantized images at low computational cost and high quality, CQ technique was proposed in this article. The simulation shows that described method can produce good quality quantized pictures with little consume time.

2. RELATED WORKS

In recent years, many works have focused on improving color image quantization by using different techniques.

Huang, S. C. [5]suggested a procedure that is divided into two stages. The initial stage is to create the palette. The N colors are generated using the RGB color space data distribution of the input image. Then, one color is chosen from N colors and added to the initial palette, and a process is repeated until the initial palette's color number equals K. This was done with different sampling rate. The second stage involves the rapid generation of quantized images using the fast K-means algorithm.

Lei et al. [13] suggests a new implementation for the Flower pollination swarm-based algorithm in the scope of image processing for solving CQ problem, in which the MSE is used as a parameter for the color quantization optimization problem to be solved. His suggested Flower pollination algorithm for CQ was validated by comparison to K-Means and other swarm intelligence techniques.

Huang, S. C. [7] improved a process of three phases for color quantization. The first stage involves generating N colors using 3D histogram computations; the second stage involves generating the original palette by choosing X colors from N colors using an ABC algorithm (artificial bee colony), and third stage involves generating quantized picture using AKM (accelerated K-means algorithm).

Roberto et al. [19] suggested a hybrid approach for image color quantization that incorporates K-means and genetic algorithms. By the use of a qualitative objective function that considers the local neighborhood, the genetic algorithm aims to enhance the quantized images provided by the K-means algorithm.

Pérez-Delgado, M. L. [20] proposed a color image quantization approach that incorporates the PSO and ATCQ algorithms. This approach utilizes PSO algorithm's basic operations but also incorporates the ATCQ algorithm to calculate each particle's fitness and to enable particles to be transferred to more advantageous locations within the search space to produce more effective solutions to the problem.

Pérez-Delgado, M. L [10] describes a process for color quantization that incorporates the Artificial Bee Colony and the Ant-tree for Color Quantization algorithms. The computational findings demonstrate that the new approach greatly decreases the amount of time required to compute relative to the original method and produces high-quality images.

Thompson et al. [21] proposed a novel CQ approach based on MacQueen's online K-means formulation. To achieve deterministic, high-speed, and high-quality quantization, the proposed approach employs adaptive and efficient cluster center initialization and quasirandom sampling.

Pérez-Delgado, M. L.[22] discussed a Shuffled frog-leaping algorithm's application for the color quantization problem. While the chosen approach was designed to address optimization issues. The suggested solution solves the optimization problem using the MSE as the objective function. To shorten the algorithm's execution time, it is extended to a subset of the original image's pixels.

Khaled et al. [23] Proposed a new color picture quantization algorithm based on the harmony search (HS) algorithm. His proposed algorithm makes use of the clustering technique, which is one of the most widely used techniques for solving the color quantization problem. The algorithm is studied in two versions. The first is a pure HS algorithm, while the second is a combination of k means (KM) and HS.

3. COLOR QUANTIZATION PROBLEM

To represent an image, we need to find the imaged of N pixels with [x rows, y columns]. Each pixel (pi) in RGB color space, with ik ∈ [1, N], is assigned three (3 integer value) numerical values between a scope from zero to 255, Each is proportional to the strength of red[Ri], green[Gi], and blue[Bi][22].

The colors used in the picture have a total count of more than 16,000,000 Sixteen million colors. The image quantization process involves two distinct methods, palette, and quantization[24].

The problem with color quantization is the following[13]:

- How to design the best palette of colour that is a process to create a group of representative colors to get the color palette (CP).
- How to map the pixels in the process of setting each pixel in the original color image to a single color in CP.

These steps can be done in different ways, the proposed method discuss these steps using k-means algorithm and ABC algorithm in both stages.

A. *K-means clustering algorithm.*

KM algorithm is an iterative clustering algorithm that is widely used in unsupervised learning because of its ease of implementation and convergence speed[25].

The major steps of the K-means algorithm are listed below:

1- Choose Kt initial cluster centroid.

2- Assign data to the cluster closest to it, according to the equation (1).

$$dis(a_i, c_i) = \sqrt{\sum_{j=1}^{d}(x_{i1} - m_{j1})^2} \quad \dots (1)$$

3- A significant task for this new cluster (C) strategy is to make the new cluster centers the core of the new clusters, according to the equation (2).

$$C_i = \frac{1}{N_i}\sum_{j=1}^{N_i} a_{ij} \quad \dots (2)$$

The algorithm is finalized when all the previous clusters are identical to the current new cluster centers. If they are not, you can go back to step2.

B. *ABC algorithm*

the basic procedures of the ABC algorithm are summarized[10]:

1- Initializing

$$x_{ij} = x_j^{min} + \text{Rand }(0,1)(x_j^{max} - x_j^{min}) \quad \dots (3)$$

x_j^{min} =The minimum limits for the parameter j_{th}.

x_j^{max} =The highest limits for the parameter j_{th}.

rand (0, 1) = the coefficient is randomly assigned a value within the range of 0 and + 1.

2- Employed bee and onlooker bee

$$v_{ij} = x_{i\,j} + \varphi ij\,(x_{i\,j} - x_{kj}) \quad \dots (4)$$

v_{ij} = candidate food source [neighbor SN of the xi].

$x_{i\,j}$ = j_{th} parameters it of the x_i food sources.

x_{kj} = j_{th} parameters of it the x_k food sources.

φij = between −1 and +1, random No.

i = number of pixel sources [1, 2, . . . , SN].

j = number of parameters [1, 2, . . . , D].

D = Dimension (RGB).

(j,k) = randomly chosen parameter and neighborhood, respectively.

generate the new solution v_i by the ABC method. The old solution x_i is the same as v_i(new solution) except that $x_{i,j}$ is changed by $v_{i,j}$.

$$fitness_i = \begin{cases} \frac{1}{1+fit_i}, & fit_i \geq 0 \\ 1 + abs(fit_i) & fit_i < 0 \end{cases} \quad .(5)$$

Where $fit_i = obj(x_i)$

$$P_i = \frac{fitness_i}{\sum_{i=1}^{NF} fitness_i} \quad \dots(6)$$

P_i = probability

3- Scout bee

$$\text{limit} = \lfloor a \times SN \times D \rfloor \quad \dots(7)$$

C. *Comparison metrices*

MSE is a statistic metric that indicates the average of the squares of the errors, or the average squared difference between the foreseen and actual values. MSE has almost always been a strictly positive indicator (it is not zero and it is better to approach to zero)[7].

$$MSE\ (I_1, I_2) = \frac{1}{3\times n\times m}\sum_{i=1}^{n}\sum_{j=1}^{m}(R_1(i,j) - (R_2(i,j))^2 + (G_1(i,j) - (G_2(i,j))^2 + (B_1(i,j) - (B_2(i,j))^2 \quad \dots (8)$$

R.(i, j) = red pixel values at location (i , j)

G.(i, j) = location (i, j) contain on the green pixel value

B(i, j) = location (i, j) contain on the blue pixel value n , m = dimensions of the images.

The S.D is another a statistic metric that expresses the degree of variation or dispersion among values of the group. A low S.D refers that the values of the set are typically close to the mean, whereas high S.D refer to values that are spread out over a larger range[26].

$$S.D = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} \quad \dots (9)$$

PSNR is most frequently used to quantify the quality of lossy compression codec reconstruction (e.g., Image compression). In this case, the signal is the original data, and the dispersion is the compression error[1].

Table (1). values of PSNR in lossy image compression

PSNR (db)	Status	No. of bit
30-50	Typical	8 bit
60	High	12 bit
60-80	Excellent	16 bit
20 -25	Acceptable	4 bit

$$PSNR\ (I_1, I_2)\ = 10Log_{10}\frac{255^2}{MSE(I_1,I_2)} \qquad \text{... (10)}$$

The compression ratio (CR) is the size of the original image on the quantized image[27].

$$\text{Compression Ratio} = \frac{\text{The size of the original image}}{\text{The size of the qauntization image}} \quad \text{..(11)}$$

4. Stages of the proposed Color Image Quantization method[CQ]

The solution involves many steps as shown in Figure (1) that describes the main procedures in blocks.

A. Loading of image

In the first step of the proposed work, the image is chosen to reduce the number of its colors, the pixels of the image are prepared mathematically for the next steps.

After this process, the number of desired colors is chosen (16,32,64,128 colors) to reduce the number of colors of the input image and to obtain the quantized image, thus obtaining the desired size that results in a faster transmission over the network.

B. K_Means algorithms (Generation of initial palette colors randomly)

Enhancements the algorithms involve many different research areas, but the hybridization of algorithms is one in particular. To optimize the performance of reducing of colors in the proposed algorithm Where the algorithm K-means was used as a preliminary step for the process of selecting the preliminary color palette in an elementary and random manner as part of the phases of the artificial bee algorithm, where the Initialization phase of ABC algorithm is developed in this work.

K-Means is used to locate color sources in a randomized field. The algorithm is selected because it is simple and has linear time complexity. K-means clusters are used as initial food positions in the ABC algorithm.

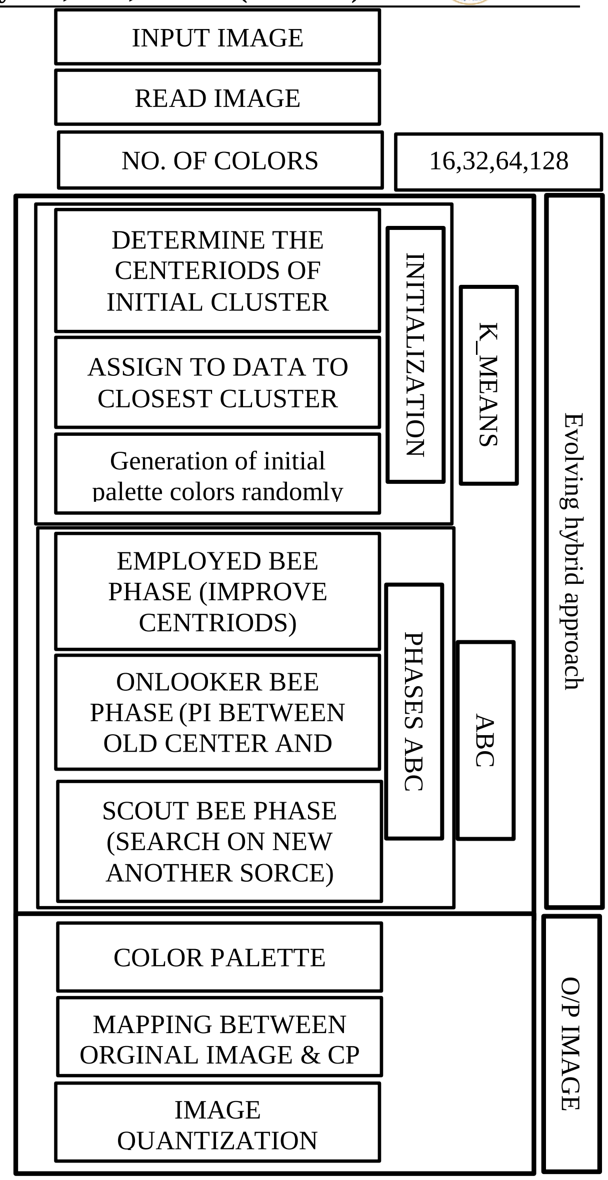

Figure 1. main steps of the proposed color quantization method.

C. Improve K centroids By ABC Algorithm

To optimize K of the initial colors from the N colors, the ABC algorithm reformation the palette colors. The basic components of this problem are shown in the following procedures of the ABC algorithm.

1- Generate New Solution (v_i) By Employ Bee

After the process of determining the centroids randomly by the K_Means algorithm that represents the initial color palette. ABC algorithm is used to improve the selection of K colors. This method speeds up the process over both ABC or K-means algorithms alone. Each pixel (food source) is assigned to an employed bee, and the total No. of bees is equal to the No. of pixels (food sources (SN)). The bees are tasked with finding new sources of local pixel units (food sources or solutions) to work within their designated areas. The ABC model offers a well-suited format for persistent problems. Equation (4) is developed to solve this step.

2- Onlooker & Scout Phases

During the employed bee process, and according to the above Section, the i-th employed bee by the method mentioned create new solution called v_i . If fitness value (x_i) < fitness value (v_i), then x_i gets replaced by v_{ii} and T1(trail) set to 0 else fitness value (v_i) > fitness value (x_i), x_i is replaced by v_i and T1 = T1 + 1.

In process of the onlooker bee, every onlooker bee that chooses a solution on the probabilistic basis and later produces a new solution using probabilities as defined in equation (6). A high-performing food type has a higher preference probability than a low-performing food type. When a bystander bee (onlooker) searches for a food source, she remains steadfast in her search.

In scout bees, the scout bee randomly generates solutions to replace x_i if x_i trails are more than the "limit". The value of the limit parameter is set to 15. The algorithm of ABC is done when the criterion ABC cycle < cycle. The best solution found in this work is O\P from this process and it represent CP.

The N ≥K criterion must be met in the second stage. The acquired K value must not be greater than the N value. Algorithm (1) shows the phases of the method.

Algorithm (1) Fundamental proceedings of the proposed algorithm

1 Initialization using K_Means:
- 1.1 Generate initial palette colors randomly
- 1.2 do N times
  - 1.2.1 Choose Kt initial cluster centroid
  - 1.2.2 Assign data to the cluster closest to it
- 1.3 Get primary palette colors

2 Do M times steps 3, 4 and 5.

3 Employed Bee step:
- 3.1 Suggest new solutions by the ABC algorithm based on the solutions identified by the K-Means algorithm.
- 3.2 Compute the selected center cluster color content of the newly discovered center cluster color.
- 3.3 Greedy selection between new and existing center cluster color are obtained by the K-Means algorithm.

4 Onlooker Bee step:
- 4.1 Probabilistic selection of food sources (center cluster color) between the sources obtained by the employed bees and sources suggested by the K-Means algorithm.
- 4.2 Normalize the results to upper and lower bounds of color values.
- 4.3 Greedy selections between new and existing sources (center cluster color) are obtained by the K-Means algorithm.

5 Scout Bee step:
- 5.1 Save the sites that contain the best resources.
- 5.2 Check for depleted sources.
- 5.3 Replenishing depleted resources by applying K-Means algorithms.

6 Using the color palate from previous steps to map the original image to obtain the quantized (reduced) image by applying the best population of the above steps to k-means.

D. Color Palette[CP]

Each pixel in an RGB color image is represented by three unsigned 8-bit integers. A color reduction strategy would be attempted in the proposed method. The objective is to specify a palette of (16,32,64,128,) colors and reshape the target image entirely in these colors. This allows for massive data compression, as each pixel would be assigned only by (4,5,6,7) bits rather than 3 bytes.

The palette will be specified using algorithms (K-means + ABC) that refer to as centroids represent the palette's colors. The secret to a color picture is a decent color palette. By using a good color palette, the restored image quality of the compressed color image can be enhanced. Several preprocessing techniques have been proposed for color image compression.

The K-means algorithm iterates two steps: to assign to each pixel its nearest centroid, and then to move the centroids using distance averages (each centroid according to its assigned pixels), The ABC algorithm modifies and tests those midpoints defined by K_Means to extract them to represent the final color palette.

Figures of (Lena, Baboon, Pepper, Airplane, Lake,MY PIC) present the pictures that have been chosen for the proposed method. Figure (2) represents the shape of the final color palette for Lena picture.

Figure 2. The palette of colors for Lena image

E. Mapping Process & Quantized Image

After the color palette is ready, the process of assigning the pixels of the original image according to the resulting color palette comes. The color palette differs from one image to another according to the existing colors and gradations in the image, and the amount of the palette colors also varies according to the number of colors to be reduced to the resulting image. That all the colors in the original image be replaced by what is corresponding to it or closer to it in the color palette to produce the quantitative image. In other words, an enormous number of colors in the input image has been reduced to a number of previously specified colors, and this process is similar to the image compression process, as in the figure (3). The benefit of this process is a small-size image on the hard disk to provide the space and speed for transmission in social media over the network, or because this process provides a light-colored image that can be supported on different devices such as medical devices or other devices. The resulting image is almost similar to the original image or difficulty distinguishing between them based on the human eye.

Figure 3. Original image & resulting image

F. Proposed hybrid k-means and ABC algorithm for Color Quantization – Reasoning and Realization

There are two proposed steps of clustering; post clustering and Pre-clustering. The first step, which is called the post-clustering stage, the first stage used the k-means algorithm for clustering the pixels in images into initial n colors. The drawback of the k-means algorithm is that the k-means may prematurely converge, or on the other hand, it takes a long time to converge, depend on the problem and the setting of the parameters. To handle this problem, a set small number of iterations for the K-Means algorithm. After running the algorithm to find the set of centroids, the centroid results theoretically will be close to the correct solution.

The centroids results are adjusted by hybrid of ABC algorithms and k-means in the second stage. The drawback of the ABC algorithm is it sensitive to initialization that easily close to local optima. To solve this problem, by using the initial centroids obtained from the K-Means algorithm in the previous stage and also imbedded k_means as a sub-step in ABC algorithm as a greedy selection step. These steps are shown in detail in Figure (1).

5. Implementation & Experimental Results

Laptop working within OS (Win7) with CPU (core i3) and 3 G Bytes of random-access memory (RAM) is used to implement the proposed algorithm on the Matlab software (2019). The work is tested over five popular images for image processing testing from USC-SIPI Image Database were used to evaluate research on the human eye and the ratio of compression obtained. The following criteria were used in the experiments, ABC-cycle = 10, source foods (SN) = 20 and K-means-cycle = 5, dimension of image is 512×512.

The CQ-ABC+K_Means is applied to the five benchmark images: Lena, Baboon, Pepper, Airplane, Lake, MY PIC into 16,32, 64 and 128, colors, which are presented in Figures below respectively.

MSE measures the distortion between the original image and its quantized image. If the MSE is small, the resulted image from CQ closely is similar to the original.

By looking at Table (2), (4), (6), (8), (10), (12), we find that the results shown in the MSE field are for measuring the amount of error of the resulting image, where the proportions are very small and slight, indicating that the resulting image is closer to the original image, and this leads to the efficiency of the proposed method.

For the results related to S.D., whether it is the original image (S.D1) or the resulting image (S.D2) through the table, it is clear that the amount of deviation of the resulting image is very close to the original image.

It shows us the results of the peak signal to noise ratio are very good, meaning that the input signal is much higher than the distortion ratio, indicating the quality and strength of the proposed method.

Tables (8) shows the results related to the RC between the input image and the resulting image.

The result was that the greater number of colors chosen to form the resulting image, the closer resulting image size was to the original image, and the opposite is that the smaller number of colors to form a resulting image, do not need a big storage size, it is easy storage on the hard disk, and faster transfer of data across the network.

Through the results of Table (2,3,4,5,6,7) it is evident that the greater the number of colors chosen in the formation of the resulting image, the smaller the error percentage because once the number of colors increases, it means that the image will approach the input image, and this explains the lack of errors in the resulting images, not only to bring us as soon as the number of iterations of the two proposed algorithms increases from the suggested iteration, the image is more accurate, finer, and closer to the original image and obtaining the best results.

With regard to the time taken, all the results we obtained are very fast and appropriate, to note only the more the number of iterations the more time to extract the results and also depends on the speed of the computer processor.

Table 2. Summarizes results of the method

Name	K	MSE	S.D.1	S.D.2	PSNR	Time
Lena	16	59.79	0.224	0.212	29.47	139.96
	32	33.131	0.224	0.218	32.8949	345.12
	64	21.49	0.224	0.221	35.1784	373.59
	128	15.36	0.224	0.22	37.1818	773.32

Original **16 colors** **32 colors** **64 colors** **128colors**

Figure 4. resulting images by methods

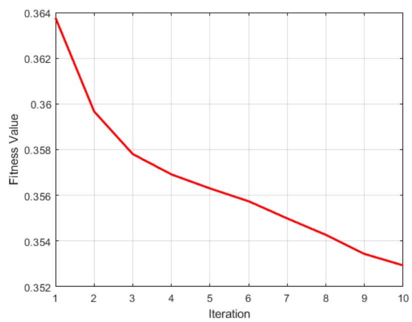

Figure 5. Iteration of ABC vs Fitness value of Colors

Here notice in figure (5) that once the Iteration increases, we get better and more accurate results regarding the determination of the specialized colors for the image quantization process.

Table 3. Summarizes results of the method

Name	K	MSE	S.D.1	S.D.2	PSNR	Time
Baboon	16	147.75	0.217	0.213	25.32	128.98
	32	76.95	0.217	0.218	27.7208	282.5
	64	44.28	0.217	0.22	29.9207	515.68
	128	27.22	0.217	0.223	31.9567	924.27

Original **16 colors** **32 colors** **64 colors** **128colors**

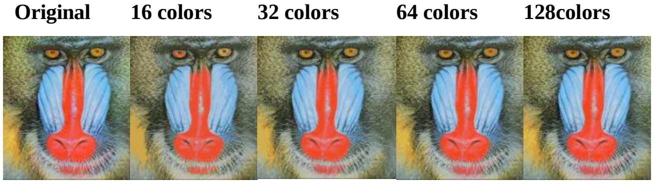

Figure 6. resulting images by methods

Table 4. Summarizes Results of the method

Name	K	MSE	S.D.1	S.D.2	PSNR	Time
Pepper	16	144.7	0.239	0.288	26.12	124.4
	32	69.89	0.239	0.282	28.6613	301
	64	41.77	0.239	0.27	31.134	529.9
	128	24.9	0.239	0.259	33.2866	972.8

Original **16 colors** **32 colors** **64 colors** **128colors**

Figure 7. resulting images by methods

Table 5. Summarizes Results of the proposed method

Name	K	MSE	S.D.1	S.D.2	PSNR	Time
Airplane	16	129.48	0.264	0.262	27	139.8
	32	79.88	0.264	0.252	29.1	223
	64	55.8	0.264	0.257	32.48	466.76
	128	42.49	0.264	0.260	34.68	830.9

Original **16 colors** **32 colors** **64 colors** **128colors**

Figure 8. resulting images by methods

Table 6. Summarizes results of the method

Name	K	MSE	S.D.1	S.D.2	PQSNR	Time
Lake	16	52.4	0.255	0.228	30.93	131.19
	32	29.6	0.255	0.220	33.4	250.5
	64	19	0.255	0.215	35.34	449.63
	128	13.84	0.255	0.209	36.7	779.92

Original **16 colors** **32 colors** **64 colors** **128colors**

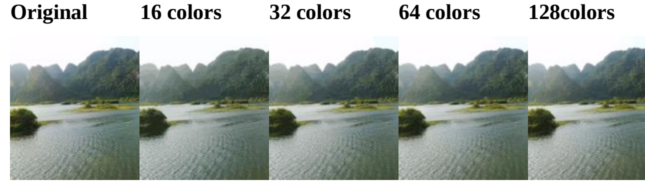

Figure 9. resulting images by proposed methods

Table 7. Summarizes results of the method

Name	K	MSE	S.D.1	S.D.2	PSNR	Time
MY PIC	16	149.29	0.276	0.239	26.39	152.8
	32	104.78	0.276	0.225	27.9	328.67
	64	76.72	0.276	0.233	29.3	455
	128	61.16	0.276	0.245	30.26	768.9

Table 8. RC results for the method

	K	ratio of compression (RC)
Proposed Method	16	6
	32	4.8
	64	4
	128	3.4

Original **16 colors** **32 colors** **64 colors** **128colors**

Figure 10. resulting images by methods

6. Algorithm Parameters

Summarizes results of the proposed method with ABC-cycle = 10, with source food (SN) = 20 and K-means-cycle = 5,' MY PIC' image only.

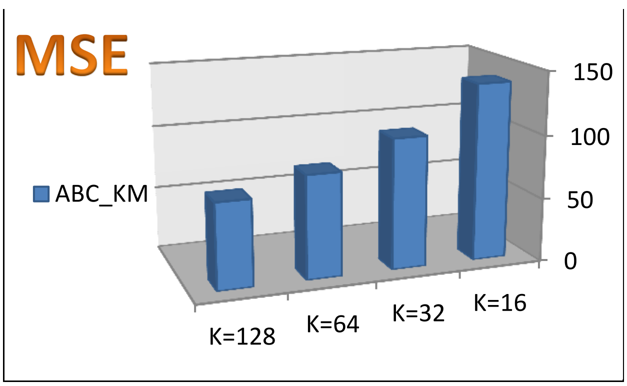

Figure 11. K vs MSE for image (MY PIC) only

Figure (11) shows the results obtained. As the value of K increases, it leads to a decrease in the MSE values. It is considered a natural thing because increasing the number of colors chosen to form a specific image, leads to its formation with higher accuracy than if you choose fewer colors for the resulting image.

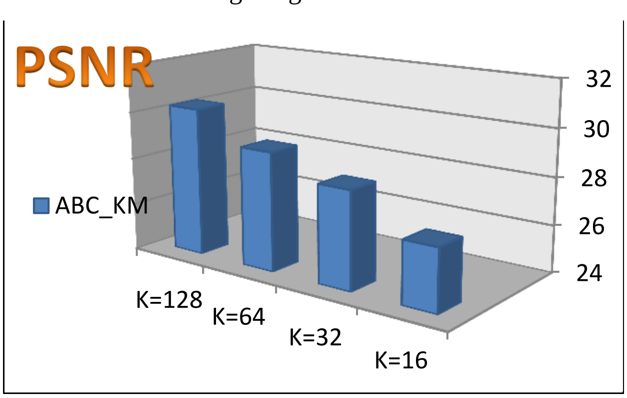

Figure 12. K vs PSNR for image (MY PIC) only

Whenever the number of the colors chosen to form the image increases, it leads to an increase in the value of PSNR as in the figure (12), indicating that an increase in the number of colors(K) to extract a specific image will lead to strength in the ratio of the resulting signal and a weakening in the error rate found in the signal, that is, the resulting image is almost closer to the original image.

PSNR has an inverse relationship with the error, PSNR increases lead to a decrease in error, and the greater the signal.

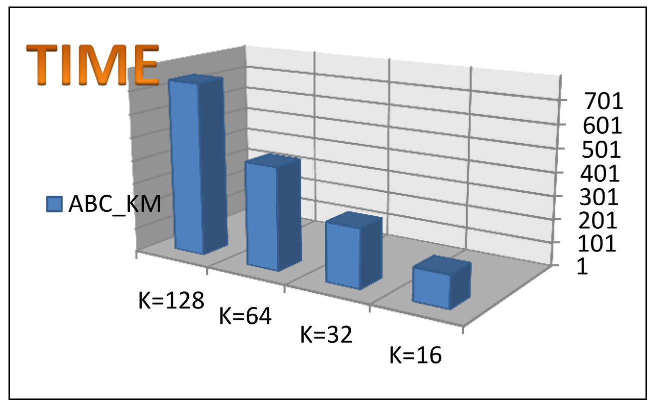

Figure 13. K vs Time for image (MY PIC) only

In figure(13),it is clear that increasing number of colors in a certain image gives more accuracy for the resulting image as well as increase the processing time.

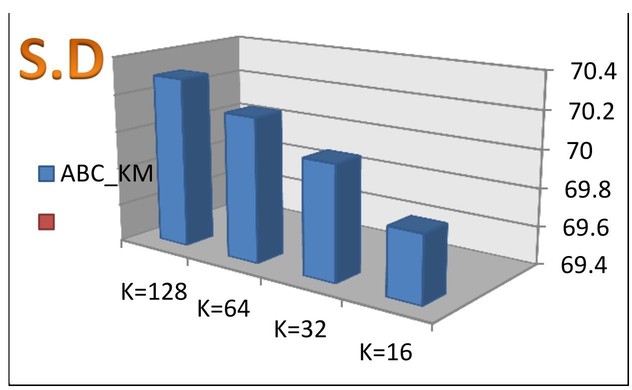

Figure 14. S.D1,2 For images (MY PIC) only

Figure (14) shows the comparison between the standard deviation of the original image and the resulting image, respectively, as it shows the difference and the amount of deviation between the two images and shows through the results the emergence of a small amount of change between the two deviations.

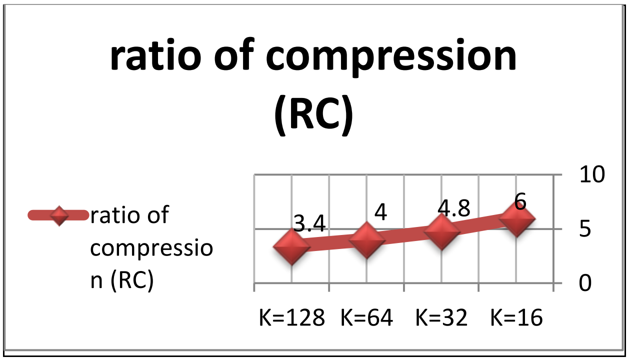

Figure 15. K vs Compression Ratio (OI, CI)

Figure (15) shows the results related to the compression ratio between the original image and the resulting image.

The result was that the greater the number of colors chosen to form the resulting image, the closer the resulting image size was to the original image, and the opposite is that the smaller the number of colors to form the resulting image, the smaller the size, the easier storage on the hard disk, and the faster the transfer of data across the network.

7. Proposed Method and other methods

When comparing the results of the proposed method in terms of MSE and PSNR with some other popular CQ algorithms to demonstrate the efficiency of the shown method, such as, Fast K-M [5], PSO+AT3[17] and ABC+AKM [6] as shown in the following:

Table 9. Results of selected methods with the same application comparing by MSE

image	K	F-KM	PSO+AT3	ABC+AKM	ABC+KM
Lena	32	123.1	118.6	121.3	50.56
	64	74	72.53	73.84	40.77
	128	47.28	46.66	47.53	36.36
Pepers	32	230.2	229.3	236.8	82.15
	64	136.7	134.6	141.7	52.9
	128	84.99	84.31	86.45	36.8
Baboon	32	381.9	375.4	385.3	72.95
	64	240.3	237.8	243.4	42.59
	128	153.4	153.2	156.1	27.22

To compare the ABC+KM algorithm with the fast K-means algorithm, PSO+ATCQ algorithm, and accelerate K-means+ABC algorithm, with five iterations of K-means (a small number of iterations was considered due to the amount of time required to execute the algorithms). Table (9) show the results of three independent tests performed for each problem and palette size; the MSE (average) for iterations are included.

To evaluate ABC+KM, a small number of K-means iterations was considered. This method can produce higher-quality images if more K-means iterations are performed. However, the execution time is significantly increased. While increasing the number of iterations of K-means can result in higher-quality images, the execution time is critical to consider. when ten iterations of K-means are executed,

When MSE is used to compare the images, the results obtained via algorithms is worse than that of the image obtained via the ABC+KM algorithm for 32 colors and is significantly better for 128 colors. Nonetheless, it is obvious that all algorithms take a long time to achieve a small reduction in error comparing with the proposed algorithm.

It was discovered that increasing the number of iterations results in a higher quality quantized image but at the expense of longer execution times. Increases in the number of particles require increased execution time, but the resulting image quality does not always improve.

When the greater number of colors to form the resulting image, we obtain weaker distortion and obtaining an image close to or somewhat similar to the original image.

The result of smaller MSE indicates that the errors in the resulting image will be less. Looking at figure (16) it is evident that the proposed method has received the least percentage of errors in the signal and quality of the resulting image compared to the results of the shown methods.

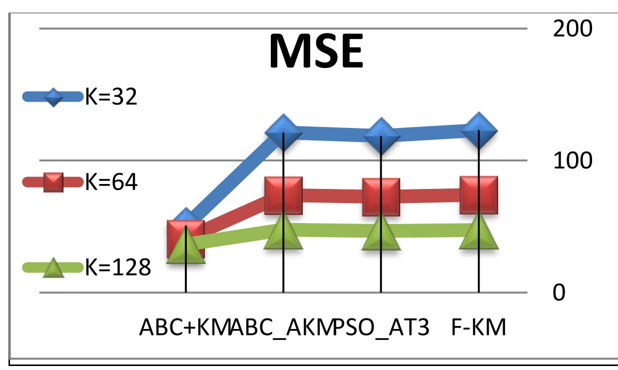

Figure 16. Results of MSE for algorithms

When implementing color quantization for RGB space, Table (14) reveals that the CQ-ABC + K-Means method obtains the best values in terms of obtaining the lowest values from MSE and the largest values in terms of PQNR in most application cases as shown in tables (2,4,6,8,10,12). Whereas, CQ-ABC + K-Means can only get better values for Lena in terms of dividing into 32, 64, and 128 colors for results related MSE. In other words, CQ-ABC+KM we get that this method is very concerned in terms of minimizing MSE and maximizing PQNR. On the other hand, the lowest K_Means method gets the lowest values against the aforementioned algorithms, so that it can be deduced that the partition-based methods are required to be optimized to obtain the best performance.

When applying the proposed method these results were obtained with k = 16,32,64,128.

1- the summation of calculation time shown in the above tables (2 to 10) is the sum of both the calculation time taken for the clustering process by the K-mean algorithm and the calculation time for the process of generating the initial color palette that is very less when compare it with other algorithms.

2- It was found that increased K leads to an increase in the calculation time for the process of generating the initial color palette. Likewise, an increase in K also leads to an increase in the computation time for the clustering process by the K-mean algorithm.

3- Whereas the method proposed in this study can produce high quality for quantized images, and we cannot notice that there is a visual difference between the two images.

4- The image compression ratio in the proposed algorithm is very small compared to the original image, meaning that there is no significant distortion between the resulting image and the input image.

In terms of looking at the implementation of color quantization in the RGB lab space, where the above table shows us that the CQ-ABC + k-means method where the results contain the best values through reducing MSE and maximizing PQNR in most cases of implementation. In particular, CQ-ABC + k-means can only get the best results for Paper and Lena, etc. in terms of splitting into 32, 64 and 128 colors. Also, the CQ-ABC + k-means method obtains the best results to the standard deviation in all cases, which concludes on the robustness of the proposed method.

One of the advantages of the synthetic bee algorithm is that it is Simplicity, flexible, and robust, and the ability to explore local solutions ability to handle the objective cost and it is more popular.

Limitations of ABC that is lack of use of secondary information and requires new fitness tests on new algorithm parameters.

One of the advantages of the K_Means algorithm is that it is relatively simple to implement, Scales to large data sets, and Guarantees convergence.

One of the disadvantages of the K_Means algorithm is that Being dependent on initial values, Clustering data of varying sizes and density, and Choosing K manually.

8. CONCLUSIONS

The new method proposed in this study is for image quantization and has been applied to color images. It is composed of hybridization the work of K-means algorithm that work for clustering but sometimes take long time to converge to acceptable error, with the ABC algorithm that work well in reduce the path to the center of the cluster as well as improve the cluster definition. This hybridization makes the proposed algorithm more accrue as well as faster than other methods.

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