Image Compression Using Swarm Intelligence

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Abstract: As a result of the development in multimedia technology and direct dealing with it in social media, it has led to interest in the techniques of compacting color images because of their importance at present. Since image compression enables the representation of color image data with the fewest number of bits, which reduces transmission time in the network and increases transmission speed. To ensure the compression process is performed without loss of data, the lossless compression methods are used because no data is lost during the compression process. In this research, a new system was presented to compress the color images with efficiency and high quality. Where the swarm intelligent methods were used, as well as hybridizing it with fuzzy using the Gustafson kessel fuzzy method to improve the clustering process and create new clustering methods with fuzzy swarm intelligence to obtain the best results. Swarm algorithms were used to perform the process of clustering the image data to be compressed and then obtaining a clustered data for this image data. In contrast, a lossless compression method was used to perform the encoding of this clustered data where the huffman method was used for encoding. Four methods were applied in this research to different color and lighting images. The PSO swarm intelligent was used, which in turn was hybridized with the Gustafson kessel fuzzy method to produce a new method for fuzzy particle swarm (FPSO), as well as the grey wolf optimization method GWO, which was hybridized with Gustafson kessel and obtained a new method, which is the fuzzy grey wolf optimizer FGWO, and the results were graded efficiently from the first to the fourth method, where the FGWO method with the huffman was the most efficient depending on the standards measurement that were calculated for all methods, the compression ratio was high in this new method, in addition to the standards of MSE, RMSE, PSNR, etc. among the important measurements of the compressing process.

Keywords: Image compression, Swarm intelligence, Particle swarm optimization PSO, Grey wolf optimization GWO, Fuzzy logic, Huffman encoding.

1. Introduction

Due to the technological development and the use of the Internet to send and deal with images, it necessitated facilitating the task in sending them. The process of compressing images is the best example of these facilities, as the best transmission of the image should not take much time, so it was necessary to compress the color image in order to take a few bytes in its representation in addition to reducing the time required to send it [1, 2]. The compressing process is converted the images into smaller files to ensure efficient storage and transmission. As one of the advanced technologies of multimedia technology where the use of multimedia is common in all social media and on a large scale. Where the high speed of

transport has acquired great importance at the present time, which led to interest in the pressing operations and its development to obtain the most efficient way [2-4]. The main performance measure for image compression is the compression ratio. And the process of compressing images is with two types of pressing with loss and pressing without loss, and the second type is the best because a file identical to its original is obtained with high accuracy [1,5]. Swarm Intelligence It is an intelligent technique centered around the study of the collective behavior of decentralized systems, where this technique simulates social behavior in a swarm in order to solve complex problems. Where the swarm solves complex problem through a number of its members without central control. In general, all techniques of swarm

intelligence depend mainly on the population, where there is a set of possible solutions, so the optimal solution is sought. population members within the overall search space are changing their locations. There are several intelligent swarm algorithms [6, 7]. Image clustering is one of the basic steps in image analysis and image processing applications. The goal of this process is to obtain meaningful areas and this is important before any treatment that occurs at the higher level of the image. Clustering is a method of grouping similar data into different groups or clusters, each group must be similar, and different groups must be non-containers of shared data. The choice of criteria for homogeneity or similarity plays an important role in the accuracy of the cluster result [7, 8]. In this research, a number of topics were linked, compression, swarm intelligence, and data clustering. Where the process of pressing for color images was performed with high efficiency through the use of swarm intelligence techniques in conducting the clustering process for color images data and then using the Hufman coding to complete the pressing process. The swarm intelligent algorithms used in this research to conduct the clustering are the particle swarm algorithm and the grey wolf algorithm, and these two algorithms were developed by hybridizing them with fuzzy logic by making use of the fuzzy membership function to make the clustering process by swarm intelligent flexible and high accuracy. Where a process of reduced the color image data was carried out using a clustering process that shrinks the data and reduces the duplicates in it, and in order to ensure that the data is not lost during the reduction, the best algorithms are used for this. Where the intelligence of the swarm was used because of its importance in finding the best solution to all problems, and that the clustering image in these methods despite the reduction of its data, but its high quality and conformity to the original image is excellent, due to the efficiency of the methods of swarm intelligence in the clustering process where the principle of the traditional clustering algorithm was used to find the Euclidean distance between each pixel with the centers of the clusters and the inclusion of this calculation within the equation for calculating the fitness function of the particle swarm algorithm and the grey wolf optimization algorithm, which produced excellent clustered data, and then this data was coded using the huffman algorithm, thus obtaining high-quality compressed images. Also in this research, fuzzy logic features were used to improve the work of swarm intelligence algorithms by using membership function values that help the pixel go to the class to which it belongs faster, in addition to using mahalanobis distance in finding the

similarity value between pixels and the centers of clusters to ensure the data cluster correctly and quickly. The membership function has a primary advantage in improving the clustering process, because each pixel has its own class belonging value, which can be used to classify the pixel correctly. Here, the particle swarm algorithm was hybridized with the Gustafson kessel algorithm and a new method called FPSO was obtained and its work was better. The fuzzy Gustafson kessel algorithm was also hybridized with the grey wolf optimization algorithm and a new FGWO algorithm was produced, which proved its success in the clustering process and obtained the best results as shown in the tables and results and for various images of different dimensions and colors. Where the best value of the PSNR measure of the new FGWO hybrid method was obtained, as well as obtaining the best values for all measurements of this method. By using swarm intelligence with Gustafson Kessel fuzzy algorithm, it gave the research importance and efficiency in image compression compared to other research.

Section 2 includes the previous work, and the proposed system of this research is explained in section 3, and in section 4 the particle swarm algorithm is explained in detail and how it was employed to perform the clustering process, in addition to improving this method by hybridizing it with the fuzzy Gustafson kessel method and obtaining the proposed FPSO algorithm for the fuzzy clustering explained in section 5. Section 6 dealt with the grey wolf optimization algorithm that was used to perform a clustering operation on image data using Euclidean distance as a function of its fitness. In section 7 the proposed fuzzy hybrid method FGWO is presented in which mahalanobis distance was used to calculate the pixel similarity amount to the cluster's centers in addition to using the membership function to improve and accelerate the clustering process. Section 8 explains the coding process represented by Huffman's algorithm. Measurements for the compression process are described in section 9. Section 10 deals with all practical results that illustrate the robustness of the methods proposed in this research, and finally the conclusions are clarified in Section 11.

2. Previous works

Prabhjeet kaur and Er. Parminder Singh proposed a new compression technique that hybridized Particle Swarm Optimization (PSO) and the genetic algorithm (GA) for image compression based on wavelet transformation. Particle swarm performance depends mainly on elementary particles. When

poorly selected particles that lead to bad results. The genetic algorithm does not guarantee global results (optimal solutions), but it is rich and powerful due to the presence of its mutations and crossover operators. These reasons led researchers to hybridized the particle swarm algorithm with the genetic algorithm [9], The proposed method was applied here on color and gray level images, and the values of the PSNR measure ranged between 32.6901 - 39.0999, while in our research and when applying the proposed methods (FGWO), the values of the PSNR measure ranged between 60.496-70.052 and thus quality of new methods was proven. Researchers S. keerthika, S. Vidhya have proposed a new method for image compression, which is a new advanced particle swarm using the fractal image compression method FIC that based on sorting. This is to speed up the encoding process and get high-quality recovered images. The image coefficients are extracted using DCT to classify the image. Then according to the coefficients of the domain areas, the search strategy for each domain block is determined using the proposed algorithm [10], When implementing this proposed method on the images, the highest PSNR values were obtained, which were 56.804, and the compression ratio was 44.342. Whereas in our research, better values of these measures were obtained where the values of the PSNR measure ranged from 60.496-70.052 and the values of the compression ratio ranged between 54.85-62.03, and thus the research methods proved their quality. Hongyi Li et al. Presented an intelligent method to feature extraction and clustering using a PSO swarm clustering algorithm and was applied to electromagnetic interference signal data. And then this method was compared with the traditional clustering methods such as K-mean, FCM and SOM, and it became clear from the results that the proposed method by researchers was superior to the algorithms that were compared with it, as well as the runtime was less [11]. Ibrahim Aljarah and others presented a developed algorithm based on grey wolf to perform data collection in various domains. The grey wolf algorithm was hybridized with a tabu search (TS), obtaining a robust clustering algorithm. It was tested on thirteen data sets, along with a statistical rank test to assess the efficiency of GWOTS compared to previous algorithms. From the results that were reached, it was found that the proposed method outperformed the previous methods [12]. The researchers Divya and Prakasha used multiple methods to perform a clustering process on medical images to discover diseases, as fuzzy cmeans, kmeans, spatial fuzzy means clustering, gustafson kessel and finally particle swarm optimization

incorporative cmeans were used. These methods were the basis for diagnosing and discovering a brain tumor in humans, by relying on the clustered data of previous methods because of the importance of the clustering in many image processing methods and is considered the main stage in the application. In this research, the accuracy of the algorithms was tested by applying them to brain images, and the resolution was high [13]. Jamil As-ad et al. Presented an efficient method of data compression, as dependend on the method of data compression without loss, represented by huffman's algorithm, is considered the most common method of compressing data. The proposed method aims to reduce the size of the huffman coding tree and also to propose a new technique for efficient memory storage for huffman tree storage. From the results they reached, they proved that their proposed method is much better than previous and current methods of compressing data [1]. Researchers Chiranjeev Singh and Apratim Gupta proposed a new method of data compression and is considered an improvement to huffman algorithm, and the work of this algorithm is similar to Huffman algorithm where a tree is used to generate the codeword for each symbol and depends on the frequency of the symbol's presence. And that each codeword is alone, meaning it does not resemble the other codeword, which prevents ambiguity. A marker is used whose code word is unique and not ambiguous. The marker was used to encode the English capital letters using lowercase letters and vice versa [3].

3. The proposed system

In this research, a system has been proposed to perform the compressing process of color images with the lowest cost and the least time in addition to obtaining the best results for the compressed images in terms of their conformity with the original image in addition to obtaining the least storage space required to store the compressed data. Where a process was done to reduction the data of color images using the clustering process, which in turn reduction the data and reduces redundancy and prepares it to perform the pressing process. In order to ensure that the data is not lost while reducing it, the best algorithms have been used for that. Where the intelligence of the swarm was used because of its importance in finding the best solution for all problems. Here the particle swarm algorithm was used to perform the clustering, and this algorithm was hybridized with fuzzy logic to obtain an easy, flexible and precise clustering operation at the same time. Grey wolf algorithm was used to perform the clustering process for data and also was hybridized
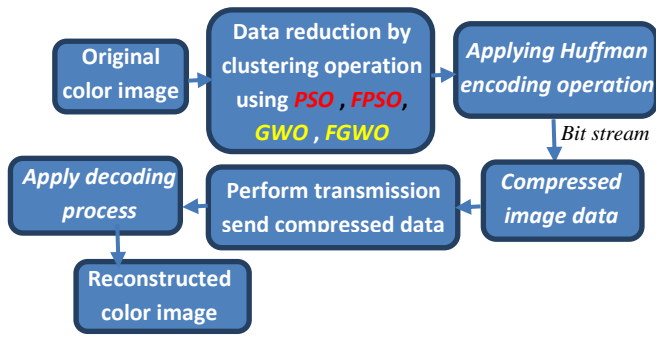
260

Figure. 1 Basic steps of the proposed system

with fuzzy logic to obtain a better algorithm than all previous methods. And then coding the clustered data using the lossless algorithm, which is the huffman that gave great results by pressing. The following diagram (Fig. 1) shows the basic steps of the proposed system.

Compression of color image data is one of the most important technologies at the present time for development of information technology. There are many methods used to compress data and make it more easy and portable. Here, in this research, two new methods are proposed that help in obtaining high-quality compressed images. Where the particle swarm algorithm has been developed by hybridizing it with fuzzy logic to form a new method for the clustering represented by FPSO, as well as proposing another hybrid method, FGWO, which has proven its worth and strength in the compression process, where, when applied to color images, the clustered images were obtained excellently and then coded and obtained data high quality pressed. In addition to using the two aforementioned methods without hybridization, their results were compared, and it was found that the last hybrid method was better than all methods, depending on the measures calculated for all the various images used in the research. In the following sections, all these methods will be explained.

4. Particle swarm algorithm PSO

The particle swarm algorithm is an algorithm that relies on its population, simulating the natural behavior of bird flocking in a computer program. Individuals are initially created with random solutions, called particles. Each of these particles has its own velocity [10]. The particles fly in the search space, where their velocity is continuously adjusted according to the behavior of the particles, so the particles have a tendency to fly towards the best solution in the search space. Each particle in the

swarm has the following characteristics: [13], $post_i$: represents current location of particle. ve_i: current velocity of particle. $best\_in_i$: best position taken by particle [14]. All particles have fitness values, which aim to improve the fitness function to find the best solution in the search space [15], where each particle uses its individual memory and the information it gained from the swarm as a whole to discover the best solutions. Where each particle adjusts its position according to its own practice and also according to its knowledge of its closest particle, as it benefits from the best location it and its neighbor encounter. Each particle's information is updated based on two values called $best\_g$ and $best\_in$ [16].

$$ve_i^{iter+1} = \omega \times ve_i^{iter} + \gamma_1 rv_1(best\_g - post_i^{iter}) + \gamma_2 rv_2(best\_in_i - post_i^{iter}) \quad (1)$$

$$post_i^{iter+1} = post_i^{iter} + ve_i^{iter+1} \quad (2)$$

Where ve represent velocity, ω represent inertia weight; γ_1, γ_2 are learning parameters (acceleration parameters); rv_1 and rv_2 represent random values (0-1); $best\_g$ position of particle that have best global fitness (best solution); $best\_in$ individual best solution.

In the algorithm of the swarm of particles that combined with traditional clustering process, each particle contains k from the cluster centers, so the swarm represents a group of solutions for the clustering process and the fitness function that reduces the error by reducing the distance between the clustering centers and the data that belong to them and enlarging the distance between the clustering centers [17]. The path of each particle of the swarm is influenced by the path of the best particle in the whole swarm, as all swarm particles are attracted quickly and simultaneously to the best particle in the search space. The optimal solution was reached according the following equations [11, 18]:

$$f = \frac{\sum_{k=1}^{cn} \sum \forall Dp \in Cl_k d(Dp, c\_cent_k)/Ds \text{ in } k}{cn} \quad (3)$$

Where cn represent number of cluster, Cl represent Cluster, Dp are Data pixel, c_cent are cluster center, and Ds means number of data set in cluster k.

$$d(Dp, c\_cent_j) = \sqrt{\sum_{k=1}^{nd}(Dp_k - c\_cent_{j\,k})^2} \quad (4)$$

To improve the performance of this algorithm, the membership function is used from one of the fuzzy logic algorithms here we used the membership

function that present in reference [19]. As shown in the following section.

In this research, a new system was proposed to perform the pressing process of color images and to obtain the best results for compressed images in terms of their conformity with the original image in addition to obtaining the least storage space required for storing the compressed data. Where a process of shrinking the color image data was carried out using a clustering process that shrinks the data and reduces the duplicates in it, and in order to ensure that the data is not lost during shrinking, the best algorithms are used for this. Where swarm intelligence was used because of its importance in finding the best solution to all problems, and here the particle swarm algorithm was used to perform the clustering process, using the principle of the traditional clustering algorithm by finding the Euclidean distance between each pixel and clusters centers and including this calculation within the equation to calculate the fitness function of the particle swarm algorithm This resulted in excellent clustered data, and then this data was coded using the Huffman algorithm, thus obtaining high-quality compressed images.

5. The new method: Fuzzy gustafson kessel particle swarm method FPSO

In this algorithm, the PSO method that used here in this research are hybridizing with fuzzy logic to perform the clustering operation of color image data. By adding the membership function to the particle swarm algorithm equation which based on its work on the traditional clustering algorithm by finding the Euclidean distance between each light point in the image with the cluster centers that selected or determined at the start of work. Features of fuzzy logic were used to improve the work of swarm intelligence algorithms by using membership function values that help the pixel go to the class to which it belongs faster, in addition to using mahalanobis distance in finding the similarity value between pixels and the centers of clusters to ensure the data clustering correctly and quickly. The membership function has a primary advantage in improving the clustering process, because each pixel has its own class belonging value, which can be used to classify the pixel correctly. Here, the particle swarm algorithm was hybridized with the Gustafson kessel algorithm. The addition of this membership function to the particle swarm algorithm equation has improved its work in finding the best solutions represented by the best centers of clusters to which the color image data belongs according to the following equations:

$$PGk_f = \frac{\sum_{k=1}^{cn} \sum \forall Dp \in Cl_k \; mship\mu \; dist(Dp, c\_cent_k)/Ds \; in \; k}{cn} \quad (5)$$

Where $mship\mu$ was membership function of Gustafson kessel, c_cent represent cluster center and $dist$ are mahalanobis distance between data pixel of image and cluster center.

$$mship\mu_{ij} = \frac{1}{\sum_{k=1}^{K} \frac{dist_{ij}}{dist_{kj}}^{\frac{2}{fuzzifier-1}}} \quad (6)$$

$$dist_{ij}^2 = (Dp_j - c\_cent_i)^T A_i (Dp_j - c\_cent_i) \quad (7)$$

fuzzifier are positive value, here the fitness function represented by the symbol PGk_f is calculated by the above equation to perform the clustering operation for all color image data. Then, after obtaining the clustering data, it is coded to obtain highly efficient compressed data without data loss.

6. Grey wolf optimizer algorithm GWO

Grey wolf algorithm is a swarm intelligent algorithm. This algorithm mimics the social leadership and hunting behavior of grey wolves in nature. Where society is divided into four sections, the first of which is alpha and symbolized by the symbol α and beta and symbolized by the symbol β and the delta and symbolized by the symbol δ and omega and symbolized by the symbol ω [12]. Grey wolves live in groups and is called the Alpha Leader, who is responsible for making decisions regarding hunting, waking time, sleeping place, etc. These decisions are given to the rest of the group members and they recognize the Leader's decisions by bending the tail down [20, 21]. The main stages of prey hunting by grey wolf are as follows: 1) Tracking, Chasing, Approaching from prey. 2) Pursuing, Encircling, Harassing until it stops moving. 3) Attack. The grey wolf algorithm works by randomly generating the initial population for a number of wolves and then defining the objective function for the problem to be found the best solution. The objective function is calculated for each search agent. After the end of all agents, the alpha wolf position will be taken as the best prey position, and then the location of each search agent will be updated according to the locations of the wolves and update all their information and values. Then calculating the objective function for all search agents and updating the values of $\overrightarrow{P_\alpha}, \overrightarrow{P_\beta}$ and $\overrightarrow{P_\delta}$. Finally an alpha wolf is the optimal solution. And the rest of the values $\vec{A}_{1,2,3}$ and $\vec{C}_{1,2,3}$ represent the vector coefficient and

$\vec{P}_{\alpha,\beta,\delta}$ represents the prey position vector according to the wolf alpha, beta, delta and the value of $\vec{P}_{1,2,3}$ represents the updated position of the wolves Alpha, beta, and delta. The vector $\vec{P}$ represents the current grey wolf position and finally $\vec{P}(t+1)$ represents the new grey wolf position vector i.e the updated. As with the following equations: [22, 23]

$$\vec{D_\alpha} = |\vec{C_1} . \vec{P_\alpha} - \vec{P}| \qquad \vec{D_\beta} = |\vec{C_2} . \vec{P_\beta} - \vec{P}|$$
$$\vec{D_\delta} = |\vec{C_3} . \vec{P_\delta} - \vec{P}| \tag{8}$$

$$\vec{P_1} = \vec{P_\alpha} - \vec{A_1} . (\vec{D_\alpha}) \quad \vec{P_2} = \vec{P_\beta} - \vec{A_2} . (\vec{D_\beta})$$
$$\vec{P_3} = \vec{P_\delta} - \vec{A_3} . (\vec{D_\delta}) \quad \vec{P}(t+1) = \frac{\vec{P_1}+\vec{P_2}+\vec{P_3}}{3} \tag{9}$$

To perform a clustering operation for image data using the GWO algorithm, a fitness function is used that calculates the Euclidean distance between the image data values and the centers of the specified clustering from the start of the work according to the following equation [12]:

$$fit = \sum_{j=1}^{cn} \sum_{i=1}^{|Cent_j|} \sigma(cent_j, data_i)^2 \tag{10}$$

Where σ are the Euclidean distance between the cluster center or centroid that indexed by $cent_j$ and ith data pixel of the image as the following equation:

$$\sigma(cent_j, data_i) =$$
$$\sqrt{\sum_{wi=1}^{dim}(cent_{j,wi} - data_{i,wi})^2} \tag{11}$$

Where $data_{i,wi}$ represent the width dimension of ith data pixel that belong to cluster center $cent_j$. To evaluate the quality of each wolf, the fitness function fit mentioned in the above equation is used here. And every wolf tries to reduce its fitness value.

In this research, the clustering process was used to reduce the image data to be compressed, as the grey wolf algorithm was used and linked to the Euclidean distance of the traditional clustering in calculating the fitness function for this method and obtaining the best clustering process for the data as this method was better than the particle swarm method.

7. The novel method: Fuzzy gustafson kessel grey wolf optimizer FGWO

In this algorithm, the grey wolf algorithm GWO, was hybridized to perform the clustering process of color image data with fuzzy logic by adding the membership function of Gustafson kessel algorithm

that using mahalanobis distance $mship\mu_{ij} = \dfrac{1}{\sum_{k=1}^{K} \dfrac{dist_{ij}^{\frac{2}{fuzzifier-1}}}{dist_{ij}}}$ (the same as that adding in PSO algorithm) to the fitness function of grey wolf, which is used in its work to calculate the distance between each pixel in the image with the optimal cluster centers of wolves, as shown in the following equation:

$$fit = \sum_{j=1}^{cn} \sum_{i=1}^{|Cent_j|} \sigma(cent_j, data_i)^2 \times mship\mu_{ij} \tag{12}$$

It has also been added to equations of updating wolves position. The addition of this membership function led to reduce the time spent on clustering the data, speed up the work and ensure its accuracy and an improvement in the algorithm's work in finding the best solutions represented by the best cluster centers to which the color image data belongs. As each wolf has k cluster centers.

In this research, and during the implementation of all its methods, it is evident that the best method to perform the clustering process of data and then encode it and obtain compressed data is the fuzzy grey wolf method, which is evident from the results obtained when implementing all the methods on various colored images and different background.

8. Huffman algorithm

It is a lossless algorithm, the goal of this algorithm is to obtain the lowest number of bits to represent the image data to be compressed to reduce the storage space required to store the data in it[24]. The basis of the work of this algorithm is to calculate the probability of the presence of each pixel in the image by calculating its frequencies and then its probability and these probabilities are arranged in descending order and then collect the two lowest probabilities and so the process continues until the last two probabilities are reached and then coding them and obtaining a codeword for each pixel[25]. And pixels that a few repeated will have the longest length of the codeword, while the pixels that repeat a lot, it has the shortest codeword and this helps in reducing the number of bits that represent the image data to be compressed [26].

When using Huffman algorithm directly on the image data, the compressed data is obtained well, but not of high quality or with an optimal storage space, so the enhancement of the compression process was required to perform a preparation of the image data before encoding it with Huffman, and here in this

research the clustering process of the data was performed before used coding, swarm intelligence methods are used in this, and in turn have been developed to become high performance. When applied to various images, high quality compressed data with excellent storage space is obtained. Where the clustering process of image data added an important feature of the compression process, where the data was shrunk and then encoded, thus it became easy and flexible in the coding process, thus resulting in a high-performance compression.

9. Compression operation measurements

To measure the accuracy and efficiency of the methods used by research, the following measurements of the color image are calculated [9]:

$$RMSE = \sqrt{\frac{1}{M^2} \sum_{i=1}^{M} \sum_{j=1}^{M} [origimage(i,j) - resimage(i,j)]^2} \quad (13)$$

origimage represent original image, *resimage* are result image, then calculate the value RMSE of full color image RMSE$_{all}$ as following:

$$RMSE_{all} = \sqrt{\frac{1}{3}(RMSE_{red}^2 + RMSE_{green}^2 + RMSE_{blue}^2)} \quad (14)$$

$$PSNR_{all} = \frac{PSNR_{red\,color} + PSNR_{greencolor} + PSNR_{blue\,color}}{3} (15)$$

$$\text{Where: } PSNR = 10 log_{10} \left[\frac{\max gray^2}{MSE} \right] dB \quad ,$$

$$MSE = \frac{1}{N}(origimage - resimage)^2$$

$$Compression\ Ratio = \frac{size\ of\ original\ image\ file}{size\ of\ compressed\ file} (16)$$

$$bits/pixels = \frac{Bits\ number}{Pixels\ number} \quad (17)$$

10. Results and discussion

In this research, a new method was used in the image compressing process, where swarm intelligence algorithms were used to perform the clustering process of image data for which to be compressed, and then to obtain clustering data. This data, in turn, a lossless compression method is used to perform the compressing process for this reduced data, as the huffman method for coding is used, which depends on the calculation of the probability of the presence of each value in the image data after performing the clustering process on it using swarm intelligence methods. In this research, several methods were used to perform the clustering process of image data before encoding it in the huffman method because of the importance of the clustering in reducing data by collecting similar data in different clusters or groups. Clustered image is compensated for each value in the cluster center to which the point belongs, thus data was preserved without losing it. Then the encoding process is performed by calculating the probability of each value being found in the resulting clustered image, performing the steps of the huffman algorithm and obtaining a compressed file which are values represented by a series of values of 0 and 1 where compressed images have been obtained with high efficiency. The images were wanted to be compressed are prepared by using four intelligent methods in which the colors of the images were divided into a group of clusters, namely: Particle Swarm Optimization PSO, Fuzzy Gustafson kessel Particle Swarm Optimization FPSO, Grey Wolf Optimization GWO, and Fuzzy Gustafson kessel Grey Wolf Optimization FGWO. Thus, clustered images will be obtained that are encoded using the Huffman encoding algorithm without losing the data, thereby obtaining compressed images with efficiency and high quality represented by the lowest number of bits.

The four intelligent clustered methods were applied to many color images with different lighting intensity rates, as well as with multiple colors and different dimensions. The dataset (images) that used here are bmp uncompressed images that takes from the internet. Research methods were initially applied to the cat image with dimensions of 317 * 159, where image data was compiled using a particle swarm optimization algorithm, an efficient method, and a clustered image was obtained on which the huffman compression algorithm was applied. Where a compressed image of appropriate quality was obtained but not at the required level, so a particle swarm optimization algorithm was developed to obtain a fuzzy particle swarm optimization algorithm that was also used to perform the clustering process on the image data that allows for easy and flexible fragmentation. When applied, its performance was better than the particle swarm optimization algorithm. After the fuzzy intelligent clustering, the clustered data was encoded with the huffman, where a better image was produced than the previous method. Grey wolf method was also used to perform the clustering process for the images to be compressed, where the clustering process in this way was better than the previous methods, and this algorithm was developed using fuzzy gustafson kessel to obtain a fuzzy intelligent clustering method used for clustering the data before it was encoded and its performance was

(a)   (b)   (c)

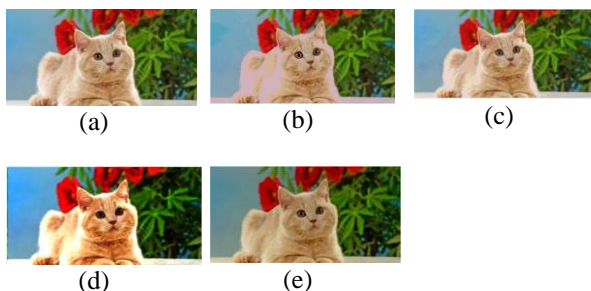

(d)   (e)

Figure. 2 Results of cat image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 1. Measurements of all methods that used in research of a cat's image with dimensions 317*159, number of light points 151209

Measure	PSO	FPSO	GWO	FGWO
MSE	131.94	64.013	0.055	0.015
RMSE	11.486	8.000	0.234	0.123
PSNR	27.236	30.067	61.028	67.397
CR	33.2:1	35.3:1	55.2:1	55.8:1
PNUM	2217	2166	1593	1554
BITPP	0.117	0.114	0.084	0.082

(a)   (b)   (c)
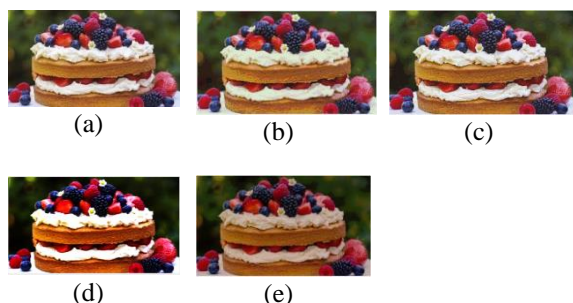

(d)   (e)

Figure. 3 Results of cake1 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image with fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

the best of all methods with a high compression ratio, the image quality is excellent and the size of the compressed file had the lowest size and the value of PSNR was the best value in this method for all the images that used in research. And the bit rate for each light point, this method has the lowest value among all the research methods.

And Figs. 2-16 shows the results of the compressing method that used in this research, where the first field of the figures represents the original image before pressing and the second field represents the reconstructed image from the compressed process using the PSO algorithm, and the third field of the table represents the result of the new method fuzzy intelligent method , and the fourth field represents the results of compressing for images using the grey wolf method, and the last field from the table represents the results of the last method of research represented

by the novel method fuzzy grey wolf method, which was the best and efficient method.

To measure the performance of the compression methods used here, the MSE values, the RMSE values, and the PSNR values were calculated, as well as the compression ratio for each method and for all the color images used in the research, in addition to calculating the value of bits per pixels (BITPP), all of which are shown in Tables 1-15.

The following table demonstrates the results of the compressing process of color images dependent on the clustering data using swarm intelligence methods and hybridizing them with fuzzy logic, where , swarm intelligence techniques were used to obtain the best compression of color images, in addition to hybridization of these algorithms with fuzzy gustafson kessel to produce new and effective methods of compression, and when used in this research was give excellent results of all images that used here.

Table 2. Measurements of cake1 image with dimensions 299*168 and number of pixel 150696

Measure	PSO	FPSO	GWO	FGWO
MSE	145.73	63.982	0.079	0.037
RMSE	12.071	7.998	0.282	0.192
PSNR	26.728	30.070	59.116	63.063
CR	33.5:1	37.4:1	54.6:1	58.8:1
PNUM	2196	1935	1596	1470
BITPP	0.116	0.102	0.084	0.078

(a)   (b)   (c)

(d)   (e)

Figure. 4 Results of cake2 image with all methods: (a) original image, (b) reconstructed image with pso, (c) reconstructed image with fpso, (d) reconstructed image with gwo, and (e) reconstructed image with fgwo

Table 3. Results of cake2 image with dimensions 279*180 and number of pixel 150660

Measure	PSO	FPSO	GWO	FGWO
MSE	116.70	63.980	0.239	0.061
RMSE	10.802	7.998	0.489	0.248
PSNR	27.962	30.070	54.334	60.495
CR	37.5:1	46.8:1	56.5:1	62.03:1
PNUM	1992	1569	1434	1344
BITPP	0.105	0.083	0.076	0.071

(a)　　　　(b)　　　　(c)

(d)　　　　(e)

Figure. 5 Results of flower 1 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 4. Results of flower 1 image with dimensions 303*166 and number of pixel 150894

Measure	PSO	FPSO	GWO	FGWO
MSE	188.81	64.000	0.087	0.045
RMSE	13.741	8.000	0.295	0.213
PSNR	26.381	30.068	58.778	62.245
CR	33.9:1	38.5:1	53.8:1	56.7:1
PNUM	2163	1830	1602	1470
BITPP	0.114	0.097	0.084	0.077

(a)　　　　(b)　　　　(c)

(d)　　　　(e)

Figure. 6 Results of flower 2 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 5. Results of flower 2 image with Dimensions 300*168 and 151200 pixels

Measure	PSO	FPSO	GWO	FGWO
MSE	92.145	64.015	0.101	0.039
RMSE	9.599	8.000	0.317	0.198
PSNR	28.554	30.067	58.446	63.355
CR	35.3:1	45.2:1	55.0:1	56.9:1
PNUM	2061	1545	1518	1400
BITPP	0.109	0.081	0.080	0.074

From all the previous results, it is noted that the highest compression ratio was obtained through the Huffman method based on a new method of the grey wolf swarm hybridized with fuzzy gustafson kessel.
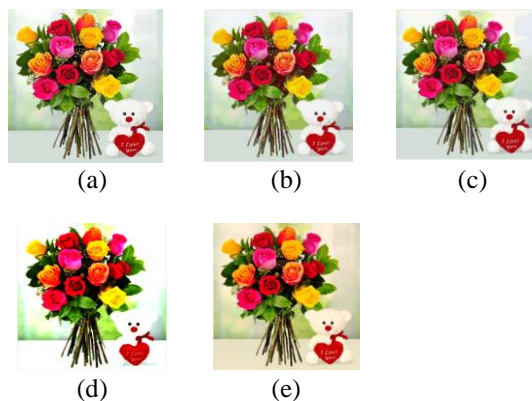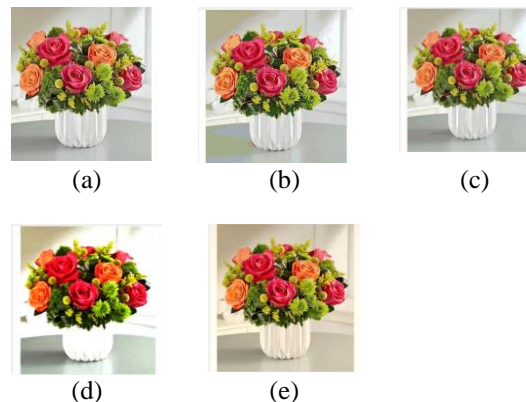

(a)　　　　(b)　　　　(c)

(d)　　　　(e)

Figure. 7 Results of Flower3 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 6. Results of flower 3 image with dimensions 225*225 and 151875 pixels

Measure	PSO	FPSO	GWO	FGWO
MSE	131.70	63.994	0.185	0.035
RMSE	11.476	7.999	0.430	0.189
PSNR	27.351	30.069	55.516	64.671
CR	35.3:1	54.2:1	54.8:1	56.5:1
PNUM	2250	1398	1020	510
BITPP	0.118	0.073	0.053	0.026

(a)　　　　(b)　　　　(c)

(d)　　　　(e)

Figure. 8 Results of flower 4 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 7. Results of flower 4 image with dimensions 225*225 and 151875 pixels

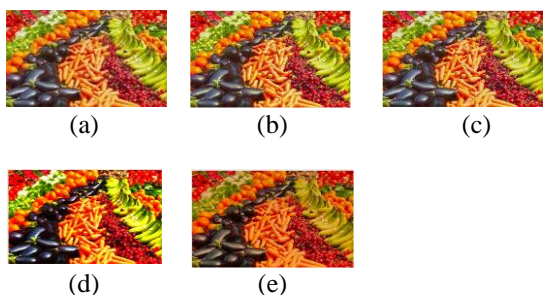| Measure	PSO	FPSO	GWO	FGWO
MSE	153.97	63.985	0.1584	0.039
RMSE	12.408	7.999	0.398	0.198
PSNR	26.894	30.069	56.147	63.980
CR	34.9:1	44.4:1	53.2:1	56.5:1
PNUM	1468	1296	1036	512
BITPP	0.077	0.068	0.054	0.026

Figure. 9 Results of fruit 1 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 8. Results of fruit1 image with dimensions 290*174 and 151380 pixel

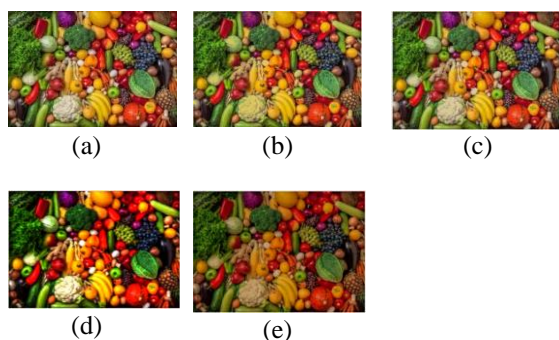| Measure	PSO	FPSO	GWO	FGWO
MSE	138.79	64.019	0.089	0.032
RMSE	11.781	8.001	0.298	0.181
PSNR	27.088	30.067	59.523	63.208
CR	32.7:1	40.9:1	53.2:1	59.2:1
PNUM	1510	1290	805	502
BITPP	0.079	0.068	0.042	0.026

Figure. 10 Results of fruit 2 image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 9. Results of fruit 2 image with Dimensions 270*186 and 150660 pixel

Measure	PSO	FPSO	GWO	FGWO
MSE	166.63	64.020	0.055	0.030
RMSE	12.908	8.001	0.236	0.174
PSNR	26.833	30.067	60.989	64.046
CR	33.4:1	34.8:1	53.4:1	59.04:1
PNUM	2136	2094	1605	1491
BITPP	0.113	0.111	0.085	0.079

The results were even better than the standard JPEG2000 compression method implemented on the standard 256 * 256 peppers image in the reference [27] where a value of 0.24 bit/pixel was obtained, the ratio of bits per light point, and when the JPEG algorithm was applied, a value of 1.57 bit/pixel was
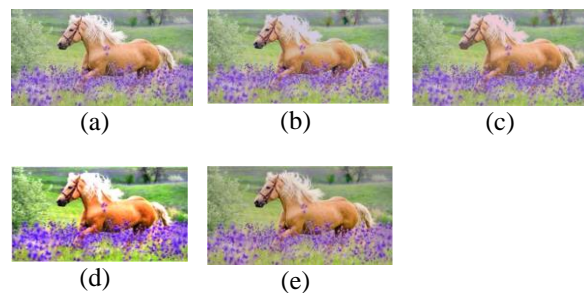

Figure. 11 Results of horse image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 10. Results of horse image with dimensions 310*163 and 151590 pixel

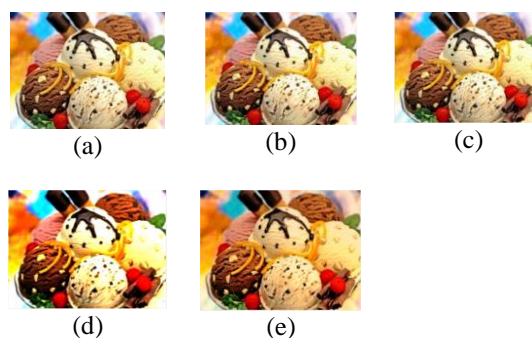| Measure	PSO	FPSO	GWO	FGWO
MSE	84.352	63.978	0.046	0.008
RMSE	9.184	7.998	0.216	0.090
PSNR	29.284	30.070	61.488	70.052
CR	34.8:1	35.0:1	53.4:1	57.8:1
PNUM	2205	1492	1080	1000
BITPP	0.116	0.078	0.056	0.052

Figure. 12 Results of ice-cream image with all methods: (a) original image, (b) reconstructed image by pso, (c) reconstructed image by fpso, (d) reconstructed image by gwo, and (e) reconstructed image by fgwo

Table 11. Results of Ice-cream image with dimensions 259*194 and 150738 pixel

Measure	PSO	FPSO	GWO	FGWO
MSE	71.884	64.002	0.167	0.034
RMSE	8.478	8.000	0.409	0.185
PSNR	29.678	30.068	56.285	64.526
CR	35.3:1	46.5:1	53.2:1	54.8:1
PNUM	2235	1731	1647	1599
BITPP	0.118	0.091	0.087	0.084

obtained. While the methods of my research when carried out on the same image, a value of 0.03 bit/pixel was obtained, and from this it appears that the compression method based-clustering with the grey wolf swarm in my research was the best even when compared with standard compression methods, this is because in my research methods,

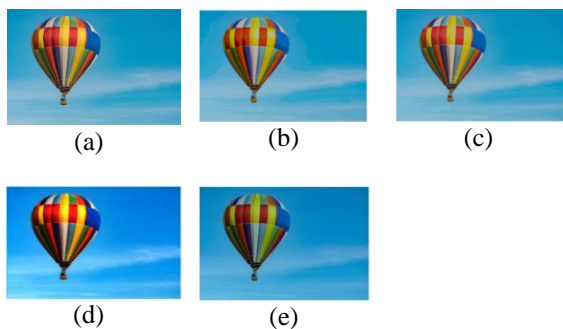(a)   (b)   (c)

(d)   (e)

Figure. 13 Results of baloon 1 image with all methods:
(a) original image, (b) reconstructed image by pso, (c)
reconstructed image by fpso, (d) reconstructed image by
gwo, and (e) reconstructed image by fgwo

Table 12. Results of baloon 1 image with dimensions
275*183 & 150975 pixel

Measure	PSO	FPSO	GWO	FGWO
MSE	143.93	64.053	0.041	0.031
RMSE	11.997	8.003	0.202	0.176
PSNR	28.109	30.065	62.700	65.008
CR	35.8:1	37 : 1	55.6:1	58.04:1
PNUM	1508	1474	1016	978
BITPP	0.079	0.078	0.053	0.051

(a)   (b)   (c)
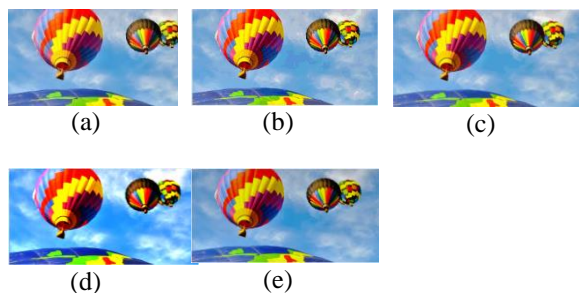

(d)   (e)

Figure 14: Results of baloon 2 image with all methods:
(a) original image, (b) reconstructed image by pso, (c)
reconstructed image by fpso, (d) reconstructed image by
gwo, and (e) reconstructed image by fgwo

Table 13. Results of baloon 2 image with dimensions
316*159 & 150732 pixel

Measure	PSO	FPSO	GWO	FGWO
MSE	63.785	63.994	0.066	0.008
RMSE	7.986	7.999	0.310	0.092
PSNR	30.545	30.069	58.563	69.680
CR	33.3:1	34.9:1	54.8:1	55.06:1
PNUM	2259	2010	1581	1502
BITPP	0.119	0.106	0.083	0.080

(a)   (b)   (c)
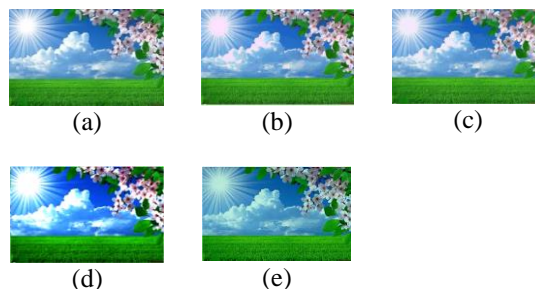

(d)   (e)

Figure. 15 Results of natural 1 image with all methods:
(a) original image, (b) reconstructed image by pso, (c)
reconstructed image by fpso, (d) reconstructed image by
gwo, and (e) reconstructed image by fgwo

Table 14. Results of natural 1 image with dimensions
284*177 & 150804 pixel

Measure	PSO	FPSO	GWO	FGWO
MSE	103.21	63.981	0.098	0.017
RMSE	10.159	7.998	0.313	0.131
PSNR	28.287	30.070	58.467	67.170
CR	33.2:1	35.1:1	53.8:1	56.76:1
PNUM	2322	2085	1593	1024
BITPP	0.123	0.110	0.084	0.054

(a)   (b)   (c)
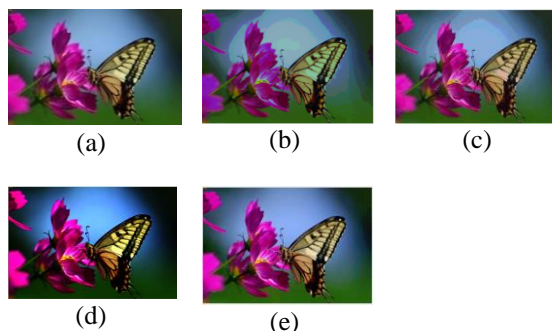

(d)   (e)

Figure. 16 Results of Butterfly image with all methods:
(a) original image, (b) reconstructed image by pso, (c)
reconstructed image by fpso, (d) reconstructed image by
gwo, and (e) reconstructed image by fgwo

Table 15. Results of butterfly image with dimensions
275*183 & 150975 pixel

Measure	PSO	FPSO	GWO	FGWO
MSE	295.54	64.002	0.049	0.080
RMSE	17.191	8.000	0.222	0.282
PSNR	25.508	30.068	61.210	60.077
CR	32.3:1	35.3:1	54.0:1	59.2:1
PNUM	2325	2220	1608	1500
BITPP	0.123	0.117	0.085	0.079

lossy compression methods were not used, but on the contrary, lossless compression methods were used by using the fuzzy clustering process with the intelligent swarm of image before encoding it in the Huffman method, because of the importance of the clustering

in collecting similar data into different groups or clusters, and compensating for each value of image by the center of the cluster that the point belongs to it, as this resulted lossless data. Also in [9] the values of the PSNR measure ranged between 32.6901 - 39.0999, while in our research and when applying the

proposed method FGWO, the values of the PSNR measure ranged between 60.496-70.052 and thus quality of new methods was proven. Finally in [10] the highest PSNR values were obtained, which were 56.804, and the compression ratio was 44.342. Whereas in our research, better values of these measurements were obtained where the values of the PSNR measure ranged from 60.496-70.052 and the values of the compression ratio ranged between 54.85-62.03, and thus the research methods proved their quality.

11. Conclusion

Digital Image Compression is considered one of the most important technologies used in the current world as a result of the development of modern technology. So the trend increased to find efficient compression methods. In this research, a new method was proposed to compress color images based on the image data clustering using swarm intelligence algorithms. To improve the pressing process, these algorithms were developed using fuzzy logic to make the clustering process easy and flexible. Then, huffman algorithm was applied to the clustered data to obtain a highly efficient compressed file with little storage space. It was noted that the process of pressing with the algorithm of compressing without loss gave a high percentage of compressing, in addition to the resulting image was similar to the original image and with high quality. Four methods of compressing were applied in this research to various color images of lighting and dimensions. The results showed that the first method PSO gave a good result, but in some images the reconstructed image have a kind of distortion, so the second developed method FPSO was used to perform the compress and gave better results than the first. Then another swarm algorithm was used for the clustering and then compressed the clustered data, as this method GWO gave excellent results and when developed as its predecessor by hybridizing it with fuzzy Then another swarm algorithm was used for the clustering and then compressed the clustered data, as this method GWO gave excellent results and when developed as its predecessor by hybridizing it with fuzzy logic FGWO, FGWO, the best results were obtained from all aspects, whether by looking or through all the calculated mathematical measurements MSE,RMSE,PSNR,CR,POINT NUM AND BITSPERPIXEL shown in the previous tables. From the previous results, it is evident that the cluster-based compression method using swarm intelligence as well as hybridization with the fuzzy Gustafson kessel algorithm has proven its success

and accuracy by obtaining satisfactory results for the pressing process.

Conflicts of Interest

Declare conflicts of interest or state "The author declares no conflict of interest." Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results.

Author Contributions

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used as follows: "Conceptualization, Shahbaa; methodology, Shahbaa; software, Shahbaa; validation, Shahbaa; formal analysis, Shahbaa; investigation, Shahbaa; resources, Shahbaa; data curation, Shahbaa; writing—original draft preparation, Shahbaa; writing—review and editing, Shahbaa; visualization, Shahbaa; supervision, Shahbaa; project administration, Shahbaa; funding acquisition, Shahbaa", etc. Authorship must be limited to those who have contributed substantially to the work reported.

Acknowledgments

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