Hybrid Swarm Intelligence Technique for CBIR Systems

[1]Anil Kumar Mishra, [2]Dr.Madhabananda Das, [3]Dr.T.C.Panda

[1]Associate Professor
Orissa Engg. College, BBSR

[2]Sr.Professor
KIIT University, BBSR

[3]Principal,
Orissa Engg. College
Bhubaneswar.

Abstract

Literature has proved the individual performance of ABC and PSO while solving various optimization problems. However, as PSO searches the solution by updating the particles and the ABC searches by bees' wandering behavior, there are drawbacks persist in the individual performance. Hence in our previous work, we have proposed a hybrid swarm optimization technique to outperform the individual performance of ABC and PSO. The experimentation was done using standard benchmark test function models and the comparisons were made against the individual performance of PSO and ABC. This work is an extension of our previous in which we take an image processing problem called Content-Based Image Retrieval (CBIR) to evaluate the performance of the proposed hybrid algorithm.

CBIR systems are the most popular image processing system in which relevant images are retrieved from a huge database when a query image is given. In such CBIR systems, multiple features are used to determine the relevance of retrieved images and query images. In this scenario, it is essential to minimize all the features distances that are determined between the query image and the database images. To perform the retrieval stage efficiently, an effective search algorithm is required. Hence, in this paper we exploit the proposed hybrid algorithm in the retrieval stage of a CBIR system to ensure the retrieval performance. The technique will be implemented in the working platform of MATLAB and the retrieval accuracy will be compared with the conventional methods.

Keywords: *particle swarm optimization, Artificial Bee colony, Content based image retrieval*

1. Introduction

Over the years many different techniques for solving optimization problems were developed [1].Swarm Intelligence (SI) is the collective behavior of decentralized, self-organized natural or artificial systems. SI systems are typically made up of a population of simple agents interacting locally with one another and with their environment [2].Swarm intelligence studies the collective behavior of systems composed of many individuals interacting locally with each other and with their environment. Some of the significant swarm intelligence techniques are as follows i) Particle Swarm Optimization (PSO); ii) Ant Colony Optimization (ACO); iii) Artificial Bee Colony Optimization (ABC); iv) Consultant-Guided Search (CGS) and so many techniques. Yet the complete swarm exhibits intelligent behavior, providing efficient solutions for complex problems such as predator evasion and shortest path finding [3] [4].

In the last two decades, the computational researchers have been increasingly interested to the natural sciences, and especially biology, as source of modeling paradigms. Many research areas are massively influenced by the behavior of various biological entities and phenomena. It gave birth to most of population-based let heuristics such as Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC) etc. Honey bees are one of the most well studied social insects. Both of the algorithms are co-operative, population-based global search swarm intelligence met heuristics.

Particle swarm optimization (PSO) is a population based computational technique inspired from the simulation of social behavior of flock of birds. PSO was originally designed and developed by Eberhart and Kennedy [5].It is initialized with a group of random particles (solutions) and then searches for optima by updating generations. Moreover, PSO has some advantages over other similar optimization techniques such as: i) It is easier to implement and there are fewer parameters to adjust. ii) In PSO, every particle remembers its own previous best value as well as the neighbourhood best. iii) PSO is more efficient in maintaining the diversity of the swarm since all the particles use the information related to the most successful particle in order to improve themselves [7]

Another popular but recent algorithm which is being in use isABC algorithm, which was proposed in [8].The Artificial Bee Colony algorithm has been proposed by Karaboga [6]. It is a population based algorithm. [5] Thecolony consists of three groups of bees: employed bees, onlookers and scouts. ABC is modelled on two processes: sending of bees to nectar (food source) and desertion of a food source. While in other swarm intelligence algorithms, the swarm represents the solution, in ABC the food source gives the solution while bees act as variation agents responsible for generating new sources of food [9] [10]. Three types of bees, namely, employed, onlooker and scout bees, aid in reaching the optimal solution. This algorithm is very simple when compared to existing swarm algorithms.These algorithms have recently been shown to produce good results in a wide variety of real-world applications.

2. Related Works

V. Selvi*et al.* [11] has discussed Swarm intelligence for computational intelligence technique to solve complex. They considered Ant Colony Optimization, Particle Swarm Optimization and Artificial Bee Colony etc. In fact, the use of swarm optimization techniques could be applied to a variety of fields in optimization problems. Thus, the job shop scheduling can be performed more effectively by achieving a lower makespan time than the conventional scheduling algorithms.

Dervis Karaboga*etal.* [12] have proposed Artificial Bee Colony (ABC) algorithm that simulate the intelligent foraging behavior of a honeybee swarm. In the proposed method, ABC was used for optimizing a large set of numerical test functions and the results produced by the ABC algorithm were compared with the results obtained by genetic algorithm, particle swarm optimization algorithm, differential evolution algorithm and evolution strategies. Results shown that the performance of the ABC was better than or similar to those of other population-based algorithms with the advantage of employing fewer control parameters.

BhartiSuri*et al.* [13] have proposed meta-heuristics algorithms based on swarm intelligence. These algorithms have been developed by modeling the behaviors of swarm of animals and insects such as birds, bees, ants, fishes etc. The Artificial Bee Colony Algorithm which has been introduced also a swarm based meta-heuristic algorithm. The algorithm models the intelligent foraging behaviors of honey bees and it is introduced for optimizing various numerical problems. Results have shown the performance of Artificial Bee Colony algorithm and presented the applications of Artificial Bee Colony Algorithm in the field of software testing.

3. Content Based Image Retrieval

The approach based on retrievingimages similar to one chosen by the user is called Content Based Image Retrieval (CBIR).Each image is described by an M-dimensional feature vector [15]. In this approach,Image processing algorithms are used to extract feature vectors that represent image properties such as color,texture, and shape which are the visual features. To retrieve the query image from the database images, a similarity measures have been find tostudy the likeness between a query image and database images.One of the main advantages of the CBIR approach is the possibility of an automatic retrieval process, instead of the traditional keyword-based approach, which usually requires very laborious and time-consuming previous annotation of database images [16]. The CBIR technology has been used in several applications such as fingerprint identification,biodiversity information systems, digital libraries, crime prevention, medicine, historical research etc. The architecture for the CBIR system [17] is shown in the fig (1).

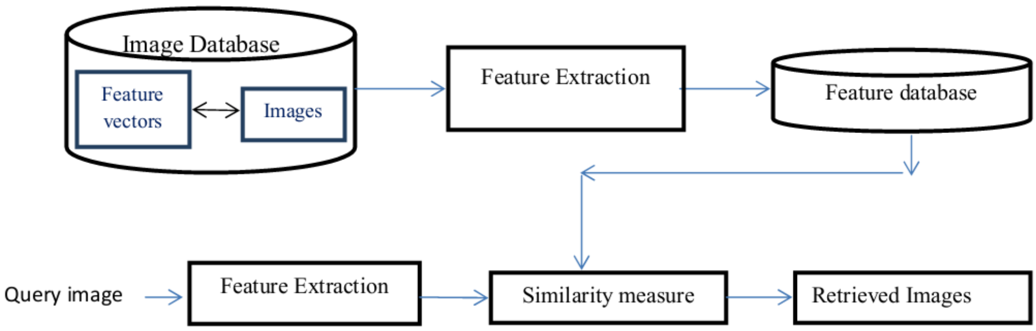

Fig (1) An architecture of a content-based image retrieval system.

Image database includes feature vectors of all images in the databases. Feature extraction is the pre-processing step, obtaining global image features like color histogram or local descriptors like shape and texture.These include histogram-based descriptors, dominant color descriptors, spatial color descriptors and texture descriptors suited for browsing and retrieval. Texture features have been modelled on the marginal distribution of wavelet coefficients using generalized Gaussian distributions and statistical method [14]. Similarity measure is used for exactmatching; content-based image retrieval calculates visual similarities between a query image and images in a database. The most important approach in the CBIR is image retrieval. Accordingly, the retrieval result is not a single image but a list of images ranked by their similarities with the query image.

4. The proposed system: ABC with PSO for CBIR system

A global search algorithm is required in the image retrieval section of the CBIR system. Since the individual performances of the PSO and ABC are outperformed by the hybrid PSO-ABC. So the hybrid PSO-ABC algorithm is used for the retrieval of query image. In the hybrid PSO-ABC algorithm, the position of a food source represents a possible solutionof the optimization problems and the random value of fitnessof the associated solution. The number of the PSO optimal values or the onlooker bees is equal to the number of solutions in the population. The steps involved in the PSO-ABC is listed out below

Step 1: The ABC generates a random initial population as Eqn (1) where Xis variables and X_i is a dimensional vector. Here, n is the number of optimized parameters.

$$X_i^{\min} \leq X_i \leq X_i^{\max} \quad (1)$$

Step 2: Calculate the fitness value for PSO optimization and if the fitness value is better than the best fitness value, Set current value as the new P_{best}

Step 3: Calculate particle velocity and position update according to the Eqn (2) and Eqn (3)where*v* is velocity, *c* is maximum velocity, r is a random value, *p* is personal best, *x* is the current position.

$$V_{id} = V_{id} + c_1 r_1 (p_{id} - x_{id}) + c_2 r_2 (p_{gd} - x_{id}) \quad (2)$$

$$x_{id} = x_{id} + v_{id} \quad (3)$$

Step 4: Assign Onlooker bee to Employed to pbest solution according to probabilities.

Step 5: If fit (Best Onlooker) < p (best), replace best onlooker with respective pbest Neighbourhood value.

Step 6: An onlooker bee chooses optimize best value associated with that food source, the fitness function is calculated by the above expression (4). Here f_i is fitness function and fit_i is the fitness after a transformation.

$$fit_i = \frac{1}{f_i} \quad (4)$$

Step 7: Condition terminates till the maximum iteration reaches.

In this proposed approach, image retrieval section of the CBIR system uses Euclidean distances as a similarity measure of the features such as color, texture, shape, contrast and homogeneity which are objective functions. Colour of an image can be found using color histogram method whereas shape can be found using boundary based method and texture can be found using statistical method. Contrast and homogeneity can be measured using Eqn (5) and Eqn (6) respectively.

$$(\sigma_C) = \sum_{i,j} \frac{x_{i,j}}{1 + |i - j|} \quad (5)$$

$$(\sigma_H) = \sum_{i,j} |i - j|^2 x_{i,j} \quad (6)$$

Distance can be measured using

$$dist\ (x, y)(a, b) = \sqrt{(x - a)^2 + (y - b)^2} \quad (7)$$

Here (x, y) are the indices of the database images and (a, b) are the indices of the query images.

Step 8: The algorithm performance of the approach is based on the precision; recall and F-measure cross over points. After evaluating Euclidean distance of the query image, the precision and recall values are generated using the following equations (8), (9) and (10) in [18].

$$precision = \frac{No.of\ relevant\ images\ retreived}{Total\ no.of\ images\ retrivd} \quad (8)$$

$$recall = \frac{No.of\ relevant\ images\ retreived}{Total\ no.of\ relevant\ images\ in\ database} \quad (9)$$

$$F = 2\frac{precision * recall}{precision + recall} \quad (10)$$

5. Experimental Results and Discussion

The CBIR technique is tested on the image database of 300 variable images includes 3 categories as butterflies, flowers and natures with 100 images for each datasets. The precision, recall and F-measure are calculated for the sample query images for each category using Eqn (8), (9) and (10). These measures are the important parameters to judge the performance of the algorithms.Precision is the fraction of the relevant images which has been retrieved, checks the completeness of the algorithm. Recall is the fraction of the relevant images which has been retrieved, checks the accuracy of the algorithm.

For each algorithm there are different set of sample images that has likeness. These are tabulated below in fig (2).

	PSO	ABC	PSO-ABC
Dataset1 (Flowers)	62	59	65
Dataset2 (Butterfly)	55	57	57

Fig 2 Total number of Retrieved dataset images for PSO, ABC and hybrid PSO-ABC

The retrieved query images from two datasets for the proposed hybrid algorithm is shown in the fig (3)

Fig 3 Retrieved images from the database images for the datasets 1 and 2 using PSO-ABC

Fig (4) and fig (5) shows the graphical representation of Precision, recall and F-measure values for PSO, ABC and

PSO-ABC of dataset 1 and 2 respectively and thereby performance of the algorithms can be analysed using CBIR.

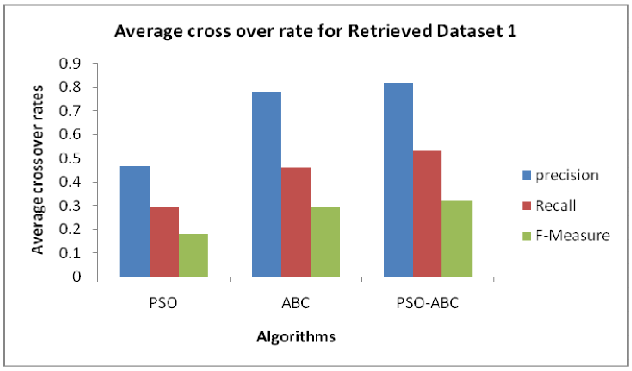

Fig 4 Precision, recall and F-measure values for PSO, ABC and PSO-ABC of dataset 1

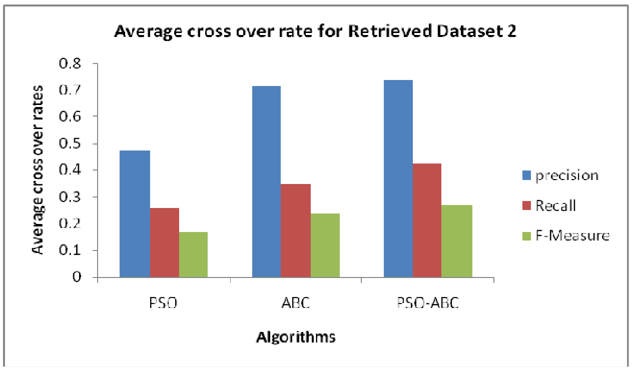

Fig 5 Precision, recall and F-measure values for PSO, ABC and PSO-ABC of dataset 2

From the fig 4 it is observed that the hybrid PSO-ABC has the precision rate as 80% and recall rate 50%, but the other two algorithms have lesser and also F-measure of the PSO-ABC is also better than the individual algorithms. In fig (5) also the proposed hybrid algorithm's performance is better than the individual PSO and ABC. Thus the comparisons are made using multiple features such as color, texture, shape, contrast and homogeneity and observed that the proposed hybrid PSO-ABC algorithm performs better than the individual PSO and ABC.

6. Conclusion

We have proposed a hybrid algorithm in the image retrieval section of the CBIR where the similarity measure of the query image features and database images can be done. Theimplementation is based on 300 sample images in the database with 3 categories: flowers, butterflies and natures. The performance of the proposed PSO-ABC algorithm is compared with the individual performance of the PSO and ABC algorithm using the precision, recall and F-measure. From the comparisons it is observed that the proposed hybrid algorithm outperforms the individual performances of the two algorithms. So it is concluded that PSO-ABC performs better than individual ABC and PSO.

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