Application of PSO and K-means Clustering algorithm for CBIR

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Abstract *— With the rapid increase in the digital data in various fields such as crime prevention, education etc, retrieval of data from the storage device has been an issue. It is due to comparison of the enquired images with of those present in the repository, using existing methods which leads to the rise in search space and algorithmic complexity. CBIR is one of the effective methods that calculate the similarity both of the images i.e. enquired images and stored images. In the following paper a hybrid technique of combine Particle Swarm Optimization (PSO) and K-clustering algorithms has been suggested for a CBIR method which performs on the basis of colour and texture of an image. Here four feature extraction methods are suggested to calculate the similarity: colour histogram, co-occurrence matrices, colour moment and wavelet moment. The final outcomes of the experiment have given a better accurate outcome compared to other systems.*

Keywords — *Content Based Image retrieval, CBIR, Image processing, Optimization, PSO, Clustering*

I. INTRODUCTION

An image database is a collection of large set of images which are combined and stored as a raw data format and are then retrieved from the images via the computerised abetted image analysis. Image retrieval is one of the features in computer system i.e. is utilized for searching and retrieving images from a large database of images. To address the challenges faced by the user to search and retrieve image from the database can be solved by using the text-based and content-based retrieval techniques. Content Based Image Retrieval (CBIR) uses the features of an image to search and retrieve the result and to simplify the problems faced due to text-based image retrieval. In CBIR retrieval of the features from an image is done by using an indexing scheme which eases the efficient searching of the image database. In PSO algorithm, the population of the feasible solutions is often called a swarm and the feasible solutions are called particles. PSO updates the current position of each particle in the swarm by making use of a velocity vector. PSO algorithm successfully intersects the initial stages of a global search but becomes relatable slow during the optimum solution. K-means is basically used to reduce the performance index. It is easy to find optimum local solution using K-means rather than global solution. Therefore, the hybrid technique of PSO and K-mean clustering algorithm for image retrieval will be more advantageous.

II. RELATED METHODOLOGY

A. Image processing

In order to extract features from an image it first undergoes certain processes such as filtering, normalization, segmentation and object identification. Then significant regions and objects are the output of this stage which is further utilized for feature extraction. CBIR system is required for feature extraction like visual low-level features such as colour, shape and texture and text-based features such as keywords, annotations. Among many visual features, colour is one of the vital features which is used in image extraction . Images characterised by colour features have many advantages such as robustness, implementation, effectiveness, simplicity, low storage and computational simplicity requirements. CBIR system uses the colour feature to reduce the robustness and simplify the processing. Colour sensitivity and colour space were proposed to colours similar to how humans perceive colour. The feature is defined as a function of one or more dimensions, each of which specifies some significant asset of an object, and is calculated such that it determines some important characteristics of the object. Different methods for texture study have been examined in the field of pattern recognition and computer vision. The texture mining techniques can be classified into three categories: statistical, structural and spectral. It is important though it's not helpful to retrieve images from the systems. As it may interfere and reduce the success rate of the retrieval structure. It aims just to select a best feature from a large set of features and maximize precision to simplify the retrieval methods. The current methods that are used to pronounce the colour and grey level information including the colour moments, foremost colours, co-occurrence matrix and colour histogram. In image processing, a colour histogram is the numerical/graphical representing the distribution of colours in an image i.e. no of pixels of the colour, colour space etc. It is one of the

former tools that is easy to calculate. Small object distortion is insensitive in non-parametric density function. Histogram commonly splits the range of data into equally sized bins. When the colour features are explained by three instants i.e. the first instant routines the mean, the second instant routines variance computation, while the third instant uses skewness, these are known as the colour moments. These are the most effective and efficient colour distributions of an image. Co-occurrence matrix indicates the frequent change in the combination of pixel values present in an image. Thus, extraction of useful features from the image is very large. The calculation of the co-occurrence of pixels with grey values i and j at a given distance ɖ i.e. the polar coordinates (ɖ, θ) with discrete orientation and length uses Co-occurrence matrix C (i, j). In practice, θ takes the values starting from 0° in an interval of 45° such as 0, 45, 90 up to 315. A wavelet is a wave like oscillation that illustrates data on image variation at different levels. It is useful in digital signal processing and image compression. The sum of wavelet functions per different measures and locations is displayed by the discrete wavelet transform which indicates the image. 1D image decomposition requires a set of waveforms for wavelet while 2D image decomposition into wavelet suggests four sub-band elements marking approximation (LL), vertical detail (HL), horizontal detail (LH), and diagonal (HH) exclusively.

B. Optimization

Optimization is the process of detecting the values of variables that minimize or maximize the given problem while fulfilling the given constraints. The optimization techniques are useful in detecting the optimum solution or unconstrained minima or maxima of continuous and differentiable functions. The CBIR feature extraction requires optimization to yield better results for the user for which many techniques are being used. Therefore, we have to evaluate and find the best optimization technique.

a). Particle Swarm optimization

PSO is a population-based random optimization process/technique which is well adapted to the optimization of nonlinear functions in multi-dimensional space. It is an artificial intelligence which can be used to find approximate solutions to impossible numerical optimization problems or extremely difficult. In PSO algorithms, the population of the feasible solutions is usually called as a swarm and the feasible solutions are called as particles. PSO updates the current position of each particle in the swarm by making use of velocity vector. Initialization is done with a group of random variables/particles and then searched for optimal solutions by improving generations.

Algorithm

(1) Population i.e. initialize the value
(2) Individual search i.e. find the personal best

$$V_{ik}+1=wV_{ik}+c_1R_1(p_{best}-P_{ik})+ c_2R_2(g_{best}-P_{ik}) \quad (1)$$

(3) Global search i.e. find the global best
(4) Update the current position

$$p_{besti}+1=P_i \text{ if } f(P_i) < f(p_{besti}) \quad (2)$$

$$p_{besti}+1=P_i \text{ if } f(P_i) > f(p_{besti}) \quad (3)$$

(5) STOP
   (a) If condition not satisfied go to (2)
   (b) If condition satisfied <END CRITERIA>

Updating of the speed & positions of the particles

Position of particle i changes according to:

$$X_i(t+1) = X_i(t)+V_i(t+1)$$

Particle speed update:

$$V_i(t+1)=w(t)V_i(t)+a_1u_1(P_i(t)-X_i(t))+a_2u_2(I_i(t)-X_i(t))$$

Where, $X_i(t)$=position
$P_i(t)$=personal best
$I_i(t)$=global best
$V_i(t)$=speed
$w(t)$=inertia weight (0.9-0.4)
a_1,a_2=acceleration coefficients(0-4)
u_1,u_2=random variables for adjustment

Stopping condition

Once the approx. fitness values of the particles or the given no. of iterations are gained the algorithm is terminated.

b). PSO clustering Algorithm

As PSO is one of the effective and fast methods to solve the optimization problems, in the document clustering research area. It likely observes the clustering problem as an optimization problem that locates the optimal centroids of the cluster rather than the optimal partition finding problem. This observation provides a chance to apply PSO optimal algorithm on the clustering solution.

The PSO clustering is divided the following 2 categories:

1) A global searching
2) A local searching

Algorithm

Phase 1: Random initial values for the velocity and position of the particle are chosen from the image dataset. Every particle is a possible solution for clustering. In the clustering circumstances, every sole particle represents the cluster's centroid. Hence, the n^{th} particle initialized is given as:

$$P_n = (Z_{n1}, Z_{n2}, ..., Z_{nk}) \quad (3)$$

Where, P_n is a particle position and Z_{nj} is the j^{th} cluster centroid in result elective by the n^{th} particle. Therefore, a clustering centroid with the number of entrants is provided by the swarm.

Phase 2: Continue for every particle,

a) Clustering criteria is the distance between cluster centre z and query image x. Established on this particle fitness is gaged. Thus, swarm definition of particle fitness as follows:

$$F(n) = \frac{\sum_{j=1}^{k} \sum_{\forall xp \in Sj} (x_p - Z_{nj})^2}{Np} \quad (4)$$

Where, N_p is considered as the number of feature paths assumed as inputs for the clustering methods. The diffusion of clusters can be abridged by reducing the fitness.

b) The superlative spot of a particle stowed in a swarm and the sites of every particle are modernized according to the following equations:

$$X_{nk}+1 = wX_{nk} + c_1R_1(p_{best} - Y_{nk}) + c_2R_2(g_{best} - Y_{nk}) \quad (5)$$

$$Y_{nk}+1 = Y_{nk} + X_{nk} + 1 \quad (6)$$

Additionally the likelihood variety of the result specifies the position and velocity of the particle. The position of the particle is established Pmax or Pmin if a particle flies far away from the boundary. However, the new velocity of the particle is established Vmax or Vmin if a new velocity is far away from the boundary, respectively.

Phase 3: Repeat phase 2 until one of the following stopping conditions is attained:

1. Predefined limit is not surpassed by the iteration count.
2. Negligible change in the centroid of the cluster.
3. No change of the cluster membership.

c). Hybrid Clustering Algorithm

PSO is very effective as a technique but it gives better effective and efficient results when merged with other computational intelligence techniques. The key aim of the following algorithm is to utilize the advantages of both PSO and K-means algorithm. The algorithm uses immediate intersection of K-means for the local search and the capability of PSO to global search at the early phase to get the final result. The algorithm follows the steps:

Phase 1: PSO clustering method is implemented till the iteration number is surpassed.

Phase 2: The PSO clustering outcome is utilized as the initial centroid vector of the K-means component.

Phase 3: Processing of the K-means starts and then the assignment is terminated by the clustering if the iteration count surpasses a predefined limit.

III. THE PROPOSED CBIR ALGORITHM

The given algorithm is used to recover images from database which are similar to that of the query images. The algorithm follows the steps:

Input: dataset of images and query colour image

Output: n no of images are recovered which are similar to that of the query image

Methods:

Phase 1: A colour image was selected as query.

Phase 2: The colour and texture features were extracted from query image through online stage and from the images present in the dataset through offline stage.

Phase 3: A feature vector representing the contents of an image is created and stored in the database.

Phase 4: The feature vector of the images which are present in the database is clustered by utilizing the suggested PSO-k-means clustering algorithm into various categories.

Phase 5: The interval connecting the centroid of each cluster and the query image is computed to note the smallest distance.

Phase 6: The top n no of images are retrieved which belong to the finest cluster that is alike to the query image. Though, the suggested technique that will be applied in this research is shown in Fig.1:

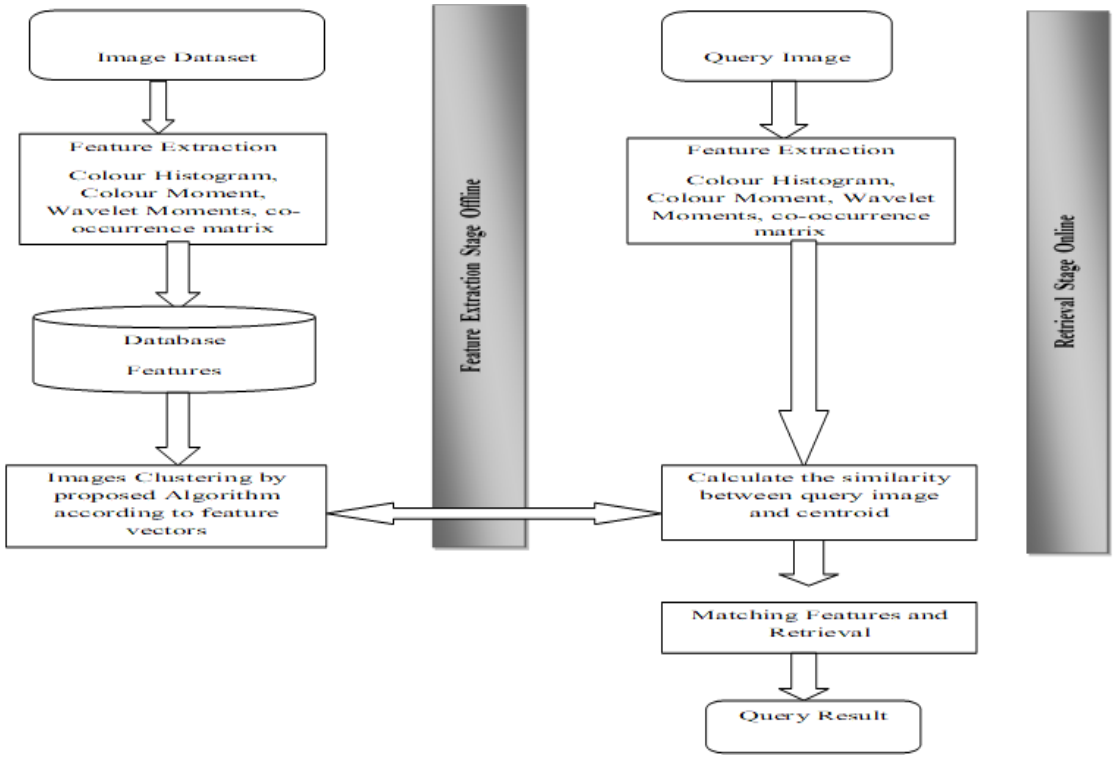

Fig. 1: Flowchart for the CBIR method

IV. CONCLUSION

As CBIR system is one of the most recent fascinating research topics. And many researchers have come up with algorithms that can effectively and efficiently retrieve accurate images and distinguish between them. Mostly the algorithms work on extracting the properties from an image and match the similarity. The algorithm basically uses grey scale images. But mostly colour images are used to extract colour and features to calculate the similarity. Thus, the texture and colour features are two of the main key features which were taken into consideration while evolving a CBIR system.

Our proposed system of PSO and K-means clustering hybrid algorithms gives more efficient and effective results than the other existing CBIR systems. Furthermore, the results are also more adequate. The future scope of this study is to overcome the difficulties and disadvantages faced during the progress of the system. Secondly, there can be improvement in the procedure of the retrieval method like extracting of the shape features for computing the similarity of an image.

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