International Journal of Signal Processing, Image Processing and Pattern Recognition
Vol.8, No.12 (2015), pp.121-134
http://dx.doi.org/10.14257/ijsip.2015.8.12.13

An Efficient Algorithm for Facial Image Classification

Dr.S.Vijayarani[1*] and M.Vinupriya[2]

[1]*Assistant Professor, Bharathiar University, Coimbatore*
[2]*M. Phil Research Scholar, Bharathiar University, Coimbatore*
[1]*vijimohan_2000@yahoo.com,* [2] *vinupriya.53@gmail.com*

Abstract

Image mining is one of the data mining research areas and it can be defined as getting hidden information from the image databases. It is used to identify unknown patterns, inherent and valuable information from images. Image mining helps to make relationships between various categories of images which are found in large image databases. These images can reveal useful information to the users. Image mining is distinct from low-level computer vision and image processing techniques. It uses methods from computer vision, image retrieval, image processing, data mining, database, machine learning, and artificial intelligence. Although all these subjects study the same object image, the vital difference between image data mining and the other subjects is, image data mining focuses on large scale set of images while image processing and pattern recognition analysis are based on only single image. Face detection is the problem of determining whether a sub-window of an image contains a face. It has received much attention and has been an extensive research topic in recent years. In this research work, facial images are classified based on its shape feature using optimization algorithms. A new algorithm, i.e. classification based similarity finding is proposed for classifying the facial images as round or oval shape. The performance of the proposed classification based similarity algorithm is compared with the particle swam optimization and genetic algorithms. The results of the existing and proposed algorithms are analyzed based on accuracy and execution time factors. From this we observed that the proposed classification based similarity finding algorithm has produced good results.

Keywords: *Image mining, Edge detection, PSO, GA, Classification based Similarity Finding*

1. Introduction

Data mining is the computer-assisted process of digging through and analyzing enormous sets of data and then extracting the meaning of the data. The various application areas of image mining are computer vision, image processing, image retrieval, data mining, machine learning, database, artificial intelligence, feature extraction, object detection, face recognition and image compression [9].

Face detection is the problem of determining whether a sub-window of an image contains a face and its important applications are face processing (*i.e.*, face expression and gesture recognition), computer human interaction, human crowd surveillance, biometric, video surveillance, artificial intelligence and content-based image retrieval. All these applications of face detection require a preprocessing step for obtaining an object. The great challenge in face detection problem is the large number of factors that govern the problem space. The long list of these factors consist of the pose, orientation, luminance conditions, facial expressions, occlusion, facial sizes found in the image, ethnicity of the

* Corresponding Author

ISSN: 2005-4254 IJSIP

subject, structural components, gender, the scene and complexity of image background [7].

The primary goal of this research work is to classify the human facial images based on the shape feature. Two types of shapes are considered; round and oval shape. The primary motive behind this image classification is, it helps to perform the image searching efficiently and quickly. In this research work, three important tasks of image mining are considered that is preprocessing, edge detection and classification.

2. Related Works

Venkata Ramana Chary *et. al.*, [15] described how to perform image retrieval process from the large image database. They applied different mathematical approaches and color projections for retrieving images. Images are sub grouped by threshold values and R, G, B color combinations are considered for retrieval of images. From the results, authors observed that the proposed method obtained efficient results than the previous methods.

Gruen [2] discussed the adaptive least squares correlation technique. This technique is very flexible, efficient and provides solution for different kinds of problems in data matching. It permits local geometrical shaping and simultaneous radiometric corrections. In this work, the system factors are assessed, corrected and optimized automatically at the time of least squares iterations. For assessment of the correlation quality, different least squares estimation tools are utilized. In addition to this, the system has provided stabilization and enhancement of the correlation procedure by using the simultaneous consideration of geometrical constraints. *e.g.,* The Co-linearity condition. Finally, the adaptive least squares correlation can be applied to a great variety of data matching problem, which focuses mainly on its utilization for image matching. The technique shows a number of attractive features, such as, high matching accuracy, monitoring of quality, precision and reliability measures.

Shivesh Bajpai, *et. al.,* **[11]** discussed the gradient vector flow and silhouettes algorithms. In the face detection research, these algorithms are most commonly used algorithms. For finding the efficiency of these algorithms, these algorithms were applied to the facial databases and its results are compared. From the results, it is come to know that the silhouette segmentation method performance is better than gradient vector flow method.

Mohammad Saber Iraji *et. al.,* **[8]** discussed human color skin recognition in color images. This is considered to be accurate and an efficient with several light intensity. In an input color image, the RGB color space is first transformed to YCBCR color space. Fuzzy and adaptive fuzzy neural network methods are used. Based on the results, the performance of adaptive fuzzy neural network is good and accurate than prior methods.

Deepak Ghimire *et al.,* **[1]** have proposed a technique to identify human faces in color images. Several existing systems used a window-based classifier that searches the whole image for the occurrence of the human face. These systems have problems in pose variation, scale variation and illumination changed. Authors proposed a technique called lighting insensitive face detection which is based on the edge and skin tone information of the input image. Main advantage of this proposed technique is it detects the faces which are in different size and poses.

Wenshuo gao *et. al.,* **[18]** proposed a technique which is the combination of soft-threshold wavelet denoising which contain white gaussian noise and sobel edge detection operator. First soft-threshold wavelet was used to remove noise, and then sobel edge detection operator is used to detect edges in the image. This technique is generally used on the images which consist of white gaussian noises.

3. Proposed Work

The objective of this research work is to implement a face recognition system to detect facial shapes from an image database. The framework of the proposed system includes preprocessing, edge detection, morphological operations and classification. First the skin regions are extracted using three segmentation algorithms namely skin segmentation using HSV color, gradient vector flow and gray world compensation. Second, the outline shape of the face image is extracted using edge detection algorithm. Sobel, Prewitt, Robert, Canny and Mar-hildreth edge detection techniques are used. Finally, the facial shapes are classified using the algorithms namely GA, PSO and CSF. Figure 1 shows the system architecture of the proposed research work.

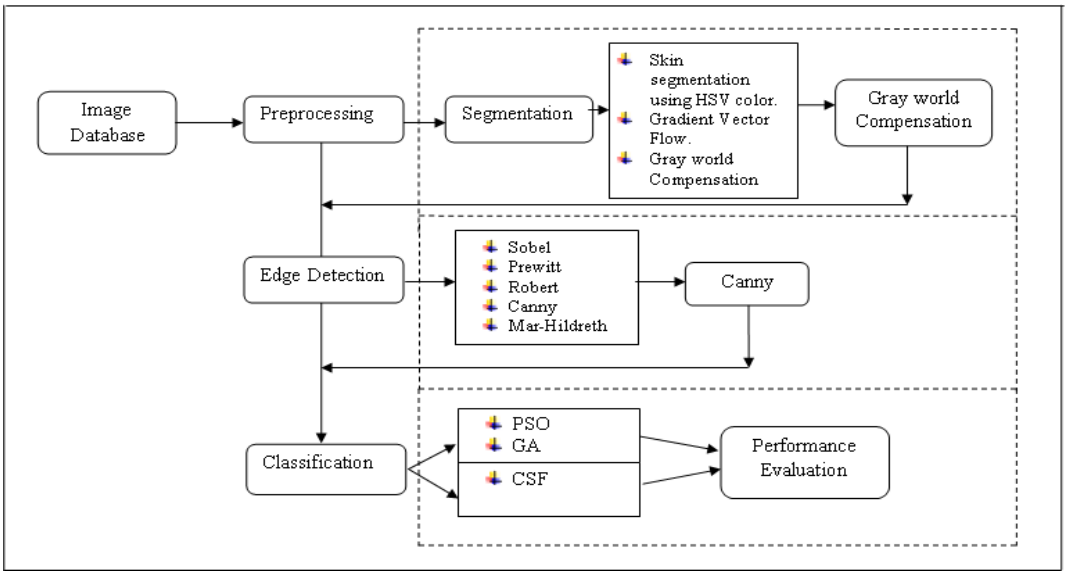

Figure 1. System Architecture

3.1. Preprocessing

Preprocessing is nothing but removing of noise, bringing the image in the proper layout. This involves preparing the data set by resolving problems like missing data, indeterminate data, unrelated fields, removal of distant points, format conversion *etc.* Image preprocessing can significantly increase the reliability of an optical inspection. Several operations such as noise filtering, feature enhancement, image segmentation, object description and classification, image compression, image re-sampling, noise removal which intensify or reduce certain image details enable an easier or faster evaluation [14].

3.2. Segmentation

A digital image is partitioned into multiple segments; this process is termed as image segmentation. The primary objective of image segmentation is to modify the representation of an image and/or to make simpler or to provide new meaning and to perform easy analysis. With the help of image segmentation we can easily trace objects and boundaries in images. Important application areas of image segmentation are medical imaging, machine vision**,** object detection, face detection, traffic control systems and video surveillance [6].

In this research work, three types of segmentation methods namely skin segmentation using HSV color, gradient vector flow and gray world compensations are used. Comparing the performance of these three methods, the gray world compensation performance is better than the other methods [16]. In gray world compensation, normally,

an image can have many number color variations, and the gray world compensation algorithm finds the average value of RGB components of the image with average to a common gray value. Many number of computational color constancy algorithms are used. Some of the important algorithms are gamut mapping, grey world, color by correlation and perfect reflector. All these algorithms have some assumptions of the color distribution of the image and these differ from each other by the illumination estimation. Illumination estimation is difficult to handle because the response of the sensor is managed by various factors; *e.g.,* illumination geometry and object shape.

3.3. Edge Detection

Edge detection of an image significantly reduces the amount of data, filters and removes unwanted information but maintaining the important structural properties of an image. It is a fundamental tool in computer vision and image processing which are primarily used in the feature detection and feature extraction areas. It identifies points in a digital image which helps to change the image brightness more sharply and properly. This process of identifying sharp changes in image brightness is to confine important changes and events. The concept of edge is highly useful in dealing with regions and boundaries as an edge point is transition in gray level associated with a point with respect to its background [12].

In this research work, five types of edge detection algorithms namely canny, mar-hildreth, sobel, Robert and prewitt are used. Comparing the performance of these edge detection algorithms, the canny edge detection algorithm's accuracy is better than other algorithms [17].

The canny edge detector is widely considered to be the standard edge detection method. Canny considered the edge detection problem as a signal processing optimization problem, so he built an objective function which is an optimized one. The resolution to this problem was rather a complex exponential function, but canny found a number of ways to approximate and optimize the edge-searching problem. The steps in the canny edge detector are as follows:

1. Smooth the image with a two dimensional Gaussian. Computation of a two dimensional Gaussian is costly in most cases, so it is estimated by two one dimensional Gaussians, one in the x direction and other in the y direction.

2. Take the gradient of the image. This proves changes in intensity, which signifies the presence of edges. This really gives two outcomes, the gradient in x direction and gradient in y direction.

3. Non-maximal suppression- Edges will occur at points where the gradient is at a maximum. Therefore, all points not at a maximum should be suppressed. To facilitate this, the magnitude and direction of the gradient is computed at each pixel. Then for every pixel verify if the magnitude of the gradient is greater at one pixel's distance away in either positive or negative direction perpendicular to the gradient. If the pixel is not larger than both, then suppress it [10].

The important steps of this algorithm are smoothing, finding gradients, non-maximum suppression, double thresholding and edge tracking by hysteresis. Smoothing step is required to remove noise from the blurred images. Finding gradients step is used to mark the edges of the image in which the image gradients has large magnitudes. A local maximum is marked as edges by using non-maximum suppression step. Double thresholding helps to determine potential edges by using thresholding. Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge are done by edge tracking by hysteresis.

3.4. Classification

Classification consists of predicting a certain outcome based on a given input. In order to predict the outcome, the algorithm processes a training set containing a set of attributes and the respective outcome, usually called goal or prediction attribute. The algorithm tries to discover relationships between the attributes that would make it possible to predict the outcome. Image classification targets to classify the images from the image database by using the classification constraints. The image in one class must differ from image in another class. For image classification, we have to use multiple features of an image [13].

3.5. Particle Swarm Optimization

Particle Swarm Optimization algorithm gives the optimal solution for a problem. Important steps in PSO algorithm are, every distinct solution is named as a "bird" in the search space and it is called as "particle". Fitness value is calculated for all the particles by evaluating the fitness function and has velocities which express flying of the particles. The particles fly throughout the problem space by following the current optimum particles [3].

In PSO, the initialization step has group of random particles and it searches for optimality by updating generations. During iteration, each particle is updated by two values. These values are termed as “best” values. First one is known as pbest and this value gives the best solution. Second one is called as gbest and this is considered as global best. Particle swarm optimizer tracked this value and this is taken as finest value. When a particle receives a part of the population as its topological neighbors, the best value is a local best and called as lbest. After locating the two best values, the particle updates its velocity and positions with following equation (a) and (b).

$$v[] = v[] + c1 * rand\ () * (pbest\ [] - present\ [] + c2 * rand\ () * (gbest\ [] - present\ []) \quad (a)$$

$$present\ [] = present\ [] + v[]) \quad (b)$$

Particle Swarm optimization has two primary operators: Velocity update and Position update. In each generation, each particle is accelerated toward the particles previous best position and the global best position. At each iteration a new velocity value for each particle is calculated based on its current velocity, the distance from its earlier best position, and the distance from the global best position. The original velocity value is then used to calculate the next position of the particle in the search space. This process is then iterated until a minimum error is achieved. Table 1 gives the PSO algorithm.

Table 1. The PSO Algorithm

```
For each particle
   Initialize particle
END
Do
   For each particle
      Calculate fitness value
      If the fitness value is better than the best fitness value (pBest) in history
         set current value as the new pBest
   End
   Choose the particle with the best fitness value of all the particles as the gBest
   For each particle
      Calculate particle velocity
      Update particle position
   End
While maximum iterations or minimum error criteria is not attained
```

RGB images are converted to HSV (Hue, Saturation and value) to detect the skin regions from the given input. The feature values are mean, standard deviation and entropy values. These values are extracted and used to find the feature values of the image to classify the shape. In all iterations, two “best” values are used for updating each particle. The fitness value is calculated based on difference between the current image feature value and previous value and it is called as Pbest value and from the overall value the maximum value is considered as gbest value. Then velocity and position update is responsible for the optimizing ability of the PSO algorithm by using the formula, where c1 stands for local min_weight, c2 for local max_weight, rand() value is taken between 0 and 1, Pbest- Best position of single iteration, Gbest-Best position of entire iteration and present iterations current position. This process is then iterated given number of times to achieve final minimum Gbest position.

3.6. Genetic Algorithm

Genetic algorithm simulates the survival of the fittest individuals among all the individuals in the population over successive generations for problem solving. Each generation consists of a population of character strings that are equivalent to the chromosome that are seen in DNA. Each entity represents a point in a search space and a possible solution. The entities in the population are then made to go through a process of evolution. GAs is based on an analogy with the genetic structure and behavior of chromosomes within a population of individuals using the following foundations: Individuals in a population compete for resources and mates. Those individuals most successful in each 'competition' will produce more offspring than those individuals that perform poorly. Genes from `good' individuals propagate throughout the population so that two good parents will sometimes produce offspring that are better than either parent [4-5].

3.7. Selection Operator

The key idea of selection operator is to give preference to better individuals (those that are nearer to the solution) by allowing them to pass on their genes to the next generation and prohibit the entrance of worst fit individuals into the next generations. The selection operator mostly works at the level of chromosomes. The goodness of each individual depends on its fitness. Fitness value may be established by an objective function or by a subjective judgment specific to the problem. As the generations exceed, the members of the population should get fitter and fitter.

3.8. Crossover

Genetic algorithms use a simple function of the fitness measure to select individuals (probabilistically) to go through genetic operations such as crossover or asexual reproduction (the propagation of genetic material unaltered). This is fitness-proportionate selection. Other implementations uses a model in which certain randomly selected individuals in a subgroup compete and the fittest is selected. This is called tournament selection and is the form of selection we see in nature when stags channel to compete for the privilege of assistant with a group of rears.

3.9. Mutation

Mutation also plays a role in this process, although how important its role is continues to be a matter of debate (some refer to it as a background operator, while others view it as playing the dominant role in the evolutionary process). It cannot be strained too strongly that the genetic algorithm (as a SIMULATION of a genetic process) is not a random

search for a solution to a problem (highly fit INDIVIDUAL).The genetic algorithm uses stochastic processes, but the result is distinctly non-random (better than random).

Input database consists of RGB images and it is converted to HSV color to segment the skin regions from the color images. Here three types of features are extracted namely centroid, area and perimeter and find the sum of values and these are used to classify the shape of the given image. Next fitness value is calculated for whole database using the formula given below.

Prob(i)= feature value/ Sum of feature value. (c)
where i=number of image feature values.

Cumulative function is calculated to find the chromosome values using the formula,

N(1)=Prob(i) (d)
N(2)= Prob(i)+Prob(i+1);for all images (e)

The random value is generated to find the input for selection operator using formula,

R=r(1)>N(1)&&<N(2) (f)

From this two minimum value is taken as input for selection operator. The selection operator mostly works at the level of chromosomes. As the iterations exceed, the members of the population should get fitter. Then crossover operator is used to generate offspring by exchanging bits in a pair of individuals taken from the input of selection operator, with the possibility that good solutions can generate better ones. Mutation operator is used to prevent from generating too similar values. Here two values are taken as Pbest and Gbest values and it gives as input to train with SVM classifier. To train the data, SVM classifier needs training label, training data and gbest-pbest values. Then SVM classifier classifies whether the image values as oval or round. The pseducocode of simple genetic algorithm is given in Table 2.

Table 2. Simple Genetic Algorithm

```
Initialize the parameters;
Generate a population P randomly;
generation ← 1;
while generation ≤ max_gen do
    Clear the new population P';
    Use a fitness function f(·) to evaluate each individual in P;
    while |P'| ≤ N do
        Select two parents from P;
        Perform crossover with rate p_c;
        Perform mutation with rate p_m;
        Insert the offspring to P';
    endwhile
    P ← P';
    generation ← generation + 1;
endwhile
```

3.10. Classification by Similarity Finding

The proposed technique is a stochastic technique, easy to implement, has fewer control parameters, easily be modified and hybridized with other meta-heuristic algorithms. It has been tailored successfully, to solve a wide variety of discrete and continuous optimization

problems. It is thus a relatively a new iterative improvement search paradigm, which has proven to be an efficient algorithm for solving combinatorial problems. The main application of the proposed work is the recognition of an object within certain images. The objective of the work is to find a pattern or template (reference image) of an object anywhere on a target scene. The experimental results, using gray scale and color images, showed that the performance of the new algorithm is accurate and executes faster in finding a pattern than PSO and GA. Table 3 shows the proposed classification by similarity finding algorithm.

Table 3. Classification by Similarity Finding

1. Parameters: n, limit
2. Objective function f (x), x = [x1, x2, ...,xd]
3. Initialize the food positions randomly xi, i= 1,2, ...,n
4. Evaluate fitness f (xi) of the objective function
   (fFitness(ind)=1+abs(fObjV(ind));
5. Evaluate fitness for food source
6. Apply greedy selection process:
   (A greedy selection is applied between the current solution and its food source. If the food source is better than the current solution, replace the solution with the food source.)
7. Calculate probability values for the solutions xi using fitness values and normalized by dividing maximum fitness value.
   Probability = {.9 x fitness / max (fitness) + 0.1}
8. Produce new solutions from xi selected using fitness value
9. Memorize the best solution achieved so far

At the first step, a randomly distributed initial population *i.e.*, input from the image database is generated. Here, gray world compensation segmentation method is used for white balancing in the brightness image. Median filtering is used to remove the unwanted noise from the resulted image. Morphological operations are used to fill the holes required in the image. In all iteration, each population is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far and second is the probability of the fitness value. After initialization, the population is subjected to repeat the cycles of the search processes to generate the fitness value respectively. After the fitness value has been generated it produces a modification on the source position and discovers a new source position. The new position gets updated till the search process gets completed. The greedy selection process is used to choose the best candidate which is to be added to the solution. Then probability of the generated solution is calculated and a new value is generated and again a best solution is chosen using greedy selection process. From this, minimum similarity value and its location are identified.

The major advantages of this algorithm which hold over other optimization algorithms are,

- Simplicity, flexibility and robustness
- Use of fewer control parameters compared with many other search techniques.
- Ease of hybridization with other optimization algorithms.
- Ability to handle the objective cost with stochastic nature.
- Ease of implementation with basic mathematical and logical operations

4. Experimental Results

Figure 2 shows the accuracy measure of the three segmentation algorithms namely skin segmentation using HSV color, gradient vector flow and gray world compensation. From the experimental results, it is observed that gray world compensation performs well when compared to other methods [16].

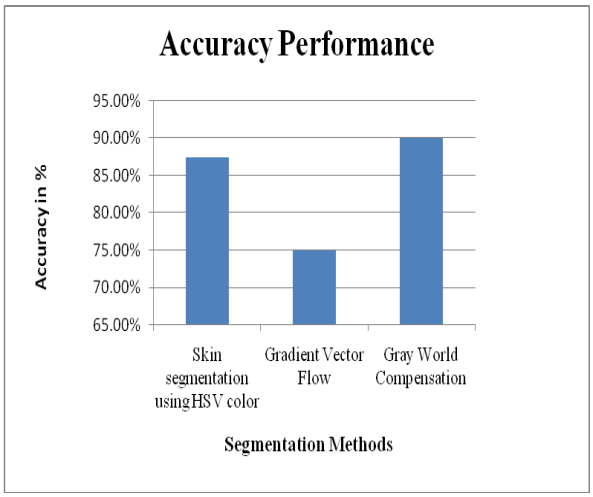

Figure 2. Accuracy Measure

Figure 3 gives the execution time required for segmentation. Gray world compensation segmentation method needs minimum execution time when compared to other methods.

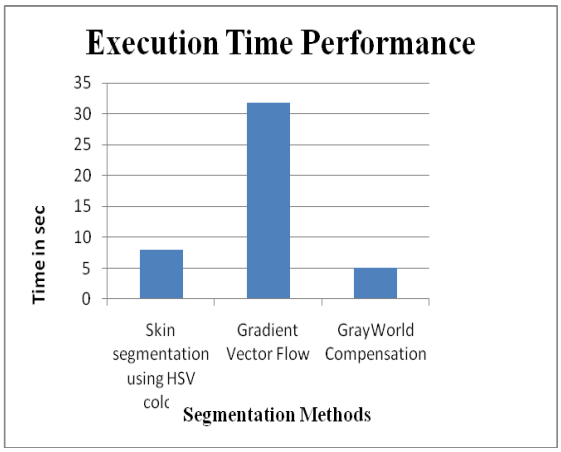

Figure 3. Execution Time

Figure 4. Gray World Compensation

Figure 4 shows the sample output of gray world compensation. Figure 5 shows the edge detection algorithms accuracy. It is observed that the canny edge detection algorithm attains high percentage of accuracy when compared to other edge detection algorithms [17].

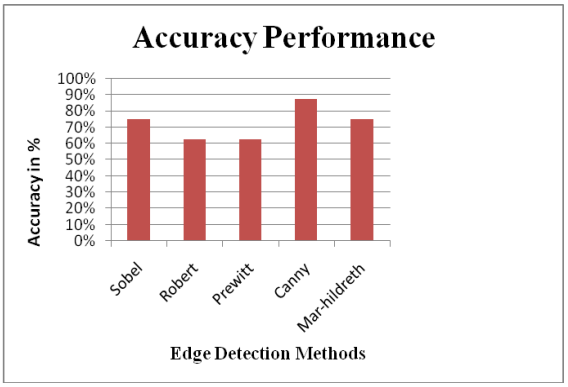

Figure 5. Edge Detection Algorithms Accuracy

Figure 6 shows the execution time required for edge detection algorithms. From this result, it is come to know that the canny edge detection algorithm required minimum execution time. Figure 7 gives the sample output for canny edge detection.

Figure 6. Execution time for Edge Detection Algorithms

Figure 7. Canny Edge Detection

Figure 8 and 9 represents the classification accuracy measure and execution time performance of classification algorithms. From the experimental results, it is observed that classification by similarity finding works better than particle swarm optimization and genetic algorithms.

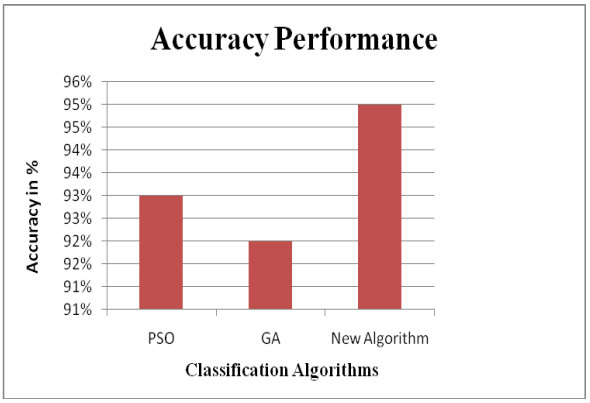

Figure 8. Classification Accuracy

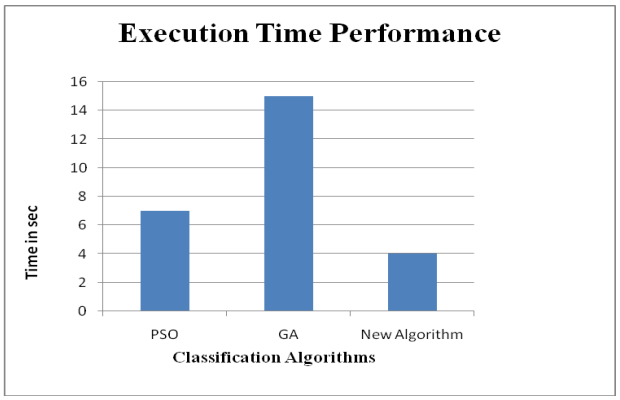

Figure 9. Execution Time

Figure 10 represents the facial images which are in oval shape.

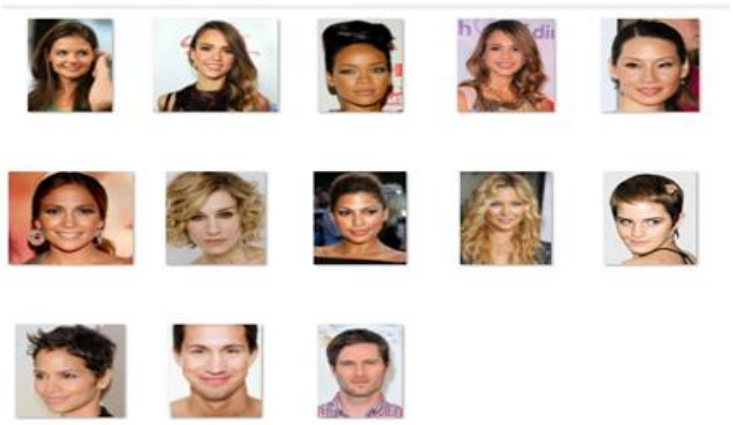

Figure 10. Oval Shape

Figure 11 represents the sample facial images which are in round shape.

Figure 11. Round Shape

4. Conclusion

Image mining has been used to solve various problems including target recognition, object recognition, face recognition, and face detection/verification. Face recognition system is a computer application which automatically identifying or verifying a person from a digital image or a single frame from a video source. In this research work, preprocessing is done using three methods namely skin segmentation using HSV color, gradient vector flow and gray world compensation. From the performance measures, it is observed that gray world compensation works better than other methods. Five edge detection algorithms namely canny, sobel, mar-hildreth, prewitt and robert have been used for detecting the outline shape of the images. The experimental results showed that canny edge detection detects with highest accuracy. PSO, GA and CSF algorithm are used to classify the images based on shape. The proposed CSF algorithm has produced better results in terms of execution time and accuracy factors.

References

[1] D. Ghimire and J. Lee, "A Robust Face Detection Method Based on Skin Color and Edges", Journal of Information Process System", vol. 9, no.1, **(2013)** March, pp. 141-156.
[2] A. W. GRUEN, "Adaptive Least Squares Correlation: A Powerful Image Matching Technique", South African Journal of Photo grammetry, Remote Sensing and Cartography, vol. 14, no. 3, **(1985)**, pp. 175-187.
[3] http://en.wikipedia.org/wiki/Particle_swarm_optimization.
[4] http://en.wikipedia.org/wiki/Genetic_algorithm.
[5] http://obitko.com/tutorials/genetic-algorithms/.
[6] H. Zhou, X. Li, Gerald Schaefer C, E. Celebi and P. Miller, "A Mean Shift based Gradient Vector Flow for Image Segmentation", Elsevier, **(2013)**, pp. 1004-1016.
[7] J. Wang and T. Tan, "A New Face Detection Method Based on Shape Information", Pattern Recognition Letters, vol. 21, no. 6–7, **(2000)** June, pp. 463–471.
[8] M. S. Iraji, "Skin Color Segmentation in YCBCR Color Space with Adaptive Fuzzy Neural Network", International Journal of Image, Graphics and Signal Processing, **(2012)**, pp. 35-41.
[9] O. R. Zaiane, "Introduction to Data Mining", Principles of Knowledge Discovery in Database, **(1999)**, pp. 1-15.
[10] P. Bao, L. Zhang and X. Wu, "Canny Edge Detection Enhancement by Scale Multiplication", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 27, no. 9, **(2005)**, pp 1485 – 1490.
[11] S. Bajpai, A. Singh and K. V. Karthik, "An Experimental Comparison of Face Detection Algorithms", International Journal of Computer Theory and Engineering, vol. 5, no. 1, **(2013)**, pp. 47-51.
[12] M. Sudarshan, P. G. Mohan, V. Suryakanth and Gangashetty, "Optimized Edge Detection Algorithm for Face Recognition", CiteSeerX, **(2012)**.
[13] T. N. Phyu, "Survey of Classification Techniques in Data Mining", Proceedings of the International MultiConference of Engineers and Computer Scientists, vol. 1, IMECS, **(2009)**.
[14] T. Heseltine, N. Pears and J. Austin, "Evaluation of Image Pre-processing Techniques for Eigenface Based Face Recognition", Proceedings of SPIE - The International Society for Optical Engineering vol. 4875, vol. 2, **(2002)** July, pp.677-685.
[15] Venkata Ramana Chary R, Rajya Lakshmi D, Sunitha K V N, "Feature Extraction Methods for Color Image Similarity", Advanced Computing: An International Journal (ACIJ), vol. 3, no. 2, **(2012)**, pp. 147-157.
[16] S. Vijayarani and M. Vinupriya, "Comparative Analysis of Skin Segmentation in Image Mining", International Journal of Computational Intelligence and Informatics, vol. 2, no. 4, **(2013)**, pp. 241-247.
[17] S. Vijayarani and M. Vinupriya, "Performance Analysis of Canny and Sobel Edge Detection Algorithms in Image Mining", The International Journal of Innovative Research in Computer and Communication Engineering, vol. 1, no. 8, **(2013)**, pp. 1760-1767.
[18] W. Gao, L. Yang, X. Zhang and H. Liu, "An Improved Sobel Edge Detection", 3rd IEEE International Conference on Computer Science and Information Technology (ICCSIT), **(2010)**, pp. 67-71.

Authors

Dr. S. Vijayarani, MCA., M. Phil, Ph.D is working as Assistant Professor in the School of Computer Science and Engineering, Bharathiar University, Coimbatore. Her fields of research interest are data mining, privacy and security issues and data streams. She has authored a book and published papers in the international journals/conferences.

M. Vinupriya has completed MCA and M.Phil. Her fields of interest are image mining and privacy preserving in data mining. She has published and presented papers in international journals and conferences.

