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Particle Swarm Optimization Algorithm for Facial Image Expression Classification

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Abstract

Image mining is used to mine knowledge from large image databases. Image segmentation, image compression, image clustering, image classification and image retrieval are significant image mining tasks. Face detection methods are used to identify the similar faces from the large collection of facial images. It has numerous computer vision applications and it has many research challenges such as rotation, scale, pose and illumination variation. Facial expression is defined as the position of the muscles beneath the skin of the face and it is a form of nonverbal communication. Facial expressions are the expression which shows the emotions and different feelings of human beings. Different facial expressions are sad, happy, fear, normal, surprise and angry. In this research work facial expressions are classified by using the optimization algorithms. PSO with LIBSVM algorithm is proposed for facial expression classification and the performance of this algorithm is compared with the existing BAT algorithm. The results of the existing and proposed algorithms are analyzed based on the two performance factors; they are classification accuracy and execution time. From the experimental results, we observed that the proposed PSO with LIBSVM algorithm has produced good results compared to existing BAT algorithm. This work is implemented in MATLAB 7.0.

Keywords: *Facial Expression, Classification, Optimization, PSO with LIBSVM, BAT*

1. Introduction

Image mining is an interdisciplinary endeavor that draws upon expertise in computer vision, image processing, image retrieval, data mining, machine learning, database, artificial intelligence, feature extraction, object detection, face recognition and image compression. Face recognition is defined as the process of automatically identifying and verifying a person from large collection of digital images. Face recognition systems are based on object recognition and tracking technologies to detect and identify faces [11]. Facial expression recognition consists of different emotions such as happy, sad, fear, surprise, normal and angry. Automatic facial expression systems can be applied to human-computer interaction, stress-monitoring systems, low-bandwidth videoconferencing, human behavior analysis, *etc.*,

The Facial Action Coding System (FACS) is a human-observer-based system that has been developed to give a linguistic description of all visibly discriminable expressions. Facial expression recognition is divided into two classes: geometrical feature-based approaches and appearance-based approaches. Geometrical feature-based approaches are used to identify the shapes and locations of facial components such as eyebrows, eyes, lips, *etc.*, [8]. In the appearance-based approaches, the whole face or specific regions in a face image are used for the feature extraction [10]. The primary objective of this work is to classify the facial expressions based on the emotions. Six different emotions are considered; they are happy, fear, sad, normal, surprise and angry. For classification the

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PSO with LIBSVM algorithm and the BAT algorithm are used. To find the best algorithm among these two we have analyzed their performances.

The remaining portion of the paper is organized as follows. Section 2 gives the related works. The PSO with LIBSVM and BAT algorithms are described in Section 3. Section 4 analyzes the experimental results and conclusion is given in Section 5.

2. Related Works

Frossard P [6] analyzed classification specific feature sampling for face recognition. In this paper, he discussed the feature selection problem, where features are selected to perform the classification task. He used random filters and Gabor wavelets for feature selection. He analyzed the results and proved that the proposed feature selection Gabor wavelets method performs accurately with uniform sampling for face recognition tasks.

Gandomi [7] described coupled eagle strategy and differential evolution for unconstrained and constrained global optimization. He used optimization tool to improve the efficiency of search algorithm. He has developed eagle strategy method in combination with the efficient differential evolution and applied to engineering problems. He finally discussed proposed algorithm and their implications for future research work.

Vijayarani *et.al.,* [12] analyzed various edge detection algorithms for facial images in image mining. They examined two edge detection algorithms; canny and mar-hildreth. Image smoothing is done for noise reduction, detection and edge localization are the steps involved in edge detection. Finally from the experimental results it is clearly shown that the canny edge detection algorithm performs well when compared to Mar-Hildreth edge detection algorithms.

Vijayarani *et.al.,* [13] analyzed the performance analysis of canny and sobel edge detection algorithms and these are used to extract edges from facial images which are used to detect face. Many edge detection techniques are carried out by performing with different set of images. They also discussed face recognition, filtering and edge detection methods. Accuracy is measured by using confusion matrix and execution time and they found that canny performance is better than sobel.

Vijayarani *et.al.,* [14] described the comparative analysis of facial image feature extraction algorithms. In this paper they discussed two different types of feature extraction algorithms such as FPD (Face part Detection) algorithm and Susan algorithm. They implemented the work using matlab and finally analyzed the experimental results and it is found that face part detection algorithm is better than susan algorithm in terms of its accuracy and execution time.

Wright [15] presented feature selection in face recognition on sparse representation perspective. Author has examined the role of feature selection in face recognition by using conventional features such as Eigenfaces and facial parts. The proposed algorithm has achieved much higher recognition accuracy on face images with variation in expression and found the differences in performance between different features.

3. Proposed Methodology

The two algorithms PSO with LIBSVM and BAT algorithms are used for classifying the images according to the facial expression such as angry, fear, happy, normal, surprise and sad. The system architecture of the proposed methodology is shown in Figure 1.

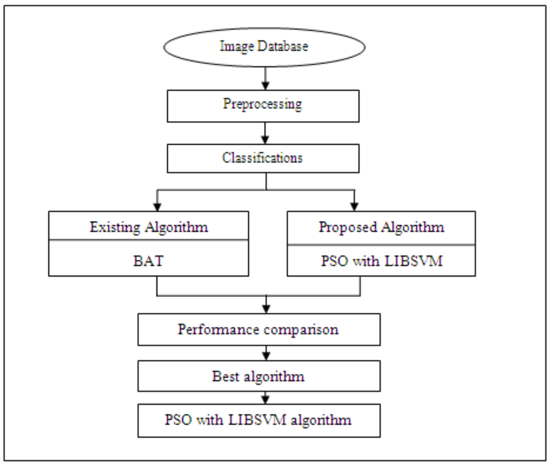

Figure 1. System Architecture

Image Database- Image database is a computerized system where images are stored in an organized form. Many image databases are available, for example, MRSID, ATERAS, PATFIT, JAFFE *etc.* In this paper we have used JAFFE database**.** JAFFE database is described as Japanese female face expression database. It contains Japanese female face model images with different face expressions.

Preprocessing- Preprocessing is the first step done before feature extraction of images. Preprocessing is the stage where filtering is done to remove noise. There are many number of filters are used for noise removal. Different filters used in this work are median filter, adaptive filter, linear filter and predefined filter. Based on their performance results it is observed that median filter has produced good results than other filters [14]. Preprocessing is essential to perform which helps to remove unwanted noise and it gives clarity to the images.

Classification- Classification consists of predicting certain outcome based on a given input. In order to predict the outcome, the algorithm processes a training set which contains a set of attributes and 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 find a description that can best describe the images in one class and to distinguish these images from all the other classes. In classification, usually multiple features are used for a set of pixels *i.e.*, many images of a particular object is needed. Image search engines are currently dependent on textual metadata. This information can be in the form of filenames, images, manual annotations or surrounding text.

BAT algorithm- BAT algorithm is a bio-inspired algorithm based on the echolocation features of microbats. All bats use echolocation to sense distance and they also know the difference between prey and background [9]. They use time delay between their ears and loudness variations to sense and bats fly randomly with velocity v_i at position x_i with a frequency f_{min} to search for prey. They can automatically adjust the wavelength of their emitted pulses and adjust the rate of pulse emission, depending on the loudness and it can vary from large to minimum constant value. Each bat is associated with a velocity v_i and a location x_i, at iteration t, in a d dimensional search or solution space in order to provide an effective mechanism to control the exploration and exploitation. In some situations, it is necessary to switch to exploitation stage, we have to vary the loudness A_i and the rate r_i of pulse emission during the iterations. Since the loudness usually decreases once a bat has found its prey, while the rate of pulse emission increases, the loudness can be chosen as any value of convenience, between A_{min} and A_{max}, assuming that a bat has just found the prey by stop emitting sound [5]. BAT algorithm uses echolocation and frequency tuning to solve problems [1]. It has a capability of automatically zooming into a region to local intensive exploitation. BAT algorithm uses parameter control which can vary the values of parameters as the iterations value changes. The different variants of bat algorithm are given below:

Fuzzy Logic Bat Algorithm- (FLBA) presented a variant by introducing fuzzy logic into the bat algorithm by their variant fuzzy bat algorithm [2]. MultiObjective BAT algorithm (MOBA) is an extended version of BAT and it deals with multiobjective optimization which has demonstrated its effectiveness for solving a few design benchmarks in engineering. K-Means BAT Algorithm (KMBA) is a combination of K-means and BAT and it is used for efficient clustering. Chaotic BAT Algorithm (CBA) uses Levy flights and chaotic maps to carry out parameter estimation in dynamic biological systems. Binary BAT algorithm (BBA) is developed and it is a discrete version of BAT algorithm to solve classifications and feature selection problems using differential operator function. Improved BAT algorithm (IBA) is an extension of BAT with a good combination and variations of loudness and pulse rates. The pseudo code of BAT algorithm is given in Table 2.

Table 1. Pseudo Code for BAT Algorithm

1. Initialize bat population x_i and velocity v_i.
2. Define pulse frequency f_i at x_i.
3. Initialize pulse rate r_i and loudness A_i.
4. while (t<maximum number of iterations).
5. Generate new solutions by adjusting frequency, and updating velocities and location.
6. Select a solution among the best solutions.
7. Generate a local solution around the selected best solution.
8. Ranks the bats and find best iteration.
9. Display results.

Particle Swarm Optimization (PSO) is a population-based optimization algorithm modeled after the simulation of social behavior of birds in a flock [3]. The algorithm of PSO is initialized with a group of random particles and then it searches for optimum by updating generations. Each particle is flown through the search space having its position adjusted is based on its distance from its own personal best position and the distance from the best particle of the swarm. The performance of each particle is measured using a fitness function which depends on the optimization problem. Each particle i fly through an n-dimensional search space R^n

x_i the current position of i^{th} particle (x-vector)

p_i the personal best position of i^{th} particle (p-vector) and

v_i, the current velocity of i^{th} particle (v-vector).

The personal best position is associated with a particle, i, is the best position that the particle has visited so far. If f denotes the fitness function, then the personal best of i at a time step t is updated as,

$$p_i(t+1) = \{p_i(t) iff (x_i(t+1)) \geq f(p_i(t)\}$$

$$x_i(t+1) iff (x_i(t+1) < f(p_i(t)) \tag{1}$$

If the position of the global best particle is denoted by *gbest*, then

$$gbest \in \{p_1(t), p_2(t), ...p_m(t)\} = \min \{f(p_1(t), f(p_2(t), ...f(p_m(t))\} \tag{2}$$

The velocity updates are calculated as a linear combination of position and velocity vectors. Thus, the velocity of particle i is updated and the position of particle i is updated by the following equations.

$$v_i(t+1) = w.v_i(t) + c_1 r_1 (p_i(t) - x_i(t)) + c_1 r_1 (gbest - x_i(t)) = x_i(t) + v_i(t+1) x_i(t+1) = x_i(t) + v_i(t+1) \tag{3}$$

In the formula, w is the inertia weight, c_1 and c_2 are the acceleration constants, r_1 and r_2 are random numbers in the range [0,1] and must be in the range $[-V_{max}, V_{max}]$ where V_{max} is the maximum velocity.

Library Support Vector Machine: LIBSVM is a library for Support Vector Machines (SVMs) and its objective is to use SVM easily in their applications. LIBSVM has gained wide popularity in machine learning and many other areas. A typical use of LIBSVM involves two steps, the first step is to train a data set to obtain a model and second step is to use the model to predict information from the test data set. LIBSVM can also produce probability estimates output and parameters for gamma in LIBSVM are taken from PSO algorithm [15] and the cost parameter is set as C, *i.e.*, C-SVC is taken. In general, kernel methods have increased due to the grown popularity of the support vector machines. Here Radial Bias Function Kernel is used and it is expressed as

$$RBF = \exp\left(\frac{1}{2\sigma^2 \| x - x_i \|^2}\right) \tag{4}$$

This RBF is considered as kernel in LIBSVM technique. With this, the classification is done for PSO using library support vector machine. The pseudo code of this algorithm is given in Table 2.

Table 2. Pseudo Code for PSO with LIBSVM Algorithm

1. Initialize the population of N particles with random positions and velocities on D dimensions in the solution space.
2. Set the velocity vectors *i v* (i=1,2,...N) to zero.
3. For each position of the particle *i P* (i=1,2,...N) from the swarm, train the SVM classifier and compute the fitness function value.
4. Detect the best global position *g p* in the swarm which showing the minimal value of the fitness function value over all explored trajectories.
5. Update the speed and position of each particle.
6. Train the SVM classifier and compute the fitness function.
7. Make SVM classification based on the trained classifier.
8. If the maximum iteration times have reached then exit.
9. Calculate the values by testing the images.
10. End.

4. Experimental Results

This work is implemented in Matlab tool. The JAFFE database is used in this work and it contains one hundred and eighty one images. Two performance measures are considered for experimental analysis; they are classification accuracy and execution time.

A. Classification Accuracy- By comparing PSO with LIBSVM and BAT algorithm it has proved that PSO with LIBSVM algorithm correctly classifies the facial images based on their expression. This algorithm accurately classified all the images in the database. Table 3 gives the classification accuracy measure for PSO with LIBSVM and BAT algorithm.

Table 3. Accuracy Measure

Algorithms	Accuracy
PSO (Particle swarm optimization)	92%
BAT algorithm	76%

By using SVM, the proposed algorithm attained highest accuracy values. SVM is done for training and testing the images datasets. Here SVM classifiers are used and it gives accurate results with highest accuracy values.

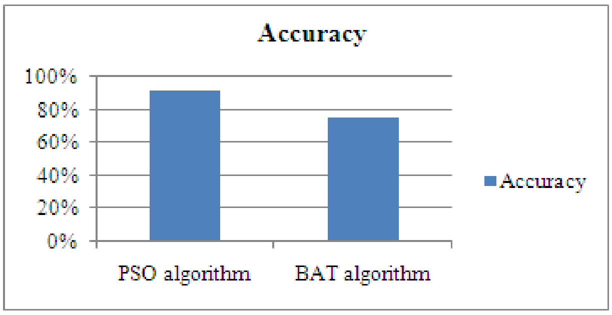

Figure 2. Classification Accuracy

Figure 2, shows the classification accuracy of PSO with LIBSVM and BAT algorithm. From this it is observed that the PSO with LIBSVM has given better accuracy than BAT algorithm.

B. Execution Time

This performance measure is used to measure the time required to complete the classification task by the existing and the proposed algorithms. This is given in Table 4.

Table 4. Execution Time

Algorithms	ExecutionTime (m.sec)
PSO (Particle swarm optimization)	10000
BAT algorithm	18000

PSO with LIBSVM algorithm has required minimum execution time compared to BAT algorithm. Figure 3, shows the execution time of PSO with LIBSVM and BAT algorithm.

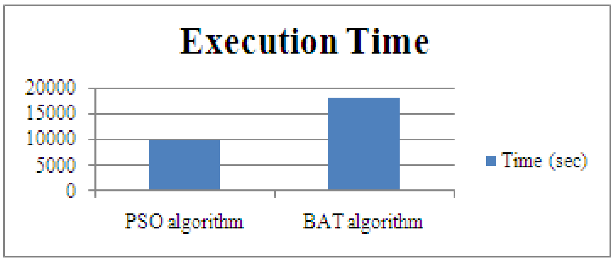

Figure 3. Execution Time

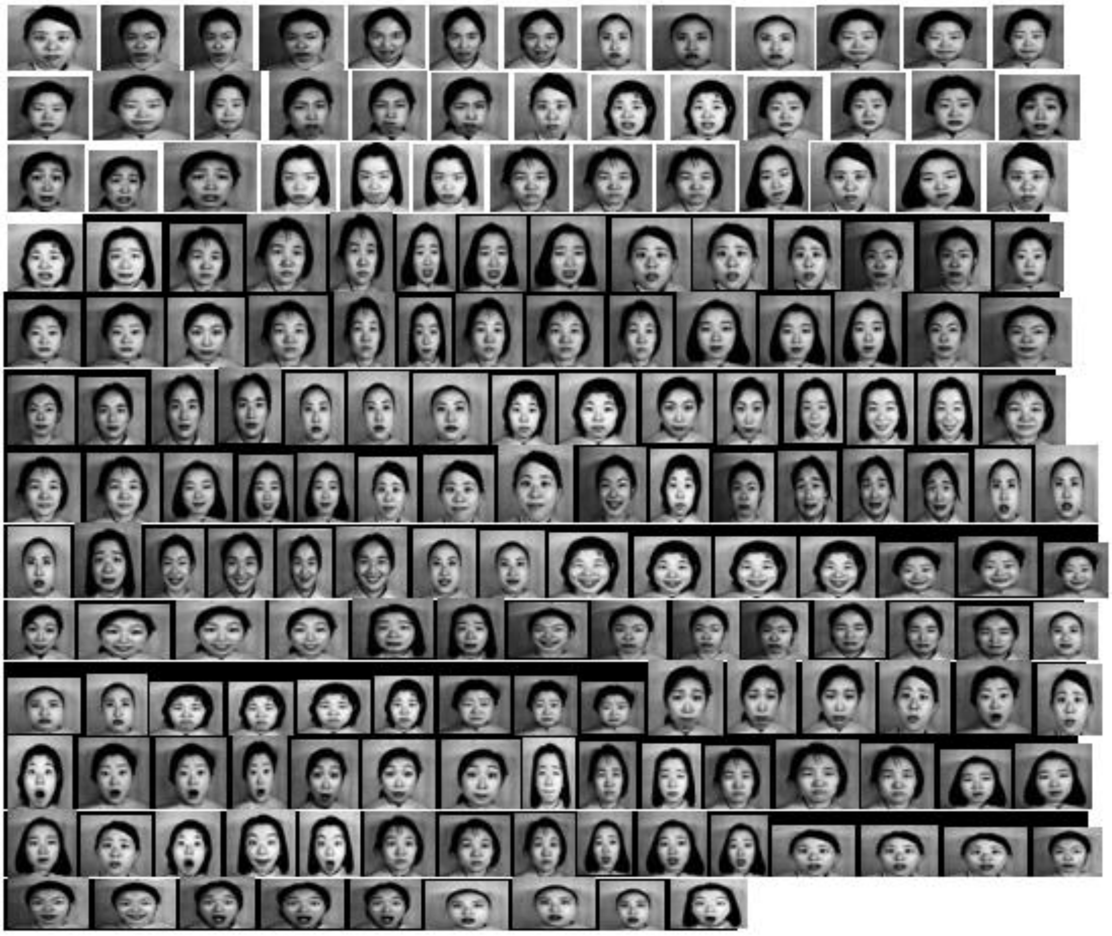

Figure 4. JAFFE-Input Image Dataset

Figure 4, shows the JAFFE database, which contains one hundred and eighty one images with different expressions. Table 5, represents the number of images classified based on their expressions by using BAT and PSO with LIBSVM algorithms.

Table 5. Expression Based Classification by BAT and PSO with LIBSVM

Algorithm	Angry	Fear	Happy	Normal	Sad	Surprise
BAT	22	21	29	14	22	15
PSO with LIBSVM	30	32	29	27	31	30

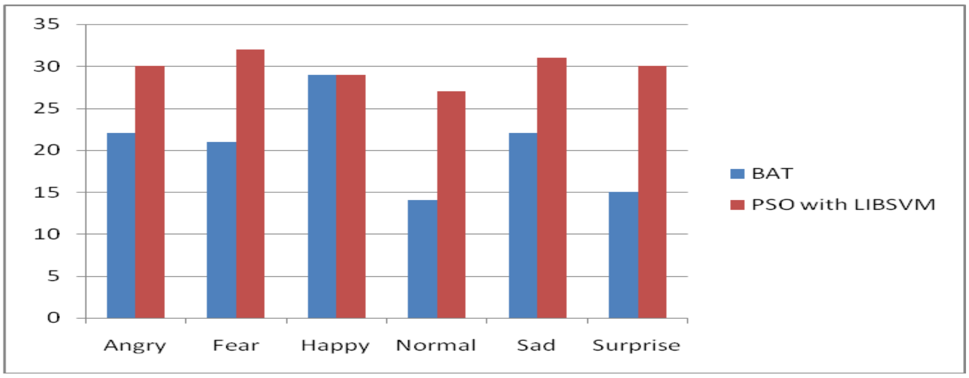

Figure 5. Expression Based Classification by BAT and PSO with LIBSVM

Figure 5, shows the number of faces classified based on their expression by the BAT and PSO with LIBSVM algorithms. The figure numbered from 6 to 17 gives the different expressions classified by the existing and the proposed algorithms.

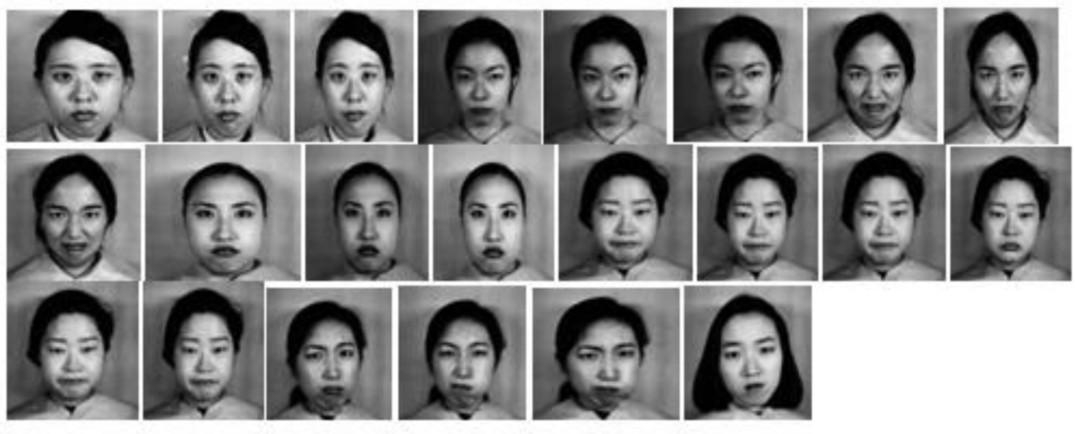

Figure 6. Angry Faces-BAT

Figure 7. Angry Faces–PSO with LIBSVM

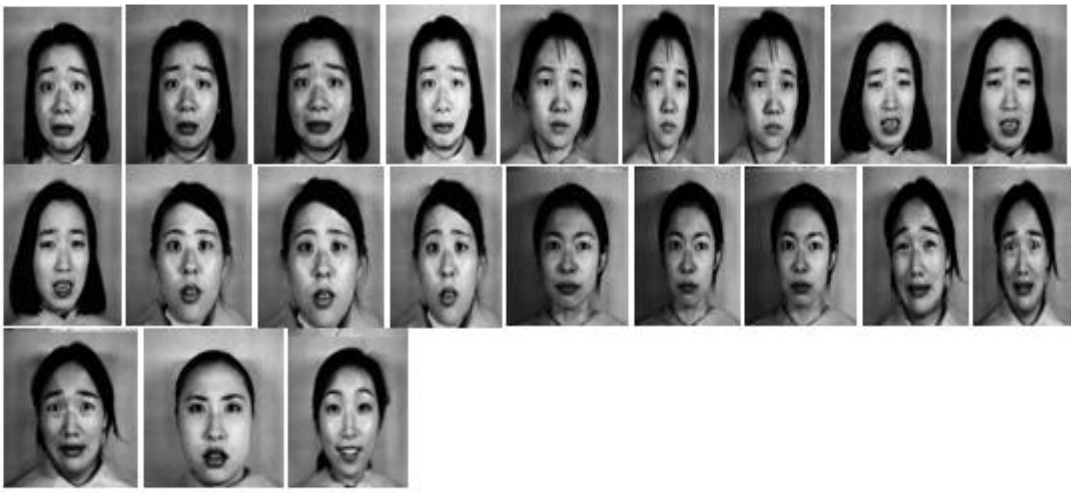

Figure 8. Fear Faces-BAT

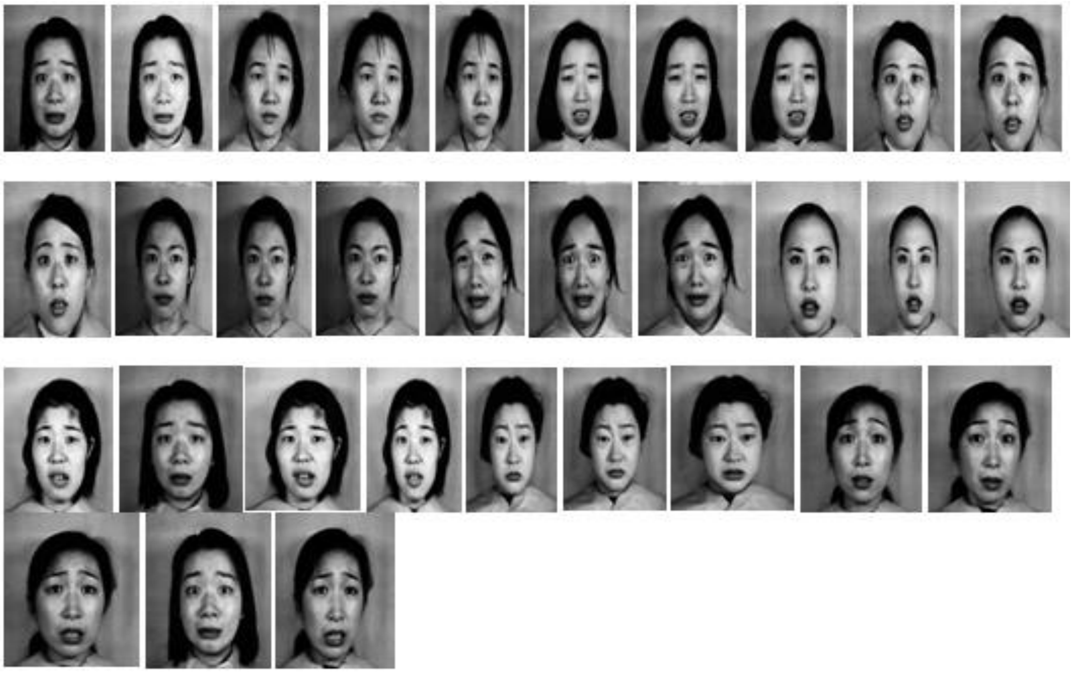

Figure 9. Fear Faces–PSO with LIBSVM

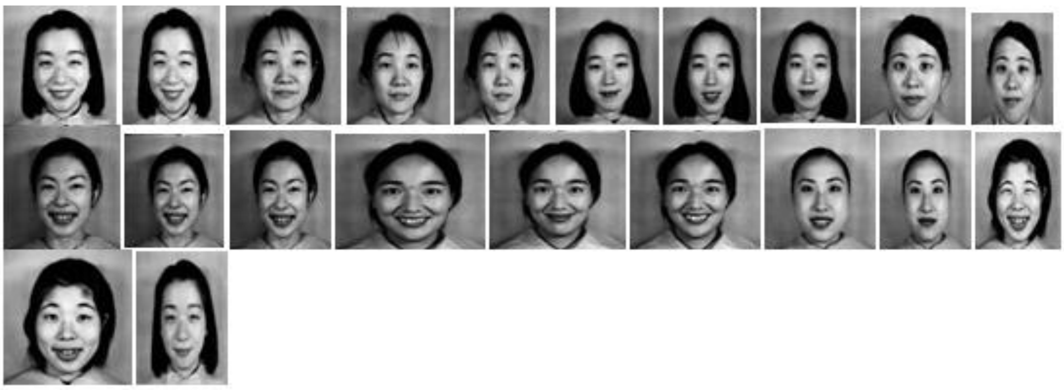

Figure 10. Happy Faces-BAT

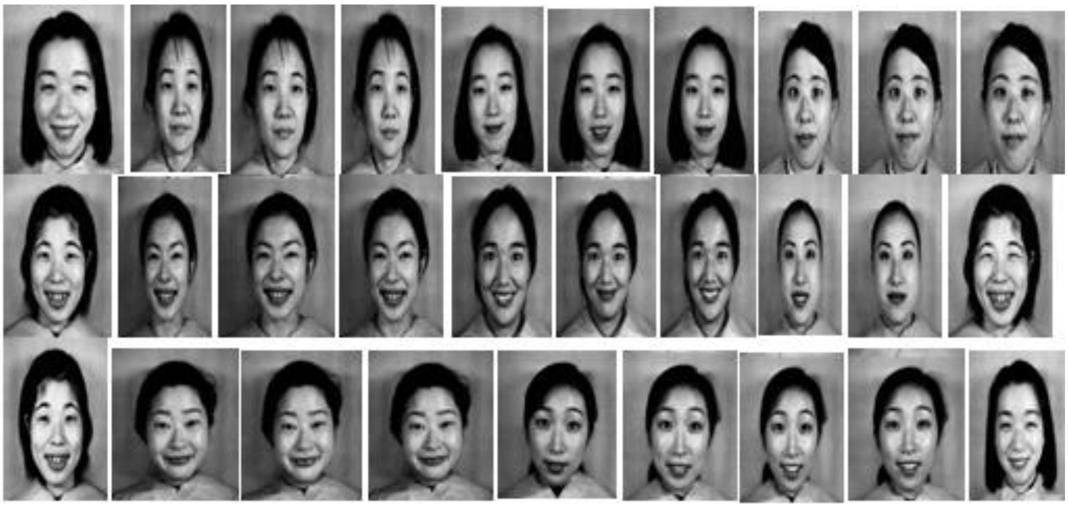

Figure 11. Happy Faces–PSO with LIBSVM

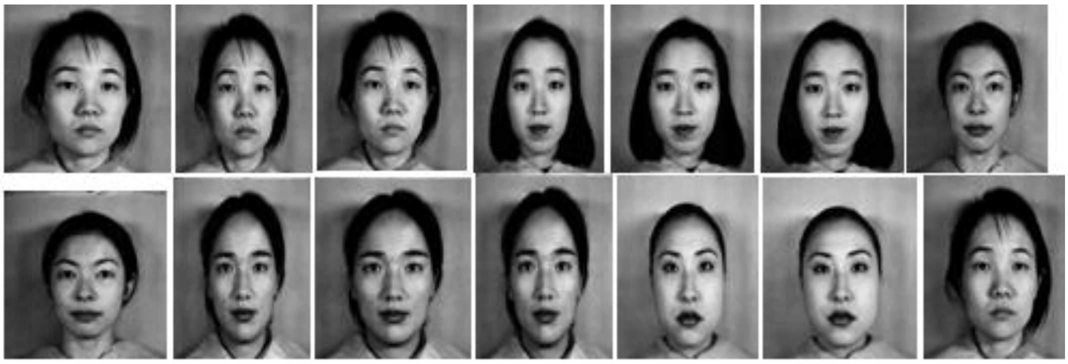

Figure 12. Normal Face-BAT

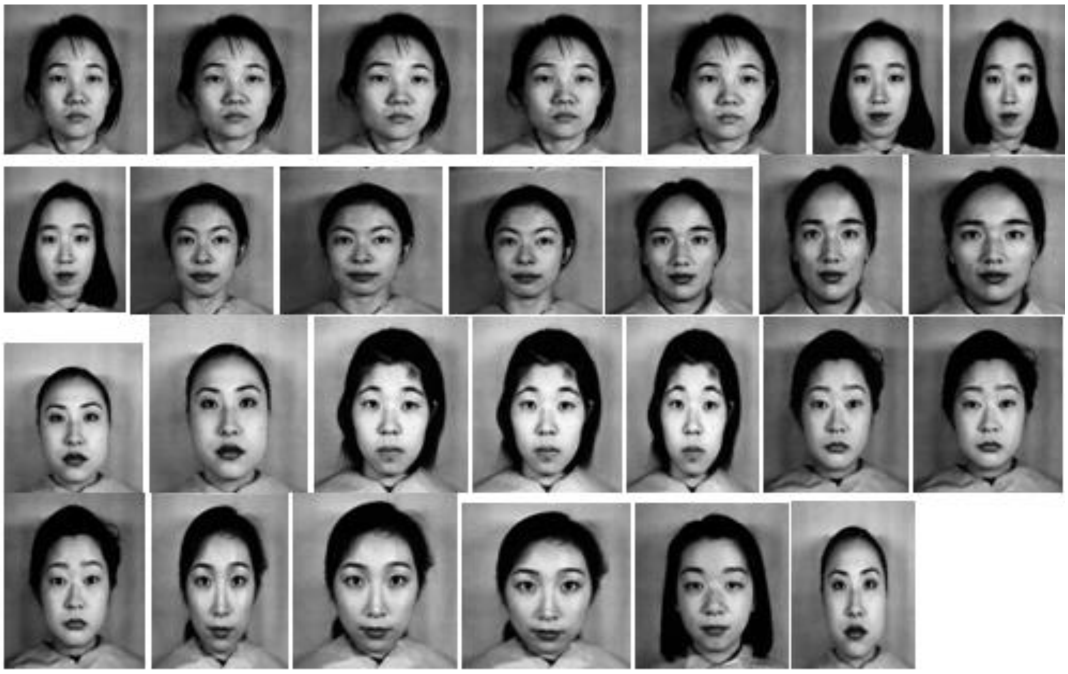

Figure 13. Normal Face–PSO with LIBSVM

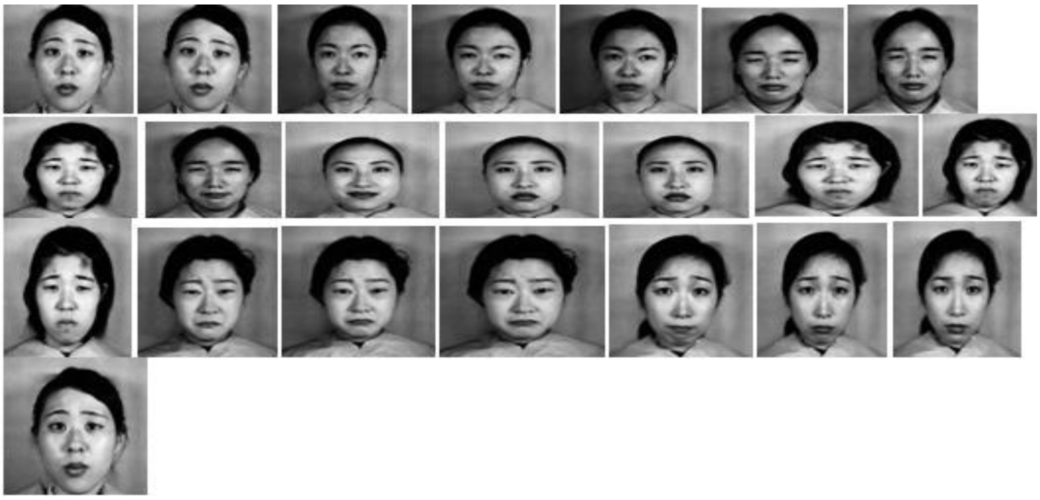

Figure 14. Sad Faces–BAT

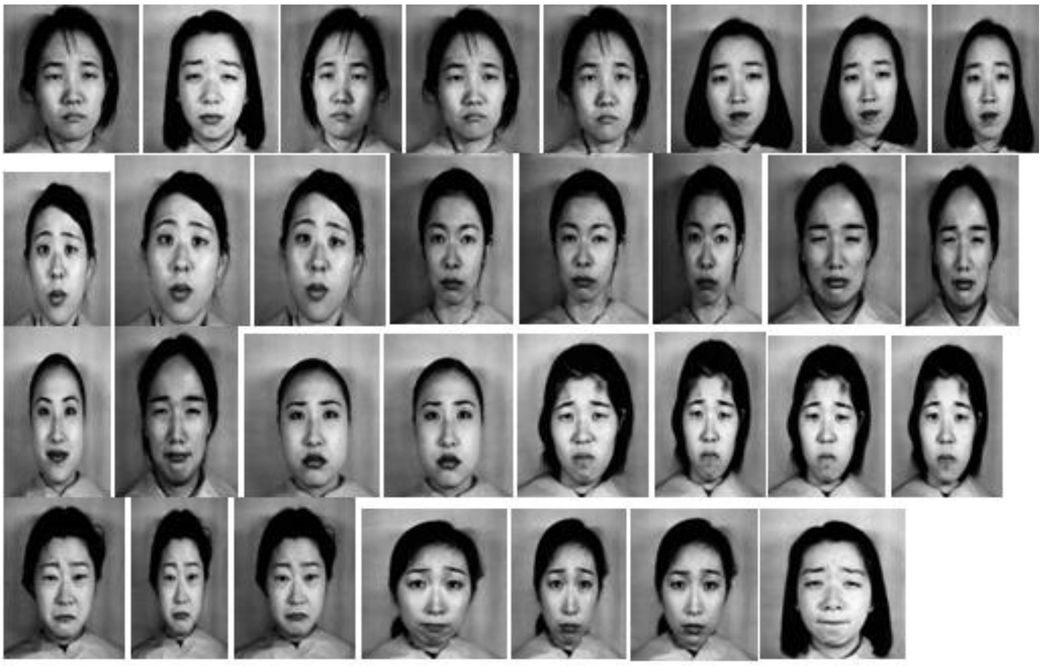

Figure 15. Sad Faces–PSO with LIBSVM

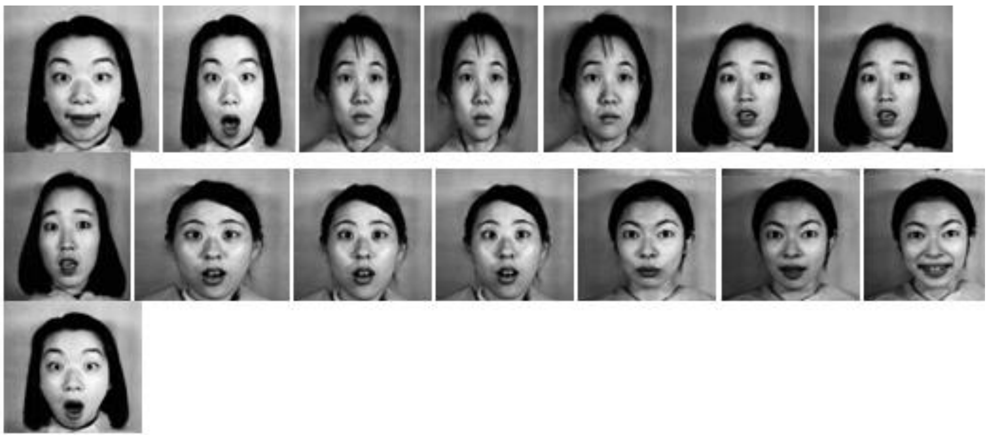

Figure 16. Surprise Faces–BAT

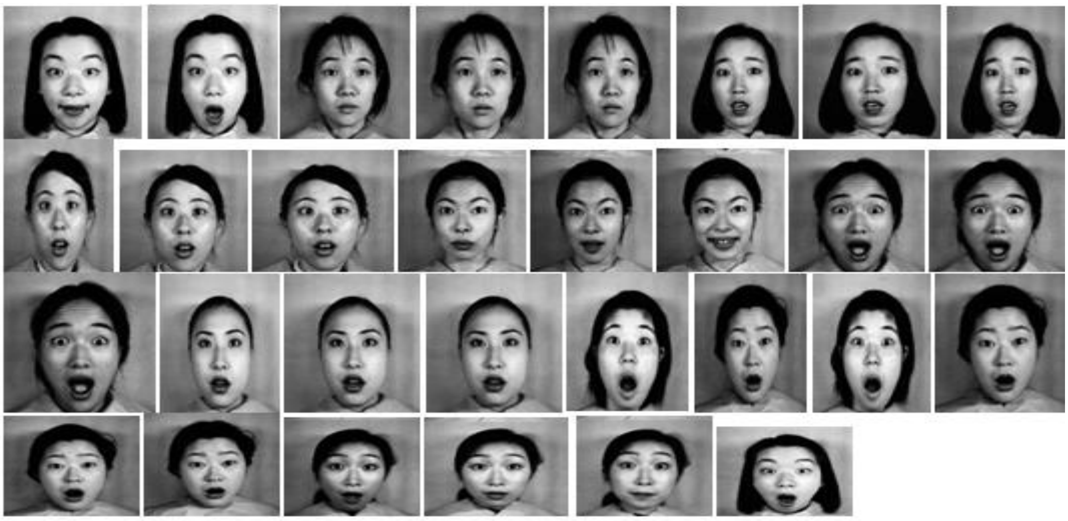

Figure 17. Surprise Faces–PSO with LIBSVM

5. Conclusion

The primary objective of this research work is to perform the classification task in the facial images based on their expressions. The existing classification algorithm BAT and the newly proposed PSO with LIBSVM classification algorithms are used in this work. From the experimental results, it is observed that PSO with LIBSVM algorithm performance is comparatively better than BAT algorithm. In future new algorithms are to be proposed to minimize the execution time and to improve the classification accuracy

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