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Parameter Optimization of Support Vector Machine Using Enhanced Hybrid Particle Swarm Optimization in Non-Linear Face Authintication Problem

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Abstract: One of the well-known machine learning methods is Support Vector Machine (SVM). With small number of training samples, it can discover the global optimal solutions for the complex non-linear problems such as face recognition. However, choosing the optimal parameters of SVM is a big challenge which has a high impact in the classification results. "Particle Swarm Optimization (PSO)" has been used to find the optimal parameters of SVM but PSO has drawbacks in inertia weight selection which is fixed number and in population initialization which is random. In this study, a new face recognition technique based on Hybrid Particle Swarm Optimization and Support Vector Machine (LOPSO-SVM) is introduced. The hybrid PSO algorithm based on Logarithm decreasing inertia weight and opposition particle swarm initialization which can improve the convergence speed in PSO. Principle Component Analysis (PCA) has been used for feature extraction process and the extracted features was passed to the proposed technique. In the experimental results, human face database CASIA V5 is utilized to verify the performance of face recognition technique LOPSO-SVM. The proposed technique is compared with PSO-SVM and AOPSO-SVM. The experimental results shows that the proposed method gave higher face recognition accuracy than PSO-SVM and AOPSO-SVM and outperform the other method in finding the optimal parameters of SVM.

Key words: Support vector machine, face recognition, PSO, optimization, LOPSO-SVM, AOPSO-SVM

INTRODUCTION

Recently, face recognition applications are became one of the significant direction in pattern recognition area and verification using human face is widely used (Shailaja and Anuradha, 2017). The non-linearity of face recognition make it complicated problem, so that, numerous studies in the past years have used artificial intelligence techniques to deal with face recognition challenges. Neural networks like "back propagation neural network" is consider as one of the most common artificial intelligence technique that are applied widely in face recognition domain. (Aitkenhead and McDonald, 2003; Sun and Tien, 2008). However, the face recognition applications which utilize the neural networks are easily fall in over-fitting and local optimal and that can lead to untrusted results.

Hence, it is very important to find a new type of techniques in face recognition to ovoid the over mentioned problems. "Support Vector Machine (SVM)" is one of the well-known approach that classified under the category of machine learning approaches. It works with small number of training samples and high dimensions problems on the principle of risk minimization which can lead to "global optimum" solutions (Gold and Sollich, 2003; Lauer and Bloch, 2008).

Nevertheless, the process of selection the training parameters of SVM has a high influence on the whole performance of SVM. Lately, "Particle Swarm Optimization (PSO)" is projected by Kennedy and Eberhart in 1995 Kalivarapu *et al.* (2009) and (Africa, 2017) which is motivated via. the social activities among folks similar as the fish grouping or birds blocking. The PSO algorithm has been used to discover the optimal or near-optimal parameters of SVM (PSO-SVM) which was introduced by Wei *et al.* (2011).

However, the standard PSO has suffer from some limitations such as the random population initialization and the fixed value of inertia weight. Therefore, a new face recognition technique based on hybrid PSO algorithm and Support Vector Machine is presented and we called it (LOPSO-SVM). The hybrid PSO merge the OPSO-SVM method which was introduced by Hasan *et al.* (2013) and logarithm decreasing inertia weight which was presented by Gao *et al.* (2008).

Literature review: Recently, several methods have been utilized different versions of PSO in order to find the optimal parameters of SVM. Wei *et al.* (2011) have been used the standard PSO to optimize the SVM parameters and presented a face recognition method named as

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(PSO-SVM). However in PSO, the populations are generated in a randomly and that can effect in the population result. To solve this problem, modified version based on opposition particle swarm optimization and SVM has been introduced by Hasan *et al.* (2013). They called their method (OPSO-SVM where the populations are generated based on random numbers and opposition as well. Another new version of PSO named Accelerated PSO with SVM has been introduced by Yang *et al.* (2011).

To find the finest kernel parameters in SVM, Accelerated PSO is used and the resulted kernel parameters are used to build the SVM. However, the utilization of random values of velocity calculation were influenced the selection of SVM parameters. Therefore and to avoid the velocity coefficient, an Abdulameer *et al.* (2014) have introduced AAPSO-SVM which is adaptive acceleration particle swarm optimization and support vector machine. They introduced new strategy based on fattiness values to choose the velocity coefficients in PSO.

Though, AAPSO-SVM still has limitation in choosing the inertia weight in PSO which is fixed number. In this study, a new face recognition technique is presented based on hybridization of "Logarithm decreasing Inertia Weight" that was introduced by Gao *et al.* (2008) and OPSO-SVM which was introduced by Hasan *et al.* (2013).

MATERIALS AND METHODS

The proposed approach: The suggested technique is composed of three parts: the first part is feature extraction via. "Principle Component Analysis (PCA)", the proposed hybrid PSO algorithm is discussed in the second part and the third part explains the process of SVM parameters selection. Figure 1 shows the basic components of the whole proposed technique.

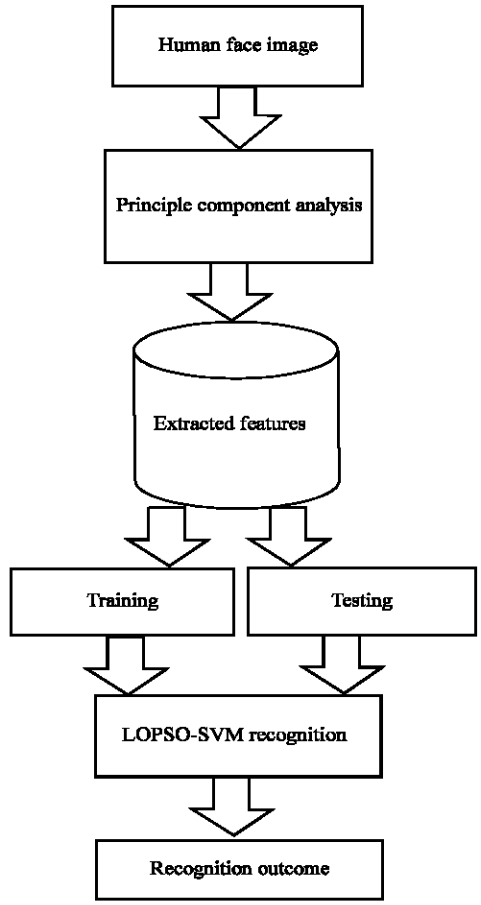

Fig. 1: The main components of the proposed technique

Principle component analysis: For the feature extraction part, the common PCA algorithm is used to extract human face features. The extracted features has a high impact on the proposed technique to verify the human face accurately.

The proposed LOPSO-SVM : PSO is initially introduced by Kennedy and Eberhart and it was mimicking the social behavior of the bird groups or fish school. The PSO is initially start with a collection of random solutions which is called (particles) so the generated particles is (random). At that point, it searches through updating generations for optimal solution.

In the proposed LOPSO-SVM, the generation of the particles are randomly generated and using opposite number as well (Jabeen *et al.*, 2009). The description of the opposition number strategy is explained briefly according to these rules:

- Consider t generated between the interval {m, n} as real number, then the opposition number t- is defined via the formula t- = m+n-t
- Consider s = {t1, t2, …, ti }as a point where i∈ {mi, ni} and depends on those points the opposition points will be defined as S- = {t1-, t2-, … , ti- } where ti- = mi+ni+ti

Each particle in every iteration is updated through two values pbest and another value obtained for any particle in the whole population which is called gbest. Next and after getting the two finest values, the velocity and positions of the particle will be updated according to the Eq. 1 and 2 as follow:

$$V[\,] = WV[\,]+f1*R(\,)*(pbest[\,]-current[\,])+ f2*R(\,)*(gbest[\,]-current[\,]) \quad (1)$$

$$\text{Current}[\,] = \text{Current}[\,] + V[\,] \quad (2)$$

v [ ] represents the velocity of particle in the swarm while Current [ ] represents the current solution. pbest [] is the best fitness value for the particle and gbest [] is the best value for the particle in the whole population. W is the inertia weight and R ( ) is a random number in the interval of (0, 1). Velocity coefficients are fi and f2 which are usually = 2.

The standard PSO originally utilized a fixed value to represents the inertia weight and the experiments have shown that may influence on the convergence speed negatively. Therefore and to enhance the PSO performance , "logarithm decreasing inertia weight" was introduced by Gao *et al.* (2008) as an attempt to increase the convergence speed. The "Logarithm Decreasing Inertia Weight" according to Gao *et al.* (2011) was represented by the following formula:

$$W = W_{max} + (W_{max} - W_{min}) \times Log\ 10\ (b + 10g/G_{max}) \quad (3)$$

where, g is the number of iterations and b is a constant to regulate the evolutionary speed, we consider b = 1 in tests. In this study, we have used the "logarithm decreasing inertia weight" with OPSO-SVM in order to gain both algorithms advantages in an enhanced LOPSO-SVM technique.

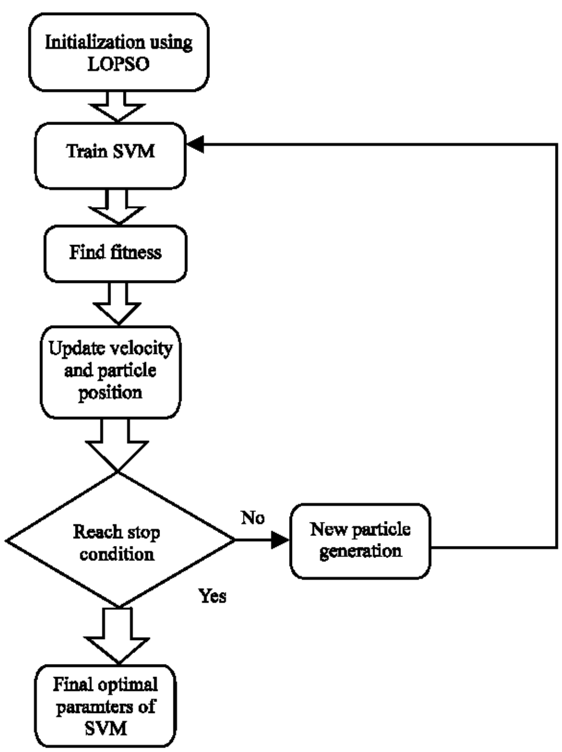

Fig. 2: Parameters optimization via. LOPSO

Selection of SVM parameters using LOPSO : The parameters of SVM are optimized using the LOPSO method as shown in Fig. 2.

RESULTS AND DISSCUSSION

The working platform of MATLAB is used for the experimentation. In this study, we worked on CASIA V5 (Anonymous, 2007) human face database investigate the face recognition performance the proposed technique.

The database are divided into training and testing images and 200 images were used in the experimentation. In the assessment process, the images in the dataset are divided 50% for training and 50% testing. The n-fold cross validation is used to examine the proposed technique and the equivalent statistical methods are utilized.

To accomplish this validation, ten folds which means (n = 10) of training and testing databases are created through folding operation. The PCA has used in feature extraction process while the proposed LOPSO-SVM has used for the recognition process. Figure 3 the example of CASIA V5 face databases images is illustrated.

From CASIA database, we have implemented 10 times. The results of the recognition process are represented by the accuracy measure and illustrated in Table 1 and Fig. 4. The results showed that the proposed LOPSO-SVM method has achieved higher accuracy than the standard methods PSO-SVM and AOPSO-SVM.

Fig. 3: CASIA face image example

Table 1: The accuracy of the PSO-SVM, AOPSO-SVM and the proposed LOPSO-SVM

Experiments	PSO-SVM	AOPSO-SVM	LOPSO-SVM
1	85	89	95
2	80	90	94
3	82	92	93
4	84	93	95
5	88	95	97
6	80	88	100
7	87	89	93
8	83	79	83
9	79	80	90
10	82	81	97

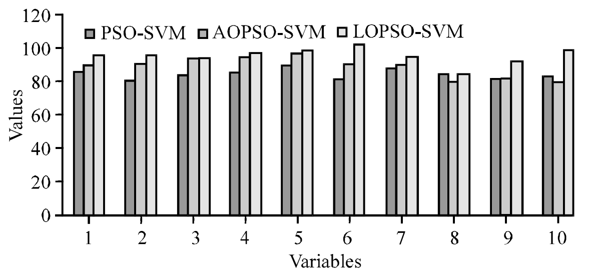

Fig. 4: Accuracy results for PSO-SVM, AOPSO-SVM and LOPSO-SVM

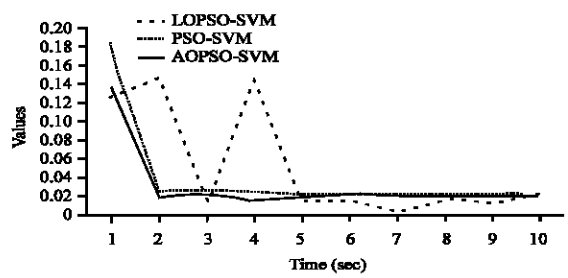

Fig. 5: Computational time in seconds for the PSO-SVM, AOPSO-SVM and LOPSO-SVM

From Fig. 4 the proposed LOPSO-SVM was better than the state of the arts PSO-SVM and AOPSO-SVM in most of the experiments in terms of accuracy measurements. In addition, the computational time of the proposed LOPSO-SVM comparing with PSO-SVM and AOPSO-SVM methods are illustrated in Fig. 5.

CONCLUSION

In this study, a Hybrid Particle Swarm Optimization and Support Vector Machine (LOPSO-SVM) was proposed and used for face classification problem. The hybrid PSO algorithm was built from "Logarithm decreasing inertia weight" and "opposition particle swarm initialization" which led to improve the convergence speed in the standard PSO. "Principle Component Analysis (PCA)" has been used for feature extraction process and the extracted features was passed to the proposed LOPSO-SVM technique. In the experimental results, human face database CASIA V5 has been utilized to verify the performance of face recognition technique LOPSO-SVM. The proposed technique then compared with PSO-SVM and AOPSO-SVM (Abdulameer *et al.*, 2018) methods. The experimental results showed that the proposed LOPSO-SVM method was outperform the standard PSO-SVM and AOPSO-SVM in terms of accuracy.

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