

Original Research Article

**Local Binary Pattern And Ant Colony
Optimization Based Feature Dimensionality
Reduction Technique For Face Recognition
System**

ABSTRACT

Feature dimensionality reduction is the process of minimizing the number of features in high dimensional feature space. It encompasses two vital approaches: feature extraction and feature selection. In face recognition domain, widely adopted face dimensionality reduction techniques include Principal Component Analysis (PCA), Discrete wavelet transform (DWT), Linear discriminant analysis (LDA), and Gabor filters. However, the performances of these techniques are limited by strict requirement of frontal face view, sensitivity to signal shift and sample size, computational intensiveness amongst others.

In this work, a feature dimensionality reduction technique that employed local binary pattern (LBP) for feature extraction and ant colony optimization (ACO) algorithms for optimal feature subset selection was developed. The developed technique identified the salient feature subsets capable of generating accurate recognition. In order to vary the amount of information on the face image, image resolution (pixel count) of 40*40, 50*50, 60*60 and 70*70 were arbitrarily chosen to evaluate performance of the technique on these resolutions. The average training and recognition time obtained from the experiment on locally acquired face data were 0.547secs and 0.244secs respectively while an average training and recognition time obtained on AT&T database were 0.340secs and 0.180secs respectively. The average recognition results obtained on both the locally acquired face database and American telephone and telegraph face database was 98.08% and 95.00% respectively for all the resolutions tested. These indicate an efficient performance of the potential combination of both methods in a two-level technique for dimensionality reduction

Keywords: feature selection, feature extraction, dimensionality reduction, local binary pattern, ant colony optimization, face recognition

1. INTRODUCTION

Dimensionality reduction refers to algorithms and techniques which create new attributes as combinations of the original attributes in order to reduce the dimensionality of a data set [1]. Dimensionality reduction is important in many domains because it mitigates the curse of dimensionality and other undesired properties of high-dimensional spaces. The goal of dimensionality reduction is to find a low dimensional representation of the data which preserves most of the information and structure of the data. Commonly researched dimensionality reduction techniques are PCA, DWT, LDA and Gabor filters amongst others.

The limitation of PCA is that the principal components which are the largest Eigen vector of the co-variance matrix generated are not often the optimal features in a lower dimension [2]; [3]; [4]; [5]. DWT is limited by lack of directionality associated with wavelets [6]; [7]; [8] and Gabor requires computation of biorthogonal wavelet which is time consuming [9]. In addition, the performance of LDA is degraded when sample size becomes large [10]; [11]. Hence the need for a robust feature dimensionality technique that projects the face data unto a spatial distribution of pixel values to obtain both shape and texture features [12]. Our aim is to develop a more promising dimensionality reduction technique which could result in better face recognition.

2. FEATURE DIMENSIONALITY REDUCTION APPROACHES

The main focus of dimensionality reduction is to present features in such a way that the informative part is preserved the most and eliminates extra data or components which are redundant to classification process [13]. Feature extraction and feature selection are the duo to perform efficient dimensionality reduction [10].

2.1 Feature Extraction

In computer vision applications, widely used is the process of retrieving desired images from a large collection on the basis of features that can be automatically extracted from the images themselves [14]. Feature extraction is a process that involves transformation of data [15]. The original set of features is transformed to provide a new set of features. These features could be certain face regions, or distances and angles between the parts of the face [16].

The goal of feature extraction is to represent samples accurately in a lower dimensional space [17]. There are various feature extraction methods such as knowledge-based method which depends on generic visual and statistical knowledge of facial components to extract features [18] and mathematical transform method which uses Karhunen-Loeve transform [19] and Discrete Cosine transform [11] to extract features of an image.

2.2 Feature Selection

Feature selection problem consists in making good predictions with as few variables/features as possible. The optimality of a feature subset is measured by an evaluation criterion [20]. The main purpose of feature selection is to reduce the number of features used in classification while maintaining acceptable classification accuracy [17]. Finding an optimal feature subset is usually very difficult and many problems related to feature selection have been shown to be non-deterministic polynomial (NP) time hard [21]. The reasons for performing feature selection as stated by [22] include: improving performance prediction, reducing computational requirements, reducing data storage requirements, reducing the cost of future measurements and improving data or model understanding.

3. Local Binary Pattern

LBP is a non-parametric texture classification method which summarizes the local structures of an image efficiently [23]. The most important properties of LBP features are tolerance against the monotonic illumination changes and computational simplicity. Due to its texture discriminative property and its very low computational cost, LBP is becoming very popular in pattern recognition [24]. LBP operators are easy to compute, hence they are suitable for real time applications. A face image can be seen as a composition of micro-patterns which are described by LBP [25]. The histogram of LBP computed over the whole face image encodes the occurrences of the micro-patterns. To obtain the local information of faces, face images were equally divided into small sub- regions to extract LBP histograms. The LBP features extracted from each sub-region are concatenated into a single, spatially enhanced feature histogram. The extracted feature histogram represents the local texture and global shape of face images. These features are the statistics of gray differential features representing the tonal variation of the gray value of pixels.

4 Ant Colony Optimization

The collective behavior which emerges from a group of social insects has been called "swarm intelligence". The ACO algorithm is based on a computational paradigm inspired by real ant colonies and the way they function. Ants are capable of finding the shortest route between a food source and the nest without the use of visual information, and they are also capable of adapting to changes in the environment [26]. An Ant Colony system involves simple agents (ants) that cooperate with one another to achieve an emergent, unified behavior for the system as a whole, producing a robust system capable of finding high-quality solutions for problems with a large search space. The ACO metaheuristic is characterized as being a distributed, stochastic search method based on the indirect communication of a colony of artificial ants, mediated by artificial pheromone trails. The pheromone trails in ACO serve as distributed numerical information used by the ants to probabilistically construct solutions to the

problem under consideration. The ants modify the pheromone trails during the algorithm's execution to reflect their search experience [27].

5. RELATED WORK

Globally, many feature dimensionality reduction techniques have been investigated and some of them have outstanding performance. [28] carried out an assessment of PCA and DCT algorithms for access control system. It was discovered that PCA proved to be a better algorithm for access control and recognition system based on the high percentage (90.43%) of correctly classified faces and its strict attendance to both FAR and FRR (0.1077, 0.0609) respectively.

[29] developed an ACO-based feature selection for face recognition system that uses discrete cosine transform (DCT) to extract features and ACO for face recognition. The work uses k-Nearest Neighbour classifier to evaluate the selected feature subsets in a wrapper mode. The result obtained when evaluated on AT&T database was 98.50% recognition accuracy. However the recognition time requirement for the performance of the system was not reported.

[30] developed a face recognition system using a hybrid of GA and ACO. The two algorithms were used to perform feature extraction and the fused features were passed unto GA for recognition of unknown face. The work produced a recognition accuracy of 93.3%. The recognition time achieved was 5.2secs. The database used was not specified.

[31] developed an algorithm for one-sample face recognition using Hidden Markov Model of fiducial areas. It uses two dimensional discrete wavelet transform (2D DWT) to extract features from images and hidden Markov model (HMM) was used for training and recognition. 90% correct recognition, false acceptance rate of 0.02% and a recognition time of 0.15secs were achieved on still frontal face images locally acquired and on a subset of the AT&T database.

[16] used Harmony Search Algorithm (HSA) to select an optimal subset of features that gives a better accuracy result in solving face recognition problem. This approach was compared with the standard PCA over a set of images from the AT&T face database. The results obtained with the HSA gives an accuracy of 94% in face recognition with the recognition time not indicated. The time requirement in terms of training time and recognition time are crucial parameters in achieving a face recognition system that mimic real-time scenario. Hence this research addresses the time requirement as well as accuracy of the face recognition system by considering the training time, recognition time and the recognition accuracy obtained using the developed technique.

6. THE PROPOSED TECHNIQUE

Face images have an inherent property of high dimension; pixels are highly correlated, leading to redundant information which causes computational burden in terms of processing speed and memory utilization. In this research, Local Binary Pattern was used to extract 2D distributions of local binary pattern and local contrast measurement. This enables texture information to be extracted from the face. The resultant feature representation serves as a suitable platform for selecting the optimal feature subsets by applying ACO algorithm on the texture pattern. The Process Flow of the proposed technique is shown in Figure 1.

The Process flow shows the training and testing phases. The training phase comprises the face database to be trained, and a two-level dimensionality reduction component which generates the feature vectors that serves as template to be used for matching. The training face database which is the first component of the training phase stores the acquired face images obtained from a publicly available face database (AT&T) as well as real time face data captured (LAFDAB). The two-level dimensionality reduction component aggregates the feature extraction and feature selection in level 1 and level 2. In level 1, feature extraction was done and LBP texture descriptor was obtained. In level 2, feature selection was done and ACO optimized feature subset was obtained.

Furthermore, from the dimensionality reduction, the feature vectors generated were saved for comparison. On the other hand, the components of the testing phase include the enrolled user to be identified, which passes through the dimensionality reduction, and the feature vectors generated which is then compared with the feature vectors in the training database by measuring the Mahalabolis distance between the two vectors in a component

connecting the training and testing phase. The choice of Mahalanobis distance is due to the fact that it overcomes the blindness to correlation problem of Euclidean distance. The next component is the classification process in which the recognition of face is done based on the distance between the test and trained vectors. The identity of the enrolled user is displayed as the last component of the framework indicating a recognized face or unrecognized.

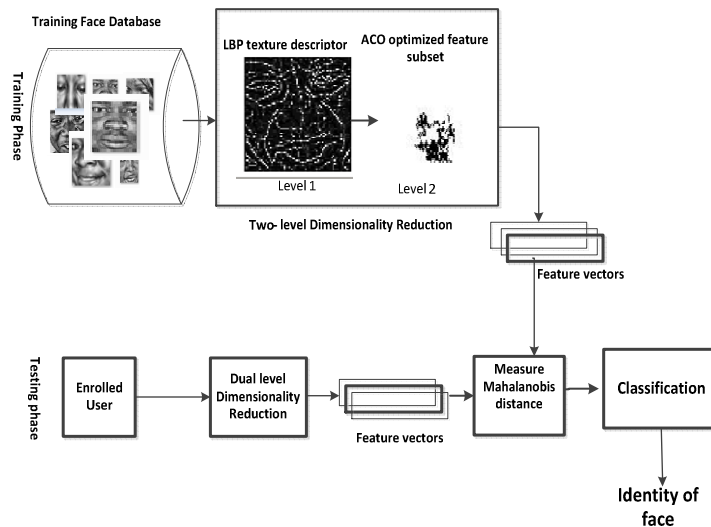
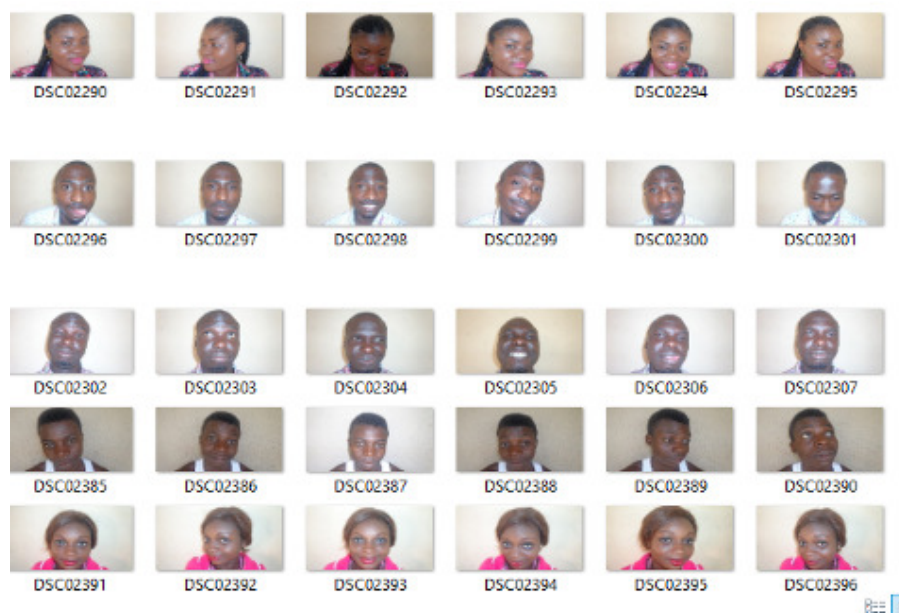


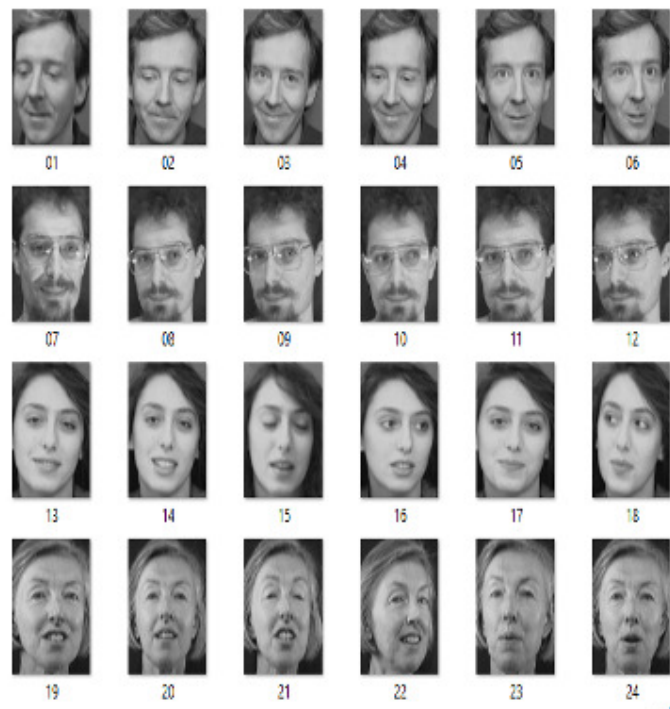
Figure 1: Process flow of the Feature Dimensionality Reduction Technique for Face Recognition System

7. EXPERIMENTAL SETUP

The locally acquired face database (LAFDAB) contains photographs of 130 randomly selected students of Kwara State University, Malete, Nigeria. The pictures were captured between October 2013 and July 2014, with HD genx 300 Camera. There are 6 different images per subject, giving a total of 780 coloured (RGB) faces having a resolution of 1080x1920. The images were taken with variation in upright position, frontal and tolerance of some tilting and rotation of about 13 degrees. There were variations in facial expression, closed eyes, glasses worn, presence of mustache, illumination variation and occlusion. The images from the subset of AT&T database used consists of 240 white faces of 40 subjects with 6 images per person, having a resolution of 92x112 pixels with 256 gray level per pixels. Figure 2 shows sample faces from the LAFDAB and AT&T respectively.



(a) faces from LAFDAB



(b) faces from AT&T

Figure 2: A sample faces from LAFDAB and AT&T

The face recognition system presented in this paper was developed, trained, and tested using MATLAB R2012a. The computer system used is a Windows professional edition with a 2.4 GHz Intel Core i3 processor, 64bit OS and 8 GB of RAM. The experiment carried out to evaluate the effects of varying the pixel resolution of the faces on the recognition time (RT) and recognition accuracy (RA) is shown in Table 1 and Table 2 respectively for the 2 datasets that were used for benchmarking in this research.

192 **8. RESULT AND DISCUSSION**

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194 The technique was simulated in MATLAB on locally acquired face database (LAFDAB)
195 as well as AT&T face database. The results obtained are shown in Tables 1, 2 and 3
196 respectively for average training time, average recognition time and average recognition
197 accuracy.

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199 **Table 1: Result of Training Time obtained using the developed technique**
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IMAGE RESOLUTION	TOTAL TRAINING TIME (SECS)		AVERAGE TRAINING TIME (SECS)	
	LAFDAB	AT&T	LAFDAB	AT&T
40X40	118.44	20.03	0.247	0.145
50X50	213.28	42.34	0.444	0.302
60X60	301.19	55.86	0.627	0.399
70X70	417.16	71.96	0.869	0.514
AVERAGE			0.547	0.340

201 Number of images in training set – LAFDAB = 480, AT&T = 140

202
203
204 **Table 2: Result of Recognition Time obtained using the developed technique**
205

IMAGE RESOLUTION	TOTAL RECOGNITION TIME (SECS)		AVERAGE RECOGNITION TIME (SECS)	
	LAFDAB	AT&T	LAFDAB	AT&T
40X40	48.08	12.13	0.160	0.121
50X50	59.13	15.85	0.197	0.159
60X60	71.18	19.07	0.237	0.191
70X70	90.06	24.95	0.300	0.250
AVERAGE			0.244	0.180

206 Number of images in testing set – LAFDAB = 300, AT&T = 100

207
208 Recognition accuracy is obtained using equation 1. From Table 3, 300 face images of the
209 LAFDAB were tested using the technique and a recognition accuracy of 98.08% was obtained.
210 Also 100 face images of AT&T tested gave 95.00% recognition accuracy. It can be seen from
211 the table that the technique performs well on both databases

212
213 **Recognition Accuracy** = $\frac{\text{total number of correct recognition}}{\text{total number of tested faces}} \times 100$ (1)

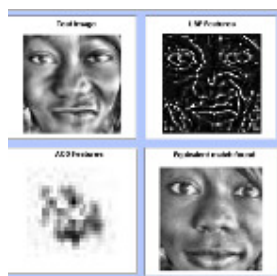
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218 **Table 3: Recognition Accuracy (RA) of the developed technique on LAFDAB and AT&T**
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IMAGE RESOLUTION (PIXELS)	LAFDAB					AT&T					
	TP	FN	TN	FP	RA	TP	FN	TN	FP	RA	
40X40	238	2	59	1	99.00%	69	1	28	2	97.00%	
50X50	237	3	59	1	98.67%	67	3	28	2	95.00%	
60X60	235	5	58	2	97.66%	66	4	29	1	95.00%	
70X70	232	8	59	1	97.00%	64	6	29	1	93.00%	
AVERAGE					98.08%	AVERAGE					95.00%

220 Total numbers of positive samples tested are 240, Negative samples are 60 (LAFDAB) Total 300
 221 Total numbers of positive samples tested are 70, Negative samples are 30 (AT&T), Total 100
 222

223 Figures 2, 3, 4 and 5 show the sample graphical user interface in MATLAB results
 224 obtained by simulating the technique on LAFDAB and AT&T respectively. From a query face,
 225 the local binary pattern is obtained, the optimal feature subset and the image in the database
 226 corresponding to the test face is displayed as the equivalent match found which indicates a
 227 recognized face as shown in Figures 2 and 4. There are very few cases of mismatch whereby
 228 equivalent image displayed does not indicate a correct match as shown in Figures 3 and 5.
 229 This was also revealed previously in Table 3.
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 233 **Figure 2: LAFDAB Face correctly recognized**
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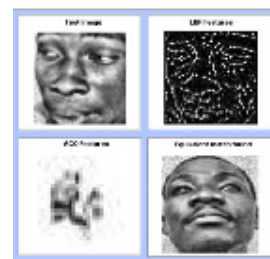
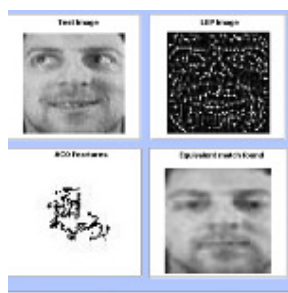


Figure 3: LAFDAB Face incorrectly recognized



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 237 **Figure 4: AT&T Face correctly recognized**
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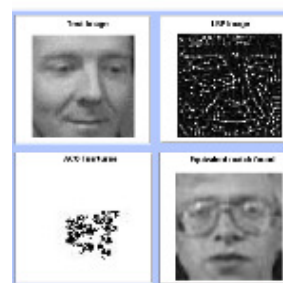


Figure 5: AT&T Face incorrectly recognized

241 8. CONCLUSION AND FURTHER WORK

242 In this research, a local binary pattern and ant colony optimization (LBPAO) based
 243 feature dimensionality reduction technique was developed for face recognition system. The
 244 technique extracted local patterns from a face image using an advanced image processing

technique called texture analysis. From this texture, ACO was used to obtain the salient features from the face image. These were done to reduce the dimension of features in a face for efficient recognition. The performance of ACO was optimized by LBP in a two-level form. The results of the experiment revealed that the two-level algorithm (LBP-ACO) is a very good combination with very high performance that produced a robust and reliable face recognition system.

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