RESEARCH ARTICLE

Enhancement of LBP-Based Face Identification System by Adopting Preprocessing Techniques

Raafat Salih Muhammad[1], Mohammed Issam Younis[1*]

Abstract: Face identification system is an active research area in these years. However, the accuracy and its dependency in real life systems are still questionable. Earlier research in face identification systems demonstrated that LBP based face recognition systems are preferred than others and give adequate accuracy. It is robust against illumination changes and considered as a high-speed algorithm. Performance metrics for such systems are calculated from time delay and accuracy. This paper introduces an improved face recognition system that is build using C++ programming language with the help of OpenCV library. Accuracy can be increased if a filter or combinations of filters are applied to the images. The accuracy increases from 95.5% (without applying any filter) to 98.5% when applying a combination of Bilateral filter, Histogram Equalization and Tan and Triggs Algorithm. Finally, the results show degradation in accuracy and increasing in recognition time if images database get bigger.

INTRODUCTION

A biometric system is an identification system that is capable of recognizing people identity from their physiological and/or biological properties. [1-2] It is used to recognize person's identity or to verify a claimed identity. The need for biometric systems is increased because it offers a very high security. [2-3]

Biometric systems have gained researchers' attention because they do require the presence of the person to be identified at the point of identification, so they are more reliable than traditional passwords and PINs and do not allow for impersonation. [1, 4] Biometric systems fall into two main categories: physiological and behavioral as shown in Figure 1. [5] The physiological biometric systems are depending on fixed physical characteristics of the human and they are: face recognition, iris, fingerprints, DNA, hand and palm geometry. While behavioral biometric systems are depending on changing behavior of a human. They are: voice recognition, signature and keystroke. Each of these systems has some advantages and drawbacks. [1-6] As such, the use of each system is application and environment dependent.

Fingerprints are more acceptable by people than other types of biometric systems and they are accurate and require for special and expensive scanners to operate. [2, 7] However, fingerprints do involve the interaction of the human with the system and hence, it would not be an automatic system. [5, 6] Also, it is a very short distance system and requires a physical contact between the system and humans. [6] Some of the people prefer not to physically been in contact with such exposed systems to avoid germs and dirt. [5-8]

While iris recognition is very accurate, but it is not widely used and not very acceptable by the people and it is very expensive. [5] Besides it does have the same properties of the fingerprints about the distance and contact. [2, 5-7]

Whereas face recognition is a good compromise between the previous two biometric systems, it is well accepted by people and provides good accuracy. [1, 5, 7] Face recognition has some advantages over other biometric approaches. One of these advantages is that face recognition system is automatic, hence, it does not require any physical contact between the person and the system and it is a long distance technology [6, 7, 9] Also, it does not require an expensive equipment such as accurate sensors. [2, 6]

A biometric system can be either a verification system or identification system. [2, 4] A verification system has a one-to-one (1:1) relation to determine if the present person is the one he claimed to be and hence, verifying his identity. An identification system has a one-to-many (1:N) relation to determine if the presented person is in the list of known entries and the system gets his identity. [2, 4]

RELATED WORK

Many works and experiments have been done in the field of face recognition in the history. A lot of techniques were used to get a system with high performance. The researchers were trying to get a high speed and accurate system. Some of those researchers worked on Holistic methods and others have worked on local features methods.

Rahim *et al.*, [10] measured the performance of LBP method on 2000 face images with different parameter-values such as radius and neighboring samples.

Maturana *et al.*, [11] used LBP operator with different recognition schemes: Ahonen, Spatial Pyramis Matching (SPM), Naive Bayes Nearest Neighbor (NBNN) and Restricted Naive Bayes Nearest Neighbor (RNBNN) algorithms. The experiment has been performed with and without applying Tan and Triggs preprocessing algorithm on 4 different datasets: AT and T-ORL, Yale, Georgia Tech and Extended Yale B.

Ahonen *et al.*, [12] did a comparison between LBP method and other local descriptors in recognition rate namely: difference histogram, an improved version of texton histogram and a homogeneous texture descriptor. The FERET dataset is used as input images. The results show that the LPB (non-weighted) has the highest recognition rate and very robust against monotonic gray scale changes. In addition, the results show that LBP (weighted and non-weighted) has the highest recognition rate when compared

[1]Department of Computer Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq.
E-mail: younismi@gmail.com
*Corresponding author

Published on Web 15/07/2017, www.inventi.in

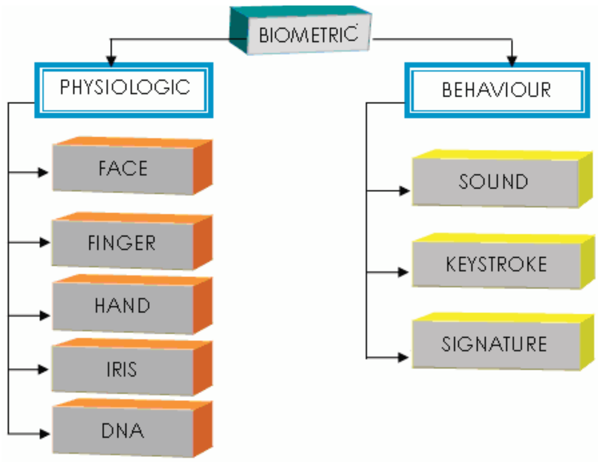

Figure 1: Biometric systems categorization [3]

among the control algorithms namely: PCA, EBGM and Bayesian algorithms.

Jain *et al.*, [1] developed a real-time medium size automatic personal identification system called F2ID that works by combining face recognition and fingerprints. The system uses face recognition for identification and fingerprint for verification. The main goal was to achieve good accuracy with acceptable response time.

FACE RECOGNITION

Face recognition process passes through three phases. They are as follows:

1. Face Detection
2. Feature Extraction
3. Face Recognition or Classification

There are many factors that affect the accuracy of face recognition process such as change in pose, illumination and age. Some of these factors can be controlled to some extent in software and some image preprocessing, others, such as aging, are very difficult to handle. [7, 13]

Face Detection

The operation of finding a face in an image is called face detection. There are so many techniques and algorithms to find a face in an image. Old techniques are very slow and unreliable. [13] In 2001, there was a significant change in Face Detection field when Viola and Jones have introduced the Haar-based cascade classifier. [14] The introduced classifier can detect faces in real time with very high accuracy (about 95%). [15]

Viola-Jones face detector algorithm search for a face in an image, then crop it and divide the face in three main section, upper, middle and lower sections. These sections correspond to the eyes and eyebrows, nose and mouth respectively. [14]

After the detection of the face, features that characterize this face must be extracted, hence, one of the feature extraction methods is applied. [13]

Feature Extraction

Feature extraction is the most important step in face recognition. It is the step that extracts the main features from an image so the image can be identified from these features. [16] There are many techniques to do so, each with its advantages and disadvantages. Feature extraction methods can be classified into three classes, Holistic methods, Local feature-based methods and Hybrid of the two methods. [13, 16, 17, 18] Holistic methods are treating the whole image as an input to recognition step while Local features methods are considering the important pixels from the image like eyes, eyebrows, nose and mouth methods. [13, 16, 17]

After the extraction of the features, these features are used in classification /recognition process.

1. Holistic Extraction

Holistic feature extraction method is a very common method that treats all face region as input data to face recognition system. There are many algorithms fall into this category such as Principal Component Analysis (PCA) using eigenfaces, Linear Discriminant Analysis (LDA) and independent component analysis (ICA) etc. [5, 18, 19]

2. Featured-Based Extraction

Featured-Based extraction method depends on some specific data in a face image. It processes the face image before using it in face recognition. [5, 18, 19] Any local extraction feature method locates some distinctive locations in a face image and extracts them like nose, mouth, eyes and eyebrows. Then, it computes the distance between those locations and their size. [5, 18, 19] One example of Local Feature Extraction method is Local Binary Pattern method. [16]

a. Local Binary Pattern Histogram

It is one of the most well-known methods used in feature extraction. It is fast, hence computational efficient, robust against facial expressions and different light conditions. All of that is because of the way it describes images. [12]

LBP operator is introduced by Ojala T *et al.*, [20] and is working only on a grayscale image with each pixel of 8-bit size. The LBP operator is found by considering a pixel value as a threshold to all its neighbors, if the neighbor pixel value (gray value) is less than the center pixel then a zero value is assigned to this neighbor pixel, else one is assigned. The LBP code for the center pixel is then computed by

Published on Web 15/07/2017, www.inventi.in

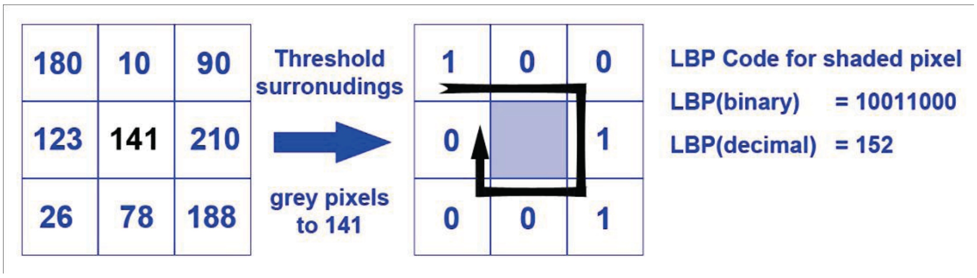

Figure 2: $LBP_{8,1}$ operator

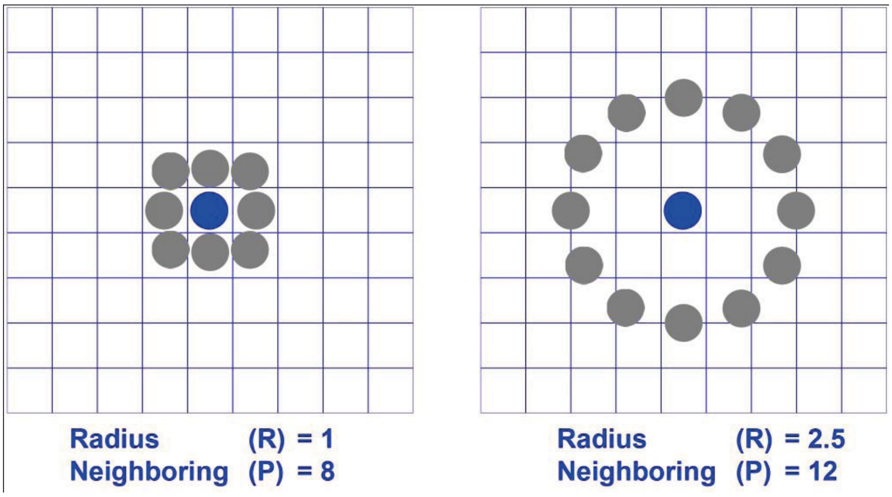

Figure 3: General $LBP_{P,R}$ operator with three different values for P and R parameters

combining all eight 1's and 0's in a clockwise direction starting from the upper left value forming one-byte value that ranges from 0-255. This LBP operator is called the original or basic LBP operator and written as $LBP_{8,1}$, illustrated in Figure 2. [10, 16]

Then, a more general operator has been introduced. This operator is denoted by $LBP_{P,R}$, R is denoting to the radius of a circle with the center pixel as its center and P is denoting to the number of neighboring pixels lays on the edge of the circle that is used to calculate the LBP code. To use this operator with any set of P and R, a bilinear interpolation must be performed. [10, 12, 17] Figure 3 illustrates this operator.

To find the coordinates of the P neighbors, simple math is required. Let (X_c,Y_c) is the coordinates of the center pixel, then a neighbor pixel coordinates (X_p,Y_p) that are lay on the edge of a circle (having the center pixel as its center and R as its radius) is found as follows:

$$X_p = X_c + R \cos\left(2\pi\, p/_P\right) \qquad (1)$$

$$Y_p = Y_c + R \sin\left(2\pi\, p/_P\right) \qquad (2)$$

With p = 1, 2, 3, ..., P-1.

In order to calculate the texture (***T***) of the pixel (X_c,Y_c) or (the LBP code), the same idea of basic LBP operator is followed. First, comparing every neighbor pixel value with the center pixel value, higher (or equal) result set to one, else zero is assigned.

$$T = \left(s(V_0 - V_c), s(V_1 - V_c), s(V_2 - V_c), \ldots, s(V_{P-1} - V_c)\right) \quad (3)$$

Where V_i refers to the gray value of the i'th pixel and ***s*** is the sign function:

$$s(x) = \begin{cases} 0 & x < 0 \\ 1 & x \geq 0 \end{cases} \qquad (4)$$

By letting

$$T = t_0, t_1, t_2, \ldots, t_{P-1} \qquad (5)$$

We can now easily calculate the LBP operator for (X_c,Y_c) pixel as follows:

$$LBP_{P,R}(X_c, Y_c) = \sum_{p=0}^{P-1} t_p\, 2^p \qquad (6)$$

This $LBP_{P,R}(X_c,Y_c)$ operator describes the texture of the pixels surrounding the center pixel (X_c,Y_c). [10, 20]

An enhancement can be done to the LBP operator if only a uniform patterns are used and then a superscript of u2 is added to the operator notation, it becomes $LBP^{u2}_{(P,R)}$. [10-12, 16] Uniform patterns are bit-patterns that have no transition in the bits sequence or two transitions at most. [12] There are only two patterns with no transitions, all ones and all zeroes. And for two transitions, it depends on the bit-length of the pattern, if we have a pattern with a P bits length then P(P-1) combinations are uniform patterns. [10]

The advantage of using only uniform patterns is to reduce the histogram length and hence save more space. [10] For a 10 bits length pattern, we have 2^{10} =1024 different patterns. Only 92 patterns are uniform (10 (10-1) = 90 patterns for two transitions at most and 2 for no transitions

Table 1: Preprocessing Methods Used in Experiment

Method	Description
Bilateral Filter	Used for noise filtering by reducing unwanted noise and keeps sharp edges [21]
Histogram Equalization	Improves the contrast of an image by starching the intensity range [22]
Tan and Triggs Algorithm	Helps to reduce the illumination effect [23]

Table 2: A Combination of Applied Preprocessing Methods

Preprocessing No.	Preprocessing Type
0	Original input image (no filter is applied)
1	Bilateral Filter
2	Histogram Equalization
3	Bilateral Filter + Histogram Equalization
4	Tan and Triggs Algorithm
5	Bilateral Filter + Tan and Triggs Algorithm
6	Histogram Equalization + Tan and Triggs Algorithm
7	Bilateral Filter + Histogram Equalization + Tan and Triggs Algorithm

Figure 4: Example of all preprocessing effects on an image

at all) and 1024-92 = 932 are non-uniform. [11] Another advantage is that the uniform patterns is describing only the important features like edges and corners, so the unimportant features will be neglected. [10]

The researcher has used LBPH because of its properties of robustness against illumination and pose changes and it is considered as fast algorithm. Also, it is easy to update a pre-trained system with LBPH, such as adding new subject to the system or deleting a subject from the system without the need for any recalculation process.

b. Recognition Process Using LBP

The feature vector of an image can be found after calculating LBP operator to each pixel in the image. In this technique, the face image is divided into several regions, then features will be extracted from those small regions. [12] Features are represented in binary patterns, each of these binary patterns is describing the surrounding of a pixel. Then a histogram of all possible patterns in a region is calculated, hence, it is called Local Binary Pattern Histogram (LBPH). Histogram of 59 pins is calculated if uniform patterns are used (56 pins for two transitions at most + 2 pins for no transition + 1 pin for all other non-uniform patterns) and 256 pins if non-uniform. The recognition is then done by measuring the chi-square distance between images histograms and the input face image histograms. [10-12]

Face Recognition / Classification

After an input image has been acquired and feature extraction process has been applied to the input image, a classification or recognition process must take place in order to classify the input image as a valid identity or not. [13]

Face Recognition step goes in one of two ways, identification or authentication. In the first one, a comparison is done between with the input face image and all database entries that hold facial data about previously collected faces. The system with a controllable threshold responds either with the most-like face in the database or didn't find a match in the database. While in Authentication, a new face image is being claimed with an identity, so this input face image is compared with the database entry corresponds the claimed person. The system will confirm the identity or reject it. [5, 13]

DESIGN AND IMPLEMENTATION

The Improved Face Recognizer (IFR) system in this paper uses LBPH algorithm as feature extraction method with no enhancement on the used recognition method itself. Instead, the enhancement has been done on the input image before it enters to the recognition system. This is done by applying some preprocessing techniques to the input image (i.e. adding filters) that improve its quality and reduce the noise. The system uses one of three filters or a combination of those filters. Filters and their description are illustrated in Table 1 and the combinations of filters are listed in Table 2 with their effect shown in Figure 4.

The system must be trained on each new subject with several images to get sufficient data for recognition process. Good training images should have different pose, illumination and emotions. A filter (or a combination of filters) can be applied to the training images before the training process. So that the system will be trained on the preprocessed training images. To have better performance, it is necessary to use the same filter (or same combination) in the training and testing images.

Table 3: Host Machine Specifications

Item Name	Type and Model
Processor	Intel(R) Core(TM) i7-2630QM CPU @ 2.00GHz (8 CPUs), ~2.0GHz
Memory	8192 MB RAM
Operating System	Windows 10 Pro 64-bit (10.0, Build 10240) (10240.th1.160104-1507)
Graphics card	NVIDIA GeForce GT 525M
Graphics card memory	4045 MB (Dedicated 973 MB, Shared 3071 MB)

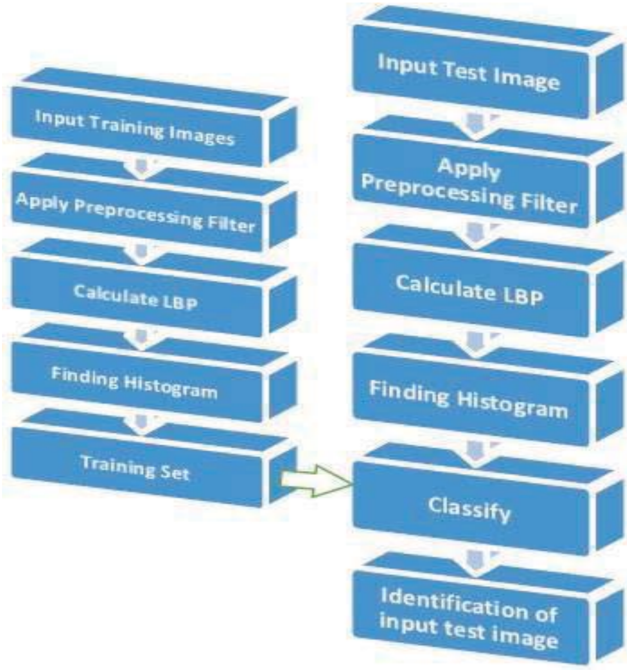

Figure 5: IFR System Flow

When applying a new face image to the pre-trained system, the system will classify the input image into one of known classes, hence the identification process happens.

The system has been written in C++ programming language and build using Microsoft Visual Studio 2010 with the use of OpenCV library, running on Windows 10 on a machine with specifications listed in Table 3.

The overall IFR system flow is depicted in Figure 5.

EXPERIMENTS

An experiment was done on AT and T-ORL dataset which consists of 40 subjects, each subject has 10 images, each image is a 92 × 112 pixels. The AT and T-ORL dataset has been chosen because this dataset has images that have a different variation in pose and illumination, with and without wearing glasses, so it would be perfect dataset to give different situations for each subject.

The experiment was performed eight times, each with a different preprocessing method mentioned early in Table 2. All of these eight experiments have used $LBP_{8,1}$ and input images have been divided into (4 × 4) regions as shown in Figure 6.

All experiments used the same number of training-set (5 images per person as training images) but with a different preprocessing method for each experiment according to Table 2. The system uses other 5 images per subject as testing-set with the same preprocessing method as training images had.

The first experiment was to train the system with 5 images per person (5 × 40) without applying any preprocessing method. Then, apply the rest 5 images per person to the system to be identified without applying any preprocessing filter too. This experiment was repeated another 7 times, each with different preprocessing method listed in Table 2, from preprocessing No. 1 to No. 7.

It is necessary to mention that in all of these 8 experiments, almost the same database size is used which consists of just 200 training images (5 images per subject). And this number is relatively low when comparing to organizations with hundreds or maybe thousands of employees, hence, the database would be much bigger. So, to study the effect of database size and its relationship to time delay, database read time and input image recognition time must be calculated.

AT and T-ORL database consist of 40 subjects. In order to measure the database size effect, the next experiment was to take parts with different sizes of AT and T database as a complete set (training and testing images). First, 10 subjects will be used instead of 40, then 20 and finally 30 subjects. These results are compared with the full database of 40 subjects.

RESULTS

After applying each preprocessing method to the input images, the results of the first experiment were gained. There were only 9 images out of the 200 test images were

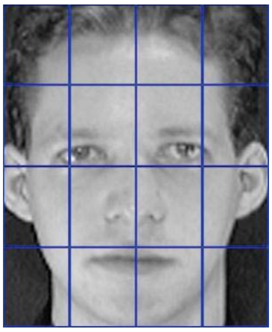

Figure 6: Input image is divided into 16 regions (4×4)

Table 4: Experiment on Different Preprocessing Methods and Corresponding Accuracies – 40 Persons Were Used

Preprocessing	Accuracy (%)
0	95.5
1	95
2	92.5
3	94.5
4	96.5
5	95.5
6	97.5
7	98.5

Table 5: Accuracies and Time Delays for Various Database Sizes of AT and T Database without Applying any Preprocessing Method on Both Training and Testing Images

Exp. No.	No. of Persons	Accuracy (%)	Average Recognition Time	Database Read Time
1	10	100	2.8 ms	90 ms
2	20	99	4.2 ms	170 ms
3	30	97.33	5.5 ms	260 ms
4	40	95.5	9 ms	360 ms

classified incorrectly and an accuracy of 95.5% has been gained when applying no preprocessing method. So, this accuracy would be the base for evaluating system performance. Then, applying all of the preprocessing methods as listed in Table 2. Results of all experiments are shown in Table 4.

Accuracy, average recognition time and database read time were calculated then. Table 5 shows the results gained from changing database size for only the first case of Table 4 (without applying any preprocessing to the input images).

DISCUSSION

System performance was calculated according to two metrics: accuracy and time delay. The system performed well in the experiment on 40 persons (all of the AT and T database are used), the average recognition time was 9 ms and the overhead for reading the database at system startup was 360 ms. The original accuracy was 95.5% which means there are 9 mispredictions out of 200 input test images. Degradation in accuracy was gained after applying a single filter (Bilateral Filter or Histogram Equalization) or even applying a combination of those two filters. But the case was different when applying Tan and Triggs filter, it raises the accuracy to 96.5% (7 mispredictions) when being applied alone. Another raising in accuracy can be seen in Table 4 when combining Tan and Triggs filter with Histogram Equalization, it gives an accuracy of 97.5% (5 mispredictions). The best accuracy of 98.5% (only 3 mispredictions) was produced when applying all filters together (Bilateral Filter and Histogram Equalization and Tan and Triggs filter).

Parts of AT and T database was used in another experiments without using any filters. An accuracy of 97.33% was produced when 30 persons are used. The database read time was 260 ms and average recognition time was 5.5 ms. For only 20 persons, the accuracy was 99% and database read time was 170 ms with average recognition time of 4.2 ms. Finally, 10 persons were used and the produced accuracy was 100% with database read time of 90 ms and average recognition time of 2.8 ms.

CONCLUSION

After observing the results, it was clear that the accuracy and time delay are database size dependent. As database size increases, accuracy will decrease and time delay will increase. This happens because of a bigger database is having more data to be compared with the input face image, hence, it takes more time. In addition, a bigger database allows for more similarity between subjects of different classes (miss prediction) and this explains the degradation of accuracy.

Average recognition time is an important factor in real-time applications such as access control systems. It is negligible with a small database like 40 persons, but from Table 5 it is clear that the average recognition time is increasing with database size and at some point if the database gets bigger the recognition time will not be sufficient for real-time applications and will slow down the system.

According to the results, further research is needed to reduce or eliminate the effect of database size on accuracy and time delay.

REFERENCES

1. Jain A, Hong L, Kulkarni Y. F2ID: A personal identification system using faces and fingerprints. In Proceedings of the 14th IEEE International Conference on Pattern Recognition. Australia, 1998.
2. Bhatia R. Biometrics and face recognition techniques. International Journal of Advanced Research in Computer Science and Software Engineering, 3(5):93-99, 2013.
3. Abdul Kadir A, Abd Wahab M H, Tukiran Z, Tomari M R M, Razali M, Mohd M N Hj. Fusion of radio frequency identification (RFID) and fingerprint in boarding school monitoring system (BoSs). In Sustainable Radio Frequency Identification Solutions. InTech, 139-158, 2010.
4. Tripathi K. A comparative study of biometric technologies with reference to human interface. International Journal of Computer Applications, 14(5):10-15, 2011.
5. Jafri R, Arabnia H R. A Survey of face recognition techniques. Journal of Information Processing Systems, 5(2):41-68, 2009.
6. Patel U A, Priya S. Development of a student attendance management system using RFID and face recognition: A Review. International Journal of Advance Research in Computer Science and Management Studies, 2(8):109-119, 2014.
7. Abate F A, Nappi M, Riccio D, Sabatino G. 2D and 3D face recognition: A survey. Pattern Recognition Letters, 28(14):1885-1906, 2007.
8. Jaber Z Q. Paralleizing face identification system based on multi-cores CPU and GPU. MSc thesis, Computer Engineering Department, University of Baghdad, Baghdad, 2014.
9. Kotkar M D, Lokhande M P, Nikam M P. Combined RFID-biometric based MIS for student information. International Journal of Engineering Trends and Technology, 4(3):307-310, 2013.
10. Rahim M A, Azam M S, Hossain N, Islam M R. Face recognition using local binary patterns (LBP). Global Journal of Computer Science and Technology, 13(4), 2013.
11. Maturana D, Mery D, Soto A. Face recognition with local binary patterns, spatial pyramid histograms and naive bayes nearest neighbor classification. In International Conference of the Chilean Computer Science Society. Santiago, TBD, Chile, 2009.
12. Ahonen T, Hadid A, Pietikainen M. Face description with local binary patterns: Application to face recognition. IEEE Transactions on Pattern Analysis and Machine Intelligence, 28(12):2037-2041, 2006.
13. Zhao W, Chellappa R, Phillips P J, Rosenfeld A. Face recognition: A literature survey. ACM computing surveys (CSUR), 35(4):399-458, 2003.
14. Viola P, Jones M J. Robust real-time face detection. International Journal of Computer Vision, 7(2):137-154, 2004.
15. Baggio D L. Mastering open CV with practical computer vision projects, Packt Publishing Ltd, Mumbai, 2012.
16. Sarfraz M S, Olaf H, Zahid R. Feature Extraction and Representation for Face Recognition. In Face Recognition. InTech, 2010.
17. Rouhi R, Amiri M, Irannejad B. A review on feature extraction techniques in face recognition. Signal and Image Processing: An International Journal (SIPIJ), 3(6), 2012.
18. Parmar D N, Mehta B B. Face recognition methods and applications. International Journal of Computer Technology and Applications, 4(1):84-86, 2014.
19. Pardeshi S A, Talbar S N. Local feature based face recognition. Face analysis, modeling and recognition systems. InTech, 53-78, 2011.
20. Ojala T, Pietikainen M, Maenpaa T. multiresolution gray-scale and rotation invariant texture classification with local binary patterns. IEEE Transactions on Pattern Analysis and Machine Intelligence, 24(7):971-987, 2002.
21. Tomasi C, Manduchi R. Bilateral filtering for gray and color images. In Proceedings of IEEE Sixth International Conference on Computer Vision. Bombay, India, 1998.
22. Patel O, Maravi Y P, Sharma S. A Comparative study of histogram equalization based image enhancement techniques for brightness preservation and contrast enhancement. Signal and Image Processing: An International Journal, 4(5):11-25, 2013.
23. Tan X, Triggs B. Enhanced local texture feature sets for face recognition under difficult lighting conditions. IEEE Transactions on Image Processing, 19(6):1635-1650, 2010.

Cite this article as: Raafat Salih Muhammad, Mohammed Issam Younis. Enhancement of LBP-Based Face Identification System by Adopting Preprocessing Techniques. Inventi Impact: Image & Video Processing, 2017(2):68-74, 2017.