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FACE IMAGE RECOGNITION BASED ON PARTIAL FACE MATCHING USING GENETIC ALGORITHM

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ABSTRACT- In various real-world face recognition applications such as forensics and surveillance, only partial face image is available. Hence, template matching and recognition are strongly needed. In this paper, a genetic algorithm to match a pattern of an image and then recognize this image by this pattern is proposed. This algorithm can use any pattern of an image such as eye, mouth or ear to recognize the image. The proposed genetic algorithm uses a small length chromosome to decrease the search space, and hence the results could be obtained in a short time. Two datasets were used to test the proposed method which are AR Face database and LFW database of face, the overall matching and recognition accuracy were calculated based on conducting sequences of experiments on random sub-datasets, where the overall matching and recognition accuracy was 91.7% and 90% respectively. The results of the proposed algorithm demonstrate the robustness and efficiency compared with other state-of-the-art algorithms.

المستخلص–في كثير من تطبيقات التعرف على الوجه جزء فقط من الوجه يكون موجود، لهذا مطابقة القالب والتعرف بواسطة القالب نكون في أمس الحاجة اليها، في هذا البحث، خوارزمية جينية للتعرف والتطابق باستخدام القالب قد قدمت. هذه الخوارزمية يمكنها ان تستخدم أي جزء مثل العين، الفم، او الاذن لتتعرف على الصورة المطلوبة. الخوارزمية المطروحة تستخدم كرموسوم طوله قصير لتقليل المساحة التخزينية المستخدمة، وهذا يزيد من سرعة الخوارزمية. لقد تم استخدام اثنين من قواعد بيانات صور الوجوه وكانت دقة نتائج التطابق والتعرف حسبت بناء على التعامل مع مجموعة عشوائية جزئية من قواعد الصور, وكانت دقة المطابقة والتمييز الكلية تساوي 91.7% و 90% لكل قاعدة صور, هذه النتائج توضح كفاءة و ثبات و جودة الخوارزمية المقدمة مقارنة بخوارزميات اخري متميزة.

Keywords:*Partial Face Matching and Recognition, Genetic Algorithm.*

INTRODUCTION

Identifying a face in an image is called face recognition. Biometric systems for personal verification in the case of human-computer interaction like surveillance systems have used face recognition massively. Because of that, face recognition algorithms performance and methodologies have received high considerations. Although Face recognition under controlled condition has achieved quite good results, on the other hand, uncontrolled situations still have many challenging problems [1, 2].

In many unconditional situations of face recognition applications, the face might be captured without user involvement. In these cases, the captured image many contain a portion of the objected face, or in other cases, the captured image may be subject to noised data like overexposing, shading, non-frontal pose, or/and facial association. This problem is called partial face recognition [2, 3].

Commercial face recognition systems usually fail to deal with partial face recognition problem. This is due to the fact that these systems fetch faces by their landmark features. In addition, the run time efficiency of such systems in case of partial face recognition is not guaranteed [3].

Partial face recognition problem is a high complexity computational problem; therefore a heuristic randomized algorithm is a quite suitable candidate algorithm for solving the problem. Hence, in this research work, a genetic algorithm to solve such problem is introduced [2, 4].

Genetic Algorithms (GAs) are considered fast if compared to other methods in finding the nearest optimal solution in a neighborhood. This fact has been proved by investigating and applying them on many optimization applications. These algorithms could be used in many phases such as image processing, pattern recognition, image segmentation, contour recognition and image registration [5-15].

Harguess and Aggarwal[16] have exploited human face symmetry in face recognition. However, bottom-up and top-down face recognition combination methodology based on Markovian stochastic mixture has been introduced in [17].

In Brunelli and Poggio[18], two human face recognition algorithms have been introduced. The first is based on geometrical features calculation. It has taken features such as mouth position, nose width and length and chin shape in consideration. The second algorithm is based on matching to a gray-level template. However, face recognition process is based on the face contents. 19 features have been extracted to be recognized in human face [19]. Eye spacing has been taken as an important feature in face recognition in [20].

The main Eigen space-based approaches have been introduced and compared to each other in [21]. Perpetual and cognitive components have been combined in an approach introduced by Burton et al., [22].

Kour, in [23], has introduced a face image preprocessing wavelet transformation methodology. A simulation using ORL database has been performed. The database contains some PGM images. The proposed algorithm is expected to increase the existing face recognition algorithms robustness.

Dekel et al., [24] have worked on unconstrained environments. They have proposed a template matching novel method in unconstrained environments. They have used the Best-Buddies Similarity (BBS) which is a parameter-free and robust similarity measure approach. The mechanism of such approach is based on having two sets of points; source and target sets; in which each point is the nearest neighbor of the other. BBS has many robust features such as background clutter and occlusions based ones.

A new face detection hybrid algorithm FPBL (Fuzzy Pattern-Based with Laplacianfaces) has been introduced by Tiwari and Lade [25]. The main goal of the algorithm is the enhancement of the true recognition rate and minimization of the false recognition rate. A comparative study has been performed among existing pattern matching and face recognition algorithms such as Fisherfaces, Eigenfaces, Laplacianfaces and Fuzzy method with FPBL. According to their results, FPBL has proven better performance than other approaches.

Nikan and Ahmadi[3] have introduced a template matching based partial face recognition strategy. The strategy is based on a template matching technique that finds face parts on the database gallery samples that matches the best to the partial image. The partial probe face identity is defined by applying feature extraction and classification techniques on the small sub images of the probe and gallery sets. The proposed approach performance has been measured by applying it on AR, LFW and FERET databases. In template matching process, Normalized Sum of Squared Difference (NSSD) outperforms Zero mean Normalized Cross Correlation (ZNCC). According to the obtained results, best recognition accuracy has been obtained in partial eyes images.

Hisham et al., [26] have made a comparative study between the Sum of Squared Differences (SSD) and Normalized Cross Correlation (NCC) image registration techniques. The study has focused on two main factors namely; the output image quality and the execution time. Moreover, they have taken the input image noise and rotation effect to output image.

Fouda in [27] has introduced a robust template matching algorithm based on reducing dimensions. The algorithm is composed of three main steps. First, convert the 2-D images into 1-D imaging. This is performed by summing up the image intensity values of in two directions horizontal and vertical. Second, square difference similarity function sum is used to match the templates among 1-D vectors. Finally, the decision is taken based on the value of similarity function. The image conversion to 1-D information vector reduces the dimensionality of the data and accelerates the computations according to the results obtained.

The main objective of this research work is to design and develop a face recognition algorithm based on matching partial face patterns using a genetic algorithm. A face will be recognized by any pattern such as eye, nose, ear or lip …etc. of that face. The proposed genetic algorithm parameters are structured and designed to reach an efficient fast algorithm. Figure 1 shows examples of the used AR [28] and Labeled faces in the wild (LFW) [29] database images.

It is assumed that an image has a space S of length M in the X-direction and N in the Y direction. Moreover, it is assumed that the unknown pattern has a space P of length K in the X-direction and L in the Y-direction, under the condition that K<M and L<N as shown in Figure 2. The pattern P is to be matched with all patterns of each image in the database file, hence the image is recognized. Moreover, a point (X,Y) is searched for in the image space S of each image to determine the pace of size X+K and Y+L that matches the pattern.

MATERIALS AND METHODS

The techniques using traditional methods in charge of several objective functions (such as correlation function, and the function of the difference between the square spaces) for the purpose of matching images consume a lot of time as well as being impractical in many applications. The genetic algorithm can use iterative way to solve these types of problems as it is suitable to solve problems that are difficult to be solved using traditional methods. The genetic algorithm is very suitable for optimization issues of the large search space, including the problem of matching images

In this problem, it is considered that the sizes of the images in the database file are equal to 256x256. In the proposed genetic algorithm (GA), each solution represent a position (X,Y) in the space of an image. The position (X, Y) is represented by a binary string that can be used as a chromosome. The elements number of the chromosome (chromosome length) is equal to 16 bits, 8 bits for X co-coordinate and 8 bits for Y co-coordinate. The chromosome form of the solution is given in figure 3.

a. The Initial Population

In theinitialpopulation, the proposed algorithm will generate 20 chromosomes as a population size (pop_size). Each chromosome isgeneratedas follows:

1. Thechromosomecanbe generatedas showninFigure3.
2. Thechromosomemustcontain at least twononezeroelements (one in X and other in Y co-coordinate).

b. Fitness function

To evaluate the quality of all the proposed solutions in the current population, a fitness function is used in each iteration of the genetic algorithm. That is; the fitness function is used as a filtering function. Here, the fitness function will check this position $(X+K, Y+L)$, if it is included in S or not as follows:

$$(X+K, Y+L) \in S$$

c. Compute the position (X, Y)

If the above chromosome in the figure 3 is considered, then, the following steps show how to compute the position (X, Y):

$$X = 1*2^0 + 1*2^1 + 1*2^2 + 0*2^3 + 1*2^4 + 1*2^5 + 0*2^6 + 0*2^7$$

$$X = 1 + 2 + 4 + 0 + 16 + 32 = 55$$

$$Y = 0*2^0 + 0*2^1 + 0*2^2 + 1*2^3 + 1*2^4 + 1*2^5 + 0*2^6 0*2^7$$

$$Y = 0 + 0 + 0 + 8 + 16 + 32 = 56$$

Hence; the chromosome in the figure 3 represent the position (55,56).

d. Genetic Crossover Operation

Crossover is utilized to generate solutions (new chromosomes) by combining the two parents' information [30]. The crossover operator cuts the parents chromosomes randomly (at a number between 1 and 1c-1, where 1c is the length of the chromosome) then the crossover operator exchanges the segments that were cut [8, 15, 31]. The operation of single point crossover is shown in figure 4.

e. Genetic Mutation Operation

The mutation operation is performed on bit-by-bit basis. If the mutation ratio (Pm) is verified, the mutation operation is applied. The mutation ratio, Pm in this approach will be estimated randomly of value 0.02. The mutated point is selected randomly. The offspring generated by mutation is shown in Figure 5.

THE ALGORITHM

The proposed GA consists of number of steps that were executed automatically. The first three steps were applied to the pattern (P) as well as to the images in the database as shown in figure 6. Figure 7 below shows the steps of the proposed GA

EXPERIMENTAL RESULTS AND DISCUSSION

The proposed method was evaluated and tested using two datasets to prove it's superiority, which are AR [28] and LFW [29] Face databases using cropped eyes, mouth and nose patterns. AR database contains 2600 face images of one hundred individual (50% women and 50% men). Images were taken at two separate sessions in 2 weeks; each session consists of 13 images. In this work, gallery and probe sets contain 3 samples per subject with different facial expressions (anger, smile and scream). The samples were taken from session 1 and 2, respectively. LFW database images consist of 13,233 web-downloaded images. In this work, 20 subjects were randomly selected with 12 images and less than 30 degree pose variation. Gallery set includes the first 6 samples per individual and probe set contains the rest. AR and LFW databases are affected by partial occlusion, expression and variations in lighting.

Sequences of experiments are conducted in order to prove the effectiveness and feasibility of the proposed GA in image matching to recognize face images. Table 1 shows the parameters setting of the proposed genetic algorithm.

The performance of the proposed GA in matching and recognizing face images is tested using several images with one pattern from each image, face images are cropped to partial images of the mouth, eyes and nose. These face patterns are most distinctive and useful components and simply identifiable by human. Thus, this work used 2 different partial sets for each database. The size of the partial face image is 32*128 pixels. In the testing process, one partial image must be selected from an image, the selected partial image has to be matched with images in the database and the image that has the same pattern has to be recognized using the proposed genetic algorithm. Figure 8 shows some partial face images samples. Experiments were conducted using Matlab (2009a) on a laptop with an Intel® CoreTM i3-2350M Processor 2.30 GHz.

The obtained results of the proposed GA were compared with one of the state of the art template matching methods [3] using the same datasets. where the authors in [3]have introduced a template matching based partial face recognition strategy using AR and LFW databases. Figure 9 illustrates matching and recognition accuracy of mouth, eyes, and nose patterns using the proposed GA. The obtained results indicate that the higher recognition accuracy was obtained using the eyes pattern compared with the mouth and nose patterns. The results show the success and effectiveness of the proposed algorithm in pattern matching and recognition compared with [3], where the overall matching and recognition accuracy was 91.7% and 90% respectively.

Since the sub-dataset used in [3]is not determined exactly in their work, the overall matching and recognition accuracy were calculated based on conducting sequences of experiments on random sub-datasets in order to be comparative to the results obtained in[3]. Figure 10 shows the overall matching and recognition accuracy using the proposed methods.

Table 2 illustrates a comparison between the results obtained by the proposed method and the results in[3]. As shown in the table, the results of the proposed method for both datasets (LFW & AR) outperformed the results obtained by Nikan and Ahmadi in [3] based on eye, nose and mouth patterns.

Another experiment was conducted to evaluate the performance of the proposed pattern face recognition method using different pattern size. Experimentally; reducing the pattern size to 12% of the original pattern will significantly decreases the recognition accuracy. Figure 11 shows the obtained performance results using different pattern sizes.

Moreover; the performance of the proposed method has been compared with the most common template matching methods [32, 33], where the authors in [33] proposed a template matching for object recognition using Correlations and Phase Angle Methods. The authors in [32] introduced an object recognition method using template matching parameters. These recent methods tried to match a template with one given image that contains number of objects with different angles. Our proposed algorithm was superior to the previous methods in the since that it can match a template with huge number of images stored in the database and recognize the image that contains the most similar pattern.

CONCLUSION

This paper introduced a genetic algorithm to match a pattern (e.g., cropped eyes, mouth or ear) of an image within stored images in a huge database and then, the image is recognized by the pattern. The proposed genetic algorithm uses a small length chromosome to decrease the search space, and hence the results could be obtained in a short time. The proposed algorithm was superior to the previously proposed methods that it can match a template with huge number of images stored in the database and recognize the image that contain the most similar template. Where, the recent methods tried to match a template with one given image that contains number of objects with different angles. Two datasets have been used to test the proposed method which are AR Face database and LFW database of face, where the overall matching and recognition accuracy was 93.1% and 91.3 respectively.

REFERENCES:

[1] Alsmadi M. (2016),Facial recognition under expression variations. Int. Arab J. Inf. Technol., 13(1A): 133-141.

[2] Liao S, Jain A K and Li S Z. (2013), Partial face recognition: Alignment-free approach. IEEE Transactions on Pattern Analysis and Machine Intelligence, 35(5): 1193-1205.

[3] Nikan S and Ahmadi M. (2015),Partial Face Recognition Based on Template Matching. In 2015 11th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), pp. 160-163.

[4] Archana T and Venugopal T. (2015),Face recognition: A template based approach. In Green Computing and Internet of Things (ICGCIoT), International Conference on, pp. 966-969.

[5] Bhanu B, Lee S and Ming J C. (1991),Self-Optimizing Image Segmentation System Using a Genetic Algorithm. In ICGA, pp. 362-369.

[6] Grefenstette J J and Fitzpatrick J M. (1985), Genetic search with approximate function evaluations. In Proceedings of an International Conference on Genetic Algorithms and Their Applications, pp. 112-120.

[7] Goldberg D E. (1989), Genetic Algorithms in Search, Optimization and Machine Learning. 372.

[8] Badawi U A and Alsmadi M K S. (2013), A Hybrid Memetic Algorithm (Genetic Algorithm and Great Deluge Local Search) With Back-Propagation Classifier for Fish Recognition International Journal of Computer Science Issues, 10(2): 348-356.

[9] Roth G and Levine M D. (1994), Geometric primitive extraction using a genetic algorithm. IEEE

Transactions on Pattern Analysis and Machine Intelligence, 16(9): 901-905.

[10] Alsmadi M, Omar K, Noah S and Almarashdeh I. (2011), A hybrid memetic algorithm with back-propagation classifier for fish classification based on robust features extraction from PLGF and shape measurements. Information Technology Journal, 10(5): 944-954.

[11] Alsmadi M, Omar K B, Noah S A and Almarashdeh I. (2010), Fish Recognition Based on Robust Features Extraction from Size and Shape Measurements Using Neural Network Journal of Computer Science, 6(10): 1088-1094.

[12] Alsmadi M K, Omar K B and Noah S A. (2011), Fish classification based on robust features extraction from color signature using back-propagation classifier. Journal of Computer Science, 7(1): 52.

[13] Alsmadi M K, Omar K B, Noah S A and Almarashdeh I. (2010), Fish recognition based on robust features extraction from color texture measurements using back-propagation classifier. Journal of Theoritical and Applied Information Technology, 18(1).

[14] Badawi U A and Alsmadi M K. (2014), A General Fish Classification Methodology Using Meta-Heuristic Algorithm With Back Propagation Classifier. Journal of Theoretical & Applied Information Technology, 66(3).

[15] Alsmadi M and Omar K. (2012), Fish Classification: Fish Classification Using Memetic Algorithms with Back Propagation Classifier.

[16] Harguess J and Aggarwal J. (2009), A case for the average-half-face in 2D and 3D for face recognition. In IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, pp. 7-12.

[17] Zhao M and Chua T-S. (2008), Markovian mixture face recognition with discriminative face alignment. In Automatic Face & Gesture Recognition. FG'08. 8th IEEE International Conference on, pp. 1-6.

[18] Brunelli R and Poggio T. (1993), Face recognition: Features versus templates. IEEE Transactions on Pattern Analysis and Machine Intelligence, 15(10): 1042-1052.

[19] Sinha P, Balas B, (2006), Ostrovsky Y and Russell R. Face recognition by humans: Nineteen results all computer vision researchers should know about. Proceedings of the IEEE, 94(11): 1948-1962.

[20] Nixon M. (1985), Eye spacing measurement for facial recognition. In 29th Annual Technical Symposium, pp. 279-285.

[21] Ruiz-del-Solar J and Navarrete P. (2005), Eigenspace-based face recognition: a comparative study of different approaches. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 35(3): 315-325.

[22] Burton A M, Bruce V and Hancock P J. (1999), From pixels to people: A model of familiar face recognition. Cognitive Science, 23(1): 1-31.

[23] Kour A. (2015), Face Recognition using Template Matching. International Journal of Computer Applications, 115(8).

[24] Dekel T, Oron S, Rubinstein M, Avidan S and Freeman W T. (2015), Best-Buddies Similarity for robust template matching. In IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 2021-2029.

[25] Tiwari A K and Lade S. (2015), Fuzzy Pattern-Based with Laplacianfaces Biometric Pattern Matching Algorithm for Face Recognition. IJCST, 6(1): 149-155.

[26] Hisham M, Yaakob S N, Raof R A, Nazren A A and Embedded N W. (2015), Template Matching using Sum of Squared Difference and Normalized Cross Correlation. In IEEE Student Conference on Research and Development (SCOReD), pp. 100-104.

[27] Fouda Y. (2015), A Robust Template Matching Algorithm Based on Reducing Dimensions. Journal of Signal and Information Processing, 6(02): 109.

[28] Martinez A M. (1998),The AR face database. CVC Technical Report, 24.

[29] Huang G B, Ramesh M, Berg T and Learned-Miller E. (2007), Labeled faces in the wild: A database for studying face recognition in unconstrained environments.

[30] Holland J H. (1975), Adaptation in natural and artificial systems. Ann Arbor, MI: University of Michigan Press.

[31] Kumar R and Jyotishree. (2012), Novel Knowledge Based Tabu Crossover In Genetic Algorithms International Journal of Advanced Research in Computer Science and Software Engineering, 2(8): 78-82.

[32] Ahuja K and Tuli P. (2013), Performance Analysis of Template Based Object Recognition Using Matching Parameter. The International Journal of Mathematics, Science, Technology and Management, 2(4): 1-5.

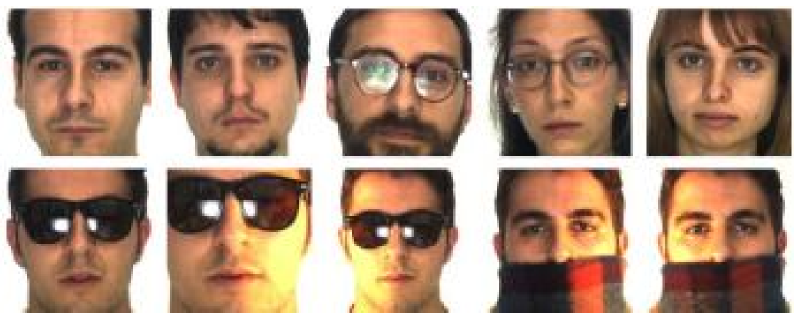
[33] Ahuja K and Tuli P. (2013), Object Recognition by Template Matching Using Correlations and Phase Angle Method. International Journal of Advanced Research in Computer and Communication Engineering, 2(3): 1368-1373.

Table 1: The parameters setting of the proposed GA

Parameters of the proposed genetic algorithm	
Generation	20
Crossover	0.90
Mutation rate	0.02
Crossover type	Single point

Table 2: Results of the proposed method vs. Nikan and Ahmadi method in [3].

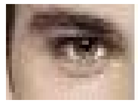
Methods	Eye		Nose		Mouth	
	LFW	AR	LFW	AR	LFW	AR
The proposed Method	91.2	93.5	89.1	89.5	89.9	92.1
Nikan and Ahmadi in [3]	60.5	87.5	39	75.5	42.3	69.9



(a)

(b)

Figure 1: (a) and (b) AR and LFW database image samples



K
A Pattern

M
An image

Figure 2: The dimension of an image and a pattern

X co-coordinate								Y co-coordinate							
1	1	1	0	1	1	0	0	0	0	0	1	1	1	0	1

Figure 3: The chromosome form

Cut point

Parent	1	1	1	0	1	1	0	0	0	0	0	1	1	0	1	1
Child	1	1	1	0	1	1	0	1	0	1	0	1	0	1	0	1
Parent	1	0	1	0	0	1	0	1	0	1	0	1	0	1	0	1

Figure 4: The single point crossover

Child	1	0	1	0	0	1	0	1	0	1	0	1	0	1	0	1
NChild	1	0	1	0	0	1	0	0	0	1	0	1	0	1	0	1

Figure 5: The mutation operation

(a) (b) (c)

Figure 6: The first three steps in the proposed method

Begin

1. *preprocessing steps:*

- *Read the pattern (P) as shows in figure 6(a).*
- *Convert P to grayscale (PG) as shows in figure 6(b).*
- *Convert PG to black and white (PB) as shows in figure 6(c).*

2. *Calculate the size of PB (K x L).*

3. *Set the parameters (Pop-size, Pm, Pc, Max-Ng).*

4. *Initialize*

- *Generate the initial population randomly as described in Sec. 3.1*

5. *Set Ng=1*

6. *Set Pop=1*

7. Selection:

- *Select two chromosomes randomly from the current population.*

8. *Perform the crossover & mutation*

- *To obtain one child, apply crossover according to Pc, then mutate the new child according to Pm.*

9. *Compute the position (X, Y) of the new child according to section (3.3)*

10. *Determine the space PS (X+K, Y+L) in the image space S.*

11. *Perform the fitness function*

Check on the space (X+K, Y+L) in the image space S, if $(X + K; Y + L) \notin S$ *, discard that child and repeat from step 9.*

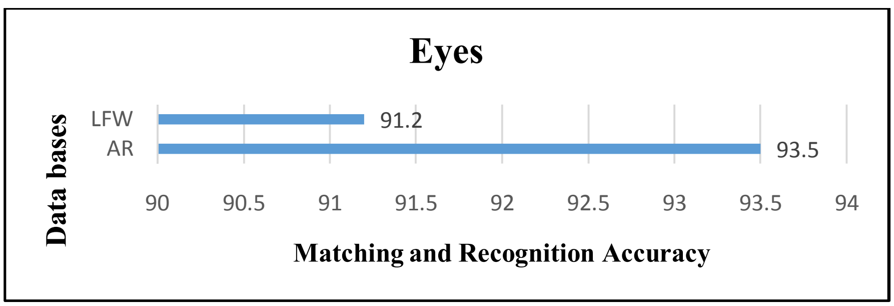
12. *Compare between the pixels of P and PS.*

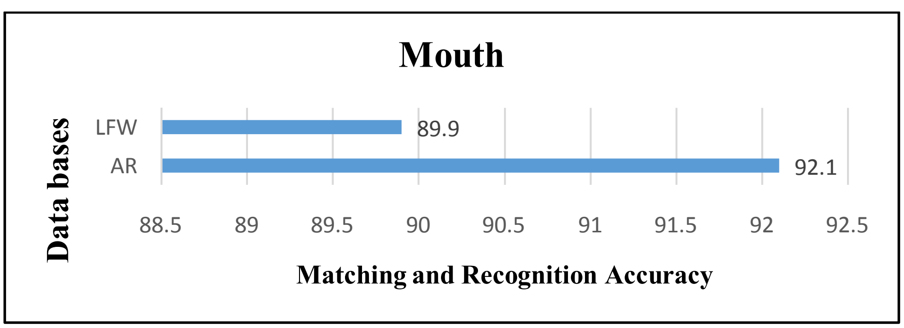
- *Compare between the pixels of the pattern P and PS, if the result compared is greater than or equal to 95%, then display the Image of that PS.*
- *Exit*

13. *Set Pop=Pop+1;*
14. *If number of the children not equal to pop_size go to step 9*
15. *Set Ng=Ng+1*
16. *If Ng=Max-Ng stop*
17. *Display "Sorry there is no image with pattern".*

Figure 7: Shows the steps of the proposed GA.

Figure 8: Partial face images of nose, mouth and eyes areas





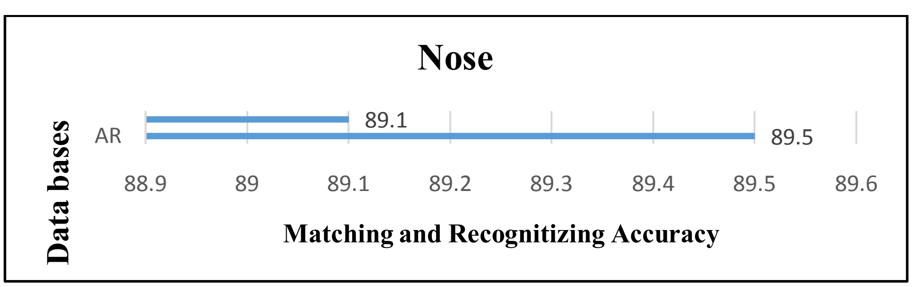


Figure 9: Matching and recognition accuracy of mouth, eyes, and nose patterns

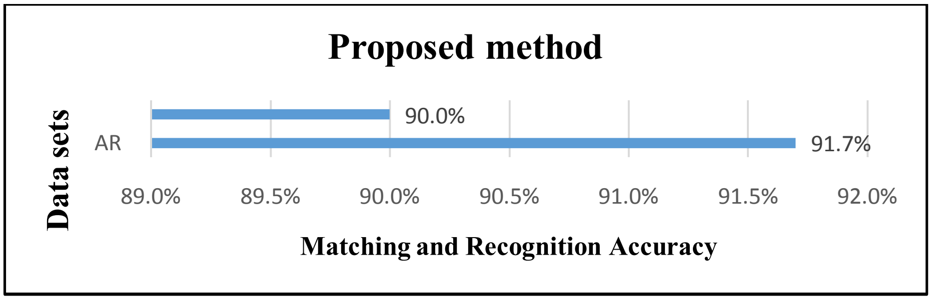


Figure 10: The overall matching and recognition accuracy using the proposed method

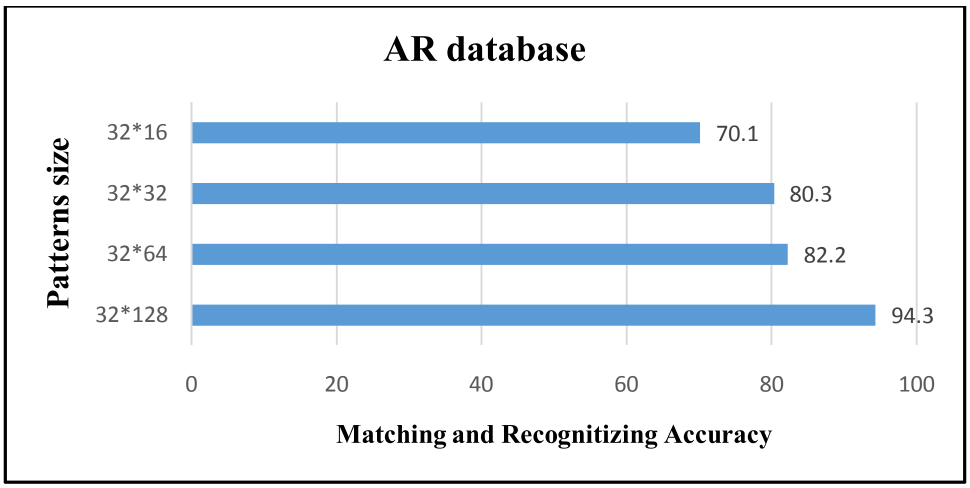


Figure 11: shows the obtained performance results using different pattern sizes