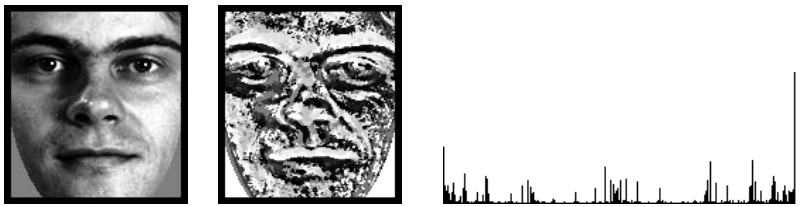
On Approaching Heuristic Weight Mask to Improve Face Recognition with Local Binary Pattern



(a) (b)

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Content

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- Two categories for face feature extraction
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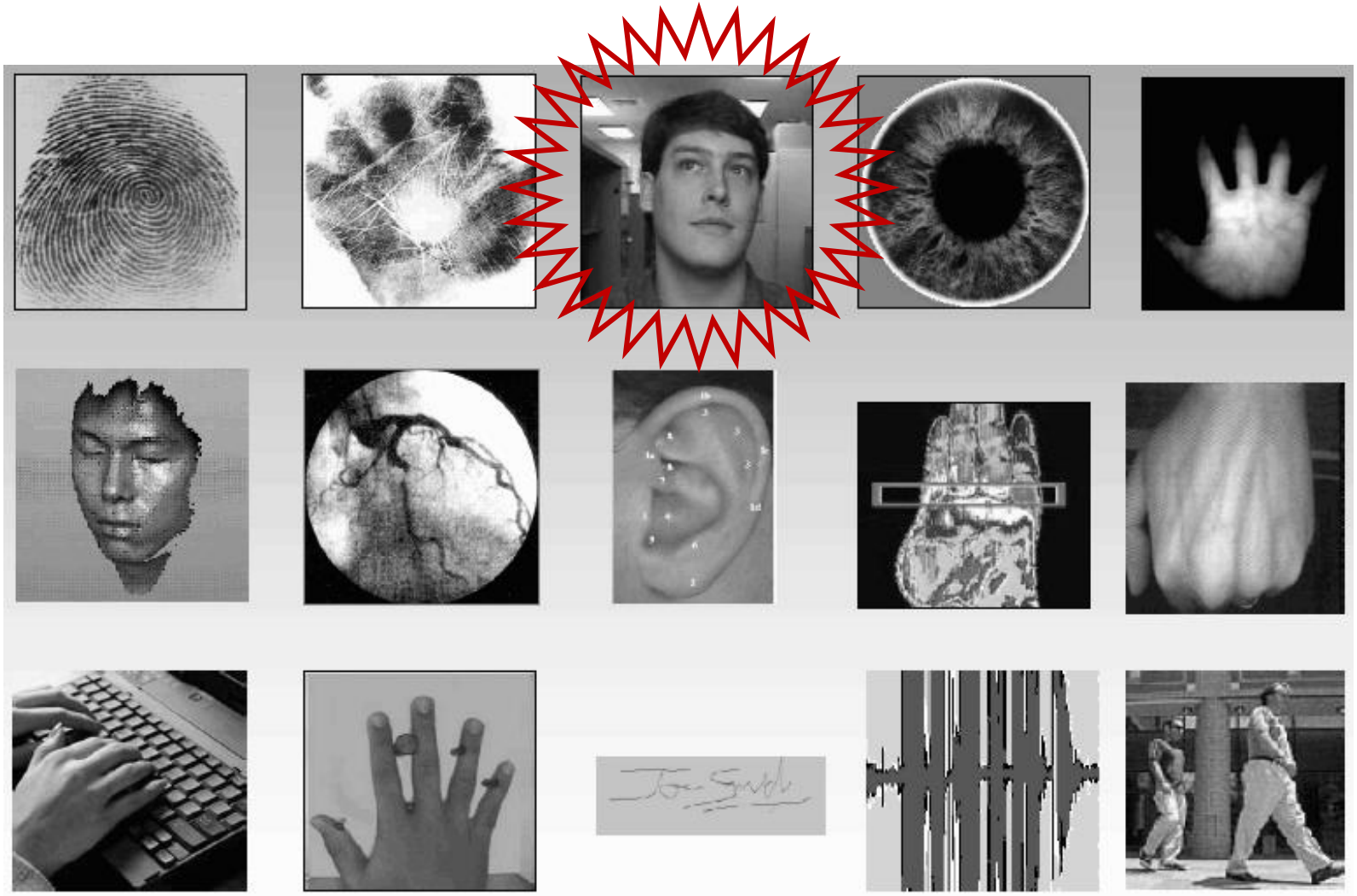
Face Recognition Problem

Face Identification



Face identification problem

Face Recognition System

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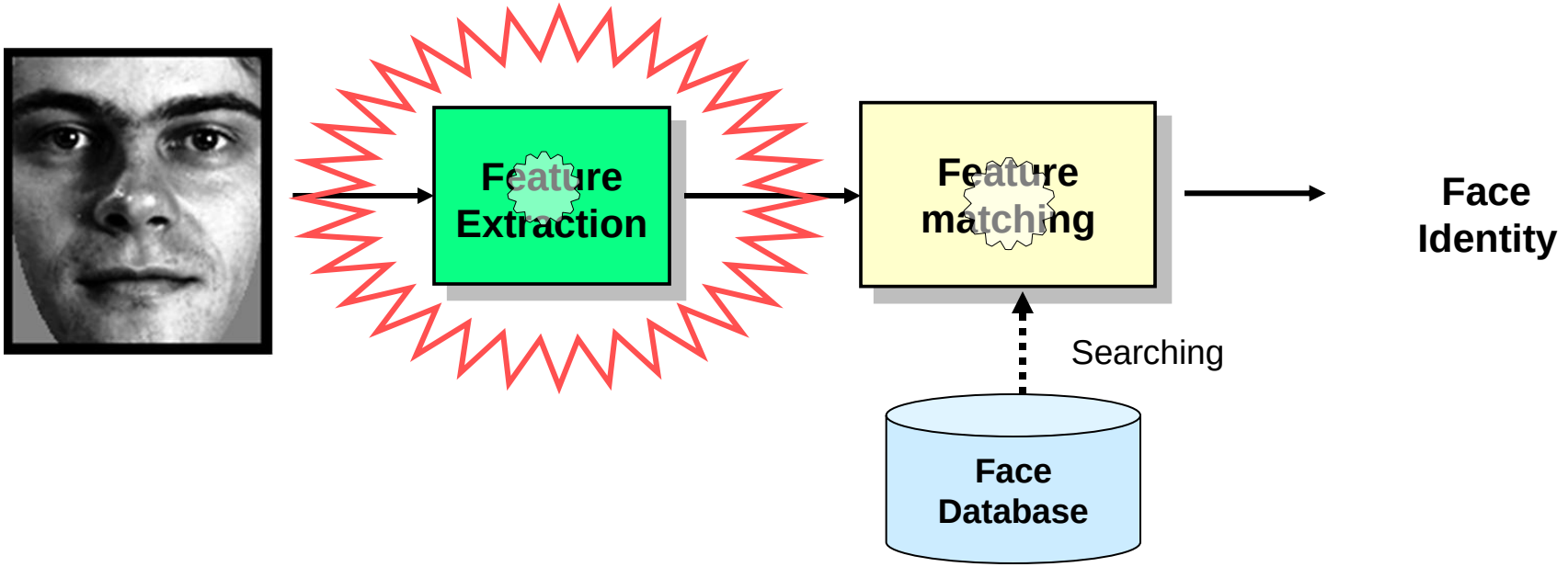
Faces Database

Feature extraction problem



Two categories for face feature extraction

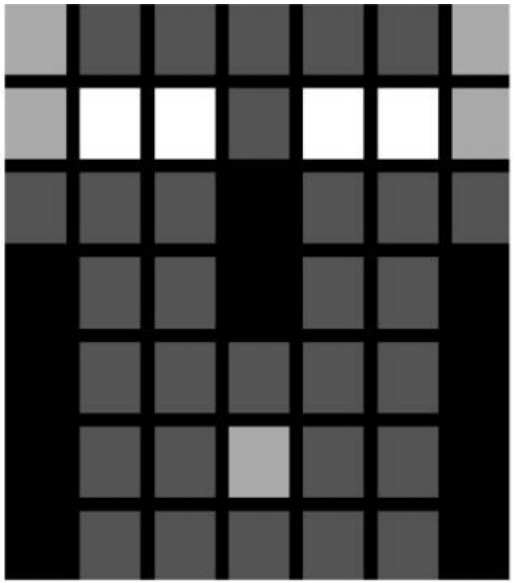
- Holistic methods consider the whole image as a target for extracting feature. Some face recognition algorithms of this approach are Principal Component Analysis (PCA) [P.N. Belhumeur 1997], Linear Discrimination Analysis [Jelsovka, D. 2011], and Support Vector Machine [Guodong Guo 2000].
- Local feature based approach use features such as nose, eye corners, and mouth for describing face (Xiaozheng Zhang 2009, R. Brunelli 1993).

Two categories for face feature extraction

- Holistic approaches require lower cost in computing than the local feature based ones.
- Local feature based methods have higher accuracy rate than holistic approaches, because of exploiting discrimination of local features on the face. However, with the revolution of computer technology (computer is becoming cheaper and faster), the limitation of computation cost of local feature based approach can be overcome in future.

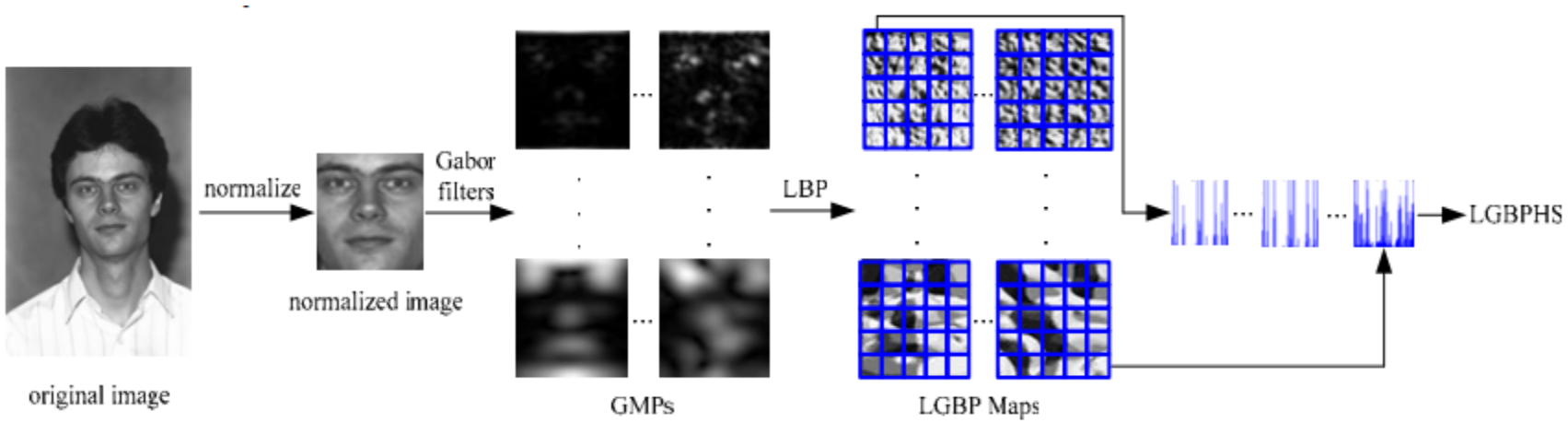
Related works

- The face image is divided into several regions from which the LBP feature distributions are extracted and concatenated into an enhanced feature vector to be used as a face descriptor (T. Ahonen 2004).



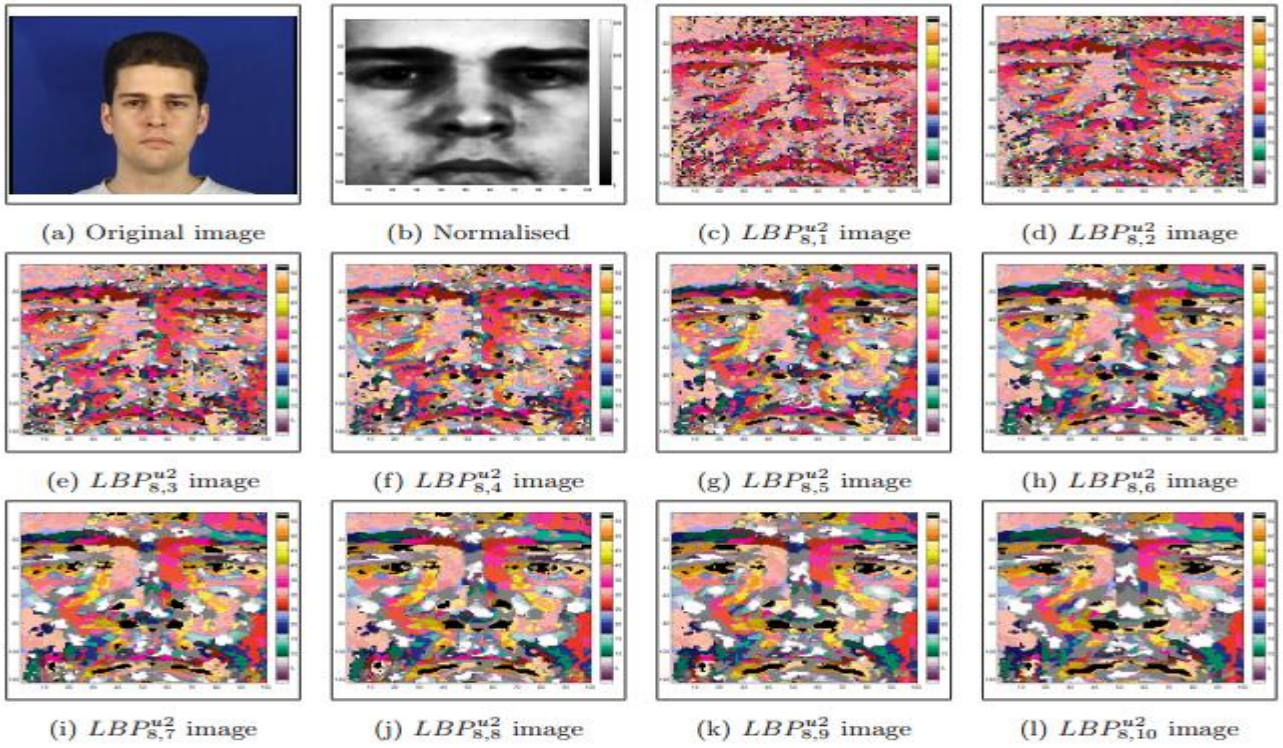
Related works

- The multi-scale and multi-orientation Gabor filters are used for decomposing face image into eight feature images, which followed by applying LBP operator to extract face features (Zhang 2005).



Related works

- Multi-scale LBP (MLBP) operator is proposed. The ideal of MLBP is sliding a set of LBP operators with various radiuses over the image. Results of those operators are combined together to produce a multi-resolution LBP presentation of face images(Chan 2007).



Related works

- Reduce the number of LBP codes that produced by LBP operator. This is done by using Maximization of Mutual Information between features and class labels, so that only effective LBP codes are selected for representing face images (Jun 2011).

- Nanni et. al. also proposed some methods for combining LBP variants that having the same radius and number neighborhoods to improve performance of LBP based classifiers(Nanni 2011,2012).

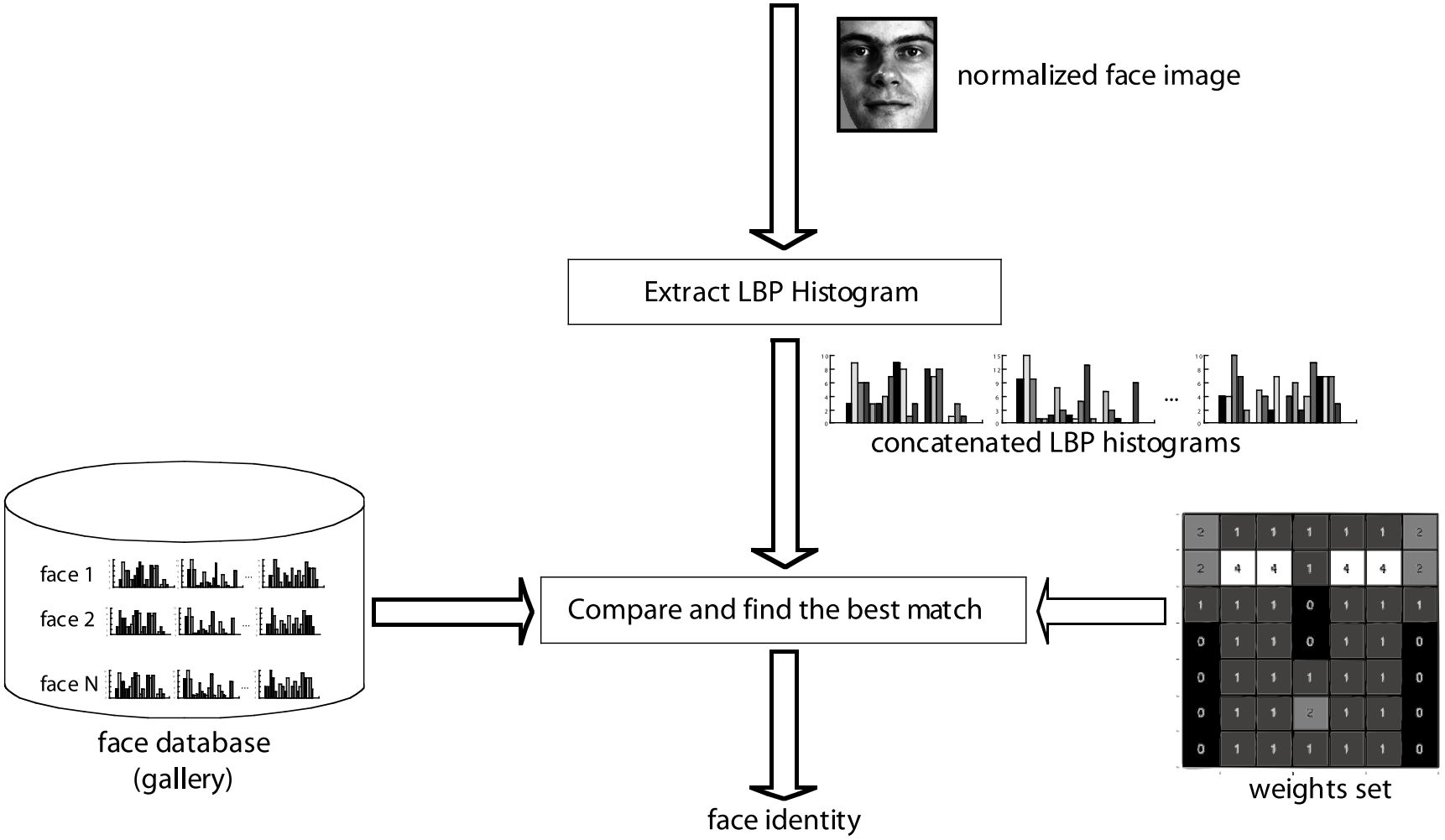
Related works

- Used Parzen-window approach to estimate the distribution of SIFT key points on thousands of aligned face images. Using the same 7x7 weight mask as Ahonen, they consider a face region is more important if it is covered by more SIFT key points. The estimation is done by using Parzen window for inferring the efficient weight value of each weight cell (Bangyou Da 2010).
- Pujol proposed a method for dividing the face image into 9 regions (instead of 7x7 = 49 regions as proposed by Ahonen et. al) that separate eyes, nose and mouth in the face image. The size and location of each region is determined by averaging size and location of regions manually extracted from 200 face images, respectively (Pujol 2012).
- Some other researches concentrate on the other difficulty aspects of face recognition (Moore's research used LBP to recognize the face expression from multi view, Moore 2011).

Our approach – Architecture for LBP based face recognizer

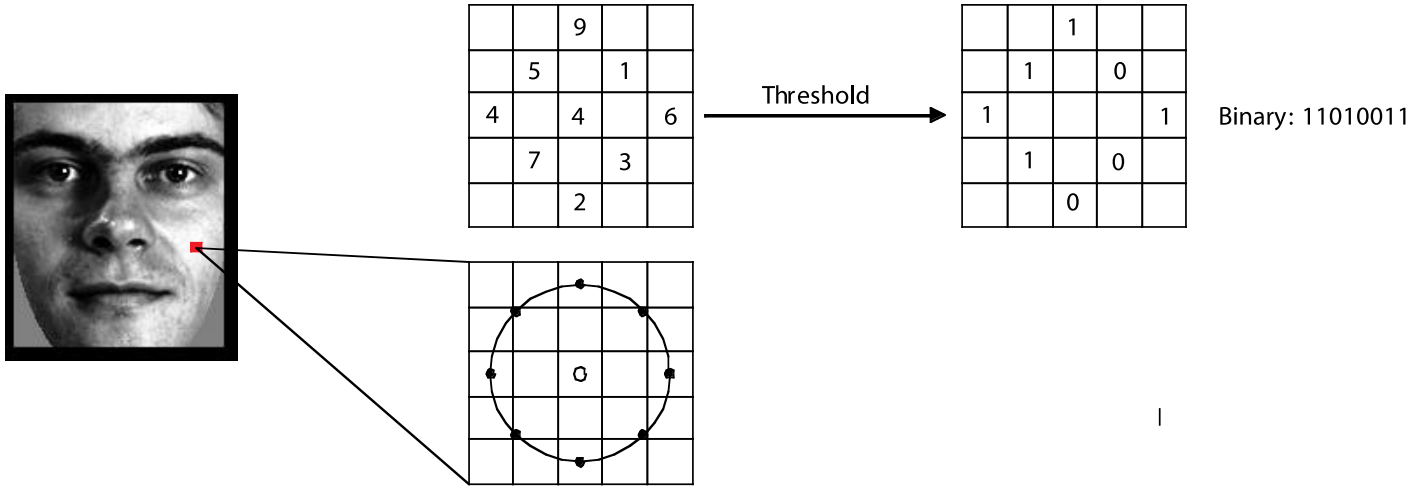
- CLBP: Face image should be split into grid of cells and then obtain LBP histogram for each cell (a 7x7 grid is chosen by Ahonen on FERET database). By linking all LBP histograms of cells together, we obtain concatenated LBP histograms, called CLBP histogram.
- Heuristic Approach For Computing Optimal Weight Set: The efficient weight value for each cell determines the contribution of each cell in face image distinction.

Our approach – Architecture for LBP based face recognizer



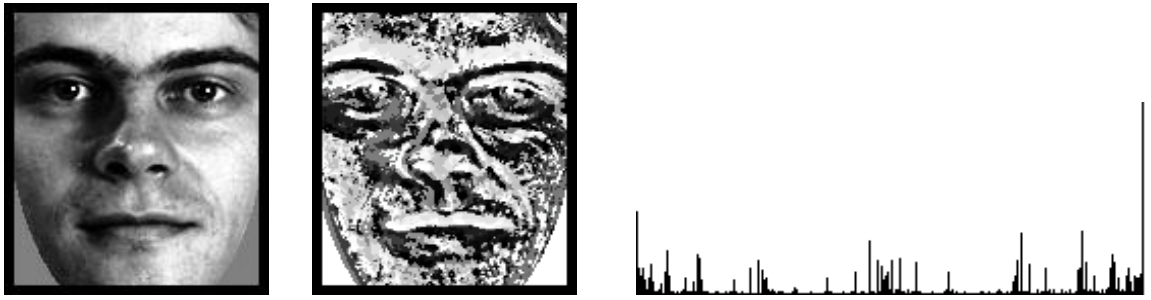
Our approach

- **LBP** (Local Binary Pattern) **(Timo Ojala et. al. 1996)**
- **Aim:** Given a location (x, y) in an image, binary outputs of neighbor pixels are concatenated to form a binary code.
- **Method:** Apply $LBP_{8,2}$ operator at location (x, y) on an image



Our proposed feature

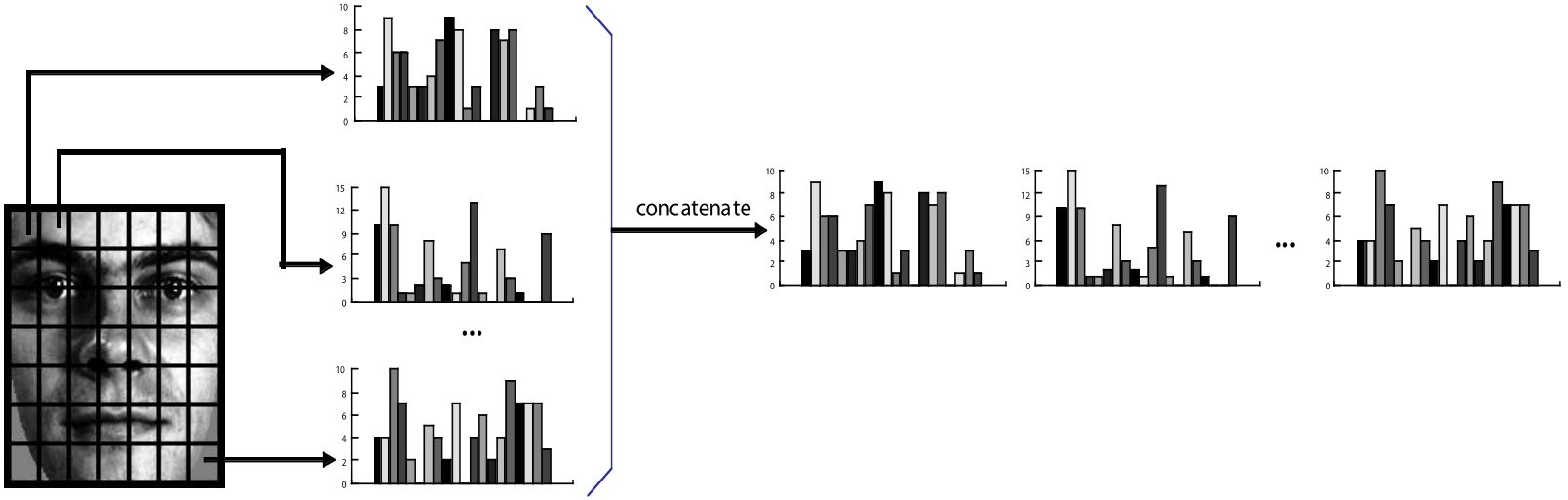
- Apply LBP: Distribution of LBP patterns on the face image can be used as a feature to describe a face. LBP histogram is use to represent this distribution. Image presentation of LBPs (a) and LBP histogram (b)



(a) (b)

Our proposed feature

- Apply CLBP: The face image should be split into grid of cells and then obtain LBP histogram for each cell. By linking all LBP histograms of cells together, we obtain concatenated LBP histograms, called CLBP histogram, as a feature vector of the face image. A 7x7 grid is chosen by Ahonen 2004 on FERET database. Face division and concatenated LBP histograms:



Our approach

- Some cells are more significant than the others in describing the face. As this reason, each cell is assigned a weight value, which is used in computing the distance between two feature vectors. The Chi squared distance between two face images becomes:

$$\chi_w^2(S,M) = \sum_{i,j} w_j \cdot \frac{(S_{i,j} - M_{i,j})^2}{S_{i,j} + M_{i,j}}$$

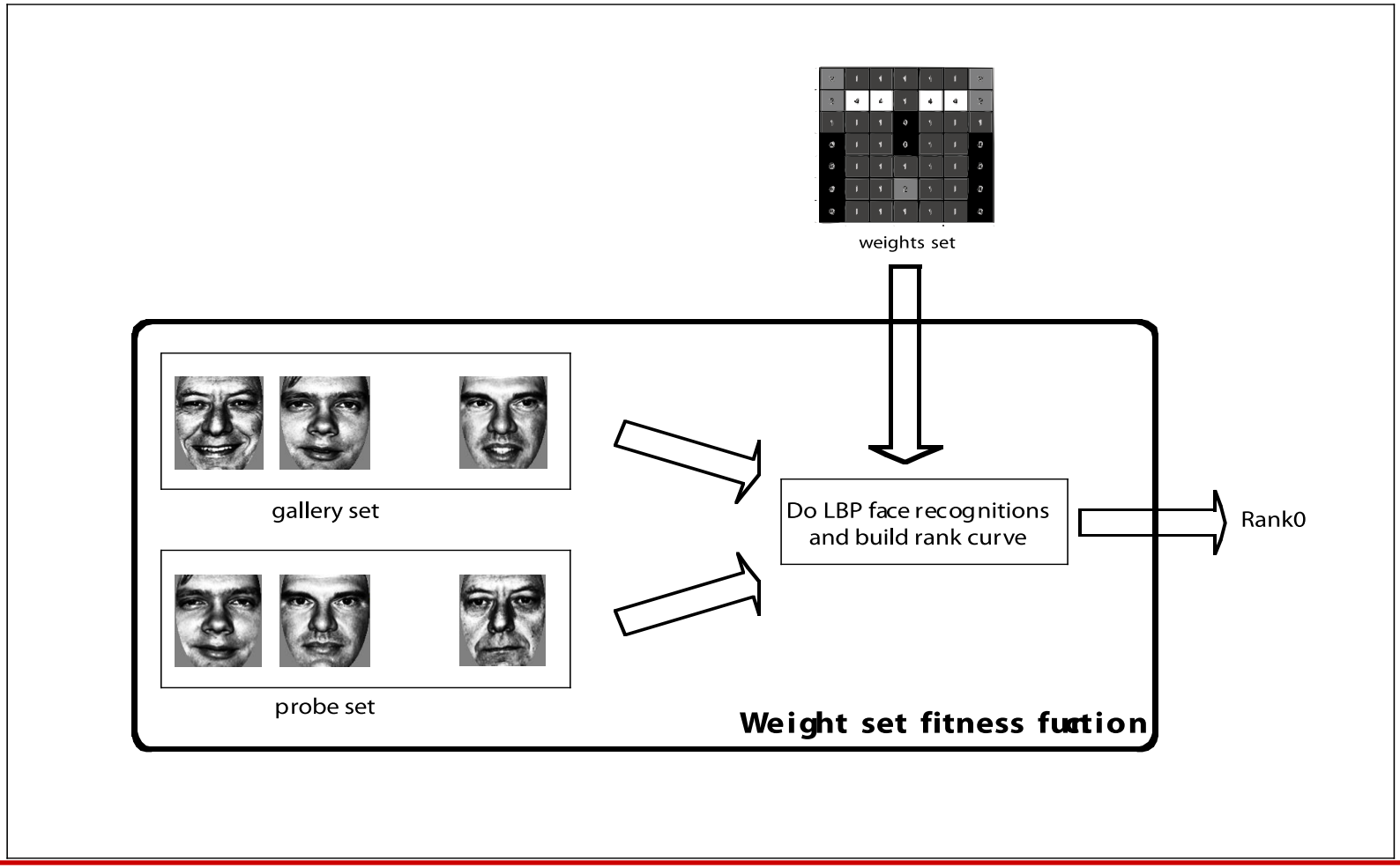
Where S and M are two CLBP histograms; $S_{i,j}$ and $M_{i,j}$ are frequencies of appearance of pattern i in cell j of S and M respectively; w_j is weight for cell j.

Our approach

- **Heuristic approach for computing optimal weight set for LBP based-Face Recognizer**
- **Aim:** we can evaluate the contribution level of every weight cells (i.e. their individually contribution in face discrimination).
- **Method includes 2 steps:** *The first step* estimates the contribution level of each cell in face discrimination. *The second step* consists of prioritizing the cells and searching the efficient weight value for each cell in the priority order.

Our approach

- Weight set fitness function (WsFitness) for evaluating goodness of a weight set is proposed:



Our approach

- Fitness of a weight set is calculated as follow:

$$WsFitness(W) = \frac{\left| \left\{ \begin{array}{l} q_i \mid q_i \in S_1,\ \ similarity(q_i, t_k, W) < \theta,\ \ label(t_k) = label(q_i), \\ t_k = \arg\min_{t_j \in S_3} \left(similarity(q_i, t_j, W) \right) \end{array} \right\} \right|}{|S_1|},$$

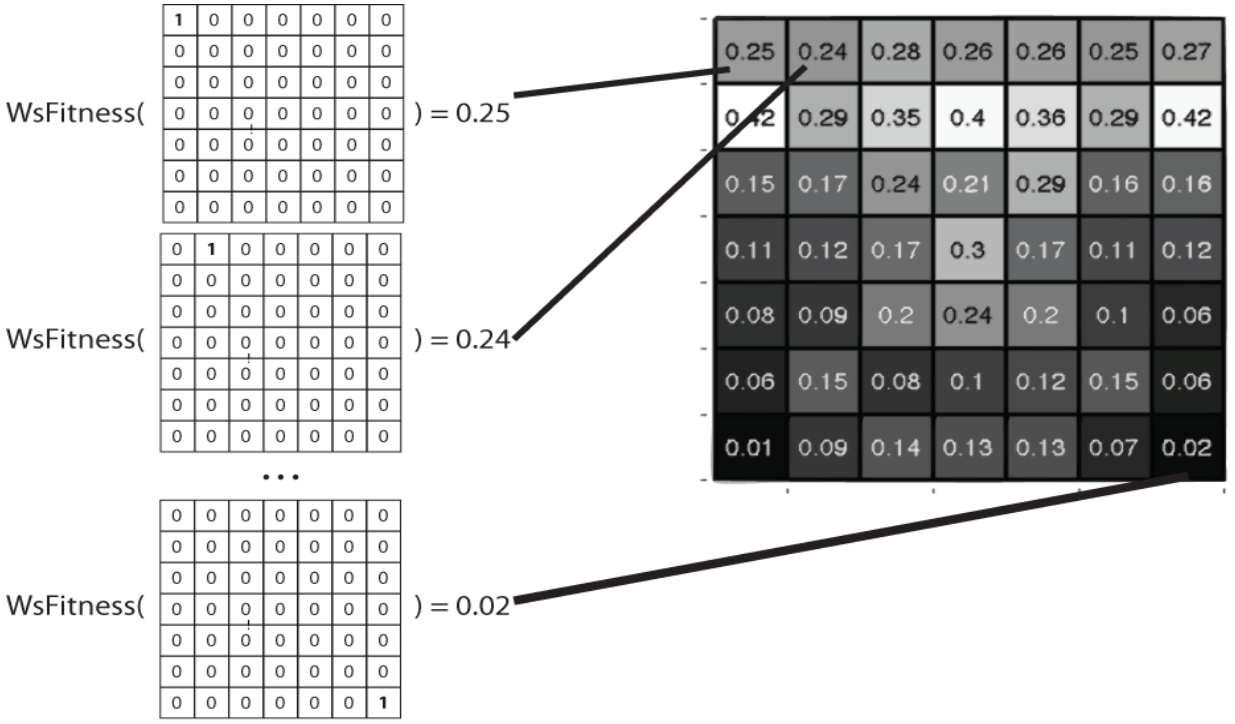
$$\theta = Min\left(\left\{ similarity(q_i, t_j, W) \ \middle|\ q_i \in S_2,\ \ t_j \in S_3 \right\} \right),$$

$$similarity(q, t, W) = \sum_{i,j} w_j . \frac{\left(h(q)_{i,j} - h(t)_{i,j} \right)^2}{h(q)_{i,j} + h(t)_{i,j}}$$

WsFitness (W) is fitness of the weight set W; S_1 is genuine probe set; S_2 is false probe set; S_3 is gallery set; *similarity(q,t,W)* is Chi Square distance between CLBP histogram of image *q* and CLBP histogram of image *t* with the weight set *W; label (x)* is class of the image *x*.

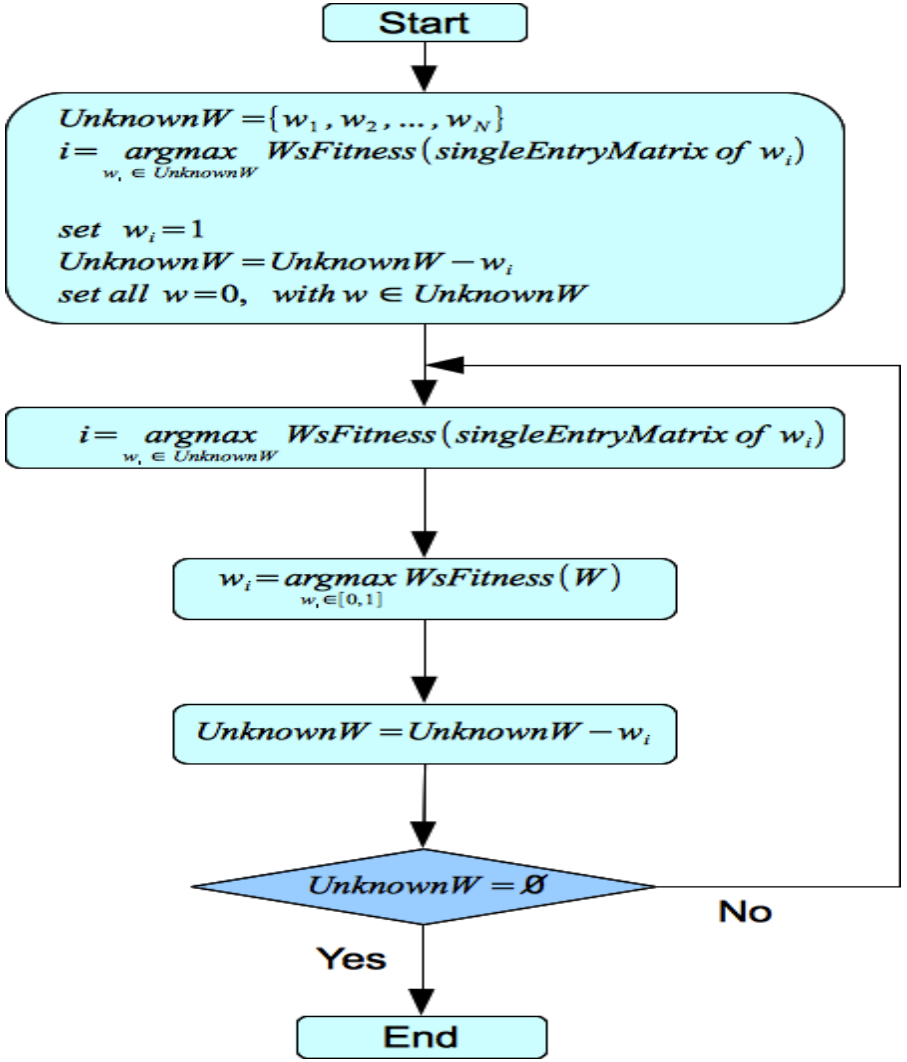
Our approach

- *For first step*, to calculate the contribution level of a cell in face distinction, we create a single entry weights matrix corresponding to the cell and calculate its WsFitness.



Our approach

- *For second step*, Finding optimal weight set by Heuristic search:



Advantage of weight set W

- The optimal weight set W can be frozen and ready to be used in LBP face recognition system. Our method is actually a hill climbing technique. In which the moment vector has constant magnitude due to we already know the good direction by using the contribution rank matrix.
- Ones might question why don't we just use the contribution matrix as the optimal weight set. The contribution matrix represents the contribution levels of each cell when each of them is used alone in doing the recognition. When all the cells come together to do the recognition, there must be a trade off between them, in which those contribution levels have to be refined further to be used as an optimal weight set.

Experimental results

- FERET database have 14051 face images; which are divided into many image sets. The division is based on characteristics and conditions of the subject. FERET Image Sets for doing experiment:

FERET image set	Role	Description
fafb.srt	Probe set	Frontal face images of individuals, which subject was in different face expression than the one in the gallery set. This set has 1195 images.
fafc.srt	Probe set	Frontal face images of individuals, which were taken in different light illumination than the one in the gallery set. This set has 194 images.
dup1.srt	Probe set	Frontal face images of individuals, which were taken between 0 to 1031 days after the day of taken fafb dataset. This set has 722 images
feret_gallery.srt	Gallery set	Contains face images of individual. Each individual only have 1 face image in gallery set. And each face image in probe set has exactly one match in the gallery. This set has 1196 images.

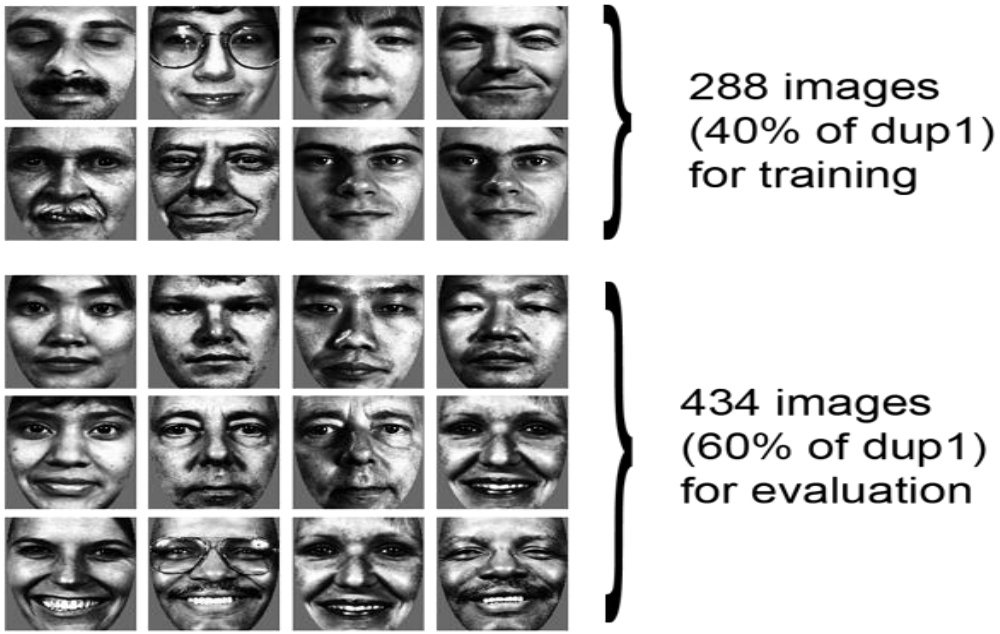
Experimental results

- Before using the FERET images for the experiment, we normalized the images by using the tool provided by CSU. The eye-mouth coordinates information that associated with FERET database is used for extracting facial part from the original image. Then the facial images are scaled down to 130x150 pixels standard resolution.

Experimental results

- **Training**

  For avoiding over-fitting, we only use 40% of each FERET image set for training. While the remaining 60% of the image set is used for evaluation. Each FERET image set is shuffled before making the division.



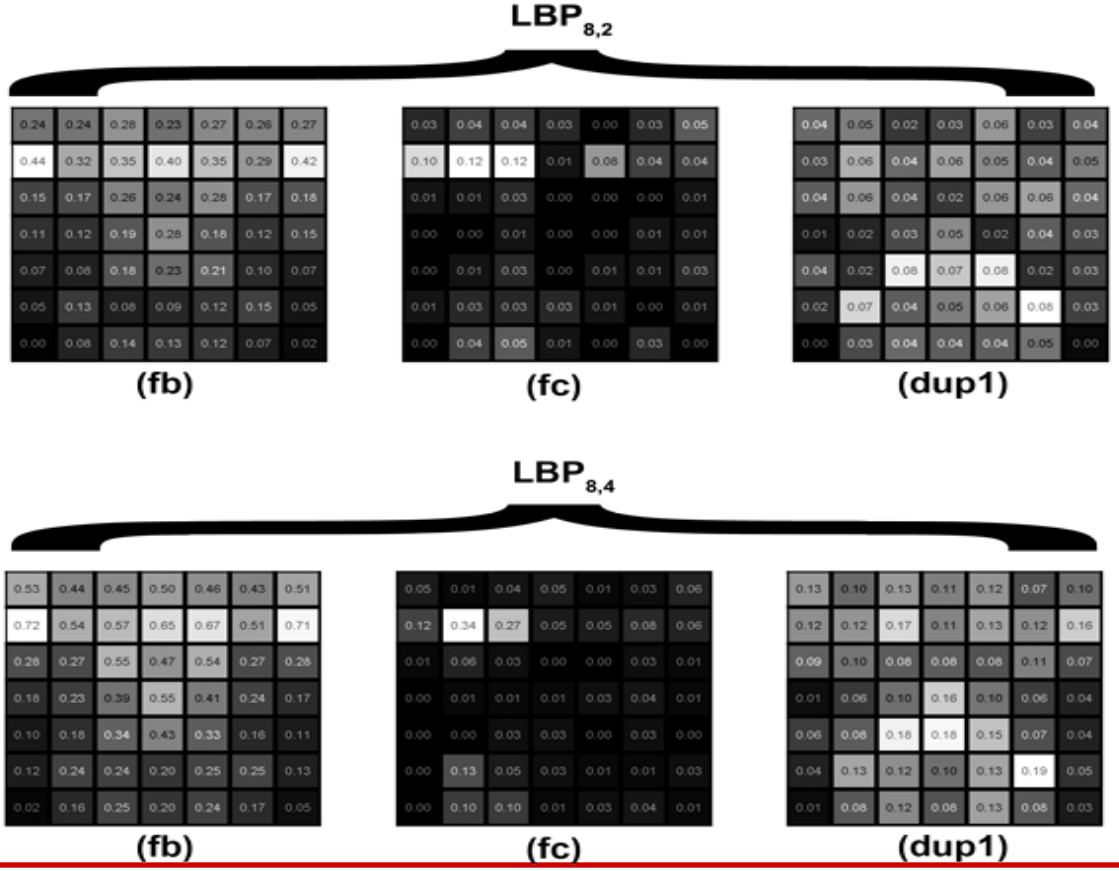
Experimental results

- **Configuration parameters sets to be used in the experiments:**

No	LBP operator	Probe set	Gallery set
1	$LBP_{8,2}$	fafb.srt	feret_gallery.srt
2	$LBP_{8,2}$	fafc.srt	feret_gallery.srt
3	$LBP_{8,2}$	dup1.srt	feret_gallery.srt
4	$LBP_{8,4}$	fafb.srt	feret_gallery.srt
5	$LBP_{8,4}$	fafc.srt	feret_gallery.srt
6	$LBP_{8,4}$	dup1.srt	feret_gallery.srt

Experimental results

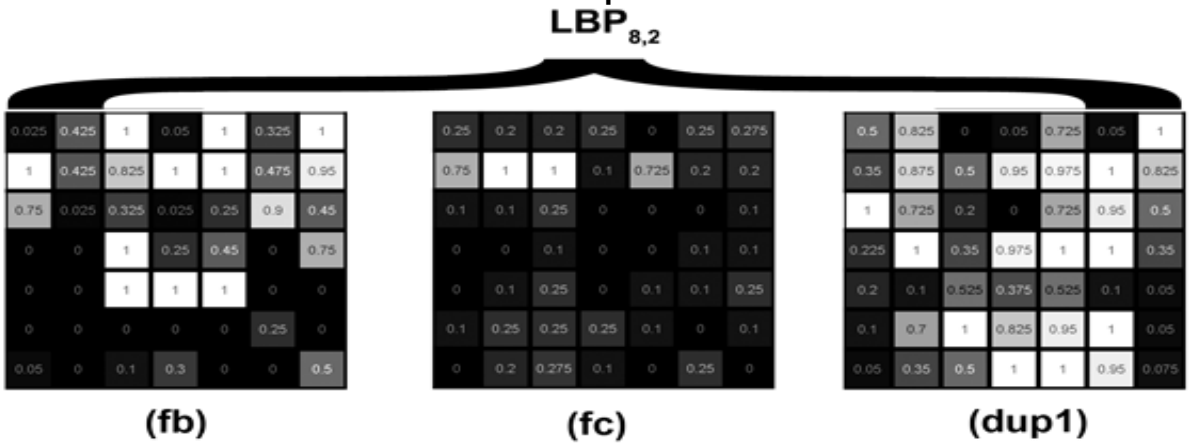
- Step 1: Estimating the contribution rank of each weight element. Each weight element is set to value 1, while the other is set to 0; and the whole weight matrix is tested on training set to estimate how much accuracy rating the weight element contribute in face discrimination upon the training set.

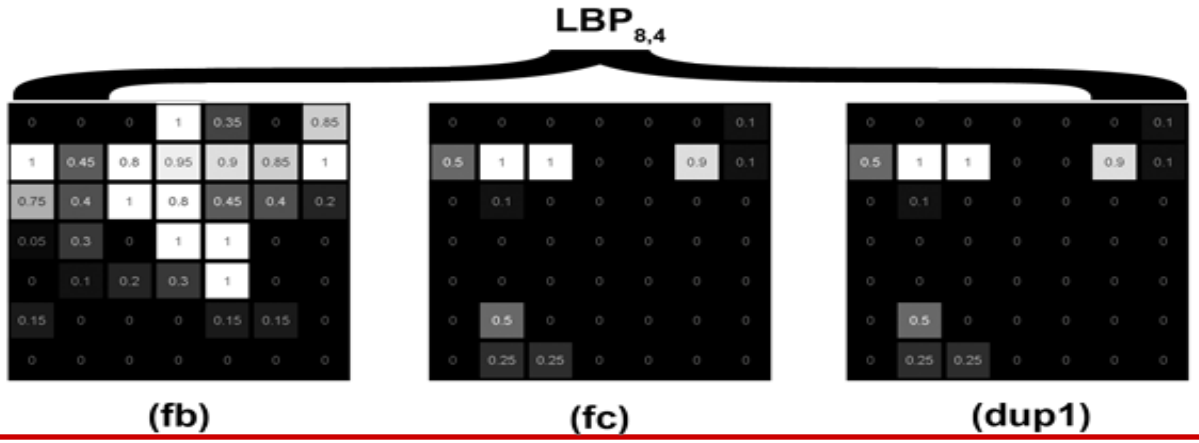


Contribution rank matrices

Experimental results

- Step 2: Heuristic search are applied to find optimal weight values for each cell. The search is based on prior knowledge of weight element contribution, which is determined in step 1.





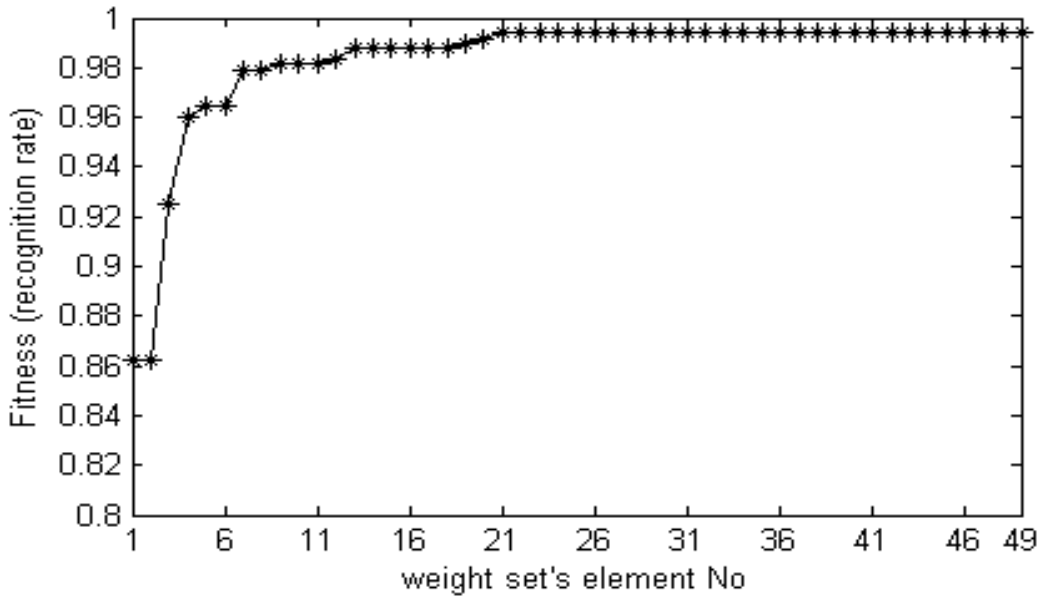
Result weight set found by our Heuristic search

Experimental results

- Each weight element needs 20 cycles for finding optimal value, in which the probe value runs from 0 to 1 with the step of 0.05.

Weight set	fafb (40%)	fafc (40%)	dup1 (40%)
Heuristic mask for $LBP_{8,2}$	98.53	74.02	61.61
Heuristic mask for $LBP_{8,4}$	99.16	81.81	73.94

Convergence of the training process



Convergence of weight set for $LBP_{8,4}$ against fafc training set

Experimental results

- **Evaluation**

  For evaluating the performance of weight sets found by our proposed method, the weight sets are tested on the evaluation image sets (which is 60% of the corresponding FERET image set). Evaluation results of weight sets on the evaluation sets:

Weight set	fafb (40%)	fafc (40%)	dup1 (40%)	fafb (60%)	fafc (60%)	dup1 (60%)
Heuristic mask for $LBP_{8,2}$	98.53	74.02	61.61	97.35	73.50	60.73
Heuristic mask for $LBP_{8,4}$	99.16	81.81	73.94	98.04	71.79	67.80

The performance of each weight set when applying on the evaluation set very close to its performance on the corresponding test set. It proves that the weight set found has successfully generalized what they have learned from the training set. Our weight set outperforms the other researches. It is 0.2% higher than weight set proposed by Bangyou Da, 0.48% higher than variant LBP operator proposed by W.Zhang, when making comparison on fafb.

Experimental results

- LBP's recognition rate with our proposed weight sets:

Operator	Mask size	Weight set	fafb	fafc	Dup1
$LBP_{8,2}$	7x7	Ahonen et al's Mask [12]	96.90	58.76	66.00
$LBP_{8,4}$	7x7	Ahonen et al's Mask [12]	97.49	56.70	69.11
$LBP^{*}_{8,2}$	9 cells	Francisco et al's Mask [14]	90.00		
$LBP^{u2}_{8,2}$	7x7	Bangyou Da et al's Mask [13]	98.20		
LGBPH	21x11	Local Gabor Binary Pattern [13]	98.00	97.00	68.00
$LBP_{8,2}$	7x7	Heuristic Mask	97.82	73.70	61.08
$LBP_{8,4}$	7x7	Heuristic Mask	98.48	80.59	70.25

Conclusions

- In this paper, we propose a robust heuristic approach for improving the weight set of LBP face recognizers. The method uses hill climbing technique with our proposed heuristic so that the local maxima can be avoided. It is potential that our method can be combined with other variants of LBP feature extraction to improve their accuracy.
- Experimental results show that the weight set found by our method is robust when compare with other researches.

THANK FOR YOUR ATTENTION

References

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