# A Robust and Efficient Face Recognition System based on Luminance Distribution using Maximum Likelihood

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**Keywords:** Face Recognition, Maximum Likelihood.

**Abstract.** In this paper, a robust and efficient face recognition system based on luminance distribution by using maximum likelihood estimation is proposed. The distribution of luminance components of the face region is acquired and applied to maximum likelihood test for face matching. The experimental results showed that the proposed method has a high recognition rate and requires less computation time.

## Introduction

Nowadays, the advents of electronics and computer technology have transformed our way of life to rely on computers and electronics to do our day-to-day work. The development of new technologies, such as electronic mail and online banking allow people to remotely access to certain personal information from a computer with proper authentication. However, security concerns are raised. Since most means of personal authentication/identification adopted today rely on surrogate representations, such as passwords, credit cards or ID Cards, which can be easily forgotten/lost. Therefore, a reliable mean of identification with high security measures is needed to address these issues.

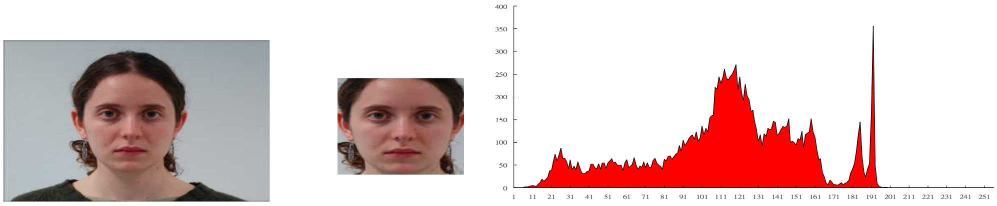
Biometric recognition systems use physiological characteristics, such as face, iris pattern and fingerprint or behavioral traits, such as voice, hand-writing and keystroke that are unique to a person to verify his/her identity automatically.

Among all the various biometrics, face recognition is one of the most widely adopted recognition methods for identification purposes due to its easiness to be integrated with traditional surveillance technologies, such as CCTV hardware can integrate with face recognition software and advantage of passiveness. (User cooperation friendly, works from a distance). It has become an important tool in image analysis and has been used in a wide range of commercial and law enforcement applications [1]. Research also demonstrated two feasible techniques used in face recognition processing: feature-based and holistic (also called template matching) approaches [2]. Moreover, several face recognition approaches have also been proposed In [3]-[5], the authors utilized discrete cosine transform (DCT) coefficients to recognize the face. Chen *et al.* utilize maximum a posterior criterion to classify hidden Markov model (HMM) face recognition [3]. Martines *et al.* applied maximum likelihood motion algorithm to depict a moving face in video sequence [4]. Tu *et al.* observed local texture of a face and given a configuration to define as the sub-patches [5]. In [6] and [7], the authors combined several methods to enhance the recognition rate. Kar *et al.* combine principal component analysis and DCT technique to identify the face [6]. Liu *et al.* propose local binary pattern feature extraction method to extract multi-resolution features to recognize the faces. Although these proposed recognition methods may achieve good recognition rate, however, they are demanding tasks required complex calculations and strenuous computation to process.

In this paper, we proposed a robust and efficient face recognition method using luminance distribution. Based on the principle of RGB color space, the "actual color" perceived by an electronic sensor (such as a camera) is dependent on the surrounding illumination. Therefore, a more robust face recognition method is proposed by using the distribution of luminance components (the RGB components) instead. After the distribution of the luminance components is acquired by a computer, the maximum likelihood estimation is used to compare the similarities among candidates facial distribution of luminance components. The distribution pattern is then matched by other distribution patterns stored in the computer database for comparison.

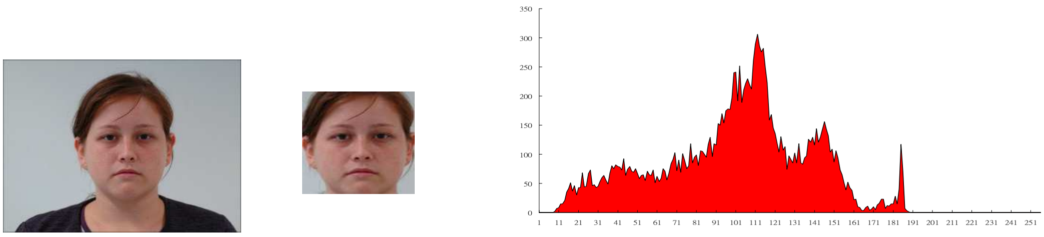
The rest of this paper is organized as follows. In Section II, the observation of the luminance distribution is provided. Section III describes the proposed efficient face recognition system. The experimental results and conclusions are made in Section IV and V, respectively.

## Facial distribution of luminance components



(a) Whole picture (b) Face region (c) Distribution of luminance components

Figures. 1 Distribution of luminance component of picture ID03



(a) Whole picture (b) Face region (c) Distribution of luminance components

Figures. 2 Distribution of luminance component of picture ID04

The distribution pattern of luminance components of an object can remain relatively similar under different lighting conditions. This offers the advantages over other RBG model based recognition systems rely on recognizing the RBG colour features of an object, which is more sensitive to change in lighting conditions. Nevertheless, the international image/video coding standard such as JPEG/JPEG2000 [8], MPEG-x [9] and H.26x [10] use YCbCr colour space as its image compressing standard. Therefore, any digital images in these formats can be readily analyzed by RBG based recognition systems without the need of format conversion.

Two examples are shown in Fig.1 and Fig.2. These figures are taken from GTAV face database [11]. Fig.1 and Fig.2 are pictures of subject ID03 and ID04, respectively. In these figures, (a) is the whole picture, (b) is the face region and (c) is the distribution of the luminance components of the face region.

In Fig. 1(c) and Fig. 2(c), the two individuals presented with distinctive facial features, the distributions of facial luminance components shown in Fig. 1(c) and Fig. 2(c) are also different. Therefore, we can use this distinctive pattern of an individual for personal identification purposes.

## Face recognition system based on luminance distribution by using maximum likelihood

The flowchart of the proposed recognition is shown in Fig. 3. After the picture into the system, the face detection algorithm is used to detect the face in advance. We have to note that the face detection is not the core of our proposed system, the OpenCV library [12]. After the face detection, the detected face is counted.

$$\begin{cases} Numberof\ Detected\ face = 1, & True \\ Otherwise, & False \end{cases} \tag{1}$$

Equation (1) is used to check the number of the detected face. If the detected face is not equal to 1, the system will return a false result.

The face detected by the system will be subject to RBG luminance distribution acquisition and the acquired facial RBG distribution of the subject will be compared with the stored facial distributions of other subjects stored in the database by the maximum likelihood estimation (ML). At this stage, the scale of the face will be adjusted to 128×128. The top k ML will then be refined by mean square error (MSE). The face with minimum MSE value and is less than the threshold, $TH_{MSE}$ will be identified, otherwise the system will return a false result.

*Maximum likelihood of distribution of luminance component*

In the proposed system, the Maximum Likelihood estimation [13] is used to measure the similarities between the candidate face and faces in database. In Fig. 1 and Fig. 2, the RBG distribution is used as maximum likelihood parameters in the proposed system. The problem is formulated by choosing best candidate face according to Eq. (2). The top $k$ corresponding face with $\hat{M}$ is selected as the recognized face.

$$\hat{M} = P(D_i), i = 1,2,3...n \tag{2}$$

$$P(D_i) = \frac{1}{2\sigma} \prod_{j=0}^{255} \exp\left( \frac{-\left|H_j - \theta\right|}{\sigma} \right) \quad , j = 1,2,3,...,255 \tag{3}$$

Equation (2) is the Maximum Likelihood function, where $n$ denotes the number of the faces in the database. The distribution model of the luminance can be obtained by Eq.(3). In Eq.(3), $H_j$ means the number of the luminance component at $j$ and $j$ is the pixel value from 0 to 255.

$$\theta = median\{H_{i,j}\}, i = 1,2,3...n, \ j = 0,1,2,3...255 \tag{4}$$

$$\sigma = \sqrt{\frac{1}{n} \sum_{j=1}^{255} \left(H_{i,j} - \theta\right)} \tag{5}$$

Equation (4) and (5) are the adjusted parameters of Eq. (3). In this proposed method, θ is median of the luminance components and σ is the standard deviation of the luminance components.

*Refinement*

After the $\hat{M}$ value has been calculated, the top k corresponding faces with $\hat{M}$ value will be selected. The refinement mechanism is used to choose the best match face in database.

In the proposed face recognition system, mean square error (MSE) is used to measure the distance between the input face and the candidate faces.

$$FR = \arg\min_i \frac{1}{N} \sqrt{\sum_{j=1}^{N} \left(D_{input,j} - D_{i,j}\right)^2}, i = 1,2 ... k \tag{6}$$

Equation (6) is the mean square error, where $N$ is the number of pixels in the face region, $D_{input}$ and $D_i$ mean the face region in the input picture and faces in the database with top $k$ $\hat{M}$ value. Candidate's face with minimum MSE and is less than $TH_{mse}$ will be determined by the system as positive identification. The $TH_{mse}$ is used to adjust the system sensitivity. The $TH_{mse}$ in the proposed system is set to 0, and $k$ is set to 5.

## Experimental results

The experimental results are provided in this section. The face database [11] is used to test the proposed system. There are 43 pictures in the database. We randomly choose 3 faces (Figure (a)-(c)) as input faces which are built-in the database and 3 faces (Figure (d)-(f)) which are not built-in the database.

The recognition rate (RR), false rejection (FR), and false acceptance (FA) were compared between two systems with full search. The full search means that the system calculates the distance between the face of input picture and faces in the database by using MSE. The training flowchart is shown in Fig. 5. Similar to recognition flowchart in Fig. 3, after the picture input to system, the system utilizes face detection technique to detect the face. If the number of detected face is not equal to 1, the system will return a fail result. After the face detected, the size of the face region will be set and the distribution of luminance will be acquired. Finally, the distribution and picture will be saved to database.

(a) ID03 (b) ID20 (c) ID29 (c) ID05 (c) ID08 (c) ID40

Figures. 4 Testing pictures in the proposed system

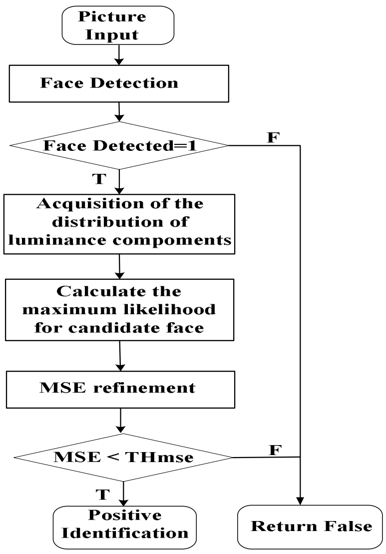



**Figure 3.** Flowchart of the proposed face recognition system

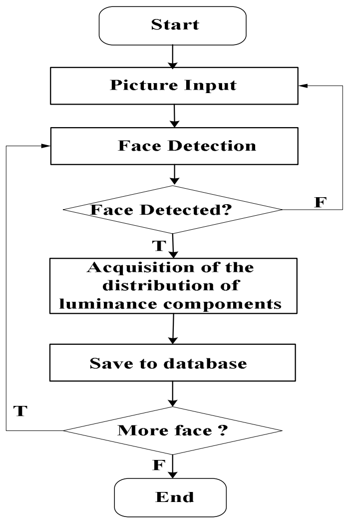



**Figure 5.** Flowchart of training procedure

**Table 1.** Comparison of recognition rate

| | Mean Square Error(MSE) | Proposed system |
|---|---|---|
| Recognition Rate | 100% | 80% |

**Table 2.** Comparison of false rejection rate

| | Mean Square Error(MSE) | Proposed system |
|---|---|---|
| False Rejection | 100% | 100% |

**Table 3.** Comparison of acceptance rate

| | Mean Square Error(MSE) | Proposed system |
|---|---|---|
| False Acceptance | 0% | 0% |

**Table 4.** Comparison of average processing time(sec)

| | Mean Square Error(MSE) | Proposed system |
|---|---|---|
| Average Processing Time | 1.843 | 0.297 |

Table 1 shows the comparison of recognition rate. In This table, we can see that the proposed system can achieve a true positive rate of 80%. Table 2 compares the false rejection rate. Since we use the refinement mechanism to enhance the accuracy, both of MSE and the proposed method also achieve 100% false rejection rate. Also, results in Table 3 show both systems have false acceptance rates of 0%. Finally, the processing time is compared in Table 4. The processing time means the time required to complete a positive identification. We can see the processing time of the proposed system is much less than MSE.

## Conclusions

The experiment results demonstrated that the proposed face recognition system based on RBG luminance distribution by using maximum likelihood method achieved a high recognition rate of 80% and a false acceptance rate of 0%. When compared with the MSE based approach, the propose system required less computation time (0.297 vs. 1.843 sec) in terms of average processing time, which means it is more efficient.

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