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Designing and implementation of a parallel genetic algorithm to optimize the efficiency of image retrieval system

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Abstract: Persons re-identification that is using face images has the advantage of being less interfering than other biometrics factors, this feature makes it distinct in security applications. This paper presents an approach for image retrieval with using of parallel genetic algorithm. At first, skin color in the image is separated by using of Gaussian model of skin color and appropriate threshold and the face space is determined by selecting the largest space in the image. The proposed approach should be able to recognize different skins color in the images with complex background. This stage causes to reduce the computational volume. Feature selection is an important stage in the discussion of image retrieval. Different features can be obtained from the images collection of database. We select appropriate features among color features in two environments of YCbCr and RGB by using of normalization and parallel genetic algorithm in order to obtain higher accuracy. In this approach, the load of saved data has decreased, the speed of retrieval has increased and the accuracy of retrieval reaches to %94.7, beside linear changes and relocation do not impress on retrieval.

Key words: *Face recognition; Parallel genetic algorithm; Image retrieval*

1. Introduction

The subject of face recognition has been an extensive research ground about machine vision and pattern recognition in the last two decades. One of extensive applications of face recognition is in the field of identity verification and security issue. Face retrieval is one of the most difficult aspects of image recognition, because the face image has a flexible structure. Initial methods of face recognition were of format matching type, it means that input face (face matrix) were compared with all existing samples in the database one by one and then the result was announced. But this approach has many problems such as high volume of data and sensitivity to face changes and radiation of light and … for that reason other approaches (like feature extraction) were created (Zhao, W., Chellappa, R., Phillips, P. J. and Rosenfeld, A, 2003). Feature extraction includes corners data and texture boundaries of different points in the face image which is on the basis of visual features. Statistical feature is about a statistical characteristic and histogram feature is of this type. Algebraic features are algebraic data from image inside. It is needed different images of person in different gestures; different directions of light radiation and… to implement face recognition system accurately. But when we want to do it in a high data volume, we encounter to some problems like the cost of data maintaining, the cost of algorithm doing, reducing speed and…. These properties can be fixed or varied. The selection of these features is highly dependent on the database. As it is mentioned before image retrieval systems use visual features to classify and retrieve images. The components of this system are presented in the Fig. 1. There is a visual database in these systems which are includes all retrievable images for user. User presents the features in his mind to the system to extract images from this database, and system must search its image bank with the use of these data to extract desirable images and display them to user. For simplification and acceleration of the search, image bank should be indexed so that the search time is the minimum and similar images are retrievable in the quickest way.

2. Recognition of skin color and finding of face

Recognition of face means that we can separate face space from background. For recognition of eye in the image, it is also necessary to firstly recognize the face space in the image. It helps to eliminate the spaces of around face and the search space will became smaller. Existing approaches for face recognition can be divided into two main categories:

1 - Image-based approaches

2- Feature-based approaches

Image-based approaches are powerful approaches and they produce excellent results. These approaches have high computational complexity and mostly used in applications which are not straightaway. Feature-based approaches use the physical features and characteristics of face such

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as hair, eye, facial asymmetry and analyzing lower level data such as edge, color and motion (T. Rajpathak, R. Kumar and E. Schwartz, 2009).

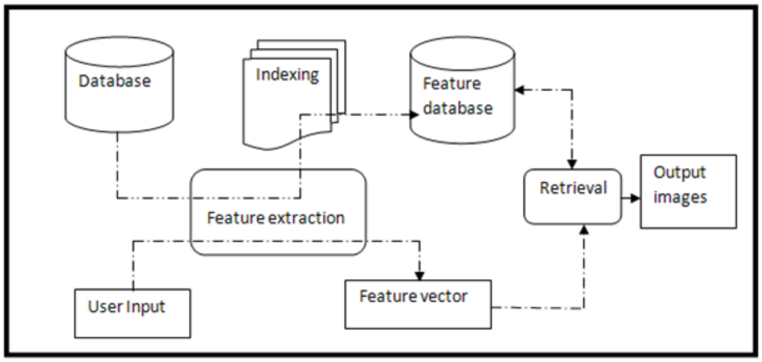


Fig. 1: A total picture of an image retrieval system

Feature-based approaches mostly are used in the straightaway applications and its using is simpler and has less computational complexity than the first group. Color is one of typical features of human face. Color processing is faster than processing other features of face; color data is fixed when the face is rotating so it will be used of skin color feature to recognize face space. It is necessary to find a specific color space that can separate colors group of human skin from the background colors well in order to make effective use of color for recognition of human skin color. RGB color space is a widely used and standard color space for presenting color images. But this color space does not seem to be efficient for scanning the skin color space, because pixels includes color data as well as data about the intensity of light and brightness. The intensity of light varies in accordance with surrounding lights from person to person, as a result of this factor; it will be weaken the consistency and stability of the searching model for scanning of skin color. Therefore we should be able to separate factor of light and brightness intensity from colored space. Chromatic color space of YCbCr is one of options for color space that is without lighting factor. So the image will be changed from RGB space in to YCbCr space, firstly. It will be used of cr and cb factors in implementation to model the color distribution.

2.1. Gaussian complex model

In spite of Gaussian simple model is doing successfully to recognize the features and to discriminate between different groups but it may have intolerable mistakes when the related factors do not have steady changes toward mean. A good approximation is the using of a Gaussian complex model. In general we can say that Gaussian complex model is a good approximation of normal distribution phenomena. Gaussian complex models have an appropriate efficiency in identification systems, especially when they are independent of the context. For this reason, it is used of Gaussian complex model in the most hybrid models as a basic system and it is also used in many experiments for comparison as a reference model. It is used of several Gaussian functions in Gaussian complex model to module the skin color Bir Bhanu, 2004). Gaussian complex is equal to sum of weights of M-components of Gaussian distribution. The probability of x feature vector toward λ_i model is calculated by Equation 1:

$g_i(x)$Is the probability of seeing x vector, and this probability is resulted from ith complex and p_i is the weight of i th complex. $g_i(x)$ is obtained from Gaussian complex with the mean of μ_i and covariance matrix of $\sum_i$. The complex weights should fulfill the condition of $\sum_{i=1}^{M} p_i = 1$. This condition ensures that Gaussian probability of each complex is a density function of correct probability. In general, it can state each one of Gaussian complex distributions with mean vector (μ_i), covariance matrix (Σ_i) and complex weight (p_i). Each one of above parameters represents a color skin.

$$\lambda_i = (\mu_i, \Sigma_i, p_i) \qquad (2)$$

The estimate of the mean vectors, covariance matrix and complex weights were done by the EM algorithm. EM algorithm is one of the basic algorithms for estimating the parameters of a Gaussian complex model. In this algorithm, firstly it is considered an initial estimate for the unknown parameters. For this purpose, training data have typically been assigned to different categories with using of pseudorandom approaches. It should be noted that each data is belonged to one category. Then it is determined the mean vector (μ_j), covariance matrix $(\Sigma_j)$and the probability of creating each region (θ_j) for each category. After determining the initial values, two basic steps of this algorithm are executed repeatedly. These two steps are:

Step 1- Estimate stage: In this stage, according to Bayes theorem, each data of x_i is assigned to one of C_j classes and meantime we calculate the Posterior probability of $p(C_j|x_i)$.

Step 2 - maximization stage: In this stage, the parameters of each category (Gaussian factor) are estimated again according to the results of the previous step and with taking into account the criteria of the most simulation. For this purpose it is necessary to each data has been assigned to a category which the posterior probability of that class be more than others. Based on maximization and assuming a normal distribution, parameter values are calculated as follows:

$$\mu_j^{new} = \frac{\sum_i p(C_j|x_i,\theta^{old}).x_i}{\sum_i p(C_j|x_i,\theta^{old})}$$
$$\theta_j^{new} = \frac{\sum_i p(C_j|x_i,\theta^{old})}{N} \quad (3)$$
$$\sum\nolimits_j^{new} = \frac{\sum_i p(C_j|x_i,\theta^{old}).(x_i-\mu_j^{new}).(x_i-\mu_j^{new})^T}{\sum_i p(C_j|x_i,\theta^{old})}$$

In the above equations, N is the total number of input samples of X , x_i is the each one value of N samples of input that is observed. The above two steps are repeated until the values of $p(C_j|x_i)$s or the parameter values in the n + 1 th stage repetition does not have much difference with the corresponding values at n^th stage repetition.

2.2. Proposed approach

The proposed approach should be able to recognize different skin colors in the images with complex background. It is clear that it is possible to reach such extent of success if you model the skin color with several complexes Gaussian, and the proposal of using Gaussian complex model for different images seems permissible. One of problems is created in determining the skin color spaces is that color of some pixels of image is similar with the skin color model which do not belongs to our proposed space at all. The existence of these additional spaces increases the computational complexity and creates interference in the correct functioning of the system. It should be selected a space from among the scanned spaces as the proposed space and do not process other spaces. For this purpose, we select the greatest space which is covered by skin color as the main space. It is possible so easily to do it with calculation the area of each space. Algorithm of proposed approach has been shown in Fig. 2. It has been presented the implementation details of the skin color recognition stage in the MATLAB simulation environment in Fig. 3.

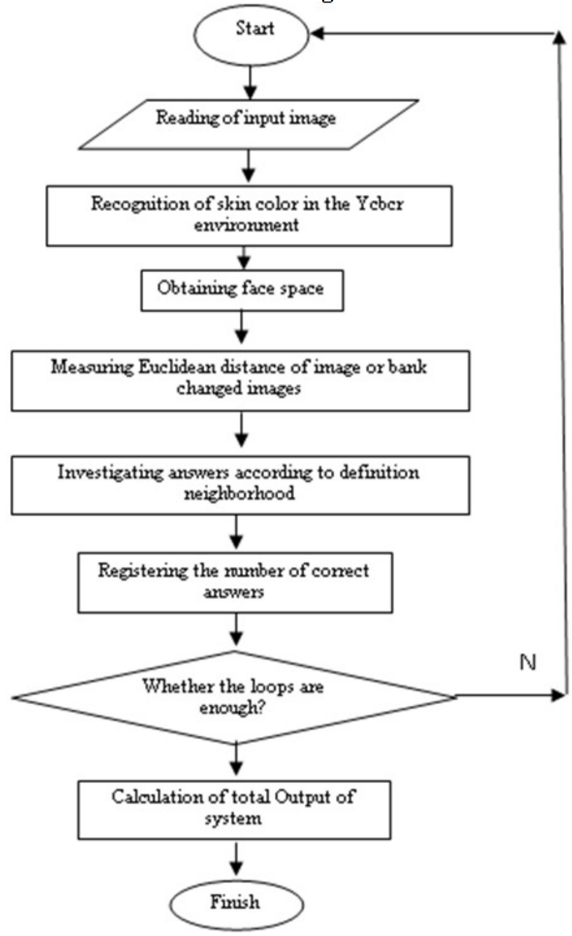


Fig. 2: the proposed algorithm flowchart

It is calculated Mahalanobis distance of each image pixel to each one of skin color models in the color classifier block. Mahalanobis distance shows that each image pixel belongs or does not belong to the skin color. As you can see this block is composed of 5 equal parts and each one of them determines Mahalanobis distance of each pixel of proposed image from each category of Gaussian complexes. Then, according to equation 4 it is determined that the pixel belongs or does not belongs to that category.

$$M.D = \frac{w_i}{2\Pi|\Sigma|^{\frac{1}{2}}} e^{-0.5(x-\mu)\Sigma^{-1}(x-\mu)^T} \quad (4)$$

μ Is mean value, Σ is covariance value and w_i is weight of each category. Each of five equal parts implements the above equation in Fig. 3. At first, it is obtained the difference between the values of C_b, C_r of each pixel with the average value of each category and then Mahalanobis distance is calculated according to the covariance value and the difference from the mean value. This leads to decrease the volume of stored data without losing the image characteristics and also selecting the important part of image for retrieval. In the second stage, we select the best color features from among color features with the using of genetic algorithm and fitness function which we have defined for them. The number of these features can be different on the basis of selected values and defined threshold value. In this section, the color is selected as the feature for retrieval. It is selected 12 color features for each image in two environments of RGB and YCbCr. The main problem of RGB space is the merging of color data with light data. For this reason it is used of a linear change:

RG = R - G, BY = 2 × B - R-G, WB = R + G + B

This change or transformation causes to reduce the emerging of light data and color and meanwhile the simplicity of processing operation remains. Another colored environment of YCbCr space is defined. This environment represents the color with more visibility and more tangible because it separates color and light and also presents color amount, color density and light amount.

It can be considered 24 features for each image in two colored environments. The evaluation scale is similarity between the input image and the database images, the Euclidean distance and in the changed images is rotation and zooming of Spearman correlation coefficient(Y. Rui,T.Huang, S.-F,1999).

$$\text{Distance} = \sum_{i-1}^{n} d_i^2 \qquad (5)$$

d_i Is the difference between the i-th element of feature vectors with the number of n features. In the Spearman's coefficient approach, the similarity amount of images with the measurement of a coefficient is the similarity between feature vectors of input image and bank images which is obtained a number between 1 and -1. Number 1 represents a perfect fit and number -1 represents a complete opposition between two images.

$$M.D = \frac{w_i}{2\Pi|\Sigma|^{\frac{1}{2}}} e^{-0.5(x-\mu)\Sigma^{-1}(x-\mu)^T} \qquad (6)$$

r_{rank} is the degree of similarity, d_i is the difference of i-th element of feature vectors and n is feature numbers(M. Analoui, and M. Fadavi Amiri, 2006). The parallel genetic algorithm can reduce the number of selected features based on the fitness function that is defined to it. Parallel genetic algorithms are used in the efficient and effective features selection which is based on the database. We use the following fitness function to select features with the using of parallel genetic algorithm.

$$F = (\sum_{i-1}^{n} a_i)^{1/2} / (\sum_{i-1}^{n} a_i \sigma^2 / \overline{\rho}_i) \qquad (7)$$

$\rho_{a,b}$ is correlation coefficient of b and a

a_i : i-th element of 0 and 1

σ_i^2 : feature variance of i

In the final stage, we perform the retrieval operation on the basis of features obtained from the previous step. In the retrieval operation, it is considered 8 neighborhood windows with the using of color feature (Azimi and Ramezanpour, 2011).

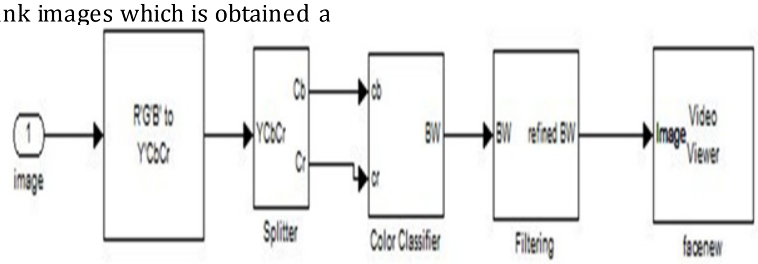
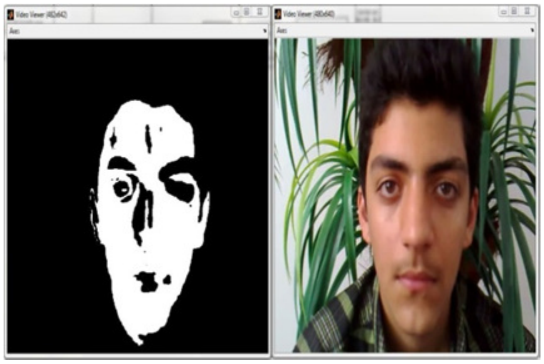


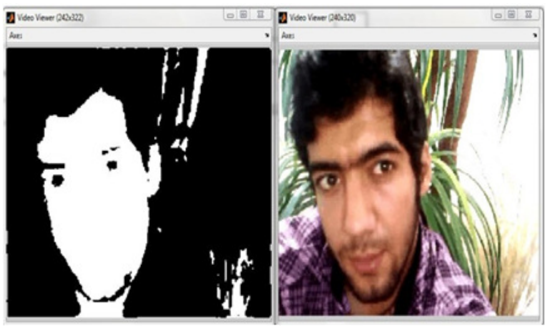
Fig. 3: the software of skin color recognition stage in the environment of Matlab software simulator

3. Conclusion

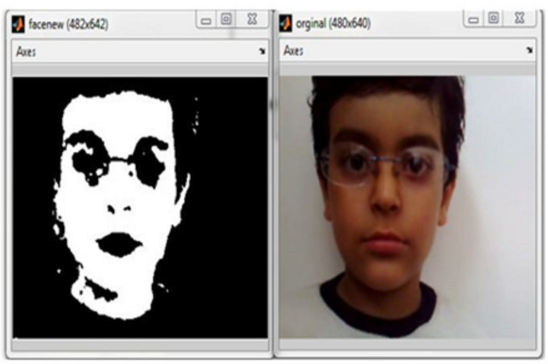
In this paper, it has been analyzed experiments that have been done about the proposed approach. In the first stage, it has been obtained some acceptable results in accordance with experiments which are done in all different conditions like images with complex backgrounds, images with changes in the light condition, head rotation, having beard and glasses. So in the proposed approach, the environmental impacts have the minimal impact on the efficiency of the proposed approach, unlike previous approaches. Moreover, the most important feature of our approach is the face recognition in images with complex background that has less computational complexity and maximum stability. In the second stage, we will do the retrieval operation with the uses of parallel genetic algorithm for the selection of features. This method improves the quality of recognition and the speed of retrieval. With the using of this approach, it can be done retrieval operation in according to spiritual states of persons which is created by 6 main feelings i.e. happiness, excitement, sadness, nervousness, hate and fear. It can be used of this approach to select the recognized space for image retrieval such as finger print, the recognition of the space which is related to finger print from background, and this operation improves recognition quality and reduce mistake rate.



(A)



(B)



(C)

Fig. 4: Examples of skin color recognition results

Fig. 5: Image query

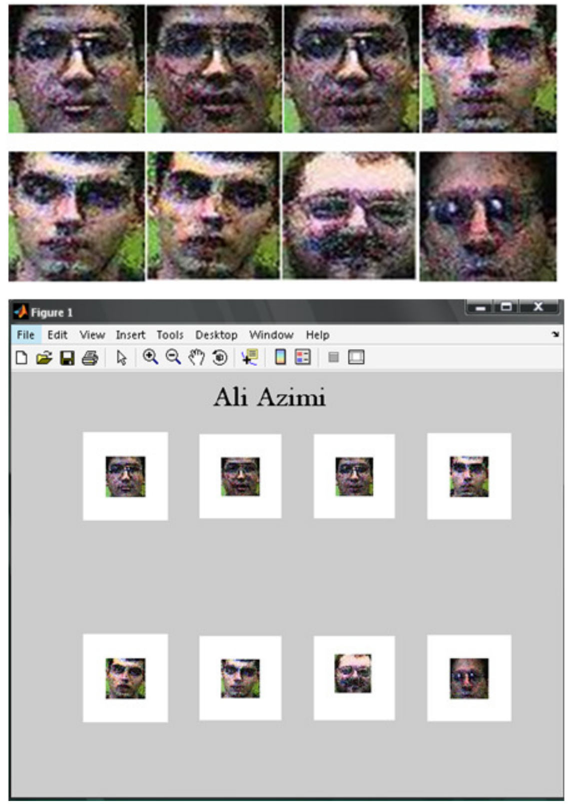


Fig. 6: The results of retrieval using the proposed algorithm

After using this approach, we can significantly reduce volume of stored data in the database and only stores those parts of image which are more important in the retrieval. We can increase the security of biometric identification systems desirably with combining the proposed approach and steganography and cryptography approaches. Comparison of different approaches is done in Table 1 and the results are presented in Fig. 7.

Table 1: comparison of different approaches

model	Feature number	Accuracy percentage of retrieval
RG-BY-WB	12	% 76.7
YCbCr	12	% 79.3
RGB/YCbCr	24	% 92.4
Proposed algorithm	10	% 94.7

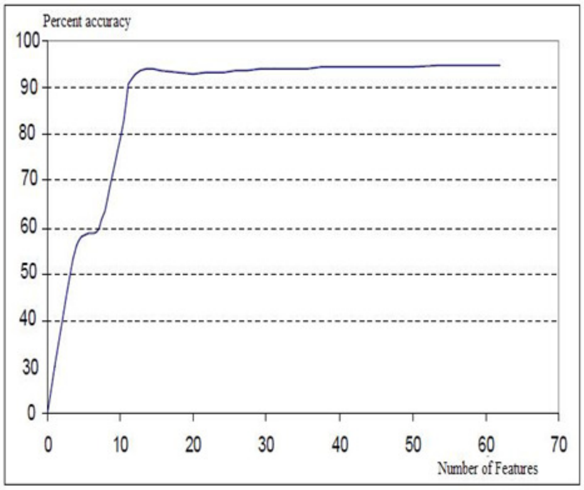


Fig. 7: accuracy amount on the basis of color index

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