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Enhanced Face Detection Technique Based on Color Correction Approach and SMQT Features

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ABSTRACT

Face detection is considered as a challenging problem in the field of image analysis and computer vision. There are many researches in this area, but because of its importance, it needs to be further developed. Successive Mean Quantization Transform (SMQT) for illumination and sensor insensitive operation and Sparse Network of Winnow (SNoW) to speed up the original classifier based face detection technique presented such a good result. In this paper we use the Mean of Medians of CbCr (MMCbCr) color correction approach to enhance the combined SMQT features and SNoW classifier face detection technique. The proposed technique is applied on color images gathered from various sources such as Internet, and Georgia Database. Experimental results show that the face detection performance of the proposed method is more effective and accurate compared to SFSC method.

Keywords: Face Detection; Color Correction; MMCbCr; SMQT Features

1. Introduction

Face detection is a computer technology that determines the locations and sizes of human faces in digital images. It detects facial features and ignores anything else, such as buildings, trees and bodies [1-3]. In recent years, face recognition has attracted much attention and its research has rapidly expanded by not only engineers but also neuroscientists, since it has many potential applications in computer vision communication and automatic access control system. Especially, face detection is an important part of face recognition as the first step of automatic face recognition. However, face detection is not straightforward because it has lots of variations of image appearance, such as pose variation (front, non-front), occlusion, image orientation, illuminating condition and facial expression [4,5].

Up to now, much work has been done in detecting and locating faces in images and there are many face detection methods, such as SMQT Features and SNoW Classifier Method (SFSC) [6], Efficient and Rank Deficient Face Detection Method (ERDFD) [7], Gabor-Feature Extraction and Neural Network Method (GFENN) [8], an efficient face candidates selector Features Method (EFCSF) [9] and Neural network based [10].

Colors of the images provide useful information for many vision applications. As a result, different cameras typically produce different color values for the same objects or scenes, as illustrated in **Figure 1**. These differences complicate the task of computer vision applications involving the use of more than one camera. A color correction approach is thus required to correct the images so that colors of the same object appear to be similar in the output from each camera [11]. There were a number of Color Correction approaches, including GW approach, WP approach, MGWWP approach, Stretch approach and MMCbCr approach [12].

In this paper, for face detection we use (SFSC) method: local SMQT features which can be used as feature extraction for object and SNoW classifier require for training. But we found that we can enhance this method by applying MMCbCr Color Correction approach on the input images that make the process of face detection better.

The outline of the paper is as follows. Introduction about face detection methods is presented in Section 1. Section 2 discusses the challenges on face detection techniques. Section 3 explains the proposed method that uses color correction approach to enhance SFSC face detection method. Section 4 describes the stage of local SMQT features. Section 5 presents the concept of split up SNoW classifier. Section 6 explains the face detection training and classification. In Section 7, we have presented the effectiveness of proposed algorithm. The proposed technique is applied on color images gathered from various sources such as Internet, UCD Face Image Database and Georgia Database. Also, we compare the results of the algorithm with SFSC method. Conclusions are presented in Section 8.

2. Challenges on Face Detection Techniques

The problem is further complicated by differing lighting conditions, image qualities and geometries, as well as the possibility of partial occlusion and disguise. An ideal face detector would therefore be able to detect the presence of any face under any set of lighting conditions, orientation, and camera distance upon any background.

Ming-Hsuan, *et al.* [1] Summarize the challenges associated with face detection in the following factors:

1) Pose: the images of a face vary due to the relative camera-face pose (frontal, 45 degree, profile, upside down), and some facial features such as an eye or the nose may become partially or wholly occluded.

2) Presence or absence of structural components: facial features such as beards, mustaches, and glasses may or may not be present and there is a great deal of variability among these components including shape, color, and size.

3) Facial expression: the appearance of faces is directly affected by a person's facial expression.

4) Occlusion: faces may be partially occluded by other objects. In an image with a group of people, some faces may partially occlude other faces.

5) Image orientation: face images directly vary for different rotations about the camera's optical axis.

6) Imaging conditions: when the image is formed, factors such as lighting (spectra, source distribution and intensity) and camera characteristics (sensor response, lenses) may change face appearance in the image. Image condition includes also size, lighting condition, distortion, noise, and compression.

7) Face Size: Size of faces also make difficult to automate a system for face detection and recognition.

Figure 1. Images captured by three different cameras.

8) A background variation: is another challenging factor for face detection in cluttered scenes. Discriminating windows including a face from non-face is more difficult when no constraints exist on background.

Some closely related problems of face detection [1]:

1) Face localization: aims to determine the image position of a single face; this is a simplified detection problem with the assumption that an input image contains only one face.

2) Face recognition or face identification: compares an input image (probe) against a database (gallery) and reports a match, if any.

3) Face authentication is to verify the claim of the identity of an individual in an input image.

4) Face tracking methods continuously estimate the location and possibly the orientation of a face in an image sequence in real time.

5) Facial expression recognition concerns identifying the affective states (happy, sad, disgusted, etc.) of humans.

6) Feature is used to denote a piece of information which is relevant for solving the computational task related to a certain application. Feature is measurable heuristic properties of the phenomena being observed.

3. Proposed Method

In the proposed method, the goal is to detect the presence of faces in an image using MMCbCr Color Correction approach and SFSC method to detect faces uniform and non-uniform background color of the scene. It is able to localize faces with different sizes in images taken under varying illumination conditions.

The phases of the proposed method as illustrated in **Figure 2**.

3.1. Color Correction Phase

In this phase we use Mean of Medians of CbCr Color Correction approach (MMCbCr) to correct the input images. The Y component contains the luminance information and the chrominance information is found in the chrominance blue Cb and in the chrominance red Cr. The

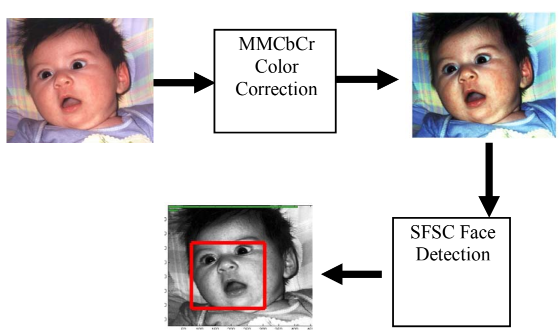

Figure 2. The phases of proposed method.

RGB components were converted to the YCbCr components using the following formula [12,13].

$$\mathrm{Y} = 0.257\times\mathrm{R} + 0.504\times\mathrm{G} + 0.098\times\mathrm{B} + 16$$

$$\mathrm{Cb} = -0.148\times\mathrm{R} - 0.291\times\mathrm{G} + 0.439\times\mathrm{B} + 128$$

$$\mathrm{Cr} = 0.439\times\mathrm{R} - 0.368\times\mathrm{G} - 0.071\times\mathrm{B} + 128$$

The following steps summarize MMCbCr approach:

1) Transform the given image from RGB to YCbCr color model.

2) Calculate the median values median (Cb), median (Cr) for Cb and Cr color component, and maximum value max(Y) in Y.

3) Calculate the mean values mean (Cb), mean (Cr) for Cb and Cr color component.

4) $\mathrm{Value} = \left(\mathrm{Median}(\mathrm{Cb}) + \mathrm{Median}(\mathrm{Cr})\right)/2$.

5) For all pixels of the image calculate $\mathrm{Y_{new}}$, $\mathrm{Cb_{new}}$, and $\mathrm{Cr_{new}}$

$$\mathrm{Y_{new}}[i,j] = \mathrm{Y}[i,j]\times 235/\mathrm{Max}(\mathrm{Y})$$

$$\mathrm{Cb_{new}}[i,j] = \mathrm{Cb}[i,j]\times \mathrm{Value}/\mathrm{Mean}(\mathrm{Cb})$$

$$\mathrm{Cr_{new}}[i,j] = \mathrm{Cr}[i,j]\times \mathrm{Value}/\mathrm{Mean}(\mathrm{Cr})$$

6) Transform the image components $\mathrm{Y_{new}}$, $\mathrm{Cb_{new}}$, and $\mathrm{Cr_{new}}$ to $\mathrm{R_{new}G_{new}\,B_{new}}$.

7) Apply histogram equalization on $\mathrm{R_{new}}$ $\mathrm{G_{new}}$ $\mathrm{B_{new}}$ separately.

8) Combine $\mathrm{R_{new}}$ $\mathrm{G_{new}}$ $\mathrm{B_{new}}$ to get the final color image.

3.2. Face Detection Phase

In this phase, we use SFSC method to localizing faces in input images. Here there are three stages: 1) Local SMQT features which can be used as feature extraction for object, 2) SNoW classifier requires for training, and 3) Face detection Training and Classification.

4. Local SMQT Features

The SMQT performs an automatic structural breakdown of information. These properties will be employed on local areas in an image to extract illumination insensitive features. Local areas can be defined in several ways. Once the local area is defined it will be a set of pixel values.

$$\mathrm{SMQTL}: D(x) \rightarrow M(x) \tag{1}$$

where *x be one pixel and D*(x) *be a set of* $|D(x)| = D$ be pixels in local area in an image. The resulting values are insensitive to gain and bias. These properties are desirable with regard to the formation of the whole intensity image $I(x)$ which is a product of the reflectance $R(x)$ and the luminance $E(x)$. Additionally, the influence of the camera can be modeled as a gain factor g and a bias term b [14]. Thus, a model of the image can be described by

$$I(x) = gE(x)R(x) + b \tag{2}$$

In order to design a robust classifier for object detection the reflectance should be extracted since it contains the object structure. In general, the separation of the reflectance and the luminance is an ill posed problem. A common approach to solving this problem involves assuming that $E(x)$ is spatially smooth. Architecture Further, if the luminance can be considered to be constant in the chosen local area then $E(x)$ is given by

$$E(x) = E,\ \forall x \in D \tag{3}$$

Given the validity of Equation (3), the SMQT on the local area will yield illumination and camera-insensitive features. This implies that all local patterns which contain the same structure will yield the same SMQT features for a specified level L.

5. Split up SNoW Classifier

The SNoW learning is a sparse network of linear units over a feature space. One of the strong properties of SNoW is the possibility to create lookup-tables for classification. Consider a Patch W of the SMQT features $M(x)$, then a classifier

$$\theta = \sum_{x\in W} h_x^{\mathrm{nonface}}\left(M(x)\right) - \sum_{x\in W} h_x^{\mathrm{face}}\left(M(x)\right) \tag{4}$$

Can be achieved using the non face table h_x^{nonface} , the face table h_x^{face} and defining a threshold for θ. Since both tables work on the same domain, this implies that one single lookup-table

$$h_x = h_x^{\mathrm{nonface}} - h_x^{\mathrm{face}} \tag{5}$$

can be created for single lookup-table classification.

The training database contain $i = 1, 2, \cdots, N$ feature patches with the SMQT features (x) and the corresponding classes *ci* (face or non face). The non face table and the face table can then be trained with the Winnow Update Rule. Initially both tables contain zeros. If an index in the table is addressed for the first time during training, the value (weight) on that index is set to one. There are three training parameters; the threshold γ, the promotion parameter $\alpha > 1$ and the demotion parameter $0 < \beta < 1$.

If $\sum_{x\in W} h_x^{\mathrm{face}}\left(M_i(x)\right) \le \gamma$ and *ci* is a face then promotion is conducted and is a face then promotion is conducted as follows

$$h_x^{\mathrm{face}}\left(M_i(x)\right) = \alpha h_x^{\mathrm{face}}\left(M_i(x)\right)\ \forall x \in W \tag{6}$$

If *ci* is a non face and $\sum_{x\in W} h_x^{\mathrm{face}}\left(M_i(x)\right) > \gamma$ then demotion takes place

$$h_x^{\mathrm{face}}\left(M_i(x)\right) = \beta h_x^{\mathrm{face}}\left(M_i(x)\right)\ \ \forall x \in W \tag{7}$$

This procedure is repeated until no changes occur. Training of the non face table is performed in the same manner, and finally the single table is created according to Equation (5). One way to speed up the classification in object recognition is to create a cascade of classifiers [15]. Here the full SNoW classifier will be split up in sub classifiers to achieve this goal. Note that there will be no additional training of sub classifiers instead the full classifier will be divided. Consider all possible feature combinations for one feature, $P_i,\ i = 1, 2, \cdots,\ (2L)D$, then

$$vx = \sum_{i=1}^{(2L)D} \left| hx\left(P_i\right) \right|, \forall x \in W \tag{8}$$

results in a relevance value with respective significance to all features in the feature patch. Sorting all the feature relevance values in the patch will result in an importance list. Let $W' \subseteq W$ be a subset chosen to contain the features with the largest relevance values. Then

$$\theta' = \sum_{x \in W'} h_x\left(M\left(x\right)\right) \tag{9}$$

can function as a weak classifier, rejecting no faces within the training database, but at the cost of an increased number of false detections. The desired threshold used on θ' is found from the face in the training database that results in the lowest classification value from Equation (9). Extending the number of sub classifiers can be achieved by selecting more subsets and performing the same operations as described for one sub classifier. Consider any division, according to the relevance values, of the full set $W' \subseteq W'' \subseteq \cdots \subseteq W$. Then W' has fewer features and more false detections compared to W'' and so forth in the same manner until the full classifier is reached. One of the advantages of this division is that W'' will use the sum result from W'. Hence, the maximum of summations and lookups in the table will be the number of features in the patch W.

6. Face Detection Training and Classification

The face detector analyzes image patches 32 × 32 pixels is applied. This patch is extracted and classified by jumping $\Delta x = 1$and $\Delta y = 1$ pixels through the whole image. In order to find faces of various sizes, the image is repeatedly downscaled and resized with a scale factor $Sc = 1.2$.

To overcome the illumination and sensor problem, the proposed local SMQT features are extracted. Each pixel will get one feature vector by analyzing its vicinity. This feature vector can further be recalculated to an index.

$$m = \sum_{i=1} V\left(x_i\right)\left(2L\right)^{i-1} \tag{10}$$

where $V(x_i)$ is a value from the feature vector at position i. This feature index can be calculated for all pixels which results in the feature indices image. A circular mask containing $P = 648$ pixels is applied to each patch to remove background pixels, avoid edge effects from possible filtering and to avoid undefined pixels at rotation operation.

The face and nonface tables are trained with the parameters $\alpha = 1.005$, $\beta = 0.995$ and $\gamma = 200$. The two trained tables are then combined into one table according to Equation (5). Given the SNoW classifier table, the proposed split up SNoW classifier is created. The splits are here performed on 20, 50, 100, 200 and 648 summations. This setting will remove over 90% of the background patches in the initial stages from video frames recorded in an office environment.

Overlapped detections are pruned using geometrical location and classification scores. Each detection is tested against all other detections. If one of the area overlap ratios is over a fixed threshold, then the different detections are considered to belong to the same face. Given that two detections overlap each other, the detection with the highest classification score is kept and the other one is removed. This procedure is repeated until no more overlapping detections are found.

7. Experimental Discussion & Results

Our experiments are performed using Matlab ver. 7.4, CPU 2.13GHZ to verify the effectiveness of the proposed method. The proposed method is applied on 150 color images gathered from various sources such as Internet, UCD Face Image Database and Georgia Database. These images are varying in: size, lighting effects, uniform and nonuniform background, number of person in each image and the rotation angle of person. **Figure 3** shows some of the output of tested images in **Figure 4** obtained by applying proposed method and SFSC method.

As can been seen in **Figure 3** the face detection performance of the proposed method is better than SFSC method. **Figure 5** illustrates Comparison between proposed method and SFSC method in terms of face detection rate, false positive rate and false negative rate.

As can be seen in **Figure 5**, face detection rate in proposed method is better than SFSC method. The proposed method could detect approximately 84.1% of the faces correctly and SFSC method could detect approximately 74.6% of the faces correctly. Although false positive rate and false negative rate in proposed method is less than in SFSC method. In proposed method false positive rate is 10.4% and false negative rate is 15.9%. In SFSC method false positive rate is 22.0% and false negative rate is 25.4%. **Figure 6** illustrates detection time among 150 images in comparison of proposed method and SFSC method, as can be seen detection time in proposed method is a little bit increased.

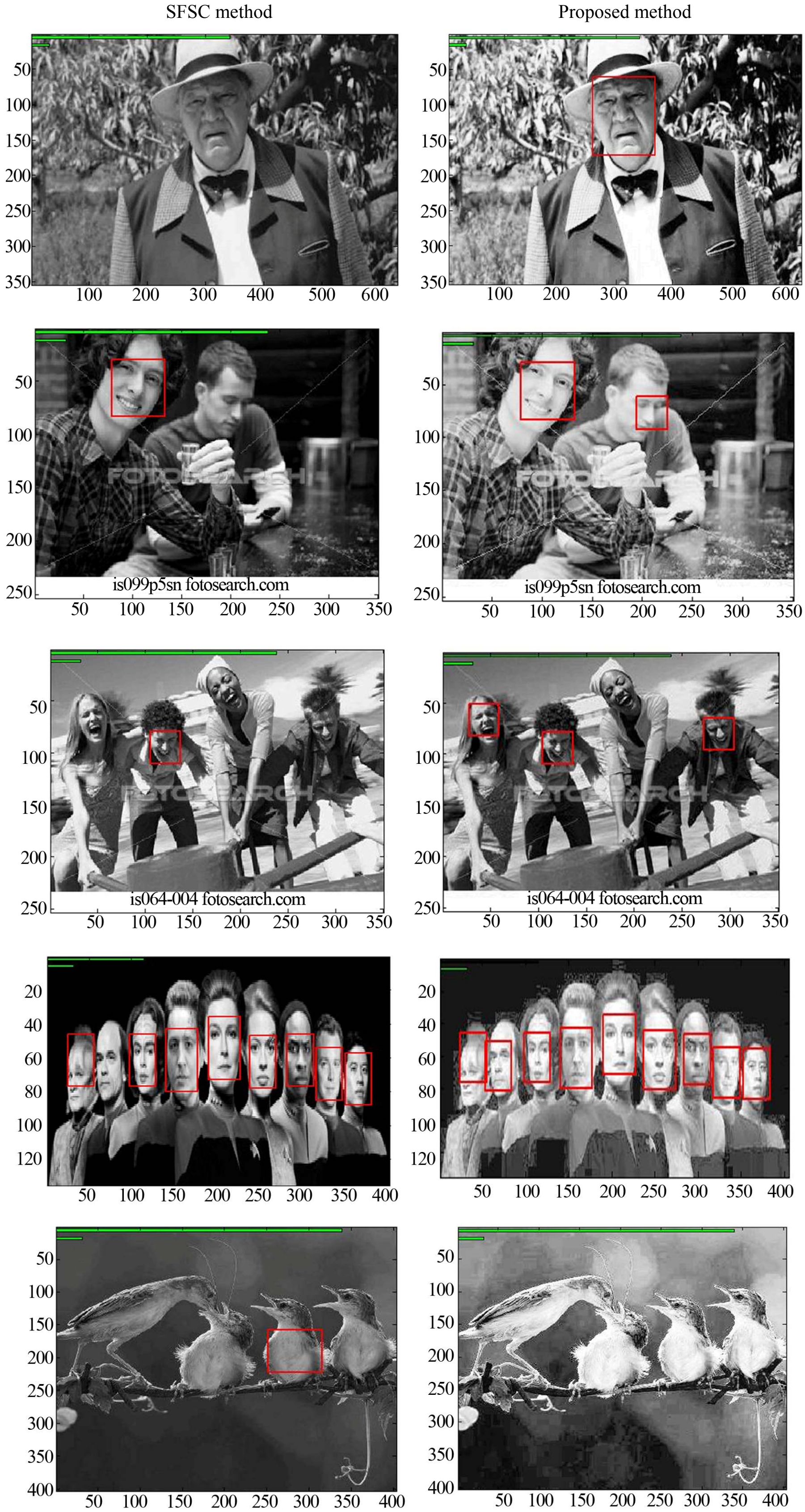

Figure 3. Detected faces after applying SFSC method and proposed method.

Figure 4. Samples of test images.

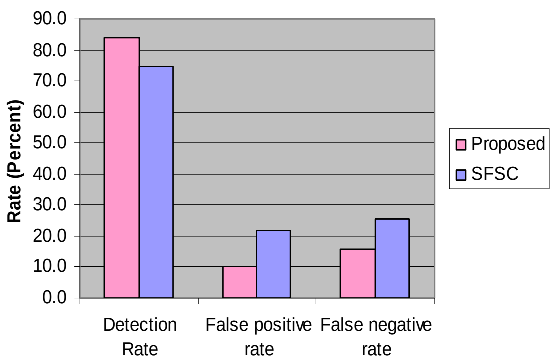

Figure 5. Comparison of two methods.

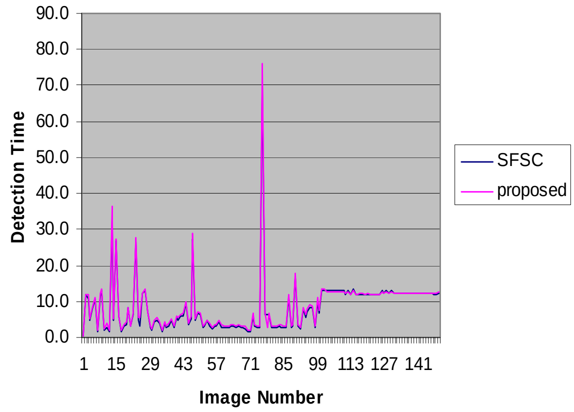

Figure 6. Detection time of the two methods.

8. Conclusion

In this paper, we presented a new approach for face detection using the MMCbCr Color Correction approach and SFSC face detection method. The whole experiment is applied on 150 color images obtained from different sources from Internet, and Georgia Database. Using matlab 7.4, the experimental results show that the proposed method is more effective and accurate compared to SFSC face detection method.

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