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Fast Face Detection Assisted with Skin Color Detection

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Abstract: *The key to e-commerce is confirming the identity of trading parties to ensure the non-repudiation of the communicating parties. The typical technologies include the digital signature-based identification technology and the biometric identification technology to identify individuals on the basis of different biological features (e.g., face, retina). Face recognition has been a popular technology, and the recognition efficiency is subject to the pre-stage face detection. Hence, it is important to achieve rapid detection of faces in images. This study proposed a fast face detection system targeting at dynamic images. The implementation method is composed of two parts: 1) conduct the pre-detection in the consecutive images using the feature detection cascade classifier proposed by P. Viola and Rainer Lienhart, and analyze the skin color of the detected face block; 2) conduct skin color detection by using the parameters obtained from skin color analysis, and then conduct rapid feature comparison using a classifier of lower complexity to reduce the environmental impact at the time of skin color detection. In addition, there is no need to use the classifier of high complexity after the lowering of dimension. This experiment conducted the performance analysis using an open face sample--George Institute of Technology Face Database. The experimental results indicated that the proposed method using a low performance classifier, along with skin color analysis, can make a relatively fast and accurate face detection system.*
Keywords: *A Skin color detection, face detection, dynamic images, adaboost*

I. Introduction

With advancement in electronization and automation of financial institutions, the financial information security problems have become increasingly prominent with increased insecurity factors of various systems. For example, the authentication of identity legality by swiping card is vulnerable to leakage of information, loss of the card, difficulty in memorizing the password and undistinguished responsibilities. With the technological advancement, computer vision technology can be used to establish the biological identification system through images and password authentication of identity can be replaced by face recognition systems in order to effectively enhance the security of the e-commerce trading. The study aimed to achieve rapid detection in the image system. The present face detection technology can be divided into the following types: (1) color-based approach to skin color face location [1]; (2) the face feature detection approach targeting at image to detect interested objects from images [2]. However, both methods have problems yet to be solved. For example, in addition to the changes of skin color in different cases of the people, the skin color is often vulnerable to environmental changes (color and illumination of the lights) in terms of accuracy. Although the approach using feature detection can be more accurate as it is not easily affected by the environmental lights, it usually takes more time to detect the features one by one when the dimensions increase. To implement a rapid and accurate face detection system, this study proposed a method to effectively integrate the skin color and feature detection technologies for the application in face detection in video.

II. Background Knowledge and Related Work

2.1. AdaBoost face detection

AdaBoost is the classification method proposed by Freund Y and Schapire R. E. [3] to improve the accuracy rate of any binary classification algorithm. The face detection method used in this study is a feature-based AdaBoost approach. Since the five organs on the face can generate light or dark blocks under illumination, the face detection is achieved using some rectangular features, as shown in Fig. 1.

Figure 1: Rectangular features and features selected in face detection

It is termed as rectangular features when using rectangles as the face detection feature vectors. Viola applied the concept of integral image in the calculation of rectangular feature value [4] to develop the Haar-like rectangular features from Haar wavelet transformation and defined many feature templates. Afterwards, Rainer Lienhart added the 45-degree angular feature to furthermore enhance the feature forms.

Paul Viola proposed the cascade decision-making classifier to improve detection rate and reduce computation complexity. After rapid computation of the rectangular feature values, it takes the AdaBoost approach to train the eigenvalue and determine the thresholds used in decision-making of the feature form at this stage. In other words, AdaBoost modeling for certain specific feature and the modeling is one of the stages of the cascade decision-making classifier. Hence, the set of each feature form can train the AdaBoost classifier of one stage. The combination of all stages can result in the so-called cascade decision-making classifier.

2.2. Skin color and color space

As human skin color is usually different from background to a certain extent, therefore skin color is often used as an important feature in face detection. The general image information obtained is usually composed of RGB primary colors. It is prone to the impact of lights when using the RGB colors to detect skin color. As a result, the RGB color space is not suitable for the representation of skin color. Suitable representation methods including XYZ, YIQ, YUV, HSV, HIS are commonly used. It was mentioned in the study of Shin [5], regarding the skin color classification problem in these color spaces, regardless of the changes of color space, the distinction of skin color and non-skin color did not change significantly. Hence, the selection of color space would not affect skin color significantly. Generally, skin color detection can be divided into two primary types (1) statistics-based models mainly including spatial conversion and skin color modeling [6], (2) physics-based method which introduced the interaction between light and skin in skin color detection to realized detection by skin color reflection model and spectral characteristics [7].

III. System Structure and Experimental Process

3.1. Face detection process

According to the method proposed in 2-1, this study developed a classifier featured with face by training method and used the function cvHaarDetectObjects () of the OpenCV [9] to design a face detection process, as shown in Fig. 2.

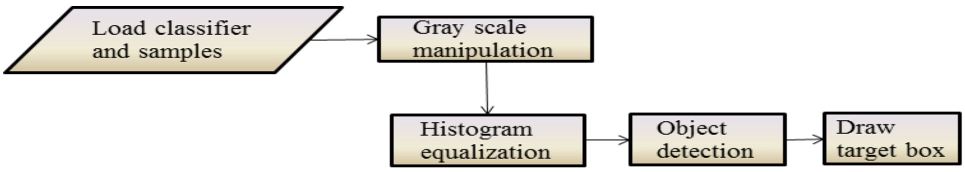

Figure 2: Object detection process

3.2. Skin color modeling and analysis

The implementation of skin color requests a group of skin color parameters. To enable the group of parameters applicable in various images, we need to analyze the skin color blocks in the image, as shown in Fig. 3.

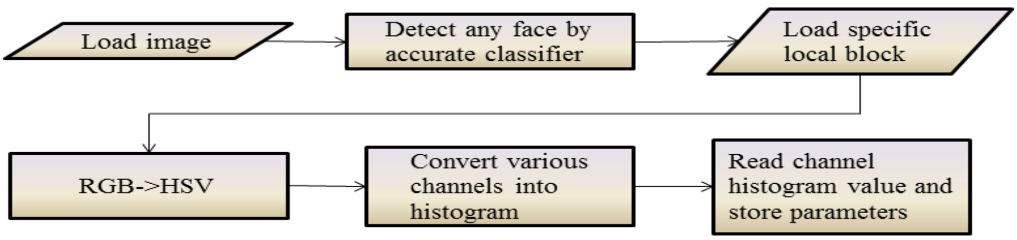

Figure 3: Skin color modeling process

Skin color modeling is to take advantage of the image continuation feature of the movie to directly acquire face blocks using an accurate face detector at the early stage of the video. Then, the skin color values are obtained from the blocks by histogram analysis to get skin color parameters. If the lights or the human skin color samples are different, it may result in consistent results when the images are converted to binary images. Hence, the implementation (Morphology) may require only one process for applications in most samples. As the area surrounding the mouth is not likely affected by hair color and the reflection of glasses, this area is taken as the sampling blocks for the skin color modeling, as shown in Fig. 4.

Figure 4: Face skin color box selection

After the conversion of image into the HSV space, the channels are converted to histograms, as shown in Fig. 5, 6, and 7, to read and filter values to be stored in the skin color parameters.

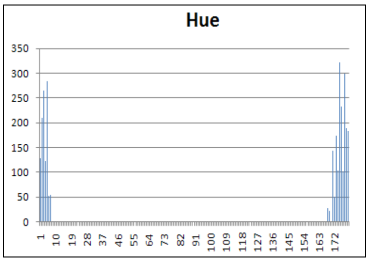

Figure 5: Hue histogram

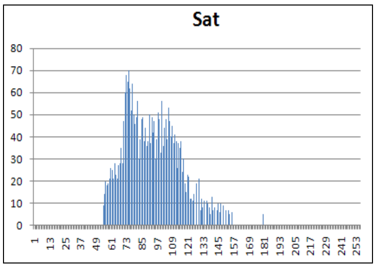

Figure 6: Saturation histogram

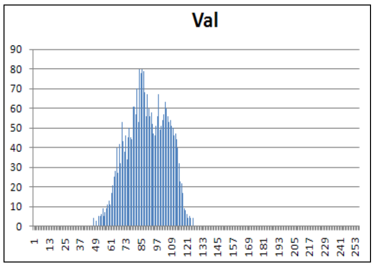

Figure 7: Value histogram

3.3. Skin color process

This study implemented one case of skin color detection according to [8] to convert the color space into HSV and designed a process as shown in Fig. 8.

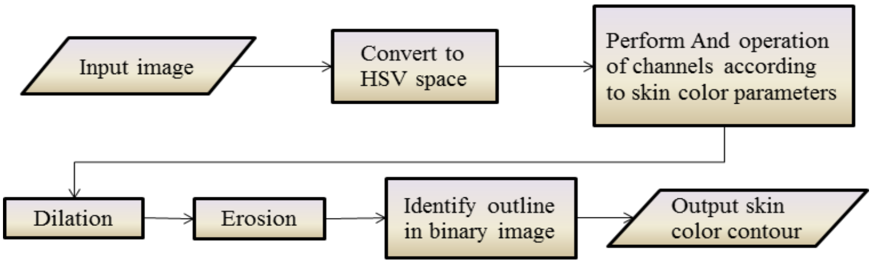

Figure 8: Skin color process

After obtaining skin color parameters, the input images are converted back to HSV space and filtered according to skin color parameters. Box selection of the skin color blocks is shown in Fig. 9.

Figure 9: Skin color results (left: binary image, middle: morphological conversion, right: drawn outline)

3.4. Experimental process

This study designed a performance test method for face samples from Georgia Tech face database, as shown in Fig. 10. First, 15 images were loaded, and face detection of each image was conducted using the face classifier of higher detection rate until a faces could be detected. Next, skin color analysis of the selected face block was conducted, while the skin color detection of the remaining samples was conducted using this group of skin color parameters. After detection of the skin color blocks, fast face detection of these skin color blocks was conducted accordingly. Such a skin color detection method is highly applicable in case of various lights and different skin color samples. The number of classifiers could be largely reduced due to the skin color filtering, and thus the face detection is more accurate and faster.

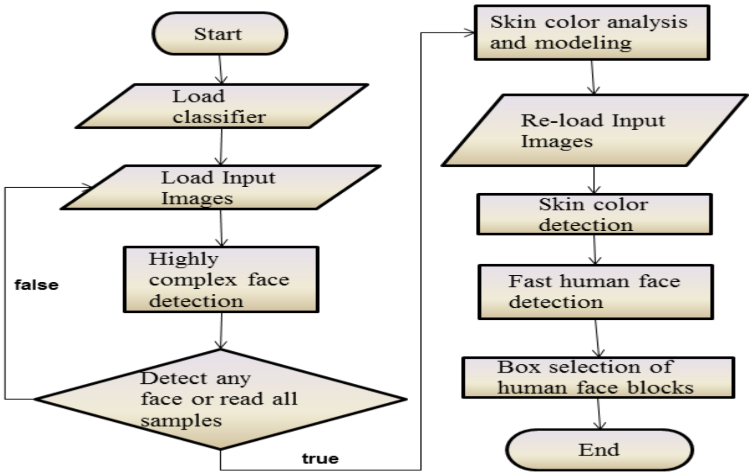

Figure 10: Experimental process

IV. Experimental Environment

4.1. Computer specifications

The CPU of the computer used in this experiment was the Intel Q9400 2.66GHz quad-core, memory was 3.5G, the operating system was Windows XP Professional SP3, and the OpenCV version was 2.0.

4.2. Face database

A segment of continuous video for detection was used for the proposed method. The test samples used in the experiment were taken from the face database of Gorge Institute of Technology, as described in detail in Table 1.

Table 1: George Institute of Technology face database

Total people number	50
Pictures taken per person	15
Image number	750
Image definition	640*480
Image color	color
race	Black, white, Asian
Image format	JPEG
Face direction	Forward, tilt, side
Expression	yes
Image background	In front of a cabinet inside a room
Light condition	Even
Similar color	The cabinet has similar colors with the skin color

The reason to use the George Tech Face Database is because it contains the faces of various races, expressions and posture, as well as the samples of the same person like as video segments. Except for the human actions, the rest background, light conditions and other factor remain unchanged. Meanwhile, all the images are taken before a cabinet its color similar to face skin color. This is considerably challenging to skin color detection, as shown in Fig. 11.

Figure 11: George Institute of Technology face database

4.3 Classifier analysis

The system has two kinds of face detection methods. One is highly complex and accurate, and takes more time. The classifier Alt2 provided by Rainer Lienhart has 1047 sub-classifiers. Another fast classifier is provided by Shiqi Yu and trained with eye as the feature. It has 523 sub-classifiers and is termed simply as Eye. This study used the George face samples to test the two classifiers to obtain the data, as shown in Tables 2 and 3. The Eye detection takes about half of that of the Alt 2. However, as the detection rate of Eye is poorer than the Alt 2 classifier with higher error rate, the actual detection rate is relatively poorer (1.1:11%, 1.2:20%, 1.3:14%).

Table 2: alt2 classifier data

Classifier	alt2		
Scale_factor	1.1	12	1.3
Detection rate (%)	96.8	96.1	93.7
Error detection rate (%)	25.8	6.4	1.9
Actual detection rate (%)	70.9	89.6	91.7
average detection time (ms)	507	264	199

Table 3: Eye classifier data

classifier	eye		
Scale_factor	1.1	1.2	1.3
Detection rate (%)	90.1	86.4	83
Error detection rate (%)	31	17.1	5.8
Actual detection rate (%)	59	69.2	77.2
average detection time (ms)	250.1	142	108

V. Results and Discussion

5.1. Face detection measurement criteria

Most of the detection rate calculation for current face detection systems discusses the accurate detection frames and the error detection frames separately. As shown in Table 4, ideal face detection system should have high detection rate and low error rate, actual detection rate can be used for measurement.

Table 4: Face detection measurement criteria

(1)	Detection rate = number of correctly detected frames /total number of faces
(2)	Rate of mistakenly detected frames = number of mistakenly detected frames /total number of detected frames
(3)	Total number of detected frames = number of correctly detected frames +number of mistakenly detected frames
(4)	Actual detection rate = detection rate -rate of mistakenly detected frames

5.2. Data analysis of high level stage classifier assisted with skin color detection

Table 5 illustrates the data analysis of high level stage classifier assisted with skin color detection. As seen in Table 2 and 5, except for the scale_facto=1.3, all the criteria of the actual detection rate improve and the detection time is shortened greatly (1.1:30.5%, 1.2:24.6%, 1.3:20.2%).

Table 5: Skin color +Alt2

Scale_factor	1.1	1.2	1.3
Detection rate (%)	95.8	94.8	93
Error detection rate (%)	17.5	4.2	1.2
Actual detection rate (%)	78.3	90.5	91.7
average detection time (ms)	352	199	158.8

5.3. Data analysis of low-level stage classifier assisted with skin color detection

Table 6 illustrates the data analysis of the low-level classifier assisted with skin color detection. Although detection time was shortened considerably, as shown in Table 5, it still took more than 158ms (scale_factor=1.3) and was unable to process real time images. Hence, the Eye classifier was used for experiment. By comparing Tables 3 and 6, the actual detection rate improved in cases of scale_factor=1.1, 1.2, and decreased slightly in case of scale_factor=1.3. However, the detection time was shortened considerably (1.1: 73.5%, 1.2:65.9%, and 1.3:60.9%).

Table 6: Skin color +eye

Scale_factor	1.1	1.2	1.3
Detection rate (%)	87.8	82.8	79.4
Error detection rate (%)	9.8	6.4	3.2
Actual detection rate (%)	78	76.3	76.2
Average detection time (ms)	66.1	48.3	42.2

5.4. Experimental results and discussion

The proposed method can be used to improve the actual detection rate of the face detection in the video. Generally, classifier is directly applied to detect in the video. If the platform performance is not sufficient, there would delay in video. Fig. 12 shows the column chart of the detection rate, and actual detection rate in case of direction detection using two classifiers without the assistance of skin color. Fig. 13 illustrates the column chart of the detection rate and actual detection rate in case of detection using two classifiers with the assistance of skin color. Fig. 14 presents the broken line graph of the average detection time by various methods. In this sample experiment, with the assistance of skin color detection, it can ensure that the actual detection rate and the detection speed can be considerably improved as the image dimensions have been narrowed down. When replacing Alt 2 with Eye, the actual detection rate is not as high as that of the Alt 2 (overall actual detection rate is around 76%), the detection time can be considerably shortened (1.1: 81.2%, 1.2:75.7%, 1.3:73.4%).

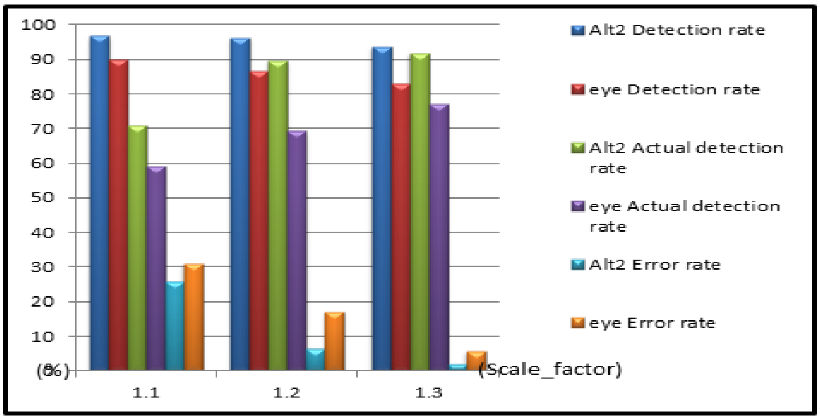

Figure 12: Column chart of direction detection rate (without skin color detection)

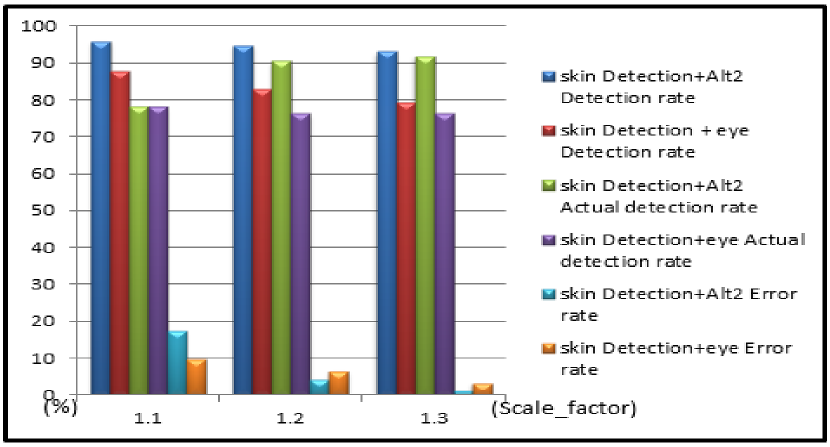

Figure 13: Column chart of detection assisted with skin color detection

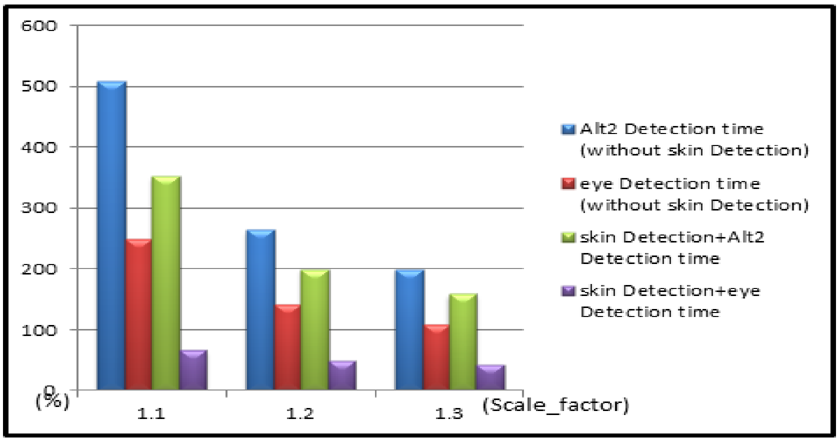

Figure 14: Average detection time of various methods

VI. Conclusion

The proposed method is a detection method assisted with skin color detection. Regardless of the classifier, the method was proven to shorten detection time with very low loss of actual detection rate. Comparison of the high-level and low-level classifiers showed that the low-level classifier (Eye) can shorten image dimensions by taking advantage of the smaller target to considerably improve detection speed. In the future, the method will be implemented in video and compare whether different cameras and lens can keep high detection rate. In addition, test on images of more than one person will also be conducted.

References

[1] C. Duan-Sheng and L. Zheng-Kai, "A survey of skin color detection", Chinese Journal of Computers, vol.29, no.2, pp. 194-207 2006.

[2] Huang Y. T., Chiang C. C., "Real-time detection of multiple faces using rule-based methods", in Information science Engineering, pp. 65, Dong-Hwa University Taiwan, 2002.

[3] Y. Freund and R. Schapire, "A desicion-theoretic generalization of on-line learning and an application to boosting", pp. 23-37, Springer, 1995.

[4] P. Viola and M. Jones, "Rapid object detection using a boosted cascade of simple features", in Computer Vision and Pattern Recognition, 2001. CVPR 2001. Proceedings of the 2001 IEEE Computer Society Conference on, pp. I-511-I-518 vol.511, 2001.

[5] M. C. Shin, K. I. Chang and L. V. Tsap, "Does colorspace transformation make any difference on skin detection?", in Applications of Computer Vision, 2002. (WACV 2002). Proceedings. Sixth IEEE Workshop on, pp. 275-279, 2002.

[6] J. Yang, W. Lu and A. Waibel, "Skin-color modeling and adaptation", Computer Vision—ACCV'98, pp. 687-694 1997.

[7] M. Störring, H. J. Andersen and E. Granum, "Physics-based modelling of human skin colour under mixed illuminants", Robotics and Autonomous Systems, vol.35, no.3–4, pp. 131-142 2001.

[8] V. Oliveira and A. Conci, "Skin detection using hsv color space", SIBGRAPI'09 Brazilian Symposium on Computer Graphics and Image Processing, pp. 1-2, 2009

[9] OpenCV Reference Manual v2.1, http://www.opencv.org.cn/index.php, 2010