Colour Face Image Database for Skin Segmentation, Face Detection, Recognition and Tracking of Black Faces Under Real-Life Situations

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Abstract

This paper presents a new face database containing only black face images. It is designed to be used for benchmarking algorithms developed for skin segmentation, face detection and recognition under real life situations. The database contains coloured images of black faces in JPEG formats taken over a period of two years (2007-2009). It contains three subfolders, where the images have been grouped for face detection, face recognition and face tracking purposes. There are over 100 images for face detection containing more than 150 face images and 600 images of ten per 60 individuals for face recognition and 10s video sequences of ten black faces. An interactive Graphic User Interface (GUI) was developed in Matlab® (7.4.1a version) for the face database providing basic information about the images as well as creating an interactive and easy to use environment.

Keywords: Skin Segmentation; Face Detection; Face Recognition; Face Tracking

1. INTRODUCTION

To benchmark face detection or face recognition algorithms, the use of standard datasets is recommended as this would allow researchers to their compare results. Since there are varieties of large databases, the choice of an appropriate one to select is based on the problem(s) intended to be solved. The common face databases are the AT&T face database [1] and the MIT database (http://www.ai.mit.edu/projects/cbcl). Others that have been mentioned and used are the MATRANORTEL database [2], AR face database [3], and FERET database [4,5].

Image is formed in the eye and in the camera by the amount of illumination reflected by an object. This explains why capturing, detecting and recognition of faces of different skin colour is of high importance. Recent studies have shown that pigmentation (i.e. surface reflectance properties, including albedo, hue, specularity, translucency, and spatial variation in these properties) cues are equally as important as shape information for face recognition [6].

In the face recognition homepage (http://www.face_rec.org/databases/), about 35 face databases were reported to exist as at July 2008. In the handbook of face recognition, 20 face databases for face recognition, 2 for face detection, 5 for non-face and sub-face datasets and 3 for facial expression analysis were reviewed [7]. The summary of some of the face databases is presented in Table 1. They include FERET database [4,5], AT&T (formerly ORL) [1], AR (Purdue) database [3], CMU PIE database [8], Indian face database [9], Chinese Academy of Sciences (CAS) database [10] and VT-AAST image database [11]. In these databases, face images were captured under controlled conditions which are far from what is obtainable in the real life. For example, the cameras used for surveillance have much more lower resolutions compared to the ones reported to have been used in capturing the images in these databases. In addition, surveillance cameras do not have the capacity or added function of providing flash when an image is to be captured, whereas most of the images in the earlier databases used either flashes or were taken under standard lighting conditions.

We venture to bridge the gap in the existing databases especially for the detection and recognition of Black faces. Black surfaces reflect a small fraction of the light rays incident on them. Therefore, under very poor illumination conditions, very little information is made available for processing, detection or recognition. Recent report have countered the notion that color is unimportant for human face recognition and suggested instead that when shape cues in images are compromised (e.g. by reductions in resolution), the brain relies on color cues to pinpoint identity [12,13].

This paper presents a new face database which contains only black face images of different skin tones, middle aged and both male and female gender. It is designed to be used for benchmarking algorithms developed for face detection, recognition and tracking under real-life conditions. Section 2 gives a description of the database, how it was populated and the results of skin segmentation performed on some of the images in the database and section 3 gives the conclusion.

2. BLACK FACE DATABASE (BFDB)

The Black-face Database comprises of two parts, Part A was taken to serve as a pilot to the second Part B and for use in the early part of a research work [14], the Part B is being developed to increase the robustness of the database for benchmarking face detection, recognition and face tracking algorithms, with its own peculiar advantage. The Part A of the database is fully reported in this paper, while work is in progress on Part B of the database. Each Part contains three sub-folders; containing images for face detection, face recognition and video sequence of faces for face tracking.

The face detection folder ‘Detect’ contains 10 uncompressed pictures containing at least 45 faces. The images were captured at different dates and periods of the day and contain images with different pose, orientation, gender, background and illumination. A summary of the images in the ‘Detect’ subfolder is shown in Table 2. The face recognition folder contains 123 images of 20 persons taken under different conditions with varying facial expressions, details are shown in Table 3. The pictures were taken between August 2008 and April, 2009. The pictures were taken with Hp 7.3 Mega-pixels camera and they are in JPEG formats. The pictures were later cropped and compressed to 448×336 pixels. Compressing the images did not necessarily affect skin detection but the time of execution was faster than when the images were not compressed [14].

The database contains twenty folders each containing at least five upright and frontal pictures of each subject (person). Each folder comprises of frontal images of each subject taken without the use of flashes. There are three variations under the illumination which are; controlled lighting, labelled as ‘bright’; outdoor but dull illumination labelled as ‘poor’; and under dark illumination labelled as ‘dark’. The variations in facial expressions were ‘smile’, ‘frown’ and ‘blink’. Shots of subject with their heads slightly rotated to the right and to the left were also taken to achieve variations in pose and were labelled ‘right’ and ‘left’ respectively. At least one of the subjects had a scarf on and at least another one was in glasses. Examples of images of two subjects (persons) are shown in Figure 1.

Name or Description of Database and Date	Number of Subjects	Conditions		Image Resolution	Number of Images
FERET (August, 1993 – July, 1996) [4,5]	1199	Facial expression Illumination Pose Time	2 2 9-20 2	256 × 384 pixels (8 bit grey scale)	14,051
AT & T (1992 – 1994) [1]	40	Varying Lighting Facial expression Facial details	 4 2	92 × 112 pixels (PGM, grey scale)	400
AR (PURDUE) (1998) [3]	116	Facial expression Illumination Occlusion Time	4 4 2 **2**	768 × 578 Pixels (RGB colour images)	3,288
CMU-PIE (October – December, 2003) [8]	68	Pose Illumination Facial expression	13 43 3	640 × 486 pixels	41,368
Indian Face (February, 2002) [9]	40	Pose Facial expression	7 4	640 × 480 pixels (JPEG, 256-grey levels)	440
CAS-PEAL (August, 2002 – April, 2003) [10]	1040 377 438 233 297 296 66	Pose Facial expression Accessory Illumination Background Distance from camera Time	21 6 6 9-15 2-4 12 2	360 × 480 (Cropped grey scale images)	30,900
VT-AAST (2007) [11]		Pose Orientation Race Structural Components	3 2 4 3	300 × 225 (JPEG & GIF)	1027

TABLE 1: Summary of some existing face databases

FIGURE 1: Examples of images in the face recognition database

Part B of the database contains two folders, ‘detect’ and ‘recognition’ folders. The ‘detect’ folder contains two folders, one contains images captured under good illumination (‘Light’) while the other contains images captured under poor illumination (“Dark’). The light folder has 50 images which contain at least 72 human faces of varying poses and illumination captured under good lighting condition. Few images were adopted from the internet one or two existing databases. The dark folder has 50 images which contain at least 68 human faces of varying poses and orientations taken under poor illumination. A summary is given in Table 3 and examples of images captured under good and poor illuminations are shown in Figures 2a and 2b respectively.

(a) Images taken under good illumination

(a) Images taken under poor illumination

FIGURE 2: Examples of images in the face detection database

Images	Total Number of faces	Gender		Pose	
		Male	Female	Rotated	Upright
Pic1	1	1		1	
Pic2	5	5			5
Pic3	1	1		1	
Pic4	1		1		1
Pic5	1		1		1
Pic6	1	1			1
Pic7	2		2		2
Pic8	2	2			2
Pic9	1		1	1	
Pic10	7	6	1		7

TABLE 2: Summary of face detection images in Part a of the database

Folders	Gender	Illumination			Rotation		Expression			Other Effects		
		Bright	Poor	Dark	Right	Left	Smile	Frown	Blink	Scarf	Cap	Glasses
f1	M	√	√	√	√	×	√	×	×	×	×	×
f2	F	√	√	√	√	×	√	√	×	√	×	×
f3	M	√	√	√	√	×	√	√	×	×	×	×
f4	M	√	×	√	√	√	√	√	×	×	×	×
f5	M	√	√	√	√	√	×	√	×	×	×	×
f6	M	√	√	√	√	×	√	√	×	×	×	×
f7	M	√	√	√	√	×	√	√	×	×	×	×
f8	M	√	×	√	√	√	√	√	×	×	×	√
f9	F	√	√	√	√	√	√	√	×	×	×	×
f10	M	√	√	√	√	×	√	×	×	×	×	×
f11	M	√	√	√	√	√	√	√	×	×	×	×
f12	F	√	√	√	√	√	√	√	×	×	×	×
f13	M	√	√	√	√	×	√	√	×	×	×	×
f14	M	√	√	√	√	×	√	√	×	×	×	×
f15	M	√	√	√	√	√	√	√	×	×	×	×
f16	M	√	√	√	×	√	√	√	×	×	×	×
f17	M	√	√	√	√	×	√	√	×	×	×	×
f18	M	√	√	√	√	×	√	√	×	×	×	×
f19	M	√	√	√	√	√	√	√	×	×	×	×
f20	M	√	×	√	√	√	√	×	×	×	×	×

TABLE 3: Summary of face recognition images in Part A of the database

Grouping	Number of Images	Number of Faces
Dark	50	72
Light	50	68
Total	100	140

TABLE 4: Summary of face detection images in Part B of the database

An interactive Graphic User Interface (GUI) was developed in Matlab^{TM} 7.4.1a version for the face database to enable an easier use. This is also an improvement over other face databases. Both the database would be copied at a known location on the user's computer and the Matlab file would be copied into the Matlab directory. The user then only needs to type the default filename "face_database in the Matlab command prompt. The interactive GUI would appear and the needed image can be selected. The user would type in the address or location of the database into the query, then select the exact image to be used. The image can then be saved and used for either face detection, training or testing a face recognition algorithm. The default filename for the face detection GUI is Database_detect. The outlooks of the GUIs are in Figures 3 and 4. The database as well as the Matlab® codes can be obtained by contacting the authors.

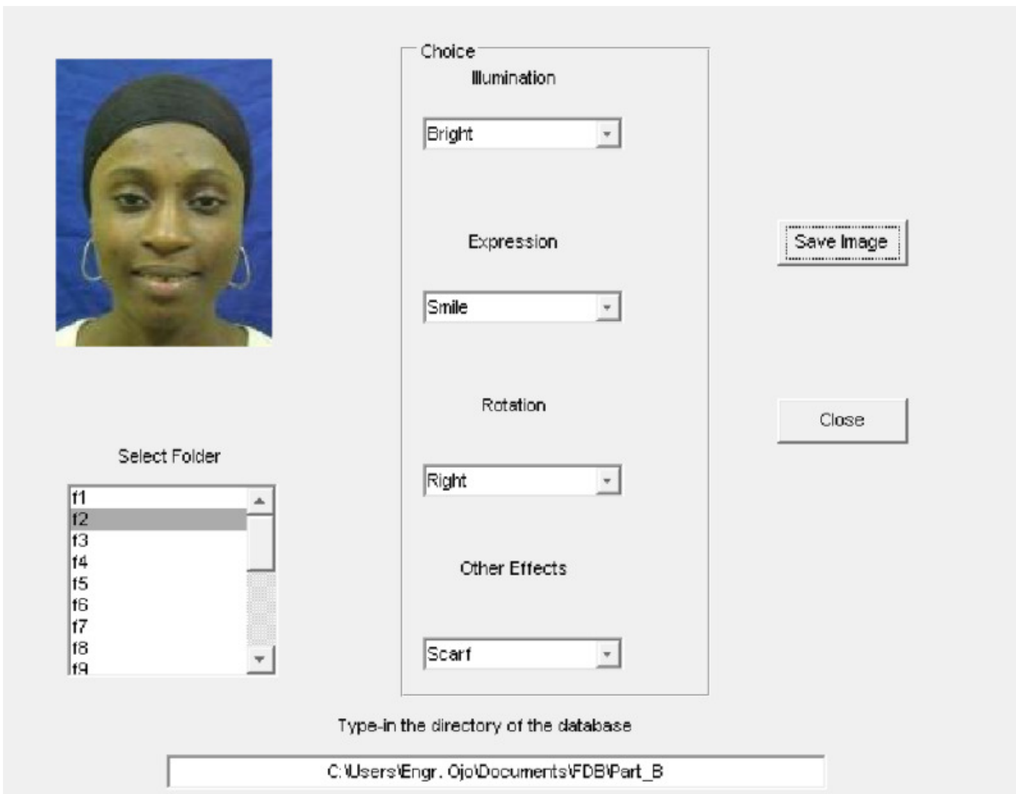

FIGURE 3: Matlab GUI for Face Detection Database

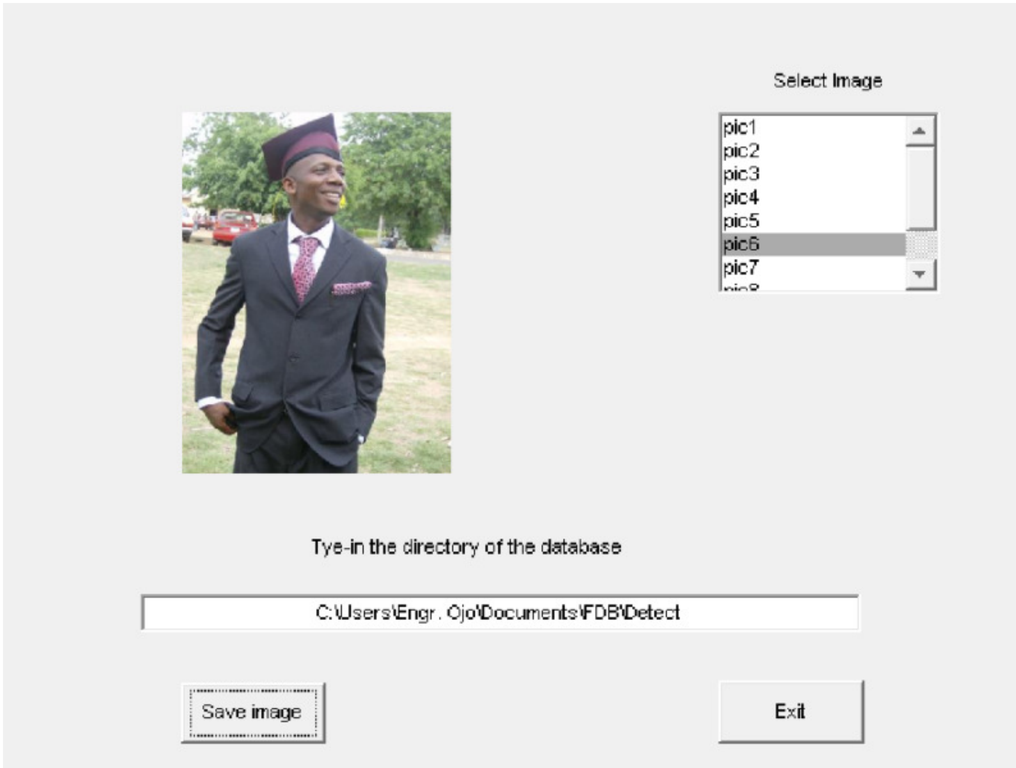

FIGURE 4: Matlab GUI for Face Recognition Database

Images in the database were tested using earlier skin segmentation algorithms [15], and some of the results are shown in Figure 5. Each of these figures shows the original image in the database and the corresponding skin-segmented images. The skin-likelihood areas in the skin segmented images appear white while other areas have deeper shades.

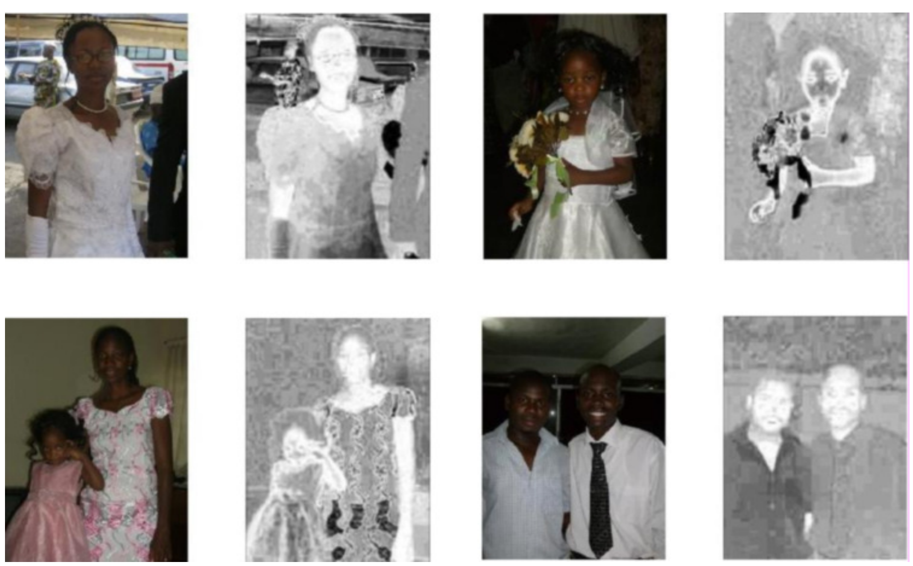

FIGURE 5: Skin segmented images from the database

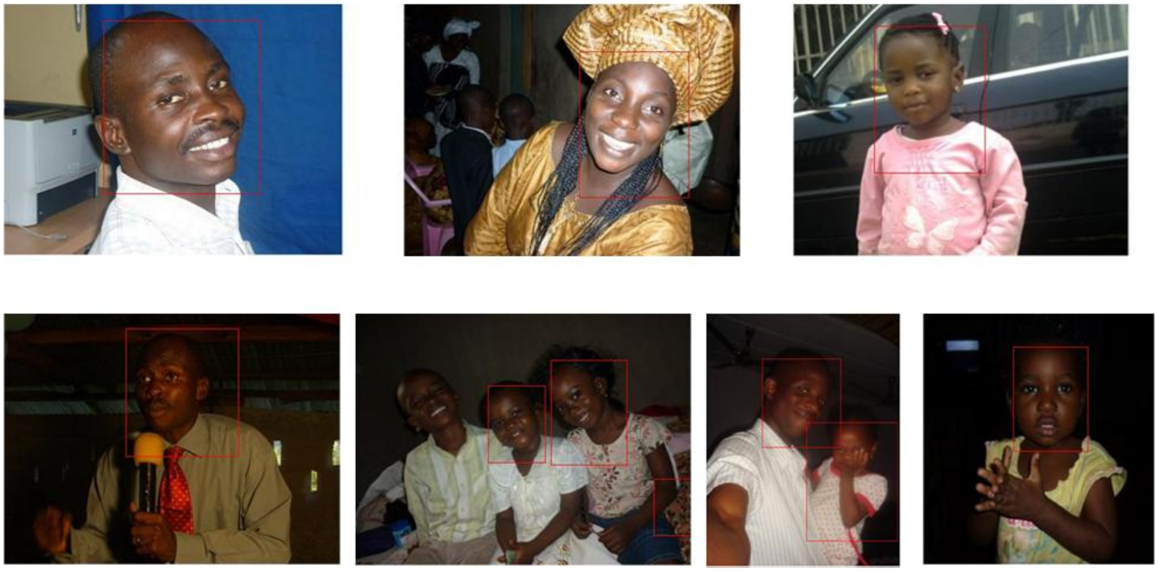

FIGURE 6: Selected images from the database showing detected faces.

Images in the face detection subfolder were tested for presence of faces using a novel face detection algorithm [16]. Some of ths results are shown in Figure 6. Detection rates of 83.8% and 76.4% were achieved for faces captured under good and poor illumination respectively. The same images were tested with earlier algorithms which have been reported to have good performances [17,18], details shown in Table 5. It is observed that although the earlier algorithms performed excellently well when benchmarked on some face detection databases, it was not so with the new database (BFDB). As a result, the new database with its unique feature of large variations under real life situations is expected create new frontiers for researches in face detection and recognition.

Detection Method	Detection Rates	
	Good illumination	**Poor illumination**
Hybrid Model [16]	83.8%	76.4%
Viola & Jones [17]	35.29%	31.94%
Pai et al [18]	66.18%	56.9%

TABLE 5: Detection rates for images taken under good Illumination

3. CONSLUSION

This paper has discussed a new face database developed to solve some challenges poised in using appropriate images to benchmark algorithms developed for skin-segmentation, face detection, recognition and face tracking, especially for Black faces. It contains images taken under large variations under real life situations and it gave good results in the study of skin-segmentation.

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