AN INDIAN FACIAL DATABASE HIGHLIGHTING THE SPECTACLE PROBLEMS

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An Indian facial database highlighting the Spectacle Problems

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***Abstract*—Occlusion, glare and secondary reflections formed due to and on the spectacles - results in poor detection, localization, and recognition of eye/face features. We term all the problems related to the usage of spectacles as *The spectacle problem*. Though several studies on the spectacle detection and removal have been reported in the literature, the study focusing on spectacle problem removal is very limited. One of the main reasons being, the nonavailability of a facial image database highlighting the spectacle problems. Therefore, we created an Indian facial image database consisting of corresponding facial images with and without spectacle problems. The release of database Version 1 contains a total of 270 images from 10 subjects - each image marked with 19 facial landmarking. This database is released now to promote research and development of Spectacle problem removal algorithms. In this paper, we describe the recording procedure and present the results of few baseline face detection algorithms.**

***Index Terms*—Indian face database, Face detection, Eye detection, Spectacles, Occlusion, Glare, Secondary reflection.**

I. Introduction

Detection, localization, and recognition of eye features is an important step in many face detection, Human-computer interaction (HCI) and Biometric applications [1], [2]. Literature [3], [4], [5], [6], [7], [8] suggests the fact that eye feature detection accuracy decreases drastically when the user wears spectacles.

We term the problems related to the usage of spectacles as ”The spectacle problem”.

A. The Spectacle Problem

Though spectacles occupy fewer area in-terms of number of pixels, it has a huge impact on face feature detection as well as tracking algorithms. Two problems occur when the user wears spectacles (see Fig.1). They are:

- Occlusion [2], [9], [8], [10]: Occlusion is the phenomena in which eye features are obstructed by the spectacle frame. Depending upon the comfort, nature, and size of spectacle frame used - most or partial amount of eye feature information may be lost.
- Glare and Secondary reflections [9], [8], [6], [7]: Glare and secondary reflections occur due to the variation of illumination in the facial images. These variations result in an apparent change on the reflectance properties of the spectacles - leading to a visual variation of the features.

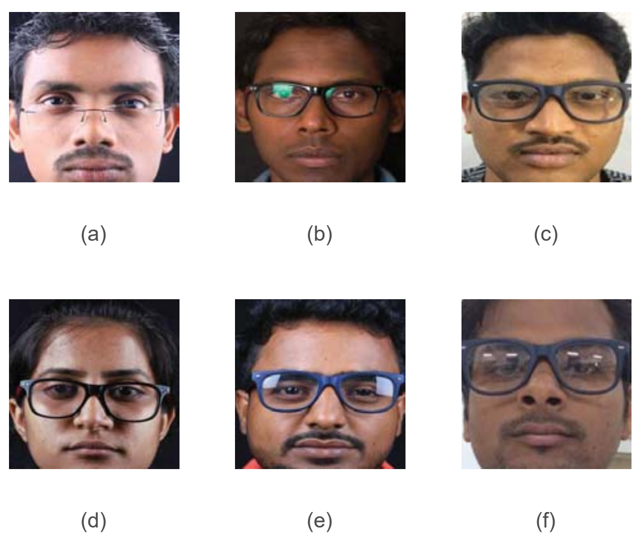

Fig. 1: Sample images of the proposed database illustrating the Spectacle problem. (a)&(d) Occlusion; (b)&(e) Glare; (c)&(f) Secondary reflection.

All the spectacle problem elements individually or cumulatively can vary or obstruct the appearance of the eye features. Although the challenges in the detection of facial features

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under spectacles are dealt in [11], [12], [10], the spectacle removal application, in general, is yet to achieve maturity.

II. Previous works

In literature, a considerable amount of work has been done in the area of spectacle detection, but very few papers discuss the spectacle removal application [1]. Spectacle detection algorithms detect and classify a given facial image as - with or without spectacles. On the other hand, the spectacle removal algorithms, remove the spectacles from a given facial image to generate a seamless output image without spectacles. Due to the unpredictability caused by occlusion, glare and secondary reflection formations, the spectacle removal problem is quite challenging than the detection application. A few of the available spectacle detection and removal algorithms are listed in TABLE I.

The spectacle detection and removal algorithms can be broadly classified into two categories namely: feature-based and sample-based learning algorithms. Feature-based methods [6], [1] explore the characteristics like local structure and image intensities to identify the eye/spectacle features. Though easy to implement, these approaches are not reliable, as any variation in shape, intensity of the features leads to poor detection accuracies. On the other hand, the sample-based learning algorithms [4], [8] are more reliable because of the adaptiveness in their approach which is based on the information gained from the training dataset. TABLE I presents a list of such publicly available datasets.

A. Literature on the available datasets

As mentioned in Section II, the efficacy of any sample-based learning approach is directly related to the variability in size, illumination, environment under which the samples are collected. An exhaustive literature survey on the availability of such databases, reveals the following facts:

- Detection, localization, and synthesis of facial images with spectacles have not been thoroughly investigated. One of the main reasons being, the nonavailability of a facial image database highlighting the spectacle problems.
- Datasets like [24], [25], [10], [14], [17], [18], [22], [10], [26], [13], [27], [28] provide facial images of subjects with spectacles only. Therefore, they can be utilized to validate spectacle detection algorithms only.
- In case of spectacle removal application, most of the proposed sample-based approaches require corresponding facial images with and without spectacles to increase the accuracy of the algorithm [8]. Few number of such sample image pairs are provided in [15], [18], [20], [9], [23].
- All the available databases (except [25]) contains facial images of Mongolian and Caucasian faces. To study the ”cross-race” effect on the face detection algorithms, there is a need to generate an Indian origin database too.
- Most importantly, the above mentioned databases are created in strict illumination conditions, wherein the spectacle problem challenges like glare, occlusion, and secondary reflection are not taken into consideration.

The above literature suggests that a complete Indian database that enlists the challenges of spectacle problem with variabilities in illumination along with the benchmark data (facial image without spectacle problem) is unavailable. Therefore, we propose to create a database with significantly more variables and challenges than the existing databases.

III. Proposed Indian facial database

The main objective of this database is to provide a platform for validating algorithms which tackle the spectacle problem. To date, our database consists of 270 facial images captured from 10 subjects. All images contain upright frontal faces wearing conventional eyeglasses. The images are taken under three categories, viz: without spectacles, with spectacles (without any spectacle problems) and with spectacle problems. A few samples of the facial images from our database can be seen in Fig.2.

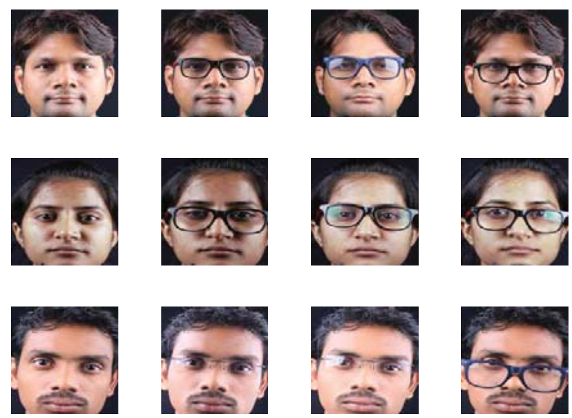


Fig. 2: First & Second columns: Samples of images without spectacle problems; Third & Fourth columns: Samples of images with spectacle problems.

A. Markup Scheme of the proposed Database

The metadata is indexed as “NUM_G_S_I_O” and the details of the nomenclature are given accordingly to the TABLE II.

- The file name of each image contains information regarding: the Subject ID; Gender; Spectacle, Illumination and Occlusion presence details.
- We provide a $MAT - file$ of 19 manual generated facial landmarking ground-truth for each image as shown in Fig.3.

B. Deliverables from database

The database described in this paper will add a new dimension in face recognition research. The generated database includes:

- Facial images with and without spectacles.

TABLE I: Literature review on the spectacle detection and removal algorithms.

Application	References	Database used	No. of facial images with spectacles	Application	References	Database used	No. of facial image pairs with and without spectacles
Spectacle-detection	[13]	The Database of Faces [14]	28	Spectacle-removal	[3]	YALE [15]	165
	[16]	XM2VTSDB [17]	103			FERET[18]	192
	[19]	MIT Face database	14		[4]		20
		Self generated	37			Self generated	123
	[11]	FERET [18]	47		[5]	KFDB [20]	300
	[21]	LFW [22]	1500		[6]	CAS-PEAL [9]	80
	[12]	Self generated	100			Self generated	60
	[2], [10]	COFW [10]	900		[7], [8]	NIR-VIS [23]	94 (VIS) 75 (NIR)

TABLE II: Metadata nomenclature format of the proposed database.

NUM_G_S_I_O								
NUM = Number	G = Gender		S = Spectacles		I = Illumination		O = Occlusion	
Subject ID	Female	Male	Wearing no spectacles	Wearing spectacles	No illumination problem	Illumination problem	No occlusion problem	Occlusion problem
000 - 270	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**

Markup scheme
0 = right eye pupil
1 = left eye pupil
2 = right mouth corner
3 = left mouth corner
4 = outer end of right eye brow
5 = inner end of right eye brow
6 = inner end of left eye brow
7 = outer end of left eye brow
8 = right temple
9 = outer corner of right eye
10 = inner corner of right eye
11 = inner corner of left eye
12 = outer corner of left eye
13 = left temple
14 = tip of nose
15 = right nostril
16 = left nostril
17 = centre point on outer edge of upper lip
18 = centre point on outer edge of lower lip

Fig. 3: Sample images with landmark markup scheme.

- Facial images with variation in spectacle frames - Full-rimmed, Half-rimmed and Rimless (see Fig.4:(c)).
- Facial images with variation in degree of occlusion (see Fig.4:(d)).
- Facial images with variation in illumination conditions (see Fig.4:(e, f)).
- 10 subjects (8 male and 2 female) with the age variation from 20 to 36 years.
- Facial images with four eye gaze positions i.e. pupil towards left, right, open and closed (see Fig.4:(a, b)).

This release of the database version 1 includes the following:

- The raw images are of size $5472X3648$ in the JPEG format.
- Cropped versions of the raw images is $256X256$.
- We provide 68 facial landmarking generated from Kazemi and Sullivan [29].
- We also provide 19 videos of the same subjects with and without spectacles too.

C. Availability

The database will be made available to interested parties by the authors upon request in email to `zefree.lazarus@gmail.com` or `nidhipanda15@gmail.com`.

D. Application Areas of this database

The database is not restricted to the usage for spectacle problem alone but can be used for applications like face detection, recognition, image synthesis, eye feature detection and localization.

IV. Experiments

In order to quantitatively measure the effect of spectacle problem, we have conducted the following experimentation on the proposed dataset.

A. Experiment 1

In this experiment, we have implemented three state-of-the-art face detection algorithms: Ahonen et al. [30], Kazemi and Sullivan [29], Viola and Jones [31] on the proposed database. A few sample face detection outputs are shown in Fig.5. To check the influence of spectacles on detection rate, we have segregated the proposed database into two categories: (a) Facial images without spectacles (82 images), (b) Facial images with spectacles (188 images). Experiment results in TABLE III shows a clear reduction in detection accuracy in case of facial images with spectacles. On the whole, the

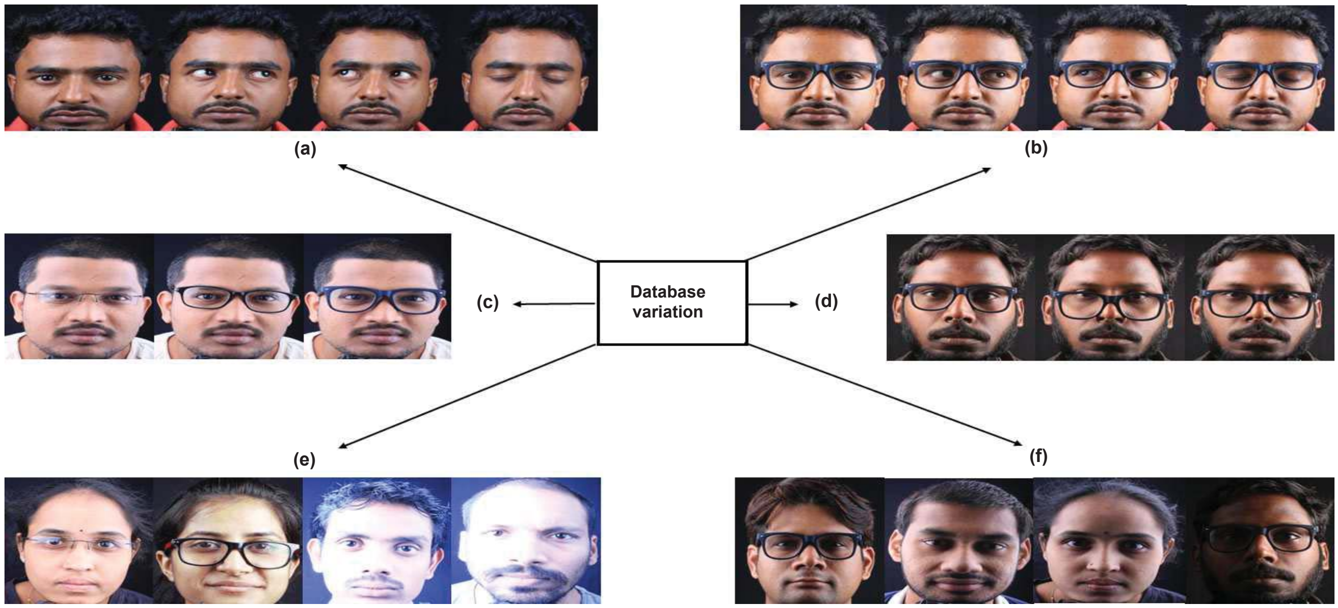


Fig. 4: Samples from the proposed database showing the considerable variability in terms of : (a,b) Eye location variation with and without spectacles respectively; (c) Spectacle frame variation; (d) Variation in occlusion by the spectacle frame; (e,f) Illumination variation.

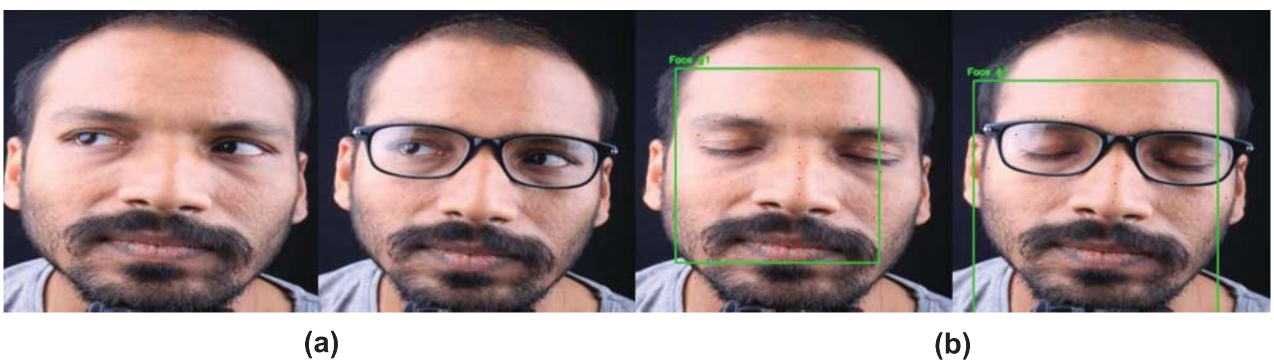


Fig. 5: Results of [29]: Samples of (a) unsuccessful, (b) successful face detections.

average detection error rate increases by 20.34% when the user wears spectacles.

B. *Experiment* 2

To check the performance of spectacle removal algorithm, on the introduction of eye dynamics under spectacles, we have implemented [8] on the proposed, and NIR-VIS [23] database. From the Fig.6:*a*, it is quite evident that the method provides acceptable results in-case of facial images without eye dynamics. On the other hand, the algorithm lacks to seamlessly recreate the output image due to the influence of eye dynamics introduced in the proposed database (The highlighted region in yellow of Fig.6:*b*).

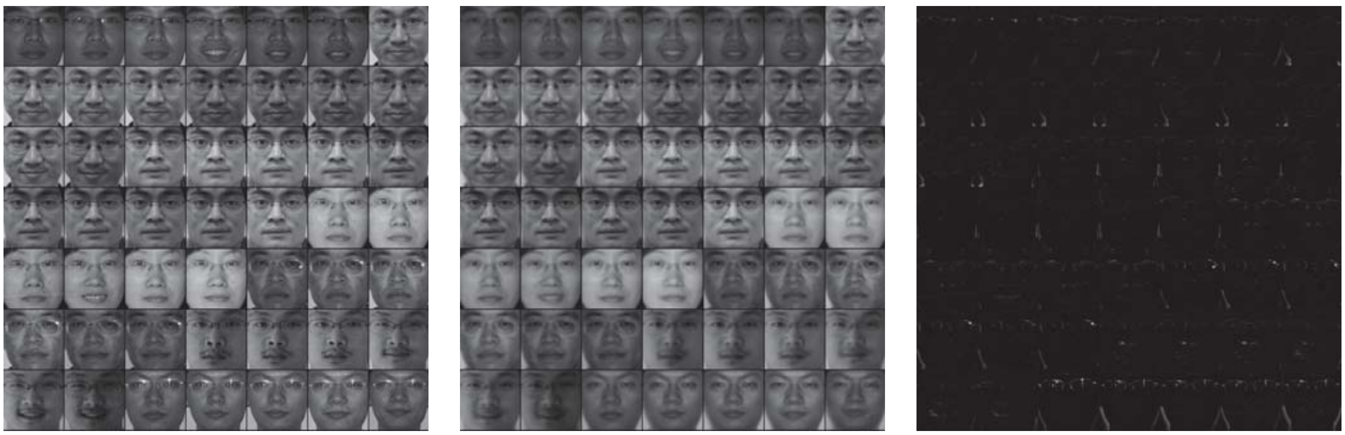
These experiments act as a baseline to provide us an insight on the influence of spectacle problem in face detection and spectacle removal applications. The proposed database acts as a challenge to the existing algorithms and provide a platform to the future proposed algorithms.

V. Conclusion

Occlusion, glare and secondary reflections on spectacles deteriorate the performance of many eye/face detection and localization algorithms. To validate the performance of spectacle problem removal algorithms, there is a necessity of a database, highlighting the spectacle problem issues. So, we provide an Indian database (version 1) containing 270 facial

TABLE III: Results demonstrating detection rate of state-of-the-art face detection algorithms [30], [29], [31].

Proposed Database	Reference	Wrong detections	Undetected	Correct detections	% of correct detections
Without spectacles	[31]	00	37	45	54.88
	[30]	04	36	42	51.22
	[29]	00	01	81	98.72
With spectacles	[31]	03	116	69	36.70
	[30]	25	115	48	25.53
	[29]	00	46	142	75.53
Total database	[31]	03	153	114	**42.22**
	[30]	29	151	90	**33.33**
	[29]	00	47	223	**82.59**



(a)

(b)

Fig. 6: Result of [8]. In both (a) and (b) each sub-plot contains original, reconstructed and error component images respectively. The ineffectiveness of recovering the eye feature dynamics is highlighted in yellow.

images as an add-on to the existing facial databases. We encourage the scientific community to use the database for carrying out further research in this area.

VI. Future Work

In the future versions of the database to come, we will increase the number of subjects and samples as well as the diversity of variation in illumination.

Acknowledgment

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