Multifarious Distances, Cameras and Illuminations Face Database

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***Abstract*—Face recognition at a distance is still a challenging problem due to the low resolution face images resulting from the remote distance. To motivate researches on the problem and make up for the shortage of existing databases, we introduce MDCI database in this paper. The database contains 677 videos and 9734 pictures from 155 subjects captured by five different cameras, at four kinds of distances (1m,3m,5m,7m), under two illuminations. Based on the evaluation protocol proposed in the paper, we tested baseline LBP and PCA algorithms on the database. Interested researchers can use the test results as a control performance when testing their own algorithms.**

I. Introduction

Face recognition as a popular field in computer vision has been studied widely in many literatures [1] [2]. The relevant algorithms such as LBP [3] have achieved excellent performance on some common face databases like FERET [4] and CMU PIE [5]. However, face images from these databases are collected under strictly constrained condition where subjects are cooperated actively. This scenario provided by these databases cannot represent the real-word settings properly. As a non-invasive biometric method, face recognition at a distance (FRAD) [6] under unconstrained situations is natural and realistic.

A low number of studies on the problem of FRAD is due to the lack of such face databases in some extent. One of the related databases is Remote Face Database [7]. It contains images captured from 5m to 250m distance from 17 subjects. The small size of samples and the limited availability of the database make its wide use difficult. SCface Databse[8] is another database provided to researchers studying on the FRAD problem. Images are collected using five different surveillance cameras at three distinct distances. It consists of 4160 images in total from 130 subjects. However, the cameras used in the capture are all advanced which make the application in daily life impossible. Other relevant face databases can refer to [9].

To mimic the real-word conditions as close as possible and to make up for the inadequacy of existing databases, we establish the MDCI face database. As the name denotes, our database includes videos captured by five different cameras, at four kinds of distances with two distinct illumination situations. And there are expression, pose changes and occlusion in videos, which are a reasonable result due to the noncooperation from the subjects.

We collect 677 videos from 155 subjects (43 females and 112 males) and 9734 images from 147 subjects (40 females and 107 males) after the face images extraction from the videos using our program. Then we classify all images into 40 folders according to the labels of cameras, distances and lighting to provide convenience for researchers.

The potential uses of our database include face detection, face identification and face verification. Prior to face recognition, it is crucial that face locations are detected correctly in images. The most significant use of this database is to test face recognition algorithm's robustness in a real-world scenario during face identification. Face verification is a one-one match problem to authenticate an individual.If the match score of the persons image with the stored face image is above a defined threshold, this subject is authenticated.

The main contributions of this paper can be summarized as follows:

1) Provide a large scale unconstrained database with videos and images captured in five different cameras, four kinds of distances and two illumination conditions.

2) Propose evaluation protocol for tests and performance measurement. And some potential uses of the database are referred as a consideration for researchers.

3) We test LBP and PCA algorithms on MDCI database to provide a benchmark performance for further algorithms improvements.

The remainder of this paper is organized as follows: In Section II, we provide a detailed description about the database. In Section III, we propose the evaluation protocol for the database. In Section IV, LBP and PCA algorithms are tested on the database to provide a baseline performance. Section V concludes the paper.

II. Database description

To promote the development of efficient and robust algorithms for face recognition at a distance, we establish the MDCI face database. We use simple but practical cameras that have different qualities to simulate the realistic scenario in which people in a video at a distance need to be identified. Since mobile phone has been widely used and has become a necessary part in people's life, we also use it for acquiring some videos.

TABLE I
CAMERAS SPECIFICATIONS

Camera	usb	3d	log	mobile
Type	Kisonli U-225	Ontop D32	Logitech C310	Sony LT 22i
Sensor	CMOS	CMOS	CMOS	CMOS
Resolution	640×480	640×480	1280×720	720×480
Frame Rate	20fps	20fps	15fps	24fps

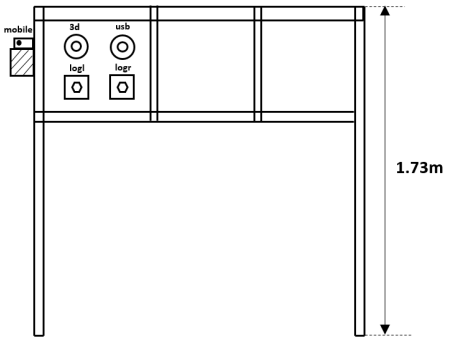

Fig. 1. Equipment installment illustration.

Fig. 2. The photo of cameras' position.

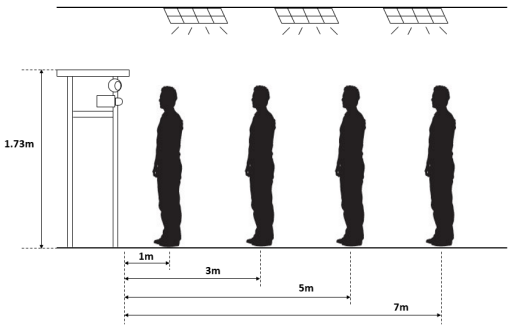

Fig. 3. Capture process at different distances.

A. Equipment setup and connection

The equipment used for acquiring data was installed in the Shenzhen Key Laboratory of Information Science and Technology, Department of Electronic Engineering, Graduate School at Shenzhen, Tsinghua University, China. Five different cameras, two computers and one usb cable were used here. Five different cameras included two log cameras, one web camera, one 3D camera having two shots and a mobile phone. The specific technical parameters about the cameras can be seen in the TABLE I. Two computers had a 500GB hard disk capacity and 32 bit Windows 7 operating system to store and process the collected data.

All cameras were installed in the same room at the height of 1.73m and positioned as showed in Fig. 1 and Fig. 2. One log camera placing in the left was named as logl, being connected to the computer A. Another one was named as logr, which was connected to the computer B. The usb web camera named as usb was connected to computer A and the 3D camera named as 3d was connected to the computer B. The videos captured by these cameras were stored in the computer A or B according to the distinct connections. Videos captured by the mobile phone named as mobile were stored in its memory card and can be exported to computer A via a usb cable.

B. Data acquisition procedure

It took more than one year to capture the videos, which was from 6th, September, 2012 to 28th, September, 2013. Participants were professors, students and employees from Graduate School at Shenzhen, Tsinghua University.

All volunteers participating in the project must pass through the following procedure. First they were demanded to look directly to the shot of one camera standing at 1m for a period of time with the indoor lighting. These short videos were used to obtain frontal face images for gallery set, which included the clearest images among all five cameras. There was only one image for per subject in the gallery set.

Then they began to walk backward to stop at the 3m for seconds. The same behavior was conducted in 5m and 7m position. In every position we obtained two images from the videos for per person. We can collect 8 images in total for one person in a camera with the indoor lighting as probe set.

After that, without the indoor lighting, participants had to stand at 7m for seconds. Then they walked forward from 7m to stop in 5m, 3m and 1m position. In this way, we acquired 8 images totally for every subject in a camera without indoor lighting as probe set.

The above described process was the same for all five cameras. The illustration about the capture procedure can be seen in the Fig. 3.

In the end, we gained 80 images for every subject in the MDCI database for all four kinds of distances, five cameras and two distinct illuminations. Since there are 155 volunteers in our project, the number of images in our database accounts for 12400 in theory. The actual number is a little less than that because some participants were absent from certain cameras and a few images exported from the videos were useless due to the poor capture quality.

C. Picture processing and classification

To obtain the face images from the collected videos, we adopted a two-step method to implement the task. First we used StormPlayer software to acquire the screenshots at multifarious distance for all videos, maintaining the picture

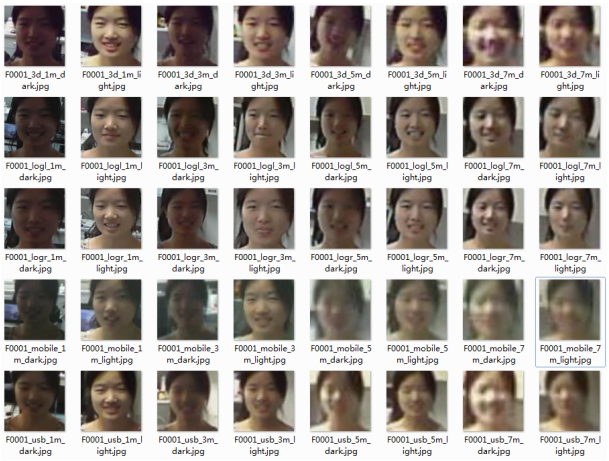

Fig. 4. Pictures from F0001 subject in the database.

quality being the same as the original videos. Next, we applied our program to extract the exact face images from the whole pictures according to the coordinate of eyes. After the processing, we can get images with 120×120 pixels, the coordinate of left eye being (40,38) and right eye being (85,38).

In terms of the picture classification, we established 40 folders to distinguish different cameras, distances and illuminations and moved the pictures to their corresponding folders. The folders were named like this: camera+"_"+distance+"_"+illumination. Illumination: "light" meant with indoor lighting and "dark" meant without indoor lighting. The pictures from F0001 subject in the final database are showed partially in Fig. 4.

III. Database Evaluation Protocol

A. Still image tests

The protocol for still images compares all images in a query set to all images in a target set. This is the most used scenario in face recognition. In our database, we provide a gallery set with an image for every subject. There are various choices for query sets, researchers can use the subsets from five cameras, four distances and two kinds of lighting as probe set.

B. Performance metrics

The widely used methods to measure the performance of recognition algorithms are rank-one recognition rate and Cumulative Match Score (CMS) curves. For face verification, ROI plots are demanded for reporting results. In addition, we suggest the use of other statistical significance test like McNemar's hypothesis test [10]. Some baseline algorithms tests like LBP, PCA provided here must accompany performance results from creative algorithms proposed by researchers.

IV. Baseline Algorithms Experiment Performance

In order to prove that our database is applicable and the problem of FRAD is still challenging, we tested LBP and PCA algorithms and offered the results. LBP and PCA are two common algorithms in the field of face recognition. The algorithm details are beyond the scope of this paper and interested readers can refer to [3] [10].

A. Common configuration

We conducted image preprocessing according to the standard procedure usually described in most face recognition papers. In the process of face images extraction from the whole body pictures, we had fixed the eyes' position in (40,38) and in (85,38) as described above. And we had scaled and rotated every image to keep the eyes of a person on a straight line. Then the images were all cropped to120×120 pixels. In the last, we turned all color images into grayscale images.

For the data used in this experiment, we established 40 distinct mat files (Matlab) with the same name as folders in the MDCI database. Every mat file included a gallery set and a probe set (pictures in the corresponding folder).A unique number was assigned to every image to identify the subject.

In this experiment, rank-one recognition rate was used to measure the algorithm performance.

B. Algorithm parameters setup

As for the parameters involved in LBP, we used a 8×8 image block without overlapping to extract the face features and adopted uniform type. We calculated the histogram distance between every image from gallery set and probe set to get a score matrix with a size of Ng(number of images in gallery set)×Np(number of images in probe set).

In terms of the parameters related with PCA, we used gallery set as training set and let the dimension of features be 30 to get the project matrixes for gallery set and probe set respectively. Then we computed the squared distance between projected features to gain the score matrix.

C. Experiment results

The rank-one recognition rate for LBP and PCA in MDCI database is listed in TABLE II to TABLE VI, classified by the distinct cameras subsets.

We can analyse the results from the TABLE II in three dimensions: distance influence, lighting difference and algorithm performance. It is obvious that the highest recognition rate occurs at 1m in LBP and with the increase of distance, the recognition rate is lower and lower. The exception of 5m and 7m can be explained by the fact that outdoor sunlight coming through the window and door around the 7m distance increases the lighting so that the results are better than 5m

TABLE II
RANK-ONE PERFORMANCE RESULTS FOR LOGL SUBSET

subset	logl_1m_l*	logl_3m_l	logl_5m_l	logl_7m_l
LBP	72.63%	48.61%	22.30%	18.95%
PCA	58.95%	31.60%	13.24%	15.44%
subset	logl_1m_d*	logl_3m_d	logl_5m_d	logl_7m_d
LBP	32.01%	21.11%	16.90%	17.93%
PCA	7.19%	5.19%	4.14%	10.34%

* l means light and d means dark

TABLE III
RANK-ONE PERFORMANCE RESULTS FOR LOGR SUBSET

subset	logr_1m_l	logr_3m_l	logr_5m_l	logr_7m_l
LBP	76.19%	45.21%	19.38%	14.24%
PCA	56.75%	28.08%	15.57%	13.54%
subset	logr_1m_d	logr_3m_d	logr_5m_d	logr_7m_d
LBP	30.91%	22.45%	16.38%	15.41%
PCA	10.18%	5.78%	3.75%	11.30%

TABLE IV
RANK-ONE PERFORMANCE RESULTS FOR 3D SUBSET

subset	3d_1m_l	3d_3m_l	3d_5m_l	3d_7m_l
LBP	77.14%	39.37%	17.96%	10.83%
PCA	40.00%	23.69%	15.14%	10.83%
subset	3d_1m_d	3d_3m_d	3d_5m_d	3d_7m_d
LBP	24.54%	14.74%	11.64%	17.28%
PCA	10.04%	6.67%	6.18%	10.66%

TABLE V
RANK-ONE PERFORMANCE RESULTS FOR USB SUBSET

subset	usb_1m_l	usb_3m_l	usb_5m_l	usb_7m_l
LBP	72.30%	21.05%	11.11%	9.20%
PCA	33.09%	17.89%	10.39%	7.28%
subset	usb_1m_d	usb_3m_d	usb_5m_d	usb_7m_d
LBP	23.13%	14.34%	10.66%	9.45%
PCA	7.12%	6.45%	4.41%	8.36%

TABLE VI
RANK-ONE PERFORMANCE RESULTS FOR MOBILE SUBSET

subset	mob*_1m_l	mob_3m_l	mob_5m_l	mob_7m_l
LBP	57.29%	28.87%	10.23%	5.26%
PCA	10.42%	13.40%	4.55%	2.63%
subset	mob_1m_d	mob_3m_d	mob_5m_d	mob_7m_d
LBP	13.70%	4.60%	2.50%	10.26%
PCA	0%	0%	0%	0%

* mob means mobile

especially in the dark condition, in which the outdoor light becomes the only resource of lighting.

When the distance is the same, the recognition rate under light condition is higher than that under dark condition for LBP and PCA. LBP achieves a better result than PCA in all conditions.

We can see from the TABLE III to VI that the results are consistent with logl subset basically.

Compared to the above four cameras, the result on mobile is the worst as listed in TABLE VI. Distance has some influence on performance, but it is not intense like lighting. We can see that the recognition rate on 7m dark is higher than 5m dark even higher than 5m light in LBP and PCA on mobile subset.

D. Discussion

The experiment results show that our MDCI database is practical realistically and challenging for the face recognition algorithms. Distance and illumination have a significant influence on the performance but the difference among camera qualities is not that important except for mobile phone. The overall rank-one recognition rate is not as satisfying as traditional recognition results, which indicates the problem of FRAD still being unsolved and having potential further improvements.

As for the specified scenarios, we can select suitable subsets. Logl and logr as high-resolution cameras are expected to apply for research purposes, contrast to the usb which is for common uses in personal PC and household. 3d camera can be used to establish 3d face model, while mobile is for face recognition based on mobile phones.

V. Conclusion

In this paper we introduce a database including 677 videos and 9734 pictures from 155 subjects. Videos were taken in unconstrained environment using five different cameras at four distances and under two distinct illuminations. The establishment of the database aims to mimic the real-world scenario as close as possible and promote the resolution to the problem of face recognition at a distance. With the launch of MDCI database, we also propose testing protocol. According to the protocol, we tested LBP and PCA algorithms on the database to provide a control performance for comparison. The results from our experiment show that face recognition at remote distance is still unsolved with a low rank-one recognition rate far from satisfying. We hope to promote the development of novel algorithms to address the issue by making the MDCI database available to all research communities. It is promising that this database will push the state-of-the-art face recognition to a new stage and motivate relevant researchers to attempt more challenging problems in the future.

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