ILL-Dataset: A Dataset Under Different Illumination Conditions for Face Recognition

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Abstract. Face recognition has achieved extraordinary success recently due to the advancement of algorithms, technology, and hardware. Also, this is partly due to the richness of the face dataset. However, face recognition in complicated environment such as illumination, occlusion, pose is still a challenging task. Among them, illumination problems are still tough challenges in the field of face recognition. The datasets play an important role in deep learning, while there are few datasets specially for different illumination conditions and the currently existing face data sets have limitations. In this paper, we collect and set up a dataset called ILL-Dataset specifically for different illumination conditions. We also provide the detected dataset which is processed by using the face detection method. After it established, it can provide image data and promote the face recognition accuracy under various illumination conditions. The experiment results indicate the ILL-Dataset is a challenge dataset on illumination face recognition.

Keywords: Face recognition · Illumination · Dataset · Deep learning

1 Introduction

The continuous improvement and development of deep learning methods have immensely improved the accuracy of face recognition, and some methods have achieved more than 99% accuracy in face recognition [1]. This is partly due to the richness of the face datasets, and we all know that datasets play an important role in deep learning. However, the images' quality used in these methods with high accuracy is relatively high. While in practical applications, recognition accuracy is far less than research due to the low quality. In real scenes, the factors affecting face recognition are complex and changeable. Recent years, research on face recognition mainly focuses on face recognition problems under complex conditions, such as illumination, posture, occlusion, age, etc. 2]. Among them illumination problems are still one of the challenges in the area of machine vision and face recognition [3]. The face recognition

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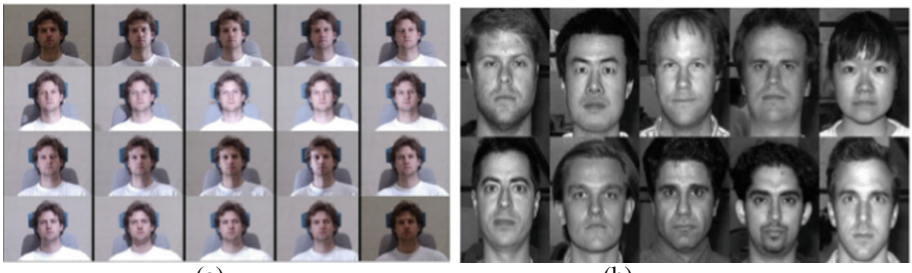
theory and experiment also prove that the difference between the same individual due to different illumination is greater than the difference between different individuals under the same illumination [4].

Although the current face datasets are diverse, there are few datasets for illumination face recognition. In addition, the existing datasets are probably not suitable for illuminating face research. First, the illumination image in these datasets is only part of it. In these datasets, not all face images are under different illumination conditions, lots of them are taken under other challenging factors like expressions, gestures, age changes, etc. leading to illumination face images only account for a part of it. Secondly, some datasets contain a small number of face images. For example, the commonly used Yale Face Database B only includes 10 subjects, 5850 images, including face images with facial expression changes. Although the number of data in MultiPIE is enough, the illumination changes are not obvious, and the image quality is high make it easier to recognize. In addition, the scenes of these datasets are relatively simple, some datasets are relatively old and only contain grayscale images, and with the advancement of technology and equipment, most of the images captured are colorful. Besides people in most of these datasets are westerners, there are fewer images of eastern face, which is not conducive to the practical application of face recognition algorithms in China. Figure 1 shows some images part of these datasets.



(a) (b)

Fig. 1. The example of part of datasets. (a) shows the figures of the MultiPIE, (b) shows the figures of the extended Yale B.

In this paper, we collect and set up face dataset specifically for different illumination conditions. This dataset contains different illumination conditions which is missing in state-of-the-art datasets, such as illumination color, illumination angle, illumination scene, and so on. After the dataset is established, it can provide illumination face images and promote face recognition research under different illumination conditions.

2 Dataset

2.1 Dataset Introduction

The currently public face datasets are diverse and each has its own characteristics. For example, LFW, MegaFace, Yale Face Database B, MultiPIE, The extended Yale Face Database B, FERET, CMU-PIE. Among them, the datasets that can be used to study the face recognition under illumination factors are The extended Yale Face Database B, MultiPIE, CMU-PIE.

Table 1. Details of the different datasets.

Dataset	Year	People	Number	Race	Purity	Illumination color	Illumination on direction	Distance	Scene
Yale B	/	10	5850	West	Gesture, illumination	White	Head	Front	Single
Extended Yale B	2001	28	16128	West	Gesture, illumination	White	Head	Front	Single
CMU-PIE	2000	68	41368	West	Gesture, illumination	White	Head, neck	Front	Single
MultiPIE	2008	337	754204	West	Gesture, illumination	White	Head, shoulder	Front	Single
CAS-PEAL	2014	1040	99450	West	Gesture, illumination	White	Head, neck, shoulder	Front	Single

Table 1 summarizes the basic information of these datasets. The problems of these datasets can be clearly seen through the table. Based on the above reasons, this paper envisages the establishment of a face dataset under various illumination conditions. In the design of the dataset, we refer to the commonly used and authoritative datasets, combine these data sets' advantages, considering the color of illumination, the angle of the illumination, the scene of the illumination, and other factors to enrich the illumination face dataset.

2.2 The Design of the ILL-Dataset

The influence of illumination on human face which will affect the face recognition accuracy is not only reflected in the illumination intensity, but also the direction, the color of the illumination and so on. The commonly used, authoritative datasets mainly involve the direction changes, maybe the distance is also slightly different. With reference to these commonly used authoritative datasets, the illumination face dataset is designed with considerations of the illumination scene, the color, the angle, the distance of the illumination, and the angle of the shot.

Illumination Scenes: We select day and night scenes, for the difference in illumination changes between two scenes is obvious.

Illumination Color: Two colors are selected, white and yellow. The color of light varies widely. White is chosen because it is most common seen in daily life and workplace. The reason for choosing yellow is that the wavelength of yellow light is 570–600 nm, which is in the sensitive band of human eyes, compared with white. It is one of the ideal choices for street light and fog light. It is widely used in road illumination and has broad applicability in real life.

Illumination Angle: The light source is arranged in five directions, such as front, right, and left. We refer to the knowledge of photography, dividing 180° into five directions by 45°.

Filming Angle: Horizontal direction: five directions of 0–180° just like the factor 3 shown, and then 4 directions are added evenly, so a total of 9 directions.

Vertical direction: three directions are chosen: overhead view, look up view, look at the front horizontal view (−45°, 45°, 0°).

Distance: For the shooting distance, there is no accurate definition and standard to clearly define it, three factors are considered:

1. Refer to the knowledge of photography.
2. Refer to the commonly used authoritative datasets, such as The extended Yale Face Database B, CMU-PIE, Multi-PIE.
3. Refer to the practical applications.

2.3 The ILL-Dataset

The ILL-Dataset is acquired using an iPhone camera. The participants are requested to sit in the chair fixed in front of white background and keep a natural expression [5]. We use different illumination sources to acquire indoor illumination variations, in the meanwhile we capture images under two scenes: day and night. We change the light sources and the filming angle, such as left, center, and right from the subject's perspective to get distinct indoor illumination environments. Besides, we distribute three rotations from −45° to 45° evenly in the horizontal direction and distribute nine rotations from −90° to 90° evenly in the vertical direction.

Finally, we collect about 15,000 images of 15 people, the images of size 2,448 × 3,264 pixels are preserved in the JPG format. All the images are processed by MTCNN [6] which is known as an effective face detection method. As a result, the final size of the dataset is 160 × 160 pixels. This essential module is often called face detection, which is important in a face recognition system. Figure 2 shows the different images with 15 participants. The participants are asked to maintain a neutral expression in order to avoid unnecessary expression changes.

Fig. 2. Participants in the dataset.

The images are named according to the principles, I01–I05 denote the 5 illumination direction, and the 9 filming angles from the left, center to right light are represented by F01–F09 respectively, P1–P15 means the number of the 15 people. In addition, D\N indicates day and night, W\Y indicates the two different color of the illumination. Figure 3 illustrates some of the angle variations for one person. Figure 4 shows part of face images under some extreme illumination conditions like shadow and exposure.

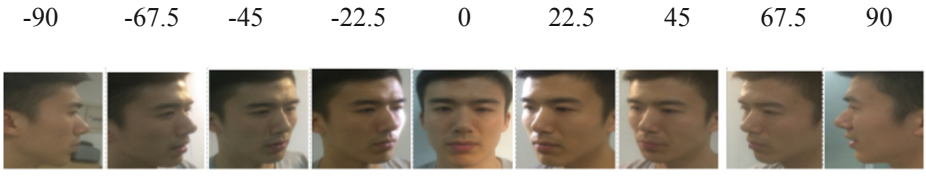


Fig. 3. The horizontal angle variations for one person.

Fig. 4. The images under extreme illumination conditions.

3 Experiments

The experiment is performed on TensorFlow platform, using NVIDIA GeForce GTX 1080Ti with 11 GB memory.

3.1 The Network

We choose FaceNet [7] to estimate the influence of the image quality especially illumination on face recognition methods. Google proposed the FaceNet algorithm, it was published in CVPR 2015. The architecture of the model is shown as Fig. 5. The parameters and specific details of the network are shown in Table 2.

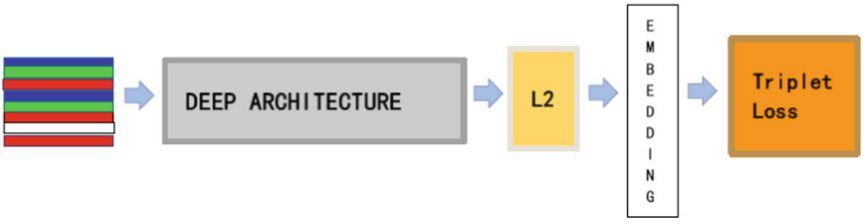


Fig. 5. The architecture of the FaceNet model.

FaceNet uses DNN to directly learn the mapping from the original image to the Euclidean distance space, so that the measure of the distance in the European space is directly related to the face similarity. We all know that the distance of the faces of the same individual is always smaller than the faces of different individuals [8]. It makes the processes of facial features learning and face recognition much easier.

Table 2. Details of the network.

Type	Output size	Depth	Params
convl	112 × 112 × 64	1	9 K
max pool+norm	56 × 56 × 64	0	
Inception(2)	56 × 56 × 192	2	115 K
Norm+max pool	28 × 28 × 192	0	
Inception(3a)	28 × 28 × 256	2	164 K
Inception(3b)	28 × 28 × 320	2	228 K
Inception(3c)	14 × 14 × 640	2	398 K
Inception(4a)	14 × 14 × 640	2	545 K
Inception(4b)	14 × 14 × 640	2	595 K
Inception(4c)	14 × 14 × 640	2	654 K
Inception(4d)	14 × 14 × 640	2	722 K
Inception(4e)	7 × 7 × 1024	2	717 K
Inception(5a)	7 × 7 × 1024	2	1.6 M
Inception(5b)	7 × 7 × 1024	2	1.6 M
avg pool	1 × 1 × 1024	0	
Fully conn	1 × 1 × 128	1	131 K
L2 normalization	1 × 1 × 128	0	

3.2 Results of Illumination Face Recognition

In this part, we report the results of face recognition by using the obtained dataset. There are about a total of 15000 images, of which 80% are randomly chosen as training sets, and the others 20% are used for the propose of testing. At the same time, we test the accuracy using the extended Yale Face Database B, the models are called Model-1, Model-2 respectively. The recognition accuracy and the time consumed are presented in Table 3. We also test the accuracy of the trained model using the LFW dataset. However, the accuracy is only about 68%.

Table 3. Experimental results of face recognition.

Dataset	Recognition accuracy	Testing time/per image
ILL-Dataset	92.70%	9.15 ms
The extended Yale B	96.49%	9.47 ms

Table 4. Experiment results on LFW.

Model	Recognition accuracy
Model-1	67.70%
Model-2	79.50%

Table 3 shows the comparison of experiment results on face recognition between different datasets. Table 4 reveals the test results on the LFW database. From the results we can learn that the accuracy is only 92.70% on the ILL-Dataset, and accuracy is higher on The Extended Yale B. The ILL-Dataset is still a challenge dataset compared to the other dataset, making it more useful for the experiments to suit real-world scenes [8]. The accuracy is low on the LFW data set. On the one hand, the images in LFW are all westerner, their facial features are a little different from us. On the other hand, face feature extraction of illumination images is more difficult. Therefore, there is still a lot work to do in the study of illuminated face recognition.

4 Conclusion

In this article, we put forward a challenging ILL-Dataset to validate the performance of face recognition. The illumination difficulty is present in the dataset. And the experiment results show that illumination is still a challenging factor that affects the accuracy of face recognition. In the future, the number of subjects and amount of samples in the produced dataset can be added to promote application in some complex neural network for more robust illumination face recognition.

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