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Effect of Number of Face Images based on Illumination Variation in the Training Process on Face Recognition Results

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ABSTRACT

The research is related to face recognition which is influenced by illumination factor. The method used is the Robust Regression, which has a better performance than many other methods. The empirical experiment, which uses Yale Face Database B Cropped, is conducted to determine the effect of number of face images in the training process on face recognition perfomance. The hypothesis proposed in this research is the greater number of face images will result in higher facial recognition performance. The empirical experiment was conducted on this research to prove the hypothesis. Based on experiments that have been done, in general, the process of data training with many images will result in high performance of face recognition. But, this trend only occurs in images in the similar illumination condition. Illumination variation of face images also have significant impact on face recognition results. The process of training data with images of illumination variations (from several subsets of the face database) results in better face recognition performance than the process of training data with images of similar illumination conditions (from a subset of the face database). By using 19 images from subset 5 of the face database, face recognition accuracy is obtained at 95.11%. Whereas by only using 5 images from several subsets, obtained face recognition accuracy up to 96.10%. Even by using 7 images from several subsets, the accuracy obtained is up to 99.47%.

Keywords: Face Recognition Performance, Robust Regression, Data Training

1. INTRODUCTION

Nowadays, face recognition is still a quite interesting topic to be investigated. This is because the problems related to the topic are quite complex and there are still many unsolved problems. These problems arise because of many factors that affect face recognition, including factors of expression, illumination, position, attributes on the face, age, gender, and so on. In this research, face recognition is related to variations in illumination, where the performance is influenced by lighting factors in the face image. The illumination variation is one of the main problems that affects the robustness of facial recognition [1]. Even in some conditions, the effect of illumination variations is greater on face recognition than other variations, for example position or expression [6]. Especially in complex lighting conditions, this problem is still difficult to solve [9].

Many methods have been developed to solve problems related to face recognition which are influenced by illumination factor. One of them is the Robust Regression method [10], as used in this research. The face recognition performance of this method is relatively high, even the results of experiments on previous research using several standard face databases showed that this method has a higher accuracy than other face recognition methods such as PCA [13], IPCA [4], Fisherfaces, and several other approaches.

In its implementation, generally a face recognition method uses a number of data, which consists of a collection of face images, as data used to recognize faces that are acquired through the camera. In the Robust Regression method, a number of face images are needed as training data to produce a classifier engine model, a regressor / predictor for each class of face images. This predictor is then used to recognize face images. Because this predictor is built from a collection of face images in the data training process, the number of face images used at this stage certainly affects the face recognition performance. The hypothesis proposed in this research is that the more face images used as data training, the face recognition performance will be better. But this hypothesis needs to be conducted empirically experiments, as was done in this research.

This research aims to find out how much influence the number of face images as training data on face recognition results. Through the results of experiments on this research, it is hoped that later the effect of the number of face images that can become the training data can be determined on face recognition performance. If the number of face images has an influence, then the effect is significant or not. This information is important to know, so that the process of training data on the face recognition process can later use face images that are needed.

2. LITERATURE REVIEW

2.1 Face Recognition with Illumination Variation

One important problem in face recognition is the variation of illumination[1] . Lighting sources that can affect facial characteristics. Even small changes in illumination can affect face recognition performance, so an algorithm used can give different results in different environments. Therefore, a lot of research has been done to solve this problem. Many face recognition methods have been developed by researchers to deal with the problem of facial image illumination, which can then be grouped into 3 categories [8], namely model based approaches, features based approaches, and preprocessing approaches.

The model-based approach is based on low-dimensional linear sub-space to reduce the effect of illumination on face images. Some examples of this method are Illumination Cone [14][7].

In the feature-based approach, the face recognition process uses the invariant illumination feature. Some examples of this method are 2D Gabor-like Filters [3], Discrete Cosine Transform [6], Local Binary Pattern [2].

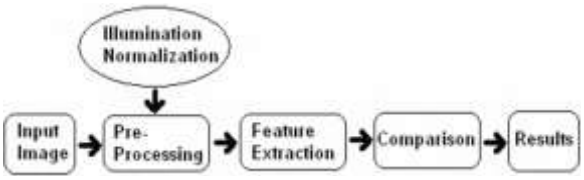

Figure 1: Face recognition system with illumination normalization techniques in the pre-processing stage (Sharif, et al., 2010)

Whereas in the pre-processing approach, the face recognition process uses techniques to normalize illumination of face images. Some examples of this method are Quotient Image [11], Self-Quotient Image / SQI [15], Histogram Equalization, and so on. This technique can improve face recognition performance in various illumination conditions. Figure 1 shows the general face recognition system with Illumination Normalization in the Pre-Processing stage [12].

2.2 Dataset

To assess face recognition performance, researchers usually use a dataset from a standard face image database. One of the face image databases that many researchers use in this field is Yale Face Database B [5]. This database contains 5,760 face images, consisting of 10 persons, where each person has 9 poses and each pose has 64 illumination conditions. All of these face images have neutral expressions. Related to the problem of face recognition with illumination variations, the face image used is only the face image with a frontal pose (the position of the face is perpendicular to the camera).
In this research, the images in this database will be cropped in a minimal area of the face (only reaching the core area of the face between the cheeks and between the eyebrows to the mouth), which in this research is called the Yale Face Database B Cropped. Figure 2 shows an example of face images from the same individual in Yale Face Database B (figure 2.a) and Yale Face Database B Cropped (figure 2.b).

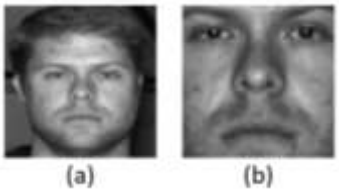

Figure 2: Example of one of the face images in Yale Face Database B and Yale Face Database B Cropped

While figure 3 shows an example of a face image of one person with 64 variations of illumination. These images show how variations in illumination on a face that get lighting from normal to extreme.

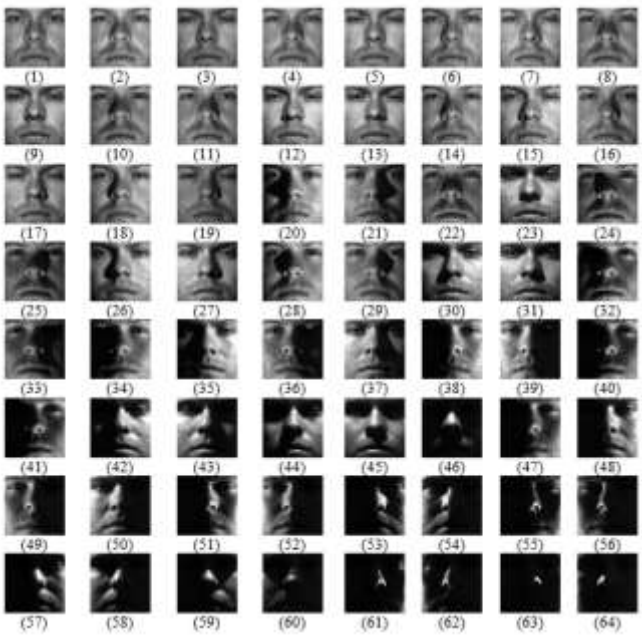

Figure 3: Example of one of the individuals in Yale Database B Cropped with 64 variations of illumination in the frontal position

The face image with 64 variations of illumination is divided into 5 subsets, which are based on the angle of lighting on the face. Table 1 shows these subsets. The images in a subset show similar illumination conditions.

Table 1: Subsets of Yale Face Database B Cropped

Subset	Lighting Angle	Number of Images	Image Number
1	0-12˚	7	1-7
2	13-25˚	12	8-19
3	26-50˚	12	20-31
4	51-77˚	14	32-45
5	> 77˚	19	46-64

Subset 1 is a collection of images 1 through 7. Image 8-19 becomes a subset 2. Image 20-31 is a subset 3. Subset 4 contains images 32-45. And subset 5 consists of images 46-64.

3. METHOD

The face recognition method used in this study is Robust Regression. Like other classifier machines, this method uses two stages, namely the training and testing stages. The training phase is carried out to build a classifier model. While the testing phase classifies a test data into one class using a regressor / predictor that has been built at the training stage.
In the training stage, before the classification process (pre-processing), a face image a x b is normalized using the Histogram Equalization technique. Then, the training image matrix is

converted into a smaller dimension vector with a maximum value of 1 and a regressor / predictor is made for each class using the training vector combination.
Whereas in the testing phase, pre-processing through illumination normalization using Histogram Equalization is also carried out on the testing image. Furthermore, the testing image matrix is converted into a smaller dimension vector with a maximum value of 1 and the testing image class is predicted using the results of the Huber estimation with the smallest distance. In this research, an experiment to assess the performance of facial recognition from the Robust Regression method uses Yale Face Database B Cropped. Experiments carried out with variations in the number of face images as training data. Furthermore, the accuracy value of each experimental result will be analyzed for the trend to determine the effect of the number of face images on the training process.

4. RESULTS AND DISCUSSION

There are several experimental scenarios that have been carried out. In the scenario 1 (table 2), the experiment was carried out using 1 face image from each subset as training data. Experimental results generally show that facial recognition performance tends to be low. However, in line 1 experiments, the accuracy was quite high, at 86.83%.

Table 2: Experiment Results 1

Experiment	Data Training	Data Testing	Accuracy (%)
1 image of subset 1	Image 1	All other images	86.83
1 image of subset 2	Image 8	All other images	76.98
1 image of subset 3	Image 20	All other images	39.37
1 image of subset 4	Image 32	All other images	42.38
1 image of subset 5	Image 46	All other images	53.49

In the scenario 2 (table 3), the experiment was carried out using 3 face images from each subset as data training. In general, the results of experiment on this scenario are better than the results of experiment 1.

Table 3: Experiment Results 2

Experiment	Data Training	Data Testing	Accuracy (%)
3 images of subset 1	Image 1, 4, 7	All other images	87.54
3 images of subset 2	Image 8, 12, 16	All other images	88.03
3 images of subset 3	Image 20, 24, 28	All other images	57.05
3 images of subset 4	Image 32, 36, 40	All other images	79.18
3 images of subset 5	Image 46, 52, 58	All other images	72.95

In the scenario 3 (table 4), the experiment was carried out using 5 face images from each subset as data training. The results of experiment in general show that face recognition performance is quite high. This result is better than the results of 2 previous experiments.

Table 4: Experiment Results 3

Experiment	Data Training	Data Testing	Accuracy (%)
5 images of subset 1	Image 1, 2, 4, 5, 7	All other images	88.64
5 images of subset 2	Image 8, 10, 12, 14, 17	All other images	91.69
5 images of subset 3	Image 20, 22, 24, 27, 30	All other images	90.51
5 images of subset 4	Image 32, 35, 38, 41, 44	All other images	90.85
5 images of subset 5	Image 46, 50, 54, 58, 61	All other images	89.49

In the scenario 4 (table 5), the experiment was carried out using all face images from each subset as data training. The results of experiment in general show that face recognition performance is quite high. This result is better than the results of 3 previous experiments.

Table 5: Experiment Results 4

Experiment	Data Training	Data Testing	Accuracy (%)
images of subset 1 (7 images)	Image 1, 2, 3, 4, 5, 6, 7	All other images	90.00
images of subset 2 (12 images)	Image 8, 9, 10, 11, 12, 13, 14, 15,16, 17, 18, 19	All other images	90.38
images of subset 3 (12 images)	Image 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31	All other images	95.96
images of subset 4 (14 images)	Image 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45	All other images	91.40
images of subset 5 (19 images)	Image 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64	All other images	95.11

In the scenario 5 (table 6), the experiment was carried out using 3 face images from 3 subsets as data training. The results of experiment in general show that face recognition performance is quite high. The results of this experiment are better than the results of experiment 2, even though they both use 3 images.

Table 6: Experiment Results 5

Experiment	Data Training	Data Testing	Accuracy (%)
3 images of subset 1, 2, 3	Image 3, 11, 22	All other images	89.84
3 images of subset 1, 3, 5	Image 1, 26, 57	All other images	86.72
3 images of subset 2, 3, 4	Image 14, 25, 41	All other images	92.30
3 images of subset 3, 4, 5	Image 21, 45, 55	All other images	91.48
3 images of subset 2, 4, 5	Image 13, 39, 48	All other images	96.56

In the scenario 6 (table 7), the experiment was carried out using 5 face images from all subsets as data training. The results of experiment in general show that face recognition performance is quite high. The results of this experiment are better than the results of experiment 3, even though they both use 5 images.

The results of experiments 5 and 6 show that illumination variation of data training have an impact on better face recognition results.

Table 7: Experiment Results 6

Experiment	Data Training	Data Testing	Accuracy (%)
5 images of all subsets	Image 1, 8, 20, 32, 46	All other images	94.75
5 images of all subsets	Image 2, 10, 23, 33, 49	All other images	80.51

5 images of all subsets	Image 3, 9, 25, 40, 58	All other images	96.10
5 images of all subsets	Image 5, 17, 28, 44, 61	All other images	96.10
5 images of all subsets	Image 7, 19, 31, 45, 64	All other images	86.10

In the scenario 7 (table 8), experiments were carried out using 7 face images from several subsets as data training. The results of experiments in general show that face recognition performance is quite high. Even in the experiment of line 4, the accuracy of face recognition reaches 99.47%.

Table 8: Experiment Results 7

Experiment	Data Training	Data Testing	Accuracy (%)
7 images of several subsets	Image 2, 11, 19, 30, 47, 52, 58	All other images	96.32
7 images of several subsets	Image 5, 16, 22, 37, 51, 57, 64	All other images	97.02
7 images of several subsets	Image 11, 19, 35, 43, 49, 57, 63	All other images	97.37
7 images of several subsets	Image 4, 15, 21, 28, 39, 48, 55	All other images	99.47
7 images of several subsets	Image 6, 14, 25, 36, 41, 52, 61	All other images	96.67

In the scenario 8 (table 9), the experiment was carried out using 10 face images from several subsets as training data. The results of experiment in general shows that face recognition performance is quite high.

Table 9: Experiment Results 8

Experiment	Data Training	Data Testing	Accuracy (%)
10 images of several subsets	Image 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	All other images	88.52
10 images of several subsets	Image 2, 5, 10, 17, 23, 26, 33, 49, 57, 60	All other images	95.74
10 images of several subsets	Image 4, 9, 15, 21, 28, 39, 43, 48, 55, 62	All other images	99.44
10 images of several subsets	Image 40, 41, 42, 43, 44, 45, 46, 47, 48, 49	All other images	96.11

In the scenario 9 (table 10), the experiment was carried out using 15 face images from several subsets as data training. The results of experiment in general shows that face recognition performance is quite high.

Table 10: Experiment Results 9

Experiment	Data Training	Data Testing	Accuracy (%)
15 images of several subsets	Image 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,14, 15	All other images	89.39
15 images of several subsets	Image 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32	All other images	97.96
15 images of several subsets	Image 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55	All other images	95.31
15 images of several subsets	Image 1, 5, 7, 15, 23, 28, 29, 34, 37, 42, 46, 50, 55, 57, 63	All other images	99.80

In the scenario 10 (table 11), the experiment was carried out using 25 face images from several subsets as data training. The results of experiment in general shows that face recognition performance is quite high.

Table 11: Experiment Results 10

Experiment	Data Training	Data Testing	Accuracy (%)
25 images of several subsets	Image 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,16, 17, 18, 19, 20, 21, 22, 23, 24, 25	All other images	88.46
25 images of several subsets	Image 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50	All other images	98.72
25 images of several subsets	Image 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64	All other images	94.87

In the scenario 11 (table 12), the experiment was carried out using 32 face images from several subsets as data training. The results of experiment in general shows that face recognition performance is quite high.

Table 12: Experiment Results 11

Experiment	Data Training	Data Testing	Accuracy (%)
32 images of several subsets	Image 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32	All other images	96.56
32 images of several subsets	Image 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64	All other images	90.63

4. CONCLUSIONS

Based on experiments that have been done, in general, the process of data training with many images will result in high performance of face recognition. But, this trend only occurs in images in the similar illumination condition. Illumination variation of face images also have significant impact on face recognition results. The process of training data with images of illumination variations (from several subsets of the face database) results in better face recognition performance than the process of training data with images of similar illumination conditions (from a subset of the face database). By using 19 images from subset 5 of the face database, face recognition accuracy is obtained at 95.11%. Whereas by only using 5 images from several subsets, obtained face recognition accuracy up to 96.10%. Even by using 7 images from several subsets, the accuracy obtained is up to 99.47%.

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