

Modified Illumination Invariant Algorithm Based Human Face Detection

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Abstract: Face recognition systems are adversely affected by multiple external factors like illumination, pose, quality of image etc. Illumination is one of the main factors that hinders the performance of the system, the proposed methodology minimizes the effects of varied lighting conditions on the images. The algorithm uses Histogram of Oriented Gradients (HOG) technique for feature extraction and Error correcting output Codes (ECOC) Multi class Support Vector Machines (SVM) for classification. The results are verified using ORL and Extended Yale Face Database B image sets and good accuracy was obtained in the classification of poor and well illuminated images.

Index Terms: Face recognition, Illumination, Histogram of Oriented Gradients, Error Correcting Output Codes, Support Vector Machines, ORL Database, Extended Yale Face Database

1. INTRODUCTION

Face recognition has been one of the most researched areas due to its applications in various domains. Its applications range from simple daily activities like phone unlocking, biometric identifications to forensic applications. The roots of facial recognition started from invention of camera which was originally intended to track miscreants. The Pinkerton National Detective Agency which was founded back in 1950 is claimed to be the first organization which took photographs of people it arrested [1]. In 1952 the jails in England started photographing prisoners, photos were also used as a means to track missing criminals. Early research on computerized face recognition systems was done in 1964 by Charles Bisson, Woody Bledsoe and Helen Chan. Apart from independent work, the research was continued in this domain by prestigious institutions like Stanford University and Massachusetts Institute of Technology (MIT) due to the futuristic applications that this technology possessed. Face recognition system that was developed by Bochum University of Germany in 1997 produced best results of the time. Due to this performance, it was used by airports for increasing security. In last 10 years' important advances have occurred in face recognition, Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are the classic methods for face recognition [2][3]. But even these techniques face problems due to multitude of problems like pose, occlusions, illumination, face expressions, ageing, image resolution, and quality of training dataset images, all the problems and possible solutions have been presented in [4]. The motivation of this paper is to present an algorithm which can attenuate the effects of uneven illumination effects and improve the accuracy of the face recognition systems. Many approaches have been presented to tackle this problem. One of the approaches is to measure the quality of the images concerning the even

lighting. This method applies defines a quality parameter that can be used to determine the affected images and special preprocessing methods are applied for them to degrade the effects of varying lighting conditions [5][6][7]. A new lone technique which can be applied to both well illuminated images and as well as unevenly illuminated images is proposed, evaluated. It's interesting to note that even though the algorithm was originally devised to handle illumination changes it's capable of handling pose changes as well. The recognition results of pose variations of input images are also presented in the paper.

2 METHODOLOGY

In this section, the various steps used in the algorithm are presented along with the training and evaluation procedures in Figure.1

2.1 Face Database

There are many face image databases for verifying the face recognition algorithm, but in this paper Extended Yale Face Database B and ORL database has been used. Both Yale database and ORL database has face images subjected to a different degree of illumination and pose [9][10]. Two different face databases are used to make sure the model has a variety of training images, 80% of the samples of a total of 400 images are taken for training and 20% is taken for testing.

2.2 Preprocessing

In this step the image is manipulated according to the needs of the system. Here images are converted into black and white. The image pixel resolution is taken as 112X92, if it doesn't match the size then it's converted into this size for easier processing. The proposed algorithm is not heavily dependent on preprocessing step for countering the effects of variable illumination, all the mentioned conversions are aimed at reducing the image data.

2.3 Histogram Oriented Gradients

Histogram of Oriented Gradients (HOG) the feature extraction technique used in the paper. The main concept behind the HOG is that local appearance and the shape of the object in an image can be expressed as distributions of direction of edges or intensity gradients. The Image will be partitioned into multiple blocks of small size which are connected regions called cells and HOG is calculated for each of them and the values are then normalized.

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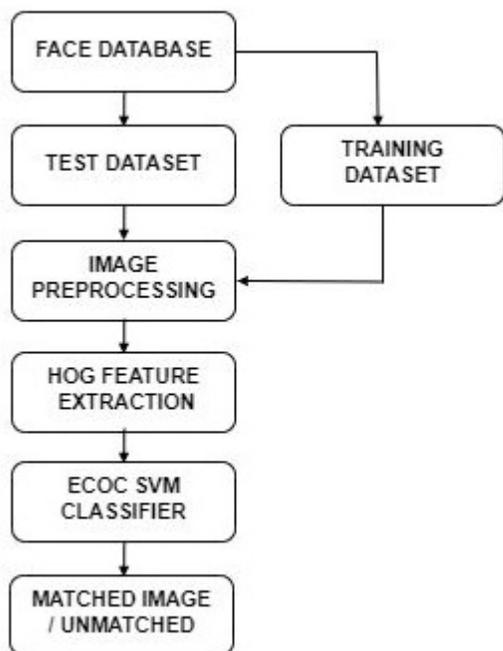


Fig. 1. Algorithm of the proposed face recognition system

HOG is calculated on each cell and hence it is invariant to changes in illumination up to a certain threshold. The HOG algorithm is implemented using following steps [11] [12]. Gradient computation: The first step is to calculate the gradient values. The functions $[-1, 0, 1]$ and $[1, 0, -1]$ is used as mask to calculate horizontal and vertical gradients. Orientation binning: In this step cell histograms are created, each cell votes for orientation based on the values found in the gradient computation. The vote can magnitude of the gradient of some well-defined function of the magnitude. Descriptor blocks: To compensate for changes in illumination and contrast, the gradients are normalized locally. All the components are combined to form concatenated vector which is the block region. Block normalization: Instead of normalizing each block, the cells are grouped to form descriptor blocks and they are normalized in the block level. There are four different methods for block normalization. Let u be the vector containing all the histograms in the given block that needs to be normalized $\|u\|$ be its k th norm value and ϵ be constant as shown in below equations 1,2 and 3

$$\text{L1-norm: } g = \frac{u}{\|u\| + \epsilon} \quad (1)$$

$$\text{L1-square-root: } g = \sqrt{\frac{u}{\|u\| + \epsilon}} \quad (2)$$

$$\text{L2-norm: } g = \sqrt{\frac{u}{\|u\|^2 + \epsilon}} \quad (3)$$

L1-hyss: L2 norm followed by limiting the maximum value of the function from u to 0.2. The above methods can be used for normalization depending upon the performance of the system.

2.4 Support Vector Machine

Support Vector machines is a supervised machine learning algorithm which can be used for regression and classification of data, however, it is mainly used for classification. The algorithm constructs a set of hyperplanes for the data points in an n -dimensional space. Support vectors are nothing but the coordinates of the data. There are some cases when there will be difficulty in classification since data can't be differentiated by simple planes. In these cases, SVM uses kernels which transforms low dimensional space into higher dimensional space which makes separation easier. Originally SVM was developed to solve problems with only two classes, recently many algorithms have been developed to work with multiple classes and these algorithms are referred to as Multi-class support vector machines (M-SVM) [13].

2.5 Error Correcting Codes

Error Correcting Output Codes (ECOC) were originally designed for error detection and correction is an excellent match for Multiclass SVM. The reason is that it converts k -class supervised learning into multiple two-class supervised problem L , now SVM can handle the problem from this step. Each of the binary classifiers is independent and the error is also uncorrelated. To classify newly added data, every learned decision tree can be used. The paper shows that the ECOC method, when used together with SVM provides improved accuracy when compared to Multiclass-SVM. An in-depth analysis of the technique and the performance improvements are also part of the paper [14]. Using mathematical analysis similar to that in communication theory, the $\log_2 K$ number of bits are sufficient to represent the K class, but the extra redundant bits help in error correction. Let the minimum Hamming distance between any two code word in D , then $(D-1)/2$ single bit error can be corrected [15].

3 RESULTS

For verifying the results as discussed in the methodology section both the Extended Yale Face database and ORL face database has been used. Images indicating different stages of the algorithm have been captured for showing the effect of the operations on input images. Figure 2. captures the different images provided by Extended Yale Face database B for a sample any of which can be used for verifying the output from the system



Fig. 2. Images with different illumination in Extended Yale Data Base B

Figure 3. shows the different samples available from the face database. Figure. 4 gives the HOG output of the sample image.



Fig 3. Comparison of the Sample images with the images in database.



Fig 4. Image of the extracted HOG feature of the test sample

Figure 5 shows the input image and recognized image for a sample from Yale Face database.



Figure 5 shows the input image and recognized image for a sample from Yale Face database.

Figure 6 and Figure 7 shows the comparison for a sample face data from ORL face database

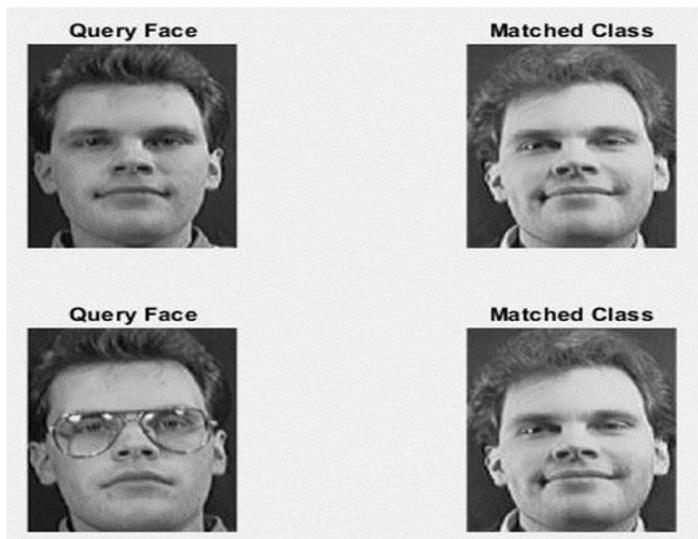


Fig 6. The matched class output for sample image from ORL database

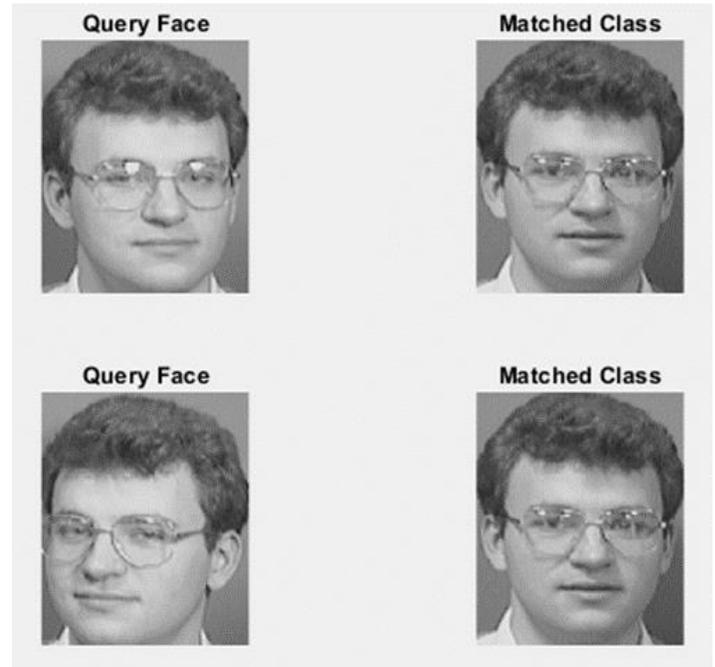


Fig 7 The matched class output for another sample image from ORL database

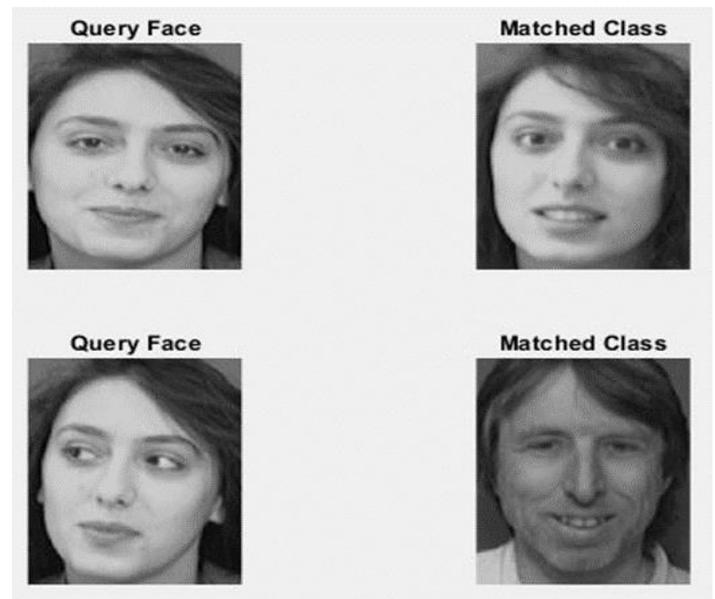


Fig 8 The wrongly matched class output for sample image from ORL database. One of the output is wrongly matched

Figure 8 shows the wrongly matched class output from the classification algorithm. The results have been tabulated in Table 1. It can be observed that the recognition accuracy for test and the training data is almost the same. There is also a small amount of error that occurred in the system which allows improving the system further in the future

Table 1: Comparison of Accuracy rates

	Proposed Method	
	Test Data	Training Data
Accuracy	97.57%	97.56%

4 CONCLUSION

The proposed solution is a demonstration of class of algorithms which has the capability of handling multiple challenges thrown by face recognition problem with good accuracy.

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