Efficient Eye Recognition for Secure Systems Using Convolutional Neural Network

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Abstract

Individual's eye recognition is an important issue in applications such as security systems, credit card control and guilty identification. Using video images cause to destroy the limitation of fixed images and to be able to receive users' image under any condition as well as doing the eye recognition. There are some challenges in these systems; changes of individual gestures, changes of light, face coverage, low quality of video images and changes of personal characteristics in each frame. There is a need for two phases in order to do the eye recognition using images; revelation and eye recognition which will use in the security systems to identify the persons. The main aim of this paper is innovation in eye recognition phase. In this paper, a new and fast method is proposed for human eye recognition that can quickly specify the human eye location in an input image. In the proposed method, eyes will be specified in an input image with a CNN neural network. This proposed method is tested on different images and provided highest accuracy for the image recognition which used in security systems.

Keywords

Eye Recognition, Information Security, Identification, Iris Features, Biometry, Convolutional Neural Network.

Introduction

Face is a unique characteristic of humans. Even twins have some differences in their faces. Therefore, face can be used as one of the important and suitable criteria of individual identification and authentication. Today, face recognition issue has many uses in different fields such as public security, authentication, protection of sensitive and important areas, access control and video basis [Wesam Bhaya *et al*, 2015]. The face recognition system are more useful in the new fields like relation of human-computer, internet services like online shopping. In recent years, researchers have done wide researches on face recognition methods [Subrat Kumar *et al*, 2014]. Two main issues that are important in face recognition applications are speed and accuracy in recognition. In two past decades, effective attempts were done on the performance improvement of recognition accuracy and speed [Elgammal *et al*, 2009]. Thus, recognition speed is still a serious issue and an obstacle for expanding simultaneous applications in face recognition.

Identification via eyes is in biometrical science field. Biometry is a science on methods and procedures for the unique humans' identification according to one/more human behavior physical qualities/characteristics. Biometry is utilized since old times, although, with digital technology development, biometry is taking the more important place in different interests, social life as well as human work areas [Marinović *et al*, 2011][Ahmed Abdulrudah Abbass *et al*, 2015].

In this paper, eye recognition issue will be examined. Eye recognition is important due to its many applications in various issues. For example, in the field of individuals' recognition in security places and their traffic recognition or in places like airports, instead of time taking of individuals' recognition process, it is possible to make sure of individual identification by using eye recognition. There are a lot of algorithms in the field of recognition and identification of eye that all these algorithms can be classified into two groups generally: the algorithms in which decision-making is based on the information that is extracted from a part of an image and another group is the algorithms in which decision-making is based on the information that is derived from the whole image. In each of these two methods, there are many successful algorithms such as Principal Components Analysis (PCA) [Kiaei *et al*, 2019], linear differentiation analysis (LDA) [Varma *et al*, 2020], Hidden Markov Model (HMM) [Rahul *et al*, 2019] and Gaussian Mixture Model (GMM) [Chen *et al*, 2019].

In order to the proper recognition of eye, still we should deal with the certain challenges such as processing of image, suitable extraction of feature as well as the reliable classifier performance. With respect to the challenges, in this article, we concentrate on developing the proper framework of eye recognition for achieved images of face distantly for using for the identification of human. Our basic aim in this work is improving accuracy of recognition utilizing an approach of deep-learning-based eye recognition. More particularly, proposed approach generalizes technique of convolutional neural network (CNN) for improving performance of classification also; we utilize the tools in MATLAB for approach of eye recognition.

In the following of this paper in section 2, previous works will be reviewed. In section 3, the proposed method is provided. In section 4, experiments' results are discussed and in the last section, the conclusion of paper is provided.

Related Works

Many study work has been published in eye recognition field so far. Different techniques have been provided by utilizing template matching, approaches based on IR, approach based on feature, method of Skin recognition, method of Hough transform, method of Eigen space/combination of these for recognition of eye.

In [Zhu *et al*, 2014] provides the new technique combining Adaboost algorithm with the hybrid matching method. At first, facial part in the whole image is located with Adaboost algorithm; area of human-eye is located via method of hybrid feature extraction. In process of extraction, density of edge, HSV and skin color cues, chrominance are separately employed. Then, several areas are eliminated with employing the rules, which are according to general geometry as well as eyes' shape. Remaining linked areas achieved via four cues are then combined in the systematic way for increasing candidate areas identification for eyes. The proposed algorithm of eye-recognition reduces eye-recognition candidate area effectively as well as improves accuracy of recognition.

In [Di *et al*, 2009] quickly detects face with utilizing algorithm of Otsu threshold segmentation, then properly locates face of driver with the horizontal projection as well as vertical projection in binary image, establishes location of eye according to algorithm of area labeling. Article gets contours points of eyes utilizing the recognition of Laplace edge, then also fits the points with ellipse fitting. Experiments have proved the accurate algorithms reliability and validity.

In [Qin *et al*, 2012] provides the method of eye location identification and recognition according to EHMM. Training images are sampled with no wearing glasses. Therefore, there will be the more errors of recognition when wearing glasses.

In [Ripon *et al*, 2019] apart the images of eye from a subject entire face image and then extract features from the images of eye by using model of convolutional neural network (CNN). Generally, models of CNN convolve images in various layers for extracting efficient features and then utilize function of soft max for producing the output of probability in last final layer. In the approach, writers utilize features of CNN and the classifier of kernel extreme learning machine (KELM) instead of soft max for modifying main model of CNN. Modified model of CNNKELM has been verified by utilizing publicly accessible CASIA.v4 database of distance image. Experimental results indicate that the proposed approach achieves the satisfactory result of recognition in comparison to some present approaches of state-of-the-art human identification.

In [Wang *et al*, 2014], the approach of time series classification according to IAL is provided for the identification of EEG eye location. This approach is new in the way that this extracts features firstly from raw data then classifies the features by utilizing feature of IAL ordering the approach based on ability of feature's discrimination. During process of training, newly extracted features are imported in system that is neural predictive in the sequential order according to ordering of feature. Compared with methods of conventional batch-training as well as the method of feature extraction with no consideration of relation among data of time-series, time series IAL experimental results indicated that this approach of machine learning is not able to just deal with issues of time series classification, however improve classification results accuracy. In addition, also experimental results imply that relation between data of time series is crucial to analysis of data in these issues of classification.

In [Park *et al*, 2012] provided novel method of implementation for ASEF in order to precisely detect states of eye positions. Normal images of face are utilized for producing ASEF, positions of eye are detected with rotating ASEF. For validating the proposed method, experiment is performed on Electronics and Telecommunications Research Institute (ETRI) dataset. This has not just frontal images of face, however rotated face images slightly. In addition, this contains different facial expressions, hairstyles, illumination, glasses. In experimental result, our method detection rate has been increased about 10% than main method of implementation.

In [Yu *et al*, 2018] provides the hybrid model for recognition of eye. Model is two classifiers integration: Support Vector Machines (SVM) and Convolutional Neural Networks (CNN). For improving recognition speed in system, eye variance filter (EVF) is built to eliminate most of the images, which are non-eye for keeping less candidate images of eye. Then CNN acts as the extractor of trainable feature for explicitly extract different latent features of eye. Lastly, trained classifier of SVM is applied for the verification of eye instead of utilizing function of CNN classification. The experiments employing a model have been performed on IMM, FERET, Bio ID and ORL databases of face. Comparisons with the other methods on similar databases show that the hybrid model has obtained higher accuracy of detection. Extensive experiments show our method robustness and efficiency with testing this on various facial images with differing the conditions of eye.

In [Kim *et al*, 2008][Sinan A. Naji *et al*, 2020] provides a method of eye recognition for facial images by utilizing the moments of Zernike as well as SVM. Particularly, method exploits Zernike moments magnitude rotation-invariant characteristics for representing patterns of eye/non-eye. The feature of rotation-invariant lets the proposed method for detecting eyes even if the face is rotated. Zernike moments magnitudes extracted from the training database of eye/non-eye, are learned by SVM for successfully determine eyes presence/absence in facial image.

The Proposed Method

In the proposed method, first some data are derived from the images. We consider the standard space of eye 270*70mm (means the length from left eye to the right eye). Because there are 40 different humans and each of them have 10 different faces so we have 400 labels. The number of image channels is 1 because the images are black and white. The aim is that the face should be first separated from the eyes. Sometimes in some images the eyes are not seen, for example there is glasses or eyes are close. For this reason, this process gives error. In the proposed method, we recognize these images and eliminate them from the dataset. In the following histogram chart we expect that we have 10 images for each person. As you can see in the histogram (Figure 1.), we do not have any image for some persons or we have low image number, so the ones who have images less than 5 are eliminated from the dataset and generally we have 37 persons whose images are available.

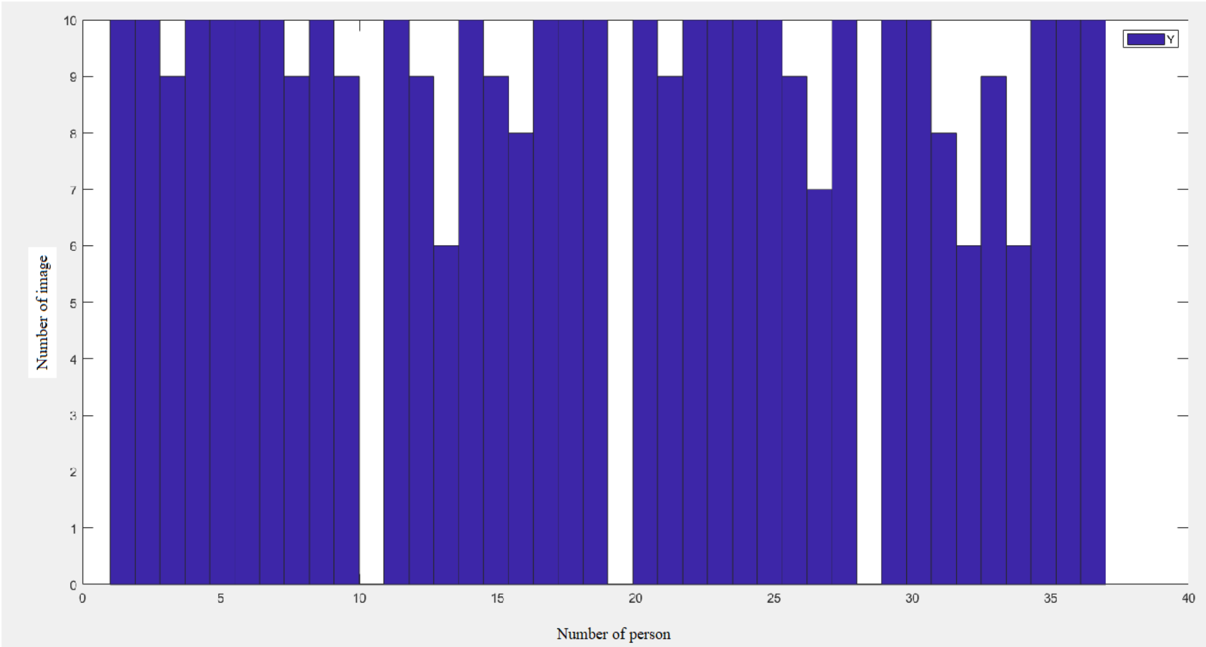

Figure 1 Histogram chart of the dataset

In training process CNN is configured in six layers including convolution, input, activation function, pooling. In first layer, input is presented including images. The image size is 270*70mm. Second layer is for convolution, its filter is 3*3 and its number is 96. Padding is also performed. Third layer function of activation is performed which the function of activation is utilized such as function of rule. Function of activation is utilized to minimize error at an output. Bias and weight are updated in every layer also; modified parameter is given as an input to next layer. Algorithm of CNN training is trained in similar as in image 2D however in this article the proposed training of CNN is for the 1D convolution for various layers as indicated in Figure 2. bellow CNN is completely linked layer in this 1*1 feature mapping so this is able to be organized in scalar form weight and bias updating make the main effect on implementation in CNN. Pooling of layer is done and max pooling 2*2 is performed. There are different parameters to be taken into account such as dimensions of filter, no. of dimensions of filter and pooling (Table 1.). Dimensions of filter are allocated for achieving max pooling at the so that max pooled output is able to be given to the function of activation so remaining layers will minimize an error to minimum value that is feasible.

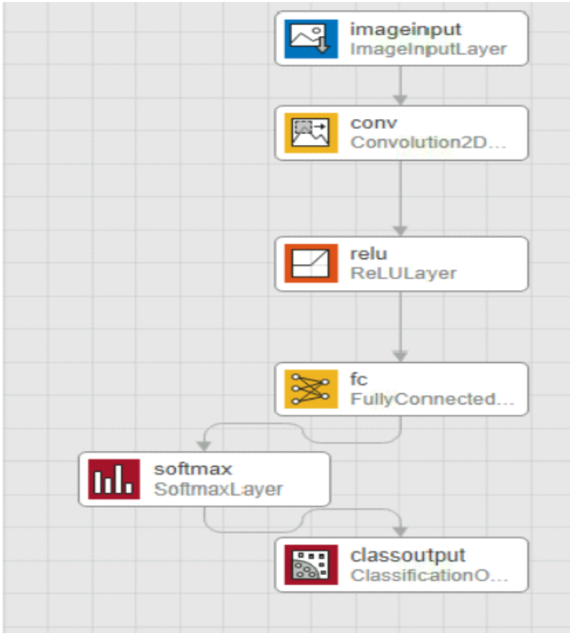

Figure 3 CNN Layer by Layer Sampling Overview

Table 1 Different Parameter in Network

Analysis Results				
	Name	Type	Activations	Learnable
1	Image Input 128*128*3 images	Input Image	128*128*3	-
2	Conv 96 3*3*3 convolution	convolution	128*128*96	Weight 3"*3*3*96 Bias 1*2*96 96 is number of filters
3	Relu	Relu	128*128*96 96 is number of filters	-
4	FC 10 fully connected	Fully connected	1*1*10	Weight 10*1572864 Bias 10*1
5	Softmax	Softmax	1*1*10	
6	Classoutput Crossentropyex	Classification output	-	

We utilize tools in MATLAB for recognition of eye. Computer Vision Toolbox cascade object detector is able to detect categories of object whose ratio of aspect does not significantly differ. The objects whose ratio of aspect remains stable including stop signs, cars, faces viewed from one side. System object of vision.CascadeObjectDetector detects objects in the images with sliding window over an image. Then detector utilizes the classifier of cascade for deciding whether window includes interest object. Window size differs for detecting the objects at various scales however; the aspect ratio of it remains stable. Detector is too sensitive to the rotation of out-of-plane due to ratio changes of aspect for the most 3D objects. Therefore, we require training the detector for every object orientation.

Results' Evaluation

We performed the experiments on ORL face database. ORL dataset includes images with the size of 92*112, this dataset consists of 40 persons and there are 10 different images for each of them.

Dataset

Each of the images is a grayscale image where each pixel has a value between 0-255. The images of this dataset include variations such as brightness, facial expression (open and close eyes, smile), images with/without glasses, scale, distance and head angle rotation. One sample of images with different expressions is shown in Figure 3.

Figure 3 One sample of ORL dataset with different expressions

Initialization of Parameters

At first, 0.8% of data are considered as training data and 0.2% of data are considered as testing data. In Table 2., the set of initial values are shown for the testing and training percentage, eye space and the number of image channels.

Table 2 Initial values for the parameters

Parameters	Initial values
Training data percentage	0.8
Testing data percentage	0.2
Eye space	70*270
The number of image channels	1

Based on confusion matrix, different parameters are to be computed such as accuracy. Each eye accuracy is computed and the mean of is taken as last accuracy. Last accuracy computed and Error rate parameter can be computed depends on true and false predictions.

Evaluation Criterion

The ability of a test in proper differentiation of accurate cases of individuals' eye recognition from the other cases is named accuracy. In order to calculate the accuracy of a test, we should derive the total ratio of proper positive and proper negative samples to the all tested cases. Mathematically, this ratio can be demonstrated as bellow.

Experimental Results

Implementation process is performed by MATLAB 2018b. This section discusses about the proposed algorithm evaluation using computational experiments. Experiments are done using a standard dataset. In order to evaluate the performance, the proposed method is compared to the paper [15] method. In Figure 4., the improvement process of neural network training with 60 repetitions is shown.

Table 3. shows the comparison results of the proposed method and paper [15] method with ORL dataset. As you see, the proposed method has better performance.

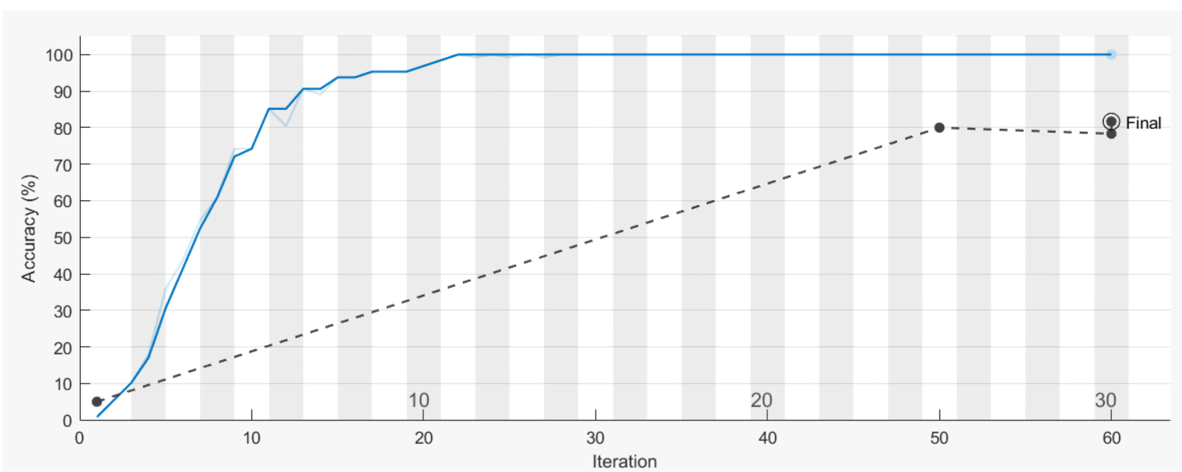

Figure 4 Improvement process of the neural network training

Table 3 The results of eye recognition for the images from database of ORL

Proposed method		Previous papers	
Error Rate	Accuracy	Error Rate	Accuracy
18.30%	81.67%	21.00%	79.00%

Conclusion

Recognition was becoming the main problem for various applications. Eyes can be segmented after removing the whole other parts such as skin, background as well as the other parts of face in an image. Several techniques applied with various studies such as template matching, Eigenvectors & Hough Transform. In the proposed method, eyes will be specified in an input image with a CNN neural network which will be used in security systems to identify persons. To compare performance of localization with detector of eye, the experiment is performed over 370 images in dataset of ORL; rate of recognition is 81.67%, error is 18.33%. However, the proposed framework obtains the highest accuracy for the database, still this suffers from common biometric identification bottleneck that contains the proper identification failure when eyes' or faces' external visual attributes change that will affect the identification of persons in the security systems. In the future work, we will address the aforementioned problems.

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