Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 2579 - 2590
Received 16 February 2021; Accepted 08 March 2021.

Modified CNN based Feature Extraction for Sclera Recognition of Off Angular Images

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ABSTRACT

Biometrics are being most unavoidable thing in terms of security and authentication. Sclera vessel patterns are one of the fast-growing biometrics which has unique features as well advantages over the previously discovered biometrics like iris, Finger print, voice, Face, Etc. As the sclera has more advantage over the past since there is a difficulty in segmenting the Sclera region and Extraction of the feature from the segmented sclera portion. Especially in sclera feature extraction the feature of sclera has limited vessel patterns because of the segmentation which eliminates the major portion of the sclera in the process of segmentation. There are several feature extraction methods like Hu moment, Discrete Fourier transforms, Affine Transform, Line descriptor segment, Harris corner, DWT co-efficient has been existing to extract the meaningful feature from the biometrics but here the feature and the behavior of the feature is complex in structure as there is limited number of features, non-linear and Nonstable in thickness. Even the eye is movable which may visibly portion of the vessels in some occasions where the it will be difficult to extract the feature and recognition of the individual. To overcome this issue a new CNN (Convolutional Neural Network) based feature extraction method has been introduced in this article and the four different version of the CNN has been discussed. The accuracy of the four different CNN based methods were explained in this paper and we scored remarkable response with this modified CNN based feature extraction approach.

Keywords
Biometrics, Sclera Recognition, Feature Extraction, Classifications, Transformation. Vain pattern recognition

Introduction

Sclera is a novel biometric which has evolved because of the lacuna created by iris. Since iris is the most secure and prominent biometric still there exist a lacuna which is in absence of the iris in acquisition leads us a difficult situation to recognize the individual [1]. There is some case study which may takes to the situation of helpless where the sclera will guide to find the individual or recognize. Vasculature pattern of the Sclera is providing the feature to recognize as it has

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relaxation in acquisition. Images acquired in visible wavelength is sufficient to find the features form the sclera. Hence there is difficulty in finding the Vessel patterns in feature extraction where the segmented images are taken as binary image may contains the eyelashes [2].

Sclera recognition system consist of Sclera image Acquisition, Preprocessing, Sclera segmentation, Enhancement, Feature extraction, Feature registration and Feature matching. The overall flow of the clear recognition system is illustrated in figure 1. Among the various stages the isolation of the sclera area from the eye image and the feature extraction of the vessel patterns plays a major influence on the accuracy of the recognition system [3].

Since 2007, many feature extraction methods have evolved and increased the performances. Still there is a lacuna in the accuracy of the vasculature recognition because of the vessels are not always in the same thickness based on the time, climate and health the thickness and the contrast will changed [4]. Due to this non static behavior leads the recognition more complex as compared to the other biometric based recognition. Hu moment, Discrete Fourier transforms, Affine Transform, Line descriptor segment, Harris corner, DWT co-efficient has been proposed for the feature extraction of the vessel patterns. Still the accuracy the recognition is not reached the final which is the vessel patterns are not linear as the non-linear feature it takes time to finalize the features [5]-[10]. Among the various feature extraction methods few has been tested with sclera recognition as the sclera is dynamic and non-linear which needs suitable method to extract the feature from the segmented sclera image.

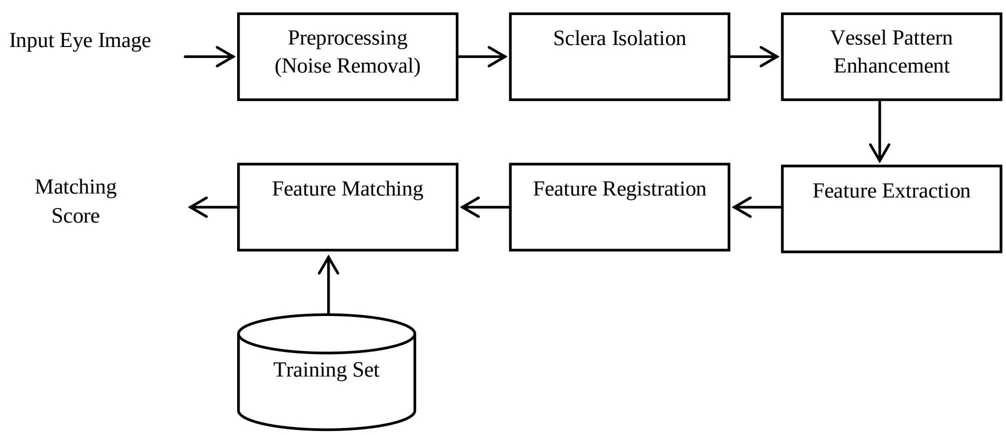

Figure 1. Sclera Recognition process

To extract the feature from the image artificial Intelligence has a various technology which learn from the inputs and the same has been implemented for the Sclera in order to extract the effective feature which leads for the accurate feature extraction [11][12][13][24]. Convolutional Neural Network (CNN) is artificial methods now in machine learning and deep learning method which has more inner layers to like pooling and convolution to extract the optimized the feature from the sclera. Architecture diagram of CNN has been described in Figure 2.

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Proposed Method

Sclera recognition system consist of Sclera image Acquisition, Preprocessing, Sclera segmentation, Enhancement, Feature extraction, Feature registration and Feature matching. The system starts with the image acquisition which is acquired using visible length camera of the capacity 5 MP [14][25]. As all the above mentioned where exist in the UBIRIS V2 which is collection of eye images of captured using the visible wavelength camera. Hence the proposed method will be tested in UBIRIS database. The System will be implemented in the Flow of below mentioned [15][26].

Preprocessing

Then the acquired image is preprocessed in order to remove the noise which is irrelevant to the further process and which affect the segmentation and feature extraction process. In generally Reflection of the camera light will be placed in the eye image as the eye is wet so the holds the reflection of the camera flash and the gaze direction of eye distance of the camera and eye, Visible wavelength. Further the segmentation of sclera will take place because the vessels of the sclera will be isolated to identify the individuals as the sclera is surrender by the iris and eyelash which has been removes as they are unwanted for the recognition process [16][27]. Sobel operator or mean or median filter is used to remove the glare from the input eye image. Where the color images are converted to gray scale image.

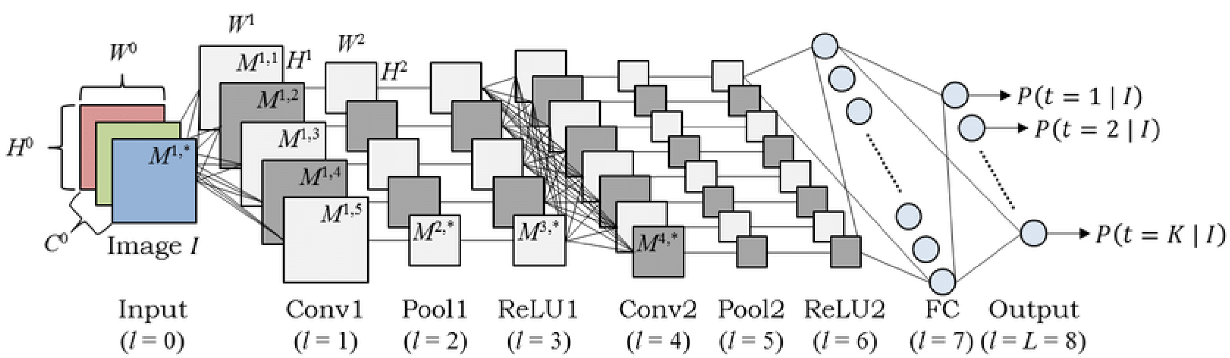

Figure 2. CNN, Convolutional Neural Network, Architecture

Sclera Isolation

Sclera isolation is the important phase in the sclera recognition as the it impacts more in the accuracy of the entire process. Where the color input image will be converted to either grayscale or single channel in order remove the isolate the sclera from the iris, eyelid and eyelash as the color image has three different channels like red, green and blue. It is difficult to process the three channel and it is time consuming so the gray scale or the single channel has been processed for the Segmentation. Integro Differential operator is used to remove the unwanted area form the

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sclera which reduces the duration of making the process [17]-[20].

Sclera Enhancement

After isolating the sclera from the iris, eyelash and eyelid it needs the enhancement to extract the feature from it. Because the vessels in the vessel patterns are not static in terms of thickness and also not visible in all the times. Since it has unique feature but not comfortable in all the situation so to eradicate the drawback it seems to be enhanced. The segmented color image will be applied to the sobel operator or wavelet-based transform or DWT based transform or Haar filter to enhance the vessel patterns [21]-[24].

Feature Extraction

Feature extraction is the processes of extracting the meaningful information form the input image which will hold the more information they may irrelevant to the matching process and also the data may be duplication.

CNN (Convolutional Neural Network) is designed based on the human's brain which is act as the human brain which is connected and function with the help of neurons. As like the convolutional neural network also have more layers which are interconnected like the neurons. The CNN has different layer like convolution layer, pool layer and fully connected layer. The segmented and enhanced image is being allowed as input for the CNN which process the mathematical model on the image and classifies the features which will be stored in database as a trained set. The same process has applied for the test set which will be the image to identify the individual. A combination of Convolution and ReLU or pooling layer and convolution layer will be sequentially processed to make the multi-dimensional input image into the one-dimensional feature set. The Work flow of CNN based feature extraction is illustrated in the Figure 3.

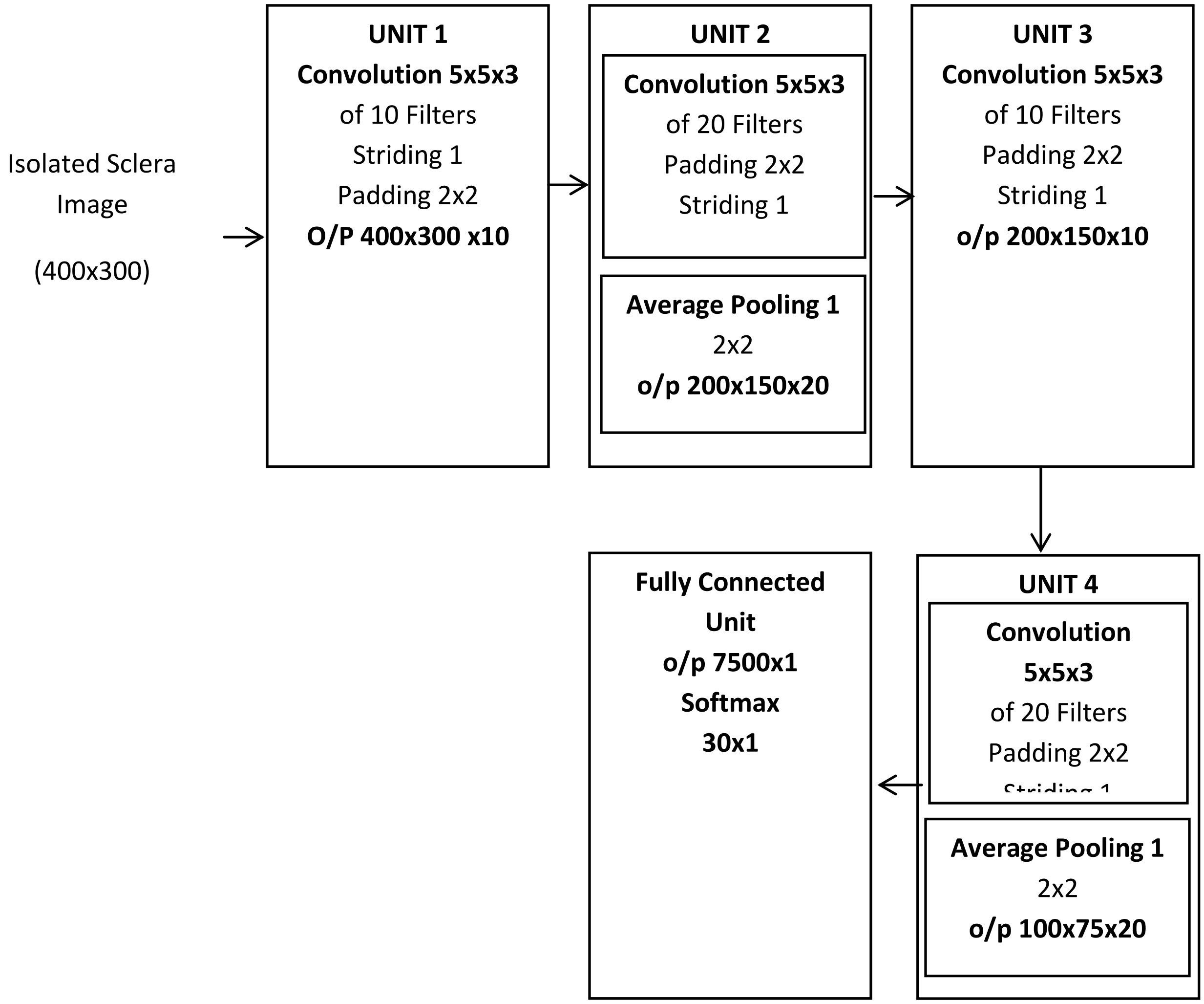

Figure 3. Work process of CNN based feature extraction

There are four convolution unit and a fully connected units is designed in the CNN architecture to extract the feature. First Convolution unit uses convolution layer which is mainly used for the feature extraction which uses the weighted or kernel filter to be convolved. As the CNN required all the test and training set should be in same size. So, the actual size of the UBIRIS is will be taken as it is which is 400x300x3. Convolution and the Pooling layer will be repeated many times, still it gained the expected mapping values. In the First convolution unit the 10 filters of size 5x5 as the height and width is 400 and 300 respectively, to retain the same after the convolution the zero is padded before the image matrix. As this is the first phase so the striding will be 1 to avoid losing the important feature form the image. The size of the filter will be 5x5 and the input image is color image so the filter will have the depth of 3 which becomes 5x5x3. Padding of 2x2 is to be used to retain the same size of the images, Since the actual input of the recogni-

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tion system was reduced from 800x600 after the segmentation process.

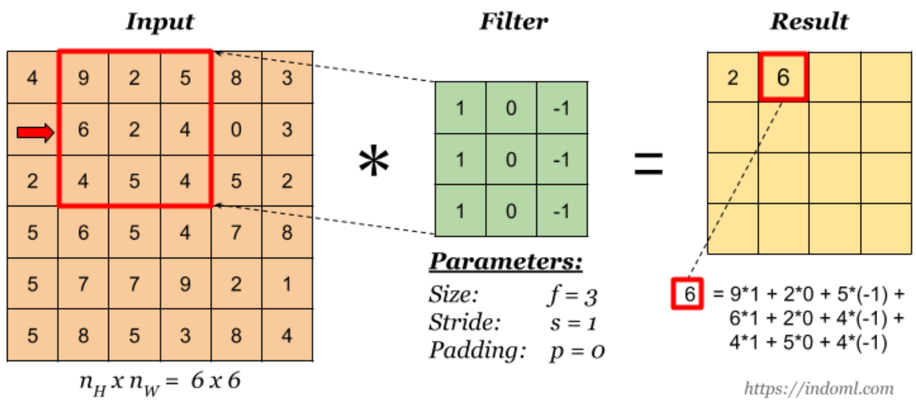

Figure 4. Convolution process

Unit 1 will take the convolution process first that takes the 5x5 filter 10 in number which is designed to retain the actual size of the input image so the padding 2x2 is used. Striding will be kept 1 by default to not losing or missing the feature of Sclera. The ReLU layer were applied after the convolution of the input image which is used to preserve the linear feature of the vessel pattern. Input for the convolution layer is Sclera segmented 400x300 RGB image. As a RGB image it would have 400x300x3 pixels for the input image which will be resized as 400x300x30.

The output of unit I will be the input of unit II which is same as the unit I where the data is undergoes two phases like convolution and average pool. There are two types of pooling layer is existing and among the two average pool has been utilized which is has 2x2 average pooling. Average pooling will be incorporate the all the data which is retrieved from the data. Due to this behavior of avoiding data loss as the vessel data are limited so the average filter has been utilized. In the unit II the first layer is about the convolution which will be taken 20 filter of size 5x5 with the 3 color channels. Then the outcome will be 400x300x20 which will be the input of next layer which is exist after the convolution layer. Average pool of size 2x2 is reduces the data size as 200x150x20 which is half the extraction phase input size.

As like the previous two layer the next two layers will be done the same which is unit III of 5x5x3 convolution filter in 10 counts and in unit IV 5x5x3 convolution filter in 20 counts and the average filter of size 2x2. After the four units of convolution and Pooling filter the final data set will be 100x75x20 will offered as the final dataset from the fully connected unit of the CNN network where the SoftMax will be calculated to reduce the dataset further. The experimental results were discussed in the further section.

Result and Discussion

The experiment is implemented over the dataset UBIRIS v1 of Section 2. As the topic is on off angular image which has been justified by the dataset UBIRS1 of section 2 because it contains

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the images which are captured in un-constrained environment and the camera is visible wave-length camera. Which has been captured around 200 persons of more than 1500 eye image will be there. Still gaze directions were high as compared to the other datasets.

Table 1 is discussing the Recognition result of the different set of UBIRIS1 of session 2 images which holds Recall, Precision FRR, GAR, FAR of the different Set. The experiment was applied over 100 set of images the table illustrates best, average and worst case of the responses in collectively. The average of the different matrices. The accuracy observed for the different sets was 93.64 as maximum in the best case, 86.36 as minimum in the worst case and in the average the accuracy will be in 90.67 percentage. As the low quality and off angular image the 90.67 percentage will be high as compared to the other versions of feature extraction algorithms. The accuracy of the Feature extraction system was listed and compared in the table II.

The best part of the proposed feature extraction where the convolution will be uses 5x5 filter as the vessels are scattered and the non-linear as to observe the whole feature the filter size has been increased and the majority of the systems will be constructed with 3x3 filter. Best part with the CNN is, it allows the 3x3 to 11x11 size filters for the convolution. Since the system will be incorporated with the Precision Test which is ratio of true positive among the test.

$$precision = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

$$False\ Reject\ Rate(FRR\ or\ FNR) = \frac{False\ Negative}{True\ Positive + False\ Negative}$$

$$False\ Reject\ Rate(FAR\ or\ FPR) = \frac{False\ Positive}{False\ Positive + True\ Negative}$$

$$Ganuine\ Acceptance\ Rate(GAR) = 1 - FRR$$

Apart from the percentage of accuracy test these are the metrics calculated for the evaluation of the performance Which prove the system more prominent and efficient than the other feature extraction methods. Over the Experiment the obtained metrics are listed in the table and the average precision of the overall section was 0.850, Recall is 0.833, FRR is 0.193, GAR is 0.785 and the finally the false acceptance rate was very low as it was 0.0092 of the average. The Experimental results has shows that the response is increased as compare the to the existing methods including the previous CNN based method.

Table II is discussing the accuracy of the various feature extraction accuracy over the same set of

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images which are low in quality and off angular. Sclera as biometrics is prominent to authenticate the individual since it has lots of difficulty with respect to identify or localize the features because the vessel patterns of the sclera are deformable, nonlinear in nature and most importantly dynamic in terms of thickness which may leads some difficulty in the feature selection. As the off angular image, the Feature vectors are very limited due to the gaze direction the vessel pattern over the sclera will be invisible for the extraction. After the preprocessing and enhancement, the features have been extracted and the which will be helps to identify the individuals. Here the CNN will consider the entire segmented image for the feature selection which avoids lacuna on selection of the features. The table reflect that the CNN based feature extraction model produces more accuracy than the existing methods of feature extraction.

Table 1. Recognition result

Set of UBIRIS V2 Images	Precision	Recall	False Reject Rate (FRR)	Genuine Acceptance Rate (GAR)	False Acceptance Rate (FAR)
1	0.79	0.39	0.53	0.47	0.001
2	0.39	0.31	1	0	0.027
3	0.99	0.65	0.55	0.45	0.01
4	0.75	0.5	0.5	0.95	0.015
5	0.78	1	0	1	0.02
6	0.95	1	0.04	0.96	0
7	0.77	1	0	1	0.001
8	0.57	0.77	0.12	0.82	0.029
9	0.61	0.9	0	0.12	0.008
10	0.5	0.91	0.76	0.24	0.035
11	0.5	0.15	0.61	0.39	0.015
12	0.6	0.59	0	1	0.028
13	0.6	1	0	1	0.003
14	0.72	1	0.33	0.67	0
15	1	1	0	1	0
16	1	1	0	1	0
17	1	1	0	1	0
18	1	1	0	1	0.02
19	1	1	0	1	0
20	1	1	0	1	0
21	1	1	0	1	0
22	1	1	0	1	0
23	1	1	0	1	0

Average	***0.80521739***	***0.8334783***	***0.1930435***	***0.7856522***	***0.0092174***

Table 2. Accuracy of the different Feature extraction model

Sl. No.	Feature Extraction models	Accuracy Rate
1	Line Descriptor method	80.55
2	LBP method	81.25
3	DWT based Feature extraction	83.24
4	KNN based model	80.54
5	Hu moment model	82.11
6	Proposed CNN Model	90.67

The line Descriptor will Convert the vessel patterns into the linear which will be computed and represented with respect to the origin of the iris. It leads avoidance nonlinear vessel pattern which impacts the accuracy of the system. Line Binary pattern is also an approximation method which will represent the patterns in terms of line and that will be avoided in the CNN based feature extraction. Later the DWT based feature extraction provides the little high accuracy still there is lacuna that the 2nd level DWT will be applied which may leads avoidance of the Features. is lacuna and KNN based methods produces the 80.54% of the accuracy. The proposed method produces 90.67 percentage of accuracy which is higher than the previous system. Still the CNN may produce different result based on accuracy of the segmentation methods because the accuracy of the recognition system will directly be affecting or responding to the accuracy of sclera segmentation.

Conclusion

We proposed a Modified Sclera Feature extraction method based on the CNN methods to enhance the accuracy of the sclera recognition system. As the CNN is the deep learning which is specially design for the feature extraction but here the scenario is different that the Vessel patterns are dynamic in terms of shape and quality. The modified CNN is proposed and the features are extracted from the Segmented Sclera images which is isolated by the Canny edge detection, integro differential operator and the same will be enhanced by the discrete wavelet transform. The isolated and vessel pattern enhanced images are processed using the proposed CNN model which extract the features effectively and achieved the accuracy rate of 90.67 percentage.

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