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Iris Identification Based On Deep Convolutional Neural Networks

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Abstract –*With the prominent needs for security and along with the increasing request for information security, security regulations and trustworthy method of identification and adjustment in biometric system in all over the world, biometric identification technology transpires extensively used in our everyday life. On account of this consideration, iris biometrics technology has gained more and more attention and interest due to its ability and reliability to dominate a sum of significant limitations of unimodal biometric systems. In this study, a new biometric identification system is proposed, which is based on a deep learning algorithm (CNN) for identifying humans using biometric modalities of iris. In interpretation of the countless performance of deep learning methods in several identification tasks, the structure of the proposed biometric identification system is based on convolutional neural networks (CNNs) which extract features and classify images by SoftMax activation function classifier. Nowadays iris identification system has turned into a reliable technique for personal and individual identification. A distinct contemplation which is given to iris identification system is liability to its high performance and reliability for identification. The system has been used for years in many commercial, mercantile and government applications that allows availability inspection and control in localities and places such as office, automated teller machines (ATMs), laboratory, and border control in airport. As a highly accurate modality of biometric identification, iris identification system uses plenty of mathematical pattern recognition techniques on images of one or both of the irises of a person's eyes.*

Keywords –*Identification, Biometric Identification System, Security, Technology, Deep Learning, Convolutional Neural Networks, Computer Vision, Iris Identification System*

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I. INTRODUCTION

With the eminent needs for security and along with the increasing request for information security, security regulations and trustworthy method of identification and adjustment in biometric system in all over the world, biometric identification technology transpires extensively used in our regularly life. In this study, a new biometric identification system is proposed, which is based on a deep learning algorithm for identifying humans using biometric modalities of iris. Lately, deep learning has made a considerable influence and generated excellent results in biometrics systems [1]. The deep learning algorithms have dominated a large number of the limitations of other machine learning algorithms, principally those related with feature extraction techniques.

Deep learning algorithms are able to cope with biometric image transformations and can extract features from raw data [2].Numerous biometrics researchers have trusted on machine learning and deep learning algorithms for identification targets. Machine learning and deep learning algorithms need almost extraction techniques to extract features from raw biometric data and transform the raw data into a suitable and reliable format before classifying it [3]. Furthermore, machine learning and deep learning algorithms necessitate and involve certain preprocessing stages to be derivedout prior to feature extraction. Additionally, some extraction techniques do not continuously work positively with different types of biometrics or different data sets of the same biometrics.Moreover, they cannot handle with biometric image transformations, for instance, zooming and rotation [4].

In interpretation of the countless performance of deep learning methods in several identification tasks, the structure of the proposed biometric identification system is based on convolutional neural networks (CNNs) which extract features and classify images by SoftMax and ReLU activation function classifier. However, current advancements and improvements in deep learning and computer vision illustrate that using convolutional neural networks (CNNs) are able to represent complex image characteristics, for feature extraction and classification respectively to increase the efficiency of recognition. Nowadays iris identification system has turned into a reputable and a reliable technique for personal and individual identification technique. The system has been used for years in numerous commercial, trade, mercantile and government applications that allows availability and serviceability inspection and control in localities and places such as office, automated teller machines (ATMs), laboratory, and border control in airport.

Iris identification or iris scanning is an automated method of biometric identification or the process of using visible and near infrared light to take a high contrast photograph of a person's iris which uses mathematical pattern recognition techniques and appears as one of the most useful methods for biometrics recognition and identification in last few decades. The goal of iris recognition is to identify human identity and their physiological or behavioral characteristics via the textural characteristics of one's iris muscular patterns. As in the 21st century most of people uses electronic devices such as smartphones, laptop computers, desktop computers, smart watches, tablets, and the usage of these personal devices are growing up. To browse over web based social platforms and ideology, store personal information such as pictures and videos, chat with others thru text or video. These quantity of personal data and information stored in electronic devices is increasing day by the day. Therefore, biometric authentication is obligatory to avoid unauthorized users and operators from abducting such information and data from personal electronic devices.

The Human cortical frontal eye consists of iris, sclera and pupil. Figure 1 better demonstrates the human frontal eye, the black denotes the pupil, the white illustrates the sclera and the edge between the sclera and pupil is called iris. Human irises have an exceptional structure that provides interlacing minute characteristics, such as freckles, coronas and stripes, these visible characteristics of iris are generally called iris texture which are unique to each individual person, and to even each eye, that makes it unique and suitable for biometric measurement [5]. The iris is an internal organ which is optical while visible outwardly,the individuality and uniqueness of iris patterns in addition to the further advantage that the iris is an internal organ thus far visible externally makes it less susceptible to damages over a person's life time. Compared with other biometrics technologies, such as palm print, face recognition, finger geometry recognition, Hand Geometry Recognition, the individuality of the iris pattern makes it further reliable and dependable and stable for identification. The procedures for iris Identification system usually consists of six elementary stages which are iris image acquisition, image preprocessing, iris segmentation, iris image normalization, feature extraction, and pattern matching. The following section of the paper is organized as, section 2 discusses the proposed study and iris identification stages, section 3 provides theExperimental Results and Analysisand section 4 will cover the conclusion of the paper.

Subsequently, consideration is possessed to improving the iris identification performance by the extraction of the most important iris textural information using a multi-scale, multi-dimensional approach based on Histogram of Oriented Gradient (HOG), VGG-16, VGG-19, ResNet-50 vs ResNet101, MobileNet, AlexNet and InceptionV3 which are fully convolutional, and are essential in improving the speed of the iris identification which reduces the dimensionality of the iris feature vector and improve the speed. Furthermore, in the matching stage, the patterns generated at iris feature extraction stage to measure the similarity between two images of iris patterns. This stage measures the similarity and dissimilarity between the two binary codes for making decision of acceptance or rejection [6]. In this research work, for iris pattern matching and image matching the enhanced ORB algorithm is proposed.

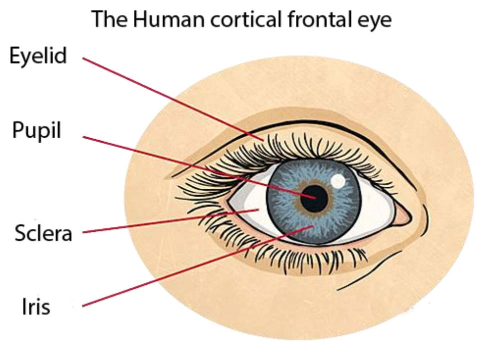

Figure 1: The human cortical frontal eye

II. IRIS IDENTIFICATION PROCESS AND PHASES

This section will be dedicated to the description of the methods and procedures done in order to obtain a high accuracy and suitable performance speed in iris identification, how they will be implemented, interpreted, trained, and how the conclusion will be met. This section is to justify the means in which this study was obtained and will help in giving it purpose and strength as it will then be truthful and analytical. All these will help in the processing of iris identification and the methods of conclusions. Furthermore, this section discusses about the iris identification stages, the proposed iris identification system includes iris image acquisition, iris image preprocessing, iris image segmentation, iris image normalization, iris feature extraction, and iris pattern matching. Figure 2 precisely describe the proposed iris identification system stages

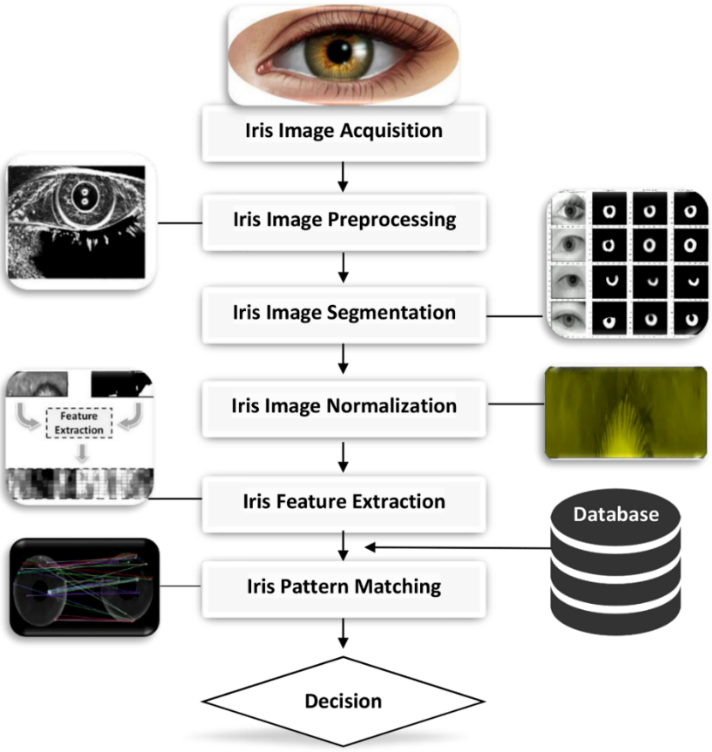

Figure 2:Iris Identification stages & Architecture

2.1 IRIS IMAGE ACQUISITION

Image acquisition could be defined as the performance of obtaining an image from sources. The iris images are acquired by capturing a picture of the complete eye area of the human through some distinct digital camera devices and locating the pictures to the storage devices. The first step is the collection of iris images. As Iris recognition system is a high accuracy biometric identification technology with the privileges of uniqueness, constancy, noninvasive, accurate matching performance. Iris image's modality and quality affect the performance of the detecting algorithms. The facility of usage and strength of the recognition is also affected by the image acquisition modality; therefore, iris image acquisition acts a significant role in the whole recognition system. Image acquisition is the operation of retrieving an image fromsource, typically, a hardware-based source, in essence, it is merely to capture an image by using hardware.

In iris identification system the primary step is image acquisition. This step is very complex and complicated since the color and size of iris of every person is unique. Due to the different lighting efficacy, the acquisition process might sometimes generate disparate results for the same person, aligning and different parting of distance. The prerequisite for iris image acquisition is the hardware design, infrared light supply, lens and CMOS sensor are significant features which affect the quality of iris image. As the salient point is stated hardware, image sensor selection acts quite important role to acquire an ideal image. Image acquisition is a huge matter and crucial in iris identification system, hence it is beyond my ability to do by myself, though there are a large numbers of iris image databases.

Currently there are eight or even more permitted available iris image databases that are free to be used for iris biometric purposes, namely they are: Chinese Academy of Sciences (CASIA [7]), with four discrete versions), University of Olomuc (UPOL [8]), University of Bath (BATH [9]), Multimedia University (MMU

[10], two versions), Iris Challenge Evaluation (ICE versions of 2005 and 2006 [11]), West Virginia University (WVU MMU [12]), University of Beira Interior (UBIRIS MMU [13]), and Gaze Interaction for Everybody(GI4E [14]).

2.2 IRIS IMAGE PREPROCESSING

The objective of iris image preprocessing is to reduce and eliminate noise in iris images, augment information and simplify the data in order to obtain and ideal iris image with steady region and high quality. In addition, if the full-face image is given in the initial step, it is significant to detect the eye. To attain the purpose, image filtering and edge detection are needed for iris image preprocessing [15].

2.2.1 IMAGE FILTERING

Image filtering is the first step in iris image preprocessing and comes before edge detection, which is to omit the intrusion and interference in the original image for the edge detection. The important goal of image preprocessing filter involves Noise Reduction, Color Normalization, Edge Detection and Histogram Equalization, and iris image preprocessing filters are primarily used to support the high frequencies in the image or the low frequencies in the image. With an effective image filtering, the Iris detection will be guaranteed. Before implementing the Mean Filter and Gaussian Filter, I am going to Implement an exponential operator. Given an exponent r compute for each input pixel P_{in} the output pixel value$P_{out}$with the following exponential operator formula:

$$P_{out} = 255 * \left(\frac{P_{in}}{255}\right)^{r} \quad (2.1)$$

Implement the function on the grayscale image which $r = 0.45$. Furthermore, Plot the histogram of the image before and after the transformation. After exponential operator, I have implemented histogram equalization operator on iris images from UBIRIS v2 database. Intensity of pixel is specified $i\epsilon[0..255]$, the image histogram h, the total number of pixels of the image N, compute the cumulative distribution function:

$$PMF(i) = \frac{1}{n}\sum_{k=0}^{i}(\text{h(k)}) \quad (2.2)$$

And then use it to perform the equalization: $P_{out} = 255MPF(P_{in})$. Equalization distributes uniformly pixel intensities amongst the assembled present range, which usually improves the contrast. Figure 3 illustrates the implementation of the function and plotting the histogram equation of the given image before and after the transformation.

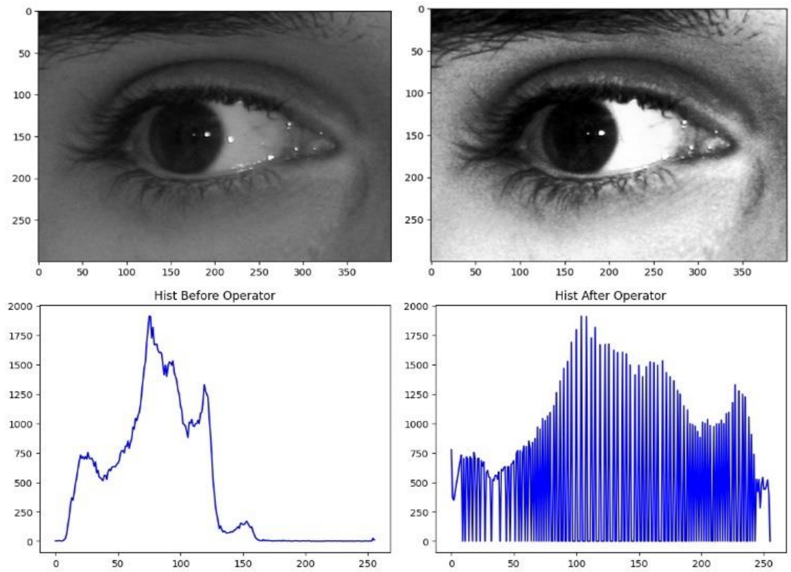

Figure 3: Histogram Equalization Implementation

In this study first the mean filter and then Gaussian filter has been applied, The Mean Filter is effective in blurring the image concerning to remove the noise. It involves specifying the mean of the pixel values within $n \times n$ in this work I have applied a mean filter of kernel size 9×9 on an image. proportionately the pixel intensity of the center element will be replaced by the mean. This eliminates some of the noise and smooths the edges of the image. The Gaussian filter is then used to blur the required region of an image and dispel the noise with superior frequencies. Its performance is the same as mean filter and are linear filters, though illustrating the average weight uniformly, which blur the edgeeffectively and reduce the noise. The Gaussian filter is a low-pass filter, whose 2D filter coefficients are computed as follows:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (2.3)$$

Where x and y are the distances from the origin along the horizontal and vertical axes, and σ = 0.8 is the standard deviation of the Gaussian distribution. Hereby the figure 4 indicate the resultant of Gaussian filter which $\sigma = 1.15$ to an image.

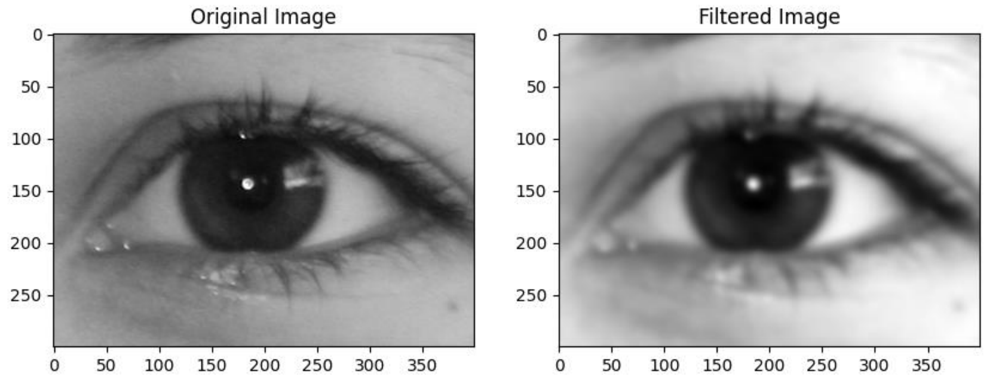

Figure 4: Gaussian filtering

2.2.2 EDGE DETECTION

Edge detection is an image processing method to find the boundaries of substances through the images, it detects interruptions in brightness. Edge detection is one of the main parts in iris identification system, edge detection method forms pupil boundary detection precisely and easier. An edge typically happens on the boundary among two different areas in an image. An edge in an iris image is a significant local alteration in the image intensity. Pupil is a superior fragment of the eyes, by Hough transform it could be easily detected the boundary of pupil by many methods such as Canny edge detection [16], Prewitt edge detection, Sobel edge detection and Otsu method can also be used to find the pupil [17]. The measure of ellipticity and ellipse fitting are interested by real world image processing problems, Similar to other measures for preliminary geometric shapes. Ellipticity become famous in industry and nature, and the method of identifying completed it important in identification in area of agricultural and medical imaging systems for identifying certain grains, onions, watermelons, cells, and even human faces as in this research it is used for iris edge detection [18], as demonstrated the result of edge detection by ellipse fitting in figure 5, and the equation is as follow:

$$\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2} = 1 \quad (2.4)$$

where (h, k) is the center of the ellipse, and $2a$ and $2b$ are the lengths of the axes of the ellipse. The longer axis is called the major axis, while the shorter axis is called the minor axis.

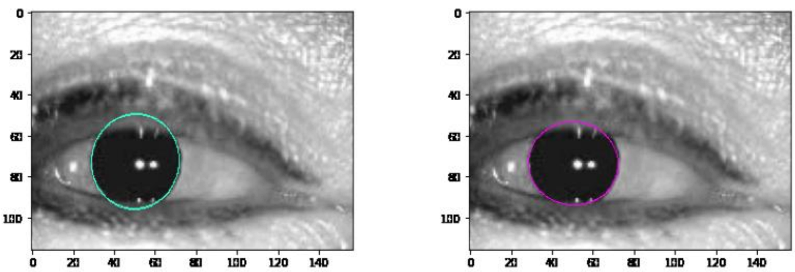

Figure 5: Ellipse Fitting iris Edge Detection

Next the Canny edge detector has been performed, moreover it is the first derivative of a Gaussian. It approximates the operator that optimizes the product of SNR [19]. As shown in Figure 6, Canny edge detection is appropriate for detecting the pupil. Canny edge detection is utilized to enhance iris outer boundary that is not identified competently in ordinary conditions.

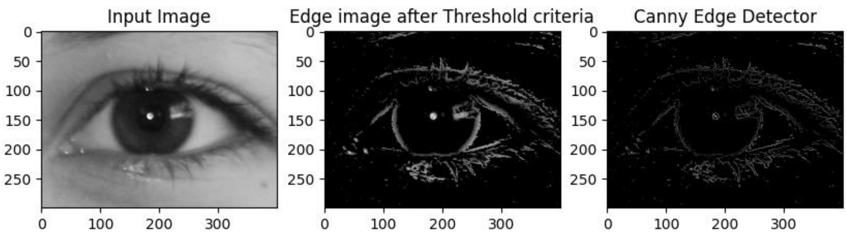

Figure 6: Iris edge detection by Canny edge detection

Hough Transform is essential to be used in case of detecting lines, circles or any kind of parametric curves. First it was introduced in 1962 Paul Hough, and for the time it was used to find lines in images, especially it was an efficient method for detecting lines in binary images [20]. The aim is clear, to find the location of the lines in the images. Compared to the line the Circular Hough Transform in fact is simpler to each other, meanwhile the parameters of the circle can be directly transfer to the parameter space identical to the line Hough transform. The equation of a circle Hough transform is:

$$r^2 = (x-a)^2 + (x-b)^2 \quad (2.5)$$

As we can see the circle obtain just three parameters, r, a and b. Where a and $b$indicate the center of the circle respectively in the x and y direction, and r illustrate the radius. So, we can get the parametric representation of the circle as follow:

$$x = a + rcos(\theta)$$

$$y = b + rsin(\theta) \quad (2.6)$$

By increasing the number of parameters required to describe the shape and similarly the dimensions of the spaceR parameter increase, likewise the complexity of the Hough transform. I have been used Hough transform in order to detect the iris outer and inner boundary as the result is demonstrated in figure 7.

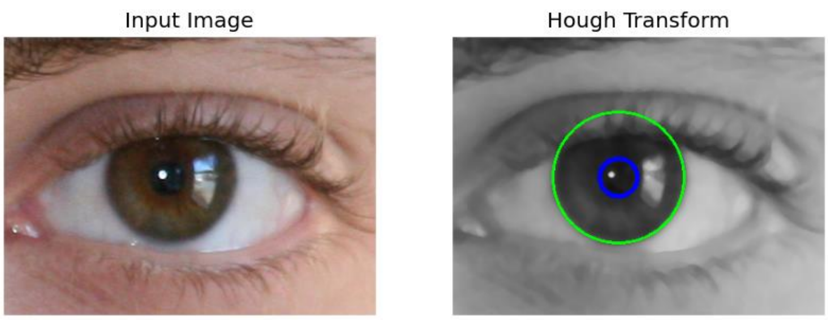

Figure 7: Hough Transform iris outer and inner boundary detection

2.3 IRIS IMAGE SEGMENTATION

Iris image segmentation is a significant step in the entire iris identification procedure and it is very critical stage as well, If the iris region is not accurately segmented, the eyelashes, eyelids, reflection and pupil noises would present in the normalized iris region. At segmentation stage, the image is essential to be cautiously localized in order to inner and outer boundaries of an iris can be modelled as a circle [21]. In terms of segmentation the U-Net model has illustrated good performance which is the proposed for this research. The architecture of the U-Net model in this research with an iris image size of 240 × 320 pixels as an input has been used. The feature maps with (width x height) dimension along on the left represented by Individually box. Designed for Conv 1, two convolution operations by a 3 × 3 convolutional kernels were performed, with the size of 256 × 256 pixels the number of feature maps is 64, and alongside the max-pooling was performed with a kernel size of 2 × 2. Figure 9 demonstrates the complete structure of the U-Net used in the iris image segmentation, which stays a representative encoder-decoder architecture. The encoder part consists of frequentative convolutional layer which has a kernel size of 3 × 3, in addition each pursues with a 2 × 2 max pooling by step 2, that regularly decreases the patch sizes. The decoder part contains the up-sampling processes with a 2 × 2 convolution, which splits the number of feature channels to half.Figure 8: The Iris image segmentation results obtained with the U-Net model. The figure exhibits (from left to right), paradigm input iris images from MMU iris dataset, further the ground truth or mask images, the initial results generated by U-Net and the end the final result generated by U-Net.

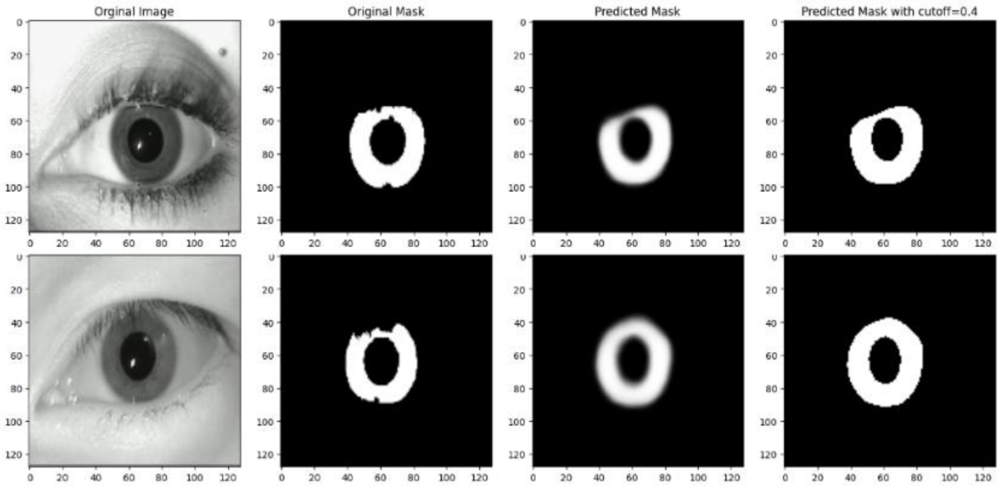

Figure 8: The result of Iris Segmentation using U-Net

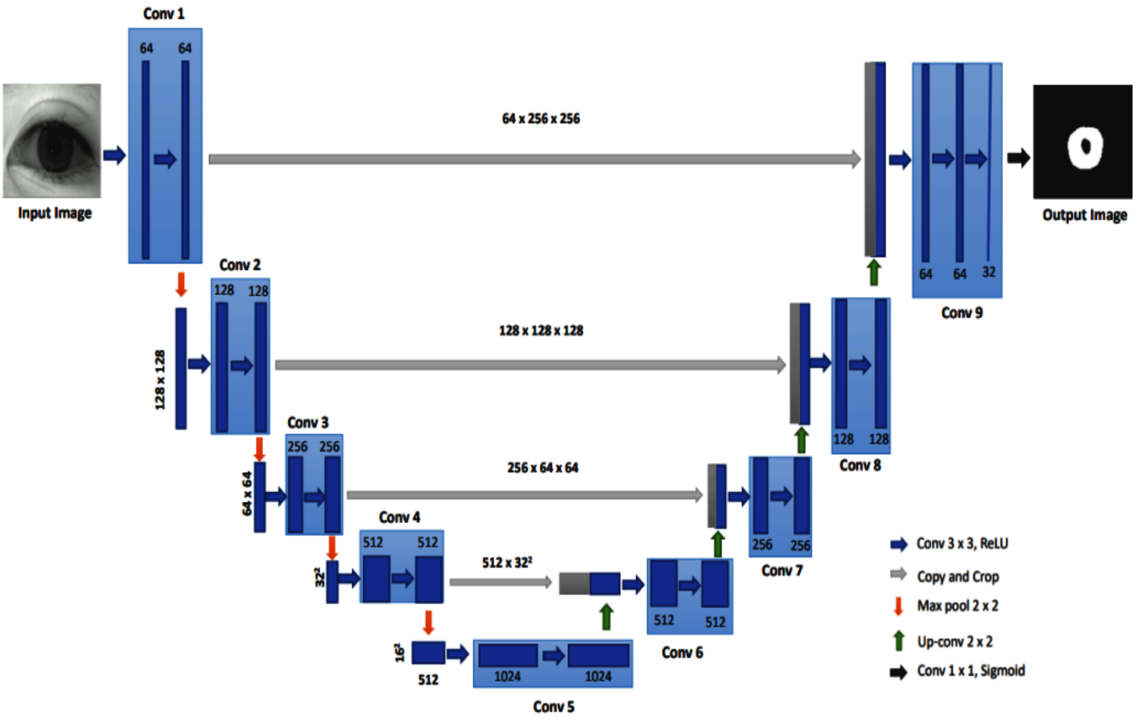

Figure 9: U-Net Structure used for Iris Image Segmentation

2.4 IRIS IMAGE NORMALIZATION

Iris images might be taken in several size and with different distance, as a result of brightness differences, the circular and redial size of the pupil may vary appropriately. Thus, the iris region has to be normalized to reimburse for this alteration. When the iris recognition systems capture an image from a person's eye. Afterwards the image of the iris needed to be segmented and then normalized for the feature extraction process. Normalization process normalizes iris images to a constant dimension and rectangular block to avoid its spatial incompatibility which might arise for several reasons such as iris imaging distance variation, revolution of the camera, illumination variation, iris stretching, eye rotation, head deformation and etc. Therefore, iris image normalization is applied to minimize all of these obstacles. Therefore, in iris normalization section Hough transform algorithm in order to detect the iris inner and outer boundaries have been implemented. And then Daugman Normalization has been applied. This model is Invented by John Daugman [17], [22]. The Homogeneous Rubber Sheet Model which devised by Daugman and proposed usage of a Rubber-Sheet Model, assigns each point in the iris region as pair antithetical coordinates ((r,θ) where r is the distance or the range between [0,1] while θ denotes the angle [0, 2π] [23]. To reallocate the iris area, the formula from(x,y) in Cartesian coordinates to normalize nonconcentric and abnormal polar is defined as follow:

$$I[x(r,\theta),y(r,\theta)] \rightarrow I(r,\theta), (2.7)$$

With $x(r,\theta) = (1-r)x_p(\theta) + rx_1(\theta)(2.8)$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_1(\theta)(2.9)$$

where $I(x,y)$ is represented as the iris region (x,y) indicates the original Cartesian coordinates, (r,θ)demonstrates the corresponding normalized polar coordinates, x_p, $y_p$and x_1, $y_1$are the coordinates of the pupil and iris boundaries along θ direction [19]. The iris within the perceived image which is detected by discovering the two closely concentric circular edges, explicitly the two boundaries among the pupil, the iris and the sclera. Figure 10 demonstrate the normalization of the iris region. The left image illustrates the observed image of the iris inner and outer boundaries detection, in the middle the segmented iris and the right image represent normalized iris image.

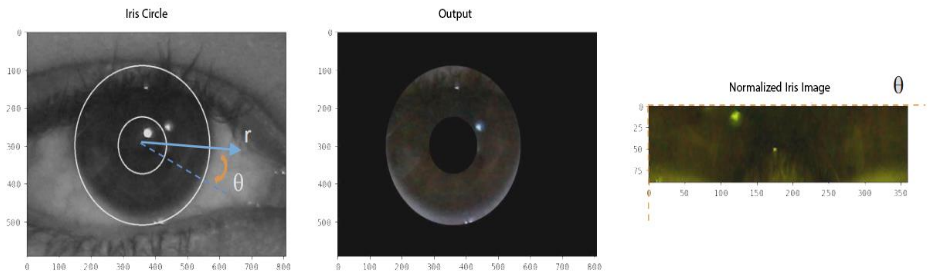

Figure 10: The Normalized iris image

With the intensification of deep convolutional neural networks, Batch Normalization (BN) naturally extends this idea across the intermediate layers within a deep convolutional neural network [24]. Nowadays, there is slight disagreement in the deep learning community that BN accelerates training, enables higher learning rates, and improves generalization accuracy [24] and Batch Normalization (BN) has successfully proliferated throughout all areas of deep learning [25 - 26]. Batch Normalization similarly has a beneficial effect on the gradient flow through the network, by decreasing the dependence of gradients on the scale of the parameters or of their initial values. This allows of much higher learning rates without the risk of divergence [27]. Furthermore, batch normalization regularizes the model and decreases the prerequisite for Dropout. The batch normalization equations are as follow:

$$\mu\beta = \frac{1}{m}\sum_{i=1}^{m} x_i \qquad (2.10)$$

$$\sigma_\beta^2 = \frac{1}{m}\sum_{i=1}^{m}(x_i - \mu\beta)^2 \qquad (2.11)$$

$$\hat{x}_i = \frac{x_i - \mu\beta}{\sqrt{\sigma_B^2 + \epsilon}} \quad (2.12)$$

$$y_i = \gamma\hat{x}_i + \beta = BN_{\gamma,\beta}(x_i) \qquad (2.13)$$

The BNtransform can be added to a network to manipulate any activation. In the notation $y_i = BN_{\gamma,\beta}(x_i)$indicates that the parameters γ and β are to be learned.

2.5 IRIS IMAGE FEATURE EXTRACTION

Once the iris region has been magnificently normalized, next stage is to extract considerable information from iris pattern which has been obtained from normalized iris images. The extracted features are programmed to produce iris patterns. Several iris identifications take the benefit of using band pass decomposition of iris image to produce biometric template [28]. In this research work first of all I have used Histogram of Oriented Gradient (HOG)[29]. Figure 11 shoes the Gradient extraction from iris image, image gradient measures the change of intensity [30]. Mathematically, for a two-dimensional function $f(x, y)$the gradients can be computed by the derivatives with respect to x and y. Meant for a digital image where x and y are distinct values, the derivatives can be approached by limited differences [31]. The gradient location x, y can be computed

$$G_x = I(x + 1, y)I(x1, y)(2.14)$$

$$G_y = I(x, y + 1)I(x, y1) \qquad (2.15)$$

Here $G_x$and $G_y$characterize the gradients in the horizontal and vertical directions individually. The figure 11 shows the HOG iris feature extraction result.

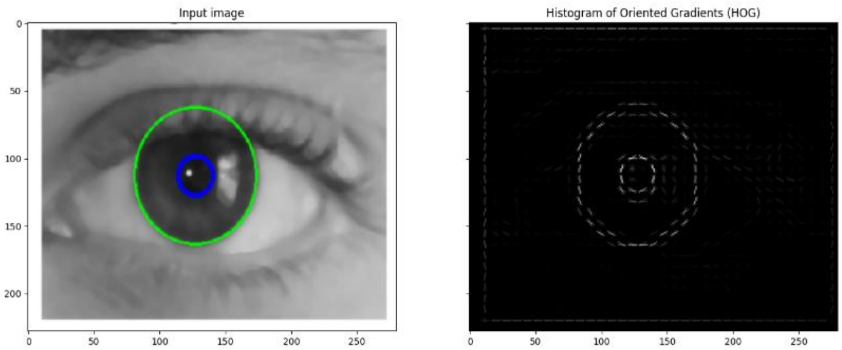

Figure 11: HOG Iris Feature Extraction

I have built a bunch of convolutional neural networks from scratch using convolutional neural network and transfer learning. In order to improve the models, I could spend a while trying different configurations, adding more layers, changing the learning rate, adjusting the number of neurons per each layer and more. However, doing this is very time consuming. Luckily, there is a technique we can use to save time and that is called transfer learning, in other words taking the patterns also called weights. In addition, this pretrained models like VGG-16, VGG-19, ResNet-50 vs ResNet101, MobileNet, AlexNet and InceptionV3 have been performed with the MMU Iris dataset and UBIRIS v2, the reason these models are used, since they are fully convolutional.

The VGG-19 model is as well proposed to extract the features of the iris images in this research, as it is the modified version. The concept of VGG-19 model (VGGNet-19) is similar to the VGG-16 except that VGG-19 contain 19 layers to be performed. In the convolutional layers the number 16 and 19 indicate the number of weight layers. Respectively the difference is between the layers, VGG-19 has three extra convolutional layers comparing to the one VGG-16. VGG-19 is a convolutional neural network architecture which consists of 19 layers deep neural network in addition it possesses more weight. VGG-19 in input takes an image size of 224×224, VGG's convolutional layers influence a minor amendable scope of 3×3 convnet to increase the depth, the minimum possible size, that is followed by a ReLU activation function. The VGG19 contains three fully connected layers [32].Figure 12 represent the VGG-16 Iris Feature Extraction Architecture.

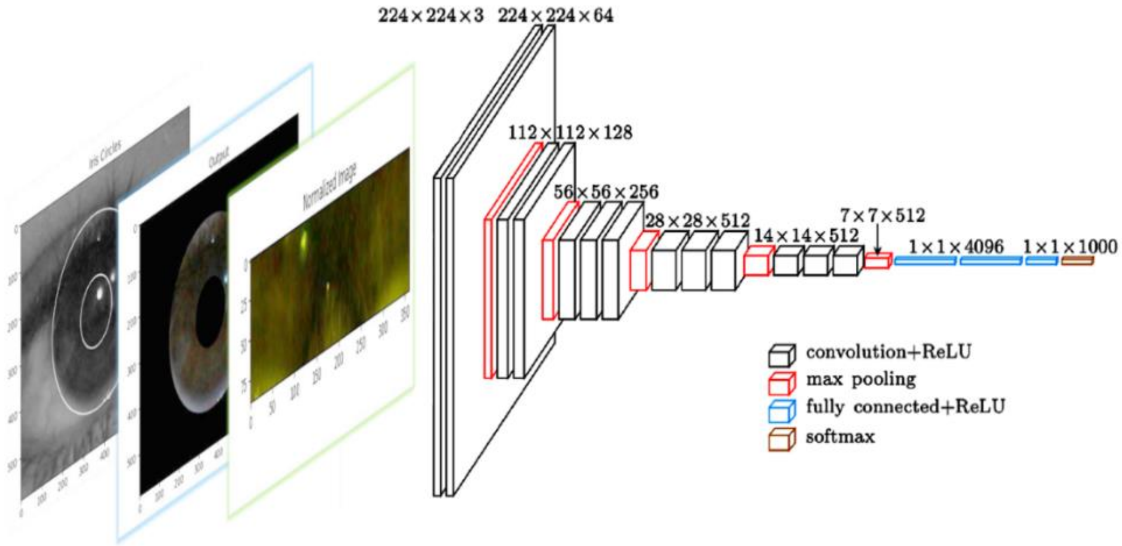

Figure 12: VGG-16 Iris Feature Extraction Architecture

2.6 IRIS IMAGE PATTERN MATCHING

The process of calculating the rating of similarity between the input test image and training image from database and purposes to extract the most perceptive features used to generate the significant iris code. In the matching stage, the patterns generated at iris feature extraction stage to measure the similarity between two images of iris patterns. This stage measures the similarity and dissimilarity between the two binary codes for making decision of acceptance or rejection [33].In this research, for iris matching templates, the image matching method based on ORB algorithm is reviewed, on this base, the enhanced ORB algorithm is proposed. Image matching is used to find the similarities between ground truth mask and predicted mask. The ORB image matching algorithm is normally divided into three stages: feature point extraction, generating feature point descriptors and feature point matching [34].

2.7 IRIS CLASSIFICATION

Recent researches illuminated that deep convolutional neural network models have become a very robust tool in many applications. For instance, one of the most popular applications of deep learning is image classification [35-36]. The model applies a convolution neural network, in order to identify unique features in images [37]. Furthermore, in iris identification the model uses a convolutional neural network (CNN). The model uses a convolutional neural network (CNN) for iris identification whereas CNN desire to differentiate between different classes of iris images. For creating the model in this study ImageNet is performed, a naive experiential for computer vision models is using the model architecture which is performing best on ImageNet [38], and the architecture is:

Input → Conv + ReLU layers (non-linearities) → Pooling layer → Fully connected (dense layer) asOutput

The details about the components of the Conv2D layer used in this study, the 2D intend that the inputs are in two dimensional (height and width), however they have 3 color channels, the convolutions can be performed on each channel individually, filters are the number of "feature extractors" which are moving over the images, kernel_size indicates the size of the filters, for instance, a kernel_size of (3, 3) represents that each filter will have the size 3×3, stride is the number of pixels a filter will move across as it covers the image, padding adds zeros to the outside of the image so the resulting output of the convolutional layer is the same as the input. After a model is created and compiled, it needs to be fitted, and here two new parameters can be noticed. Steps_per_epoch can be the number of batches a model will go through per epoch, in this case, the model go through all batches so it is equal to the length of train_data and test_data. The figure 13 illustrates the model's training performance, the accuracyand loss curves of CNN model, the model was performed with 3 convolution-pooling blocks.

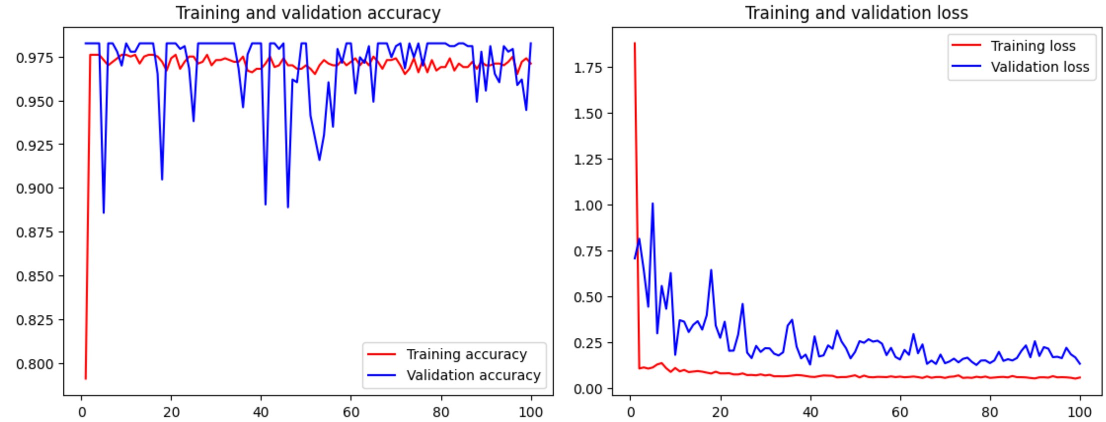

Figure 13: The accuracy and loss curves of model's training performance

III. EXPERIMENTAL RESULTS AND ANALYSIS

This section discusses about the resultand the analysis of the accuracy, performance and time efficiency of the proposed iris model (Iris identification based on Deep Convolutional Neural Network).I have conducted some experiments to evaluate the performance of the proposed schemes and summarized the results in this part.

3.1. ACCURACY AND EVALUATION OF THE IRIS SEGMENTATION SCHEME

To validate the performance of the proposed iris image segmentation scheme, several experiments were carried out on the selected datasets. A number of different segmentation approaches were applied to segment the iris images. The iris images are segmented using: Hough Transform, U-Net and Daugman's model. In this research study for iris segmentation, U-Net model, illustrated good performance in terms of segmentation. In U-Net segmentation model training after 150 epochs attaining 94.06 % accuracy on the training set and 93.82 % on test set, and this amount is sufficient because this is the first time, I have used U-Net model to segment the iris images. Four thresholds with the numbers of 0.1, 0.2, 0.3 and 0.4 have been used, it mainly extracts foreground based on gray value information, so it is especially useful for segmentation of images with strong contrast between foreground objects and background, and figure 14 demonstrates Iris Segmentation accuracy and loss graph.

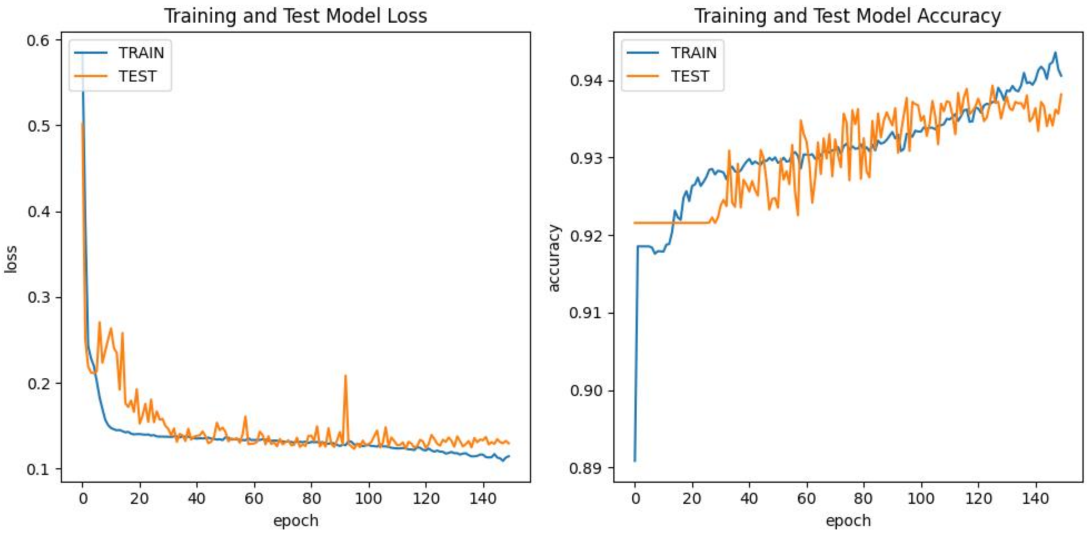

Figure 14: Iris Segmentation accuracy and loss graph

3.2. EVALUATION OF THE FEATURE EXTRACTION SCHEME

To validate the feature extraction method, the iris images in the selected datasets are first segmented using the proposed iris segmentation algorithm then normalized in order to attain advanced accuracy. The proposed feature extraction method based on Histogram of oriented gradients (HOG), VGG-16, VGG-19, ResNet-50 vs ResNet101, MobileNet, AlexNet and InceptionV3 was performed.An experiment was performed

with only 10 percent of the training images in feature extraction. The feature extraction layer has 23,568,898 parameters which are pre-learned patterns, we can say that the model has already learned on the ImageNet dataset [39].
The ResNet50 V2 feature extraction, model was able to attain around 97.33% accuracy on the training set and almost 98.23% accuracy on the test set. Then EfficientNetB0 model has been performed, which does even better than the ResNet50 V2 model [40]. Achieving 97.83% accuracy on the training and 98.35 on test set again through only 10% of the training data. Figure 15 illuminates the result on EfficientNetB0.

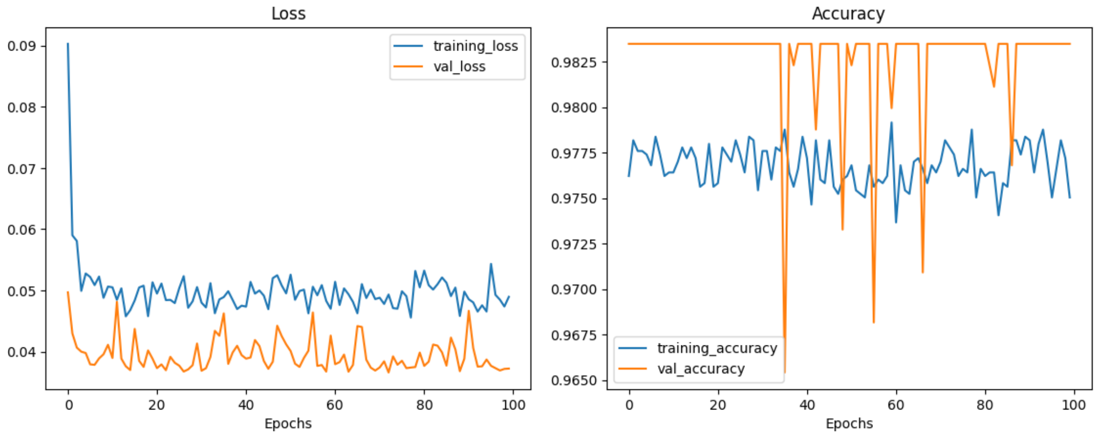

Figure 15: Model training accuracy and loss result on EfficientNetB0

3.3. EVALUATION OF THE IRIS CLASSIFICATION SCHEME

In iris identification the model uses a convolutional neural network (CNN). First, I have created training and a test set which is very significant for training the model, the next step is to turn the data into batches. First the model was performed with 3 convolution-pooling blocks. The figure 16 illustrates the model's training performance, the accuracy and loss curves of CNN model

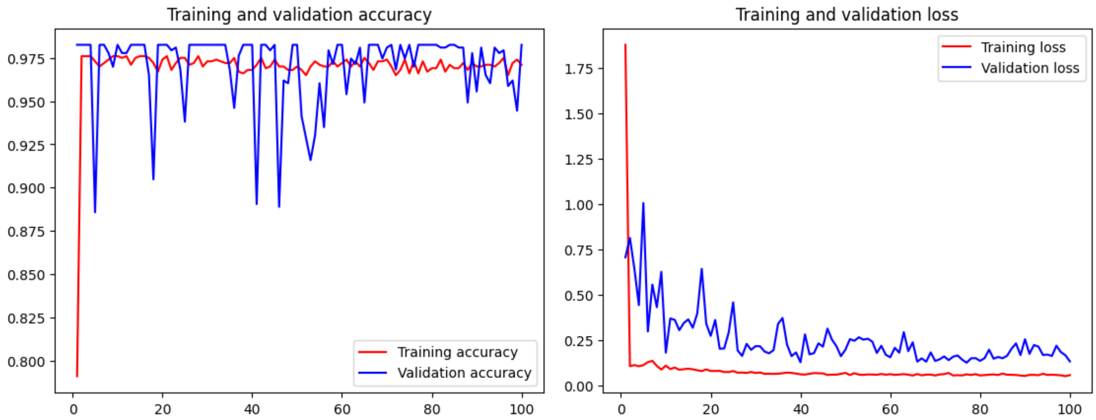

Figure 16: The accuracy and loss curves of model's training performance on CNN

Then ImageNet is performed to create the model [41]. After a model is created and compiled, it has been fitted, which obtain 98.11% accuracy on the training and 98.35% on test set on ImageNet. And furthermore, I have created a CNN model on TinyVGG with a 3-layer Convolutional Neural Network, achieving 98.01% accuracy on the training and 98.35% accuracy on test set on TinyVGG. Figure 17 demonstrate the model's training performance on TinyVGG and the accuracy and loss curves.

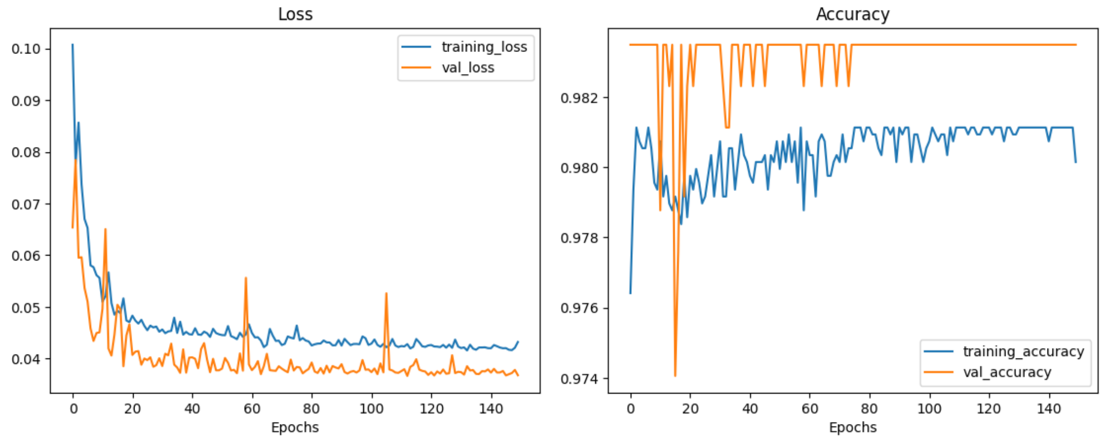

Figure 17: TinyVGG accuracy and loss performance

IV. SUMMARY

This research proposed a new iris identification system which achieves a very high accuracy on different public datasets based on convolutional neural network. The study also proposes a new iris segmentation method which raise the efficacy of final accuracy on training and testing the data. Lately, deep learning has made a considerable influence and generated excellent results image processing such as image preprocessing, image filtering, image segmentation, image feature extraction and image classification. Additionally, deep learning and computer vision has earned a good credit in biometrics systems with the eminent needs for security and along with the increasing request for information security.

I tested the proposed approaches with different heterogeneous iris image datasets.To validate the performance of the proposed iris image segmentation scheme, several experiments were carried out on the selected datasets. The iris images are segmented using: Hough Transform, U-Net and Daugman's model. To validate the feature extraction method, the iris images in the selected datasets are first segmented, then normalized in order to attain advanced accuracy. The proposed feature extraction method based on Histogram of oriented gradients (HOG), VGG-16, VGG-19, ResNet-50 vs ResNet101, MobileNet, AlexNet and InceptionV3 was performed. Then EfficientNetB0 model was implemented. Finally, Evaluation of the Iris Classification with convolutional neural network (CNN), whereas CNN desire to differentiate between different classes of iris images was performed.

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