

Differentiating Monozygotic Twins By Facial Features

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Abstract:

Biometrics is a technology which is applied to authenticate an individual by considering their corporeal or comportment characteristics. This expertise technology is mainly used for people who are under scrutiny. There are various types of biometrics traits which can be utilized to recognize an individual and the results shows 100% accuracy. But, in case of Monozygotic twins or identical twins categorizing them is a complex task as they resemble each other in all aspects as they form from a single zygote. Studies shows that even the DNA which is considered to be a unique biometric of every person are similar in case of identical twins. There are various physical biometrics which can be compared such as face, finger print, facial marks, iris, retina, facial features to identify a person. In this paper, the proposed study shows on how to distinguish twins who resemble each other by means of their facial features using the combination of RNN (Recurrent Neural Network) classification and CNN (Convolutional Neural Network) for filters.

Keywords - *Biometrics, Identical Twins, Multi Modal Biometrics, Facial Features, CNN, RNN classification.*

1.0 INTRODUCTION

There are various types of twins. They are 1. Conjoined Twins, 2. Superfetation Twins, 3. Heter-paternal super fecundation twins, 4. Polar Body Twins, 5. Monozygotic Twins, 6. Mirror Image Twins, 7. Parasitic Twins, 8. Semi Identical Twins, 9. Twins of Different Races. The two principal classifications of twins are monozygotic or dizygotic. Monozygotic refers to the twins who are alike in physical aspects as they are developed from a single zygote. Whereas, in the other case dizygotic are twins who are developed from two separate reproductive cells. As monozygotic twins establish from a single egg cell, research studies says that the DNA of identical twins are also similar. Sex shows that a greater number of twins were delivered during the period from 1990's to mid of 2000's. As per statistics, the birth rate of twins has increased from 18.9 to 33.3 for every 1000 births. For every 80 births, there is a production of twins in Australia. As the natality of twins are expanding every year it is highly complex to examine the difference between identical twins who are a look alike of each other in their appearance. Fraternal twins can be either of same gender or of contradictory gender. They can be identified certainly as they look different in appearance. It is a very rare scenario that the dizygotic twins look similar. But, in the former case, identical twins are predominantly of the same gender and cannot be easily recognized. Identical twins at times appear to be the mirror image of each other (i.e.,) the pattern of the hair whorls will swirl in the opposite direction, they would be people of opposite hand practice, they would have developed birth marks in the opposite direction. In exceptional cases they may also inherit internal organs which appear to be a mirror image in both the twins.

In the proposed study monozygotic twins are compared by means of their facial features by implementing the RNN classification technique. The comparison is initially focused on the external structure of face of the twins. Secondly, the features of the face are examined by extracting the eyes, nose and mouth of both the twins. The study is implemented using RNN classification and CNN algorithm for filters to get better results. RNN is a division of ANN (Artificial Neural Network) where every points are connected to each other in a consecutive structure. The RNN technique is essentially applied to discriminate patterns and CNN is generally directed to learn the obtained pattern with that of area. CNN is used for image classification and image recognition and segmentation process. In CNN technique the image is permitted through the convolutional layer where the image is filtered into smaller matrix. Then, the image is passed on to the pooling layer where the image is dimensionally reduced. The work flow of RNN is that the output of the preceding node serves as an input to the current node, hence the name recursive. RNN is largely implemented for sequential classification, sentimental classification and video classification. The proposed structure utilizes the Long Short Term Memory (LSTM) network of the RNN as it remembers the input which was passed to all the nodes and stores the data in the memory which makes the model easier to pull the data from the memory for

further processing. RNN classification also functions as a decision maker by examining the feedback at every node point for certification and also discards if the output is not required for advance processing.

2.0 RELATED WORK

There are a lot of research study performed on identical twins by implementing various techniques to bring out a good accuracy level. The comparison between twins were done either by examining the unimodal biometric traits or by examining the multimodal biometric traits. Previous studies shows that multimodal verification of biometric in identical twins gives more precise results. A research study done by Klare, B., Paulino, A.A., & Jain, A.K.[1], in the year 2011 in the paper “Analysis of Facial Features in Identical” has compared the like twins by means of facial features by applying the technique of LDA(Linear Discriminant Analysis) sampling method. The proposed study was implemented on 87 pairs of twins with different poses and none of the images had eye glasses. Gaussian Filters were used to reduce the noise on the images. The study also says that the MLBP and SIFT fail to detect the features of the face but the result showed good perfection in evaluating the mouth components. The paper also mentioned that the performance can be improved by increasing the dataset.

Pruitt, M.t., Grant, et al.[2], in his research paper “Facial Recognition of Identical Twins”, has distinguished twins by means of face identification using PCA(Principle Component Algorithm) technique. The proposed study was also implemented using LR-PCA(Local Region Principal Component Analysis) to detect the features regions of the face such as sections between the eyebrow for both the eyes, the upper, lower regions of the nose and the area around the mouth. Pittsburgh Pattern Recognition System was also used for determined images. He also proved that the combination of MBGC (Multiple Biometrics Grand Challenge) and PittPatt gives an accuracy level of 90%. The technique was examined with a large number of datasets of 1,600,000 images. On the other hand, the performance rate of only PittPatt resulted around 62%. Verilook matching experiments on the twin images were performed which resulted in a matrix ranging from 0 to 180, where the pixel with higher value shows good level of matching when compared with that of the twin image. The images where are compared with normal expressive face and also with face image with a smile which revealed. The study also said that distinguishing twins by only facial recognition and features shows very high false accept rates. The result would give good outcome if the facial features are combined with other variables such as facial marks, retina, iris etc. For future scope the aging of twins can also be taken into consideration.

In the paper “Identical Twins Facial Recognition System”, a study done by Srinatha T D, Rahul S Hangal and Shashidhara[3] has implemented a face recognition project to differentiate using the cloud technology. The algorithms used in the proposed study are OpenCV, Keras, Tensorflow and CNN. The isolated facial features from the image are stored in the cloud and are compared with the database stored in the open cloud. It was also said that the project shows good output when tested with restricted dataset, but for future enhancement the same can be implemented with large amount of dataset.

Earlier research study which was done by Nafees, M., & Uddin, J., [4] (2018) by comparing the identical twins using facial features biometric. The researcher has used three classifiers to classify every feature of the face such as face, eyes and lips. The classifiers are Haarcascade Frontalface is used for face recognition, Haarcascade eye is used for identifying the eyes and Haarcascade mouth classifier is used to detect the mouth parts. Further (Gray Level Co-occurrence Matrix) GLCM is implemented to enhance the texture of the image by considering every pixel. The average accuracy percentage obtained for the proposed structure is 96.67. The author found the results to be of low percentage level when the dataset between the twins had a difference in their expression or the position of the image is changed during input.

A Research study done by Prema, R., & Shanmugapriya, P [5] distinguish twins by means of Face detection technique using the algorithm Fast Radial Symmetry Detector (FRSD) for classification purpose and Gaussian Pyramid Construction for filtering. Gaussian Filters are used to reduce the noise and also to identify the facial features in the face. FRSD is used to detect the dark and bright pixels on the images of the twins which is utilized to detect the facial marks in the image. Comparison between the two images is done using bipartite graph matching.

In a study done by S.Jayanthi et al.[6] in the year 2017 has implemented a study on the facial recognition in identical twins using the technique of (Support Vector Machine)SVM classifier and Gaber filters. The categorization of the pixels in the image is done using the k-nearest neighbor technique. The author concluded saying that the proposed technology using k-nearest neighbor serves best to identify the images as twin or non-twin.

Adding on to the other researches performed on identical twins, an author named Vengatesan. K, et.al[7] in his proposal has studies on the Facial Recognition on Identical twins using the technology of (Support Vector

Machine)SVM classifier and (Gray Level Co-occurrence Matrix)GLCM filters and arrived at an accuracy of 79.82%. The study also proves that by intensifying the evaluation time the precision level can be increased further.

In an Analysis done by Xu, K.,[8] on identical twins has used 3 dimensional images and extracted the facial features from the twin images using the CNN method. A convolutional kernel model with two layers of filtration process is used and established an accuracy rate that is 2.85% higher than the existing accuracy level. The study concluded saying that the image detection can be enriched from loss function, Back Propagation method and Gradient Descent Algorithm.

3.0 PROPOSED METHOD

3.1 ANALYSIS OF FACIAL FEATURES

The proposed methodology is identifying the facial feature in identical using the (Recurrent Neural Network) RNN technique and the (Convolutional Neural Network) CNN technique. RNN is a method that is widely appropriate in case of progressive dataset and is largely used as an algorithm in Artificial Intelligence. In this method the output from the precession node of a directed graph serves as an input to the other successive nodes in the graph. The data is validated in every stage by means of the inbuilt (Long Short Term Memory) LSTM process. RNN is a well-known method for its inner memory, as it recalls the input which is specified in the initial level. It works on an interconnected node that acts on a directed graph. RNN is also used for predicting values through a consecutive set of data, based on the category of the input fed.

On the other hand, the CNN is essentially used for Image Filtration Processes and segmentation of the associated datasets. The filtration is operated on the image which is given as input, or to the feature map. CNN functions with three layers of filtration and max pooling, which would result in a perfect output. Figure 1 shows the step by step process involved in classifying the images of twins by facial features.

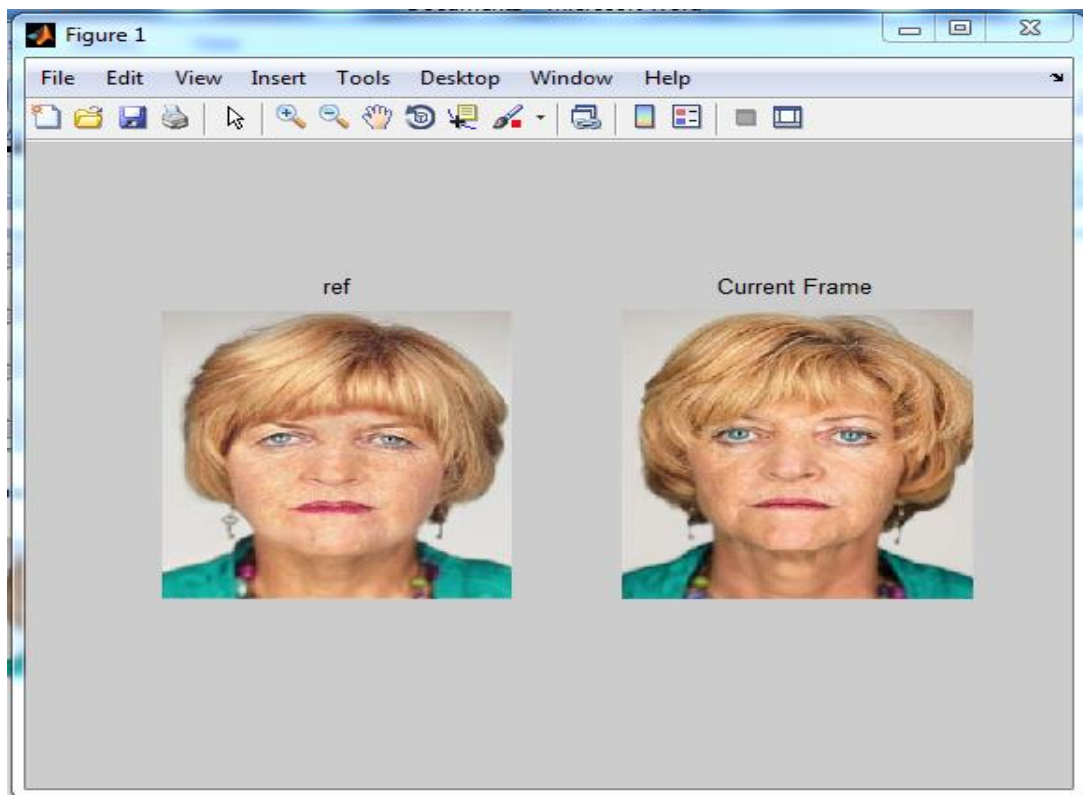


Figure 2: Images of twins

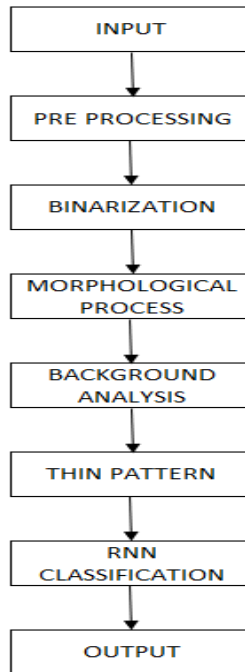


Figure 1: Workflow Diagram

3.2 IMAGE PREPROCESSING

Every image which is given as input should undergo the process of preprocessing where the images are progressed by reducing the noise in the image and to enhance the major areas of the image. Briefly, saying Image preprocessing is a process where the images undergo filtration and enhancement methods. The following are the Image Preprocessing steps followed in the proposed study.

1. Image Acquisition
2. Gray Scale Conversion
3. Filtration

3.2.1 IMAGE ACQUISITION

Image Acquisition is a process of obtaining real time image dataset from a hardware device as a source file for the purpose of data collection. Figure 2. Shows the image of twins which serves as an input for the proposed study.

Face recognition is implemented using Image Processing systems. Initially the image which is given as input endure filtration to enhance the edges in an image. Once the edge detection process is completed the image is screened to remove unnecessary noises and finally the image is smoothed. Then the image is normalized which is used to characterize the facial marks by means of centroid coordinating system. Then the facial marks are detected from the normalized image by applying filters to isolate the regions were the marks shows its appearance. The facial marks such as moles, freckles, wrinkles, darkened and lightened skin are determined. Gaussian filters, Gabor filters, Laplacian of Gaussian filters are some of the filters which are used to detect the facial marks. The obtained results are compared with that of the other twin image by arranging the obtained data on linear combinations. If the two images show similarity, then the next level of comparison is considered or else the obtained results stand exclusive for identifying twin. The Facial features are justified by comparing the Euclidean distance between the eyes, nose and mouth. Figure 2 best illustrates the process of identifying facial features and facial marks.

3.2.2 GRAY SCALE

The purpose of transferring a colored image to a grayscale image is to ignore the irrelevant information which is confined in the colored images. A grayscale image comprises of only shades of gray in an image. Grayscale images are articulated in a matrix format which comprises of only two values 0 and 1. The value 0 is represented for a pixel which is black in color and the value 1 is represented for a pixel which is white in color. In former images of grayscale will be displayed by 16 various colors and is stored in a binary format, each consisting of 4 bits. Grayscale conversion is implemented with RGB image using the below formula in case of average method.

$$\text{GrayScale} = (R + G + B) / 3 \quad \dots\dots\dots (1)$$

But the problem with the average method of grayscale compilation is that it turns the image to black and white format, which would not serve well for the expected result. Therefore, the proposed study uses the conversion of RGB image to Grayscale by means of the weighted method or also called as luminosity method which diminishes the influence of red color and intensifies the influence of green color, which is calculated by the formula (2).

$$\text{GrayScale} = ((0.3 * R) + (0.59 * G) + (0.11 * B)) \quad \dots\dots\dots (2)$$

Figure 3 shows the conversion of RGB image to Gray Scale image from the acquired image in the proposed study.

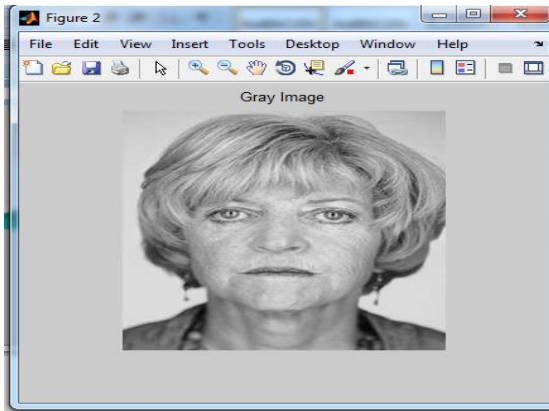


Figure 3: Gray Scale Image

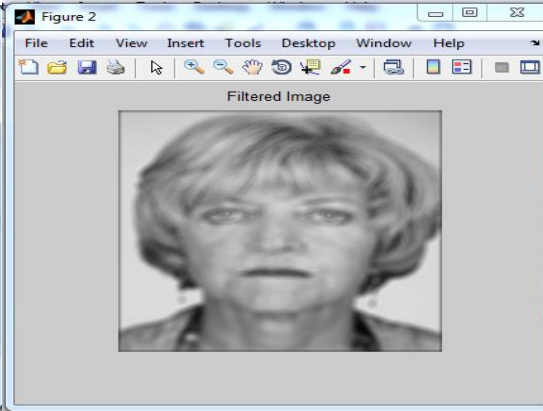


Figure 4: Filtered Image

3.3 BINARIZATION

Binarization of an image is normally performed to convert the image into a vector arrangement which consists of 0's and 1's. In simple words it can be said that an image which comprises of colors ranging from 0 to 255 can be made to ease by transforming them to a matrix format which involves only 0 and 1. This process is implemented on the image, so that the image would consume lesser memory and hence it would not be fussy for classification progress. Binarization is generally implemented on Grayscale images and convert them to a threshold value by validating every pixel for its consistency of gray. The threshold values are calculated by the mean value of the image.

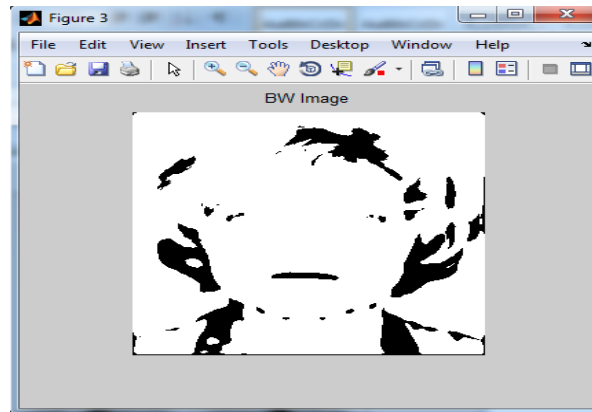


Figure 5: Binarization

Figure 5. shows the image after the process of binarization where the image is converted to an image consisting of only two shades, (i.e.,) black and white. Therefore, after binarization the image only consists of necessary information, so that the storage space can be minimized.

3.4 CENTROID

Before training the data with the given data set, it is required to estimate the number of centroids and the centroid position before classifying an image. From the arrived matrix format the centroid is detected by means of the utmost number of elements located in a specific zone. The centroid of a matrix is determined by dividing the image into primary features, and then dividing them as per the region with maximum portions. The distance between the centroids is calculated for every preliminary shapes with their x and y coordinates. Figure 6 shows the image for which the centroid is determined for the given input image.

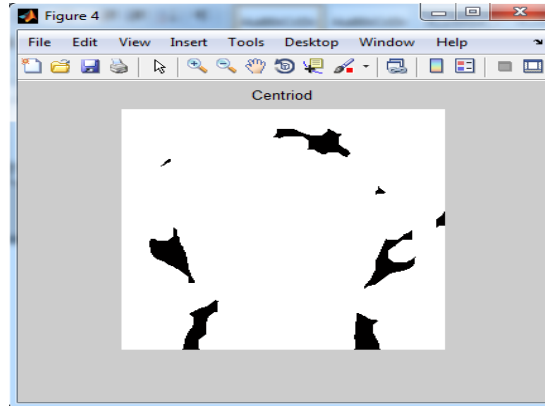


Figure 6: Centroid

3.5 MORPHOLOGICAL PROCESS

The transformed Binary image (image that consists of only 0 and 1) undergoes morphological process to eliminate certain faultiness such as noises and consistency by means of threshold values. Morphological process is principally done to configure the image. Apart from reducing the noise the process also smoothens the delineation of an image even on a gray scale image.

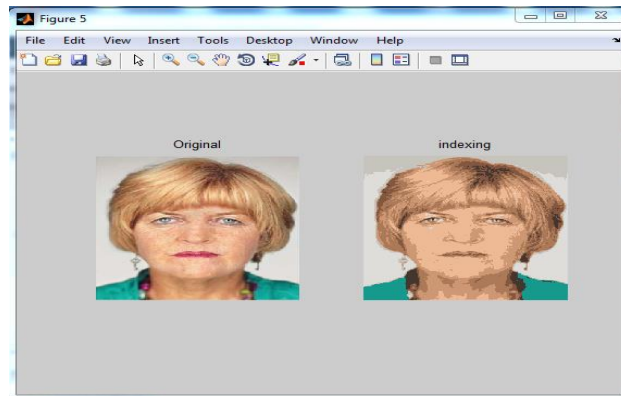


Figure 7: Morphological Image

3.6 BACKGROUND ANALYSIS

The process of deducting the background and highlight only the foreground of the image is background analysis or background subtraction. In, simple terms it can also be defined as background analysis is dividing an image into foreground and background. The process also enhances the foreground pixels of an image for further classification. The process is also utilized to reveal transferring objects in a video image. The splitting process is done pixel by pixel. A pixel comes under the category of background if it satisfies the specified standards or else falls under the category of foreground.

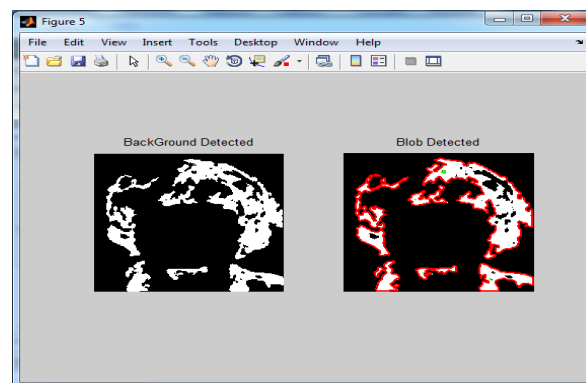


Figure 8: Background Subtraction

3.7 THIN PATTERN

Thinning is a methodology of delineation of an image and reduce it to a thin line. Thinning algorithms are implemented for the transformation of an image. The major function of the thinning process is to condense the data for image transformation without consuming the foremost portion of the image. In simple terms it can be said as application of the thinning process on the foreground of an image. The process is generally used for pattern recognition in case of Optical Character Recognition (OCR). Above mentioned methodology acts upon the binarized image. The result obtained after thinning is also a binary image. Figure below shows the image which is given as input in the thinning pattern.

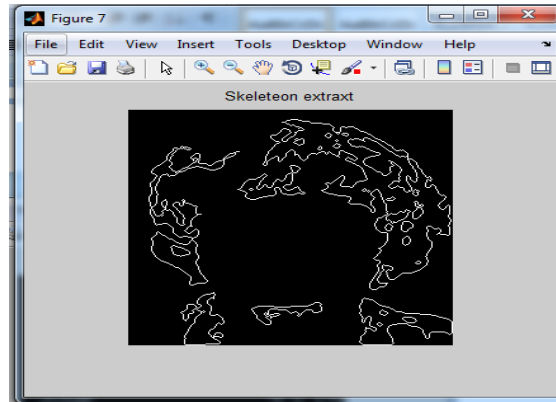


Figure 9: Skeletonization

3.8 FACIAL FEATURES IDENTIFICATION

Identical twins resemble each other in various aspects such as, gender, blood group, eye, hair color etc. Differentiating them by considering their facial feature is a tough chore. Facial features of both the twin images are compared by studying the measurement of their eyes, nose and mouth. The distance between the two eyes, area between the eyes and nose, space between the nose and the mouth are also taken into consideration for more accurate results. In the proposed study the techniques (Convolutional Neural Network) CNN and RNN are used to extract the facial feature from both the input images. The filtration process is performed using the CNN technique.

The Convolutional Neural Network comprises of two layers. They are (i) Convolutional Layer and (ii) Pooling Layer. The Convolutional Layer acts as a filter on the which rise up in a stimulation process. The filtration process is applied repeatedly which results in a representation of feature maps. The Convolutional process is followed by the Pooling process performed by the Pooling Layer. The Pooling Layer is generally used to reduce the dimension of the image. The layer acts on every feature map, that is produced by the convolutional layer. There are two pooling techniques (i) max and (ii) average. The study uses max pooling technique.

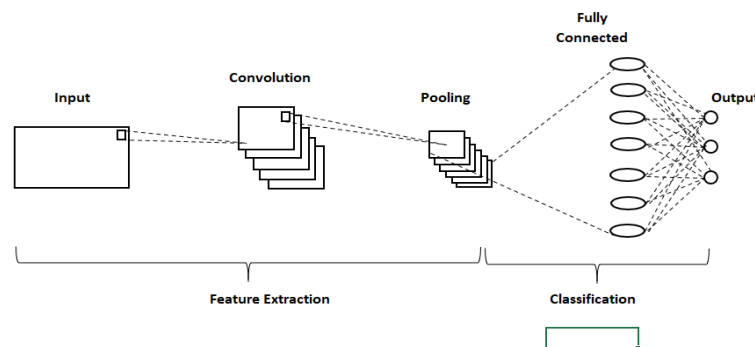


Figure 10: Architecture of CNN technique

3.9 RNN CLASSIFICATION

Recurrent Neural Network (RNN) is a method where the output from one node is passed as an input to the next node. The category of RNN used in the proposed study is Sequence Classification. Sequence Classification gives the end product after examining the complete categorization. The combination of CNN and RNN on images gives good results. In RNN the input is fed to the node again by means of a loop to procure the output. The study uses the forward pass

of the RNN classification where the activations are measured by assigning the value $t = \tau - 1$ and recursively computing by reducing the value of t at each step until $t = 1$. The basic structure is created with primed weights and biases. The model is trained with adjusted weights and biases to increase the accuracy level. As the classification consists of inbuilt optimization function, accuracy percentage increases at every iteration. The gradient is calculated by formula (3) given below.

$$\begin{aligned} \nabla_{h^{(t)}} L &= \left(\frac{\partial h^{(t+1)}}{\partial h^{(t)}} \right)^\top (\nabla_{h^{(t+1)}} L) + \left(\frac{\partial o^{(t)}}{\partial h^{(t)}} \right)^\top (\nabla_{o^{(t)}} L) \\ &= W^\top \text{diag} \left(1 - \left(h^{(t+1)} \right)^2 \right) (\nabla_{h^{(t+1)}} L) + V^\top (\nabla_{o^{(t)}} L) \end{aligned} \tag{3}$$

At every iteration the loss function is reduced by updating the weight parameter by the below formula.

$$W \leftarrow W - \alpha \frac{\partial L}{\partial W} \tag{4}$$

The final results obtained at every iteration is summed up using formula (5).

$$\frac{\partial O}{\partial w_{ij}} = \sum_{t=1}^T \frac{\partial O}{\partial a_j^t} \frac{\partial a_j^t}{\partial w_{ij}} = \sum_{t=1}^T \delta_j^t b_i^t \tag{5}$$

As the input experiences multiple repetition process, the classification is termed as Recurrent. The result obtained on the proposed study by comparing the facial features of twins is 86.2%. Dataset of 200 images of twins was collected and implemented on the proposed structure.

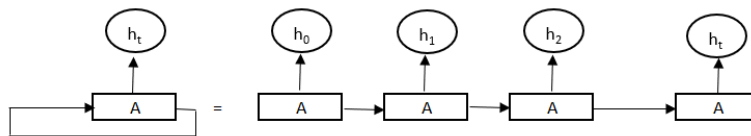


Figure 11: Recurrent Neural Networ

4.0. DATA ANALYSIS

The study was conducted on the KAGGLE dataset and Center for Biometrics and Security Research (CBSR) dataset. The KAGGLE dataset contains 541 pairs of twin images who are identical to each other of which the proposal was tested with 100 pairs of twins by extracting their facial features. KAGGLE database consists of a total of 541 gallery images and 100 images as test dataset. The research was done on the test dataset. The CBSR dataset consists of 97,547 dataset of gallery images of twins. The CBSR dataset consists of different classes of twin images which vary in angle, expression, aging etc. Images were filtered as per the study requirement and then tested. The images obtained from the KAGGLE dataset where colored images which was updated in the year 2019. Images of the twins includes both indoor and outdoor lighting and the angle of the face varied from -90 to +90 degrees where 0 degrees was considered as the frontal view. Additionally, the images consisted of both natural and smiling expressions. As the study was considering the facial features the above factors need to be considered for better accuracy level. The standard KAGGLE and CBSR subsets are used in this study to compare various face recognition algorithms and the proposed method under different challenges for identical twins.

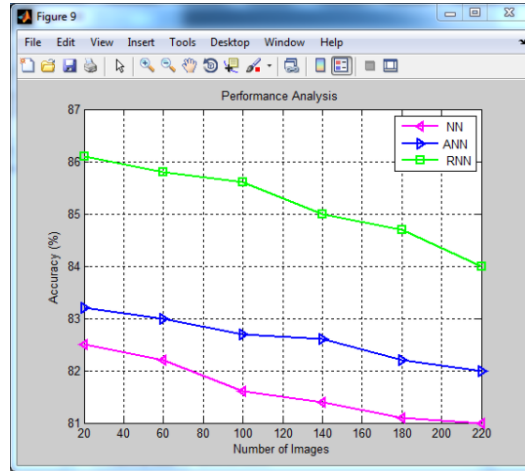


Figure 12: Accuracy Graph

S.No	Technology	Accuracy	Sensitivity	Specificity
1.	RNN	86.1%	90.7%	88%
2.	NN	82.5%	86%	84%
3.	ANN	83.2%	88.2%	85.56%

Table 1: Performance Analysis

5.0 RESULTS AND ANALYSIS

The prime objective of this paper is to examine and analyze identical twins by comparing their facial features. The results obtained by matching the facial features of the twins was compared with other existing techniques and arrived at 86.1% accuracy level. The data was collected from the Twins Day Festival in Twinsburg, Ohio. The sensitivity graph which shows the positive values obtained from the above data was calculated and arrived at a result of 90.7%. Figure 12 shows the accuracy graph where the proposed structure was compared with various existing models. Table 1 illustrates the performance analysis of RNN technology considering the accuracy level, sensitivity percentage and specificity percentage when implemented with other existing technologies. The results of the study determine the significance of facial feature as a biometric feature, especially in case of identical twins who are exactly alike to each other.

6.0 CONCLUSION

A unique technique is obtained to identify monozygotic twins by analyzing their facial features. The proposed method is applied using the CNN method for filtration purpose and RNN technology for classifying the image. PCA, KNN, LBP are some of the methods through which the features of the face can be extracted and classified. The proposed method is implemented using the KAGGLE dataset and CBNR dataset. The difference level between the images is fewer when the test samples are attained with constant illumination and normal appearance of the twins. Results shows that the accuracy value is independent of the age factor. Identical twins who are highly similar to each other produces less performance level when matched with the images of non-twin’s data. The proposed study in identifying identical twins by comparing their facial features works good with RNN classification when compared with other technologies. The study can deliver better results when implemented with additional biometric traits. A combination of other techniques can be inherited along with the proposed study to give more accuracy in detection of identical twins. The function can be upgraded when a bulk volume of data samples is taken into consideration and utilized on genetic algorithms. The facial features can be merged with other comparative parameters such as facial marks, iris, dental, handedness, gait etc. for enhanced operation. There are studies that proves that identical twins have varying hand behavior and they also show difference in their hair whorl structure. In future, the physical characteristics and the behavioral characteristics of the twins can be considered which would result in a highly secured biometric even in case of identical twins.

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