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Forecasting Personality Based On Calligraphy Using CNN and MLP

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***Abstract*-** The way of living has modified since the digital age. Everything can be dealt with a tip of the finger, but all these luxuries are at risk at a cost of protection or fraud. Handwritten script or calligraphy explore about a person's personality. It tells concerning the character of the person and predicts the attribute like optimistic, Social Maturity, balanced, shy within the calligraphy as writing is linked with brain and it subconsciously leaves a sample. Various forms of calligraphy styles taken into thought are slope, baseline, top margin, word size, line spacing, word spacing, left or right or normal slant or irregular of the sentence, etc. The complete system evaluates the script based on the above-mentioned calligraphy styles and it is divided into three modules with the primary module being input the image of written text, then apply the preprocess to removes noise and sharpens the contrast of the image for better results. Extract the 7 features from each image in the dataset, then apply Convolutional Neural Network (CNN) combined with Multi Layer Perceptron(MLP). The proposed system reveals a better result compared to literature survey.

***Keywords*-** Graphology, Personality Traits, Calligraphy, Feature Extraction, CNN, MLP

I. INTRODUCTION

Calligraphy or handwriting is one of the distinctive attribute humans have, everybody has a style of writing and it is often used to get information concerning about the character of the person. Distinctive does not mean a person has a unique personality but certainly it is used to compare it with certain patterns which in turn can be used to find out the character of a person. Calligraphy style is not something which humans develop overnight it's a continuous process. It also changes according to the mood of the person, if the person is drowsy the calligraphy tends to be more unconventional to read whereas if the person is enthusiastic the calligraphy tends to be more understandable and neater. Thus, studying such patterns and analyzing various writing styles is called graphology. Writing is linked with brain, the brain sends various signals to the writing hand to write, during this process brain also sends some other signals subconsciously which gets reflected, the calligraphic script thus contains a trail which was subconsciously left by brain while writing and this trail is noticeable and can be used to know the character or thinking of that person while writing. Calligraphy analysis is thus the study of writing styles where the graphologists examines the written sample and checks for numerous trails present in the sample and predicts the personality trait present in the calligraphy. The traditional method of analyzing a calligraphic script is to write on a plain white paper and then letting the calligraphy expert check the written sample, this method is possible if the quantity of the handwriting samples to be checked are less however if the quantity of these written samples are more than the time needed to do the analysis will increase considerably, the time required to analyze the calligraphy can be reduced by computational or digital means where the image of the calligraphy sample can be taken and then it can be analyzed by the system. Also it can be implemented in the case of job interviews where the participants' character or personality can be identified.

In the era of a digital world wherever everything is shifted from handwritten resource to digital resource thereby reducing the human effort. World is constantly developing particularly in the Information Technology (IT) industry, recruiting countless number of new employee's each year. This recruiting method are often typically burdening for the Human Resource (HR) department and this is where a calligraphy analysis can be used to provide a heads up regarding the character of an individual, as an individual could lie in an interview however the brain writing can be tough to manipulate. The digital world additionally shifted the traditional matchmaking to matrimonial websites. Digitalizing resolved the matter of gathering an outsized quantity of information and for the quality results, efficient and well-tried strategies should be enforced. The calligraphy analysis can be used in matrimonial websites where the calligraphy of the user needs to be tested with various proven data sets and the results generated from the users calligraphy can be cross-referenced with the various users and the pair with the most similar personality can be tagged as the best match. This paper focuses on analyzing various style of calligraphy like ascending, descending and straight inclination of the baseline of a sentence, Spacing between words, the right, left, irregular slants which will be used in identifying a set of traits associated with the person.

A. Working

Existing method involves identifying various personality based on handwritten characters by applying CNN .In the existing method only images of baseline, slant and word space are used. The proposed work is split into many modules. Within the initial module image of calligraphy is taken from the IAM Dataset, within the second module pre-processing on the image is finished by numerous technique to get rid of noise and to smoothen the image for higher results. Within the third module, feature extraction ie extraction of the above mentioned 7 features are performed. In the last module, for better accurate result the images along with the extracted feature is passed to a combined model consisting of CNN and MLP. By observing probabilities of different output labels, we can predict the most dominant class to which the testing written sample belongs or the personality traits that the person has.

II. LITERATURE SURVEY

Subham Nagar et al[1] analyzed personality based only on space in the written text. Skew normalization was performed on the image and then it compared the new image with old one. Loops in the character were considered to decide the personality.

Behnam Fallah et al [2] used hidden maker model neural network to perform classification. It was used to identify properties which are not related to writer and those related to them. Various pre-processing steps like removing noise, smoothing word fonts, etc. were performed. It combined data of both an online test as well as calligraphy. It achieved an efficiency of 76% as compared with k-means having an efficiency of 20% for the same set of data and operations.

Anamika Sen and Harsh Shah [3], checked for features MATLAB guide, pre-processing was also done in MATLAB. It did not group different types of people having the same characteristic. Features focused in were predefined and did not compare the input with other sets of features. At a time only one feature was compared with the database of images and not all the features were compared.
Bala Mallikarjunarao Garlapati and Srinivasa Rao Chalamala [4], separated calligraphic script printed text and then both were given in separate documents. SVM was used to classify them into a category. It separated only two different classes. It used10 fold cross-validation technique to find accuracy.

Xinxin Xie et al [5]described the gaussian algorithm which removes noise in the input images and improved the contrast of the image by using only adaptive threshold algorithm unlike other algorithms were both noise removal and contrast were done by two algorithms.

Vaishali R. Lokhande and Bharti W. Gawali [6], used a signature for determining the personality of a person, signatures can be easily copied as compared to copying a calligraphy. It checked for personality based on the parameters like the baseline under the main signature, the style of the dot over certain alphabets, start style of the signature, end style of the signature, and the space or gap in the signature. The dataset included only 60 images and were taken from only 10 different people. The output of the signature was determined based on the segmentation where the main parameters taken into consideration were horizontal segmentation and the vertical segmentation.

Afnan H. Garoot et al[7] performed a survey on multiple calligraphy analysis and described in detail about what graphology means, what are the advantages and disadvantages of implementing it through computerized method. And compared various papers which were on the topic of calligraphy analysis but were implemented using different methods like image processing or artificial intelligence. It also stated that deep learning is not yet applied to the field of calligraphy analysis.

Anupam Varshney and Shalini Puri [8], performed a survey on human personality based on the handwriting using artificial neural network, it covered various aspects of calligraphy through which calligraphy can be analyzed. The various parameter were zones where the calligraphic script is divided into three categories and then analyzed accordingly, connections which looks out for how the connection between alphabets in a word is made, slant which checks for the inclination of the handwritten text line, spacing where the spacing between the words are considered, margin is the space left at the start of the sentence or the space between the page border and the handwritten text, letter size where the size of every word is taken into consideration.

Vasundhara Bhade and Trupti Baraskar [9], classified the photos of calligraphy based on only three features. Bounding box technique-which comes under image processing was used in their study. It classified only the photos of calligraphy based on only three features which were left, right margin word spacing. The processing was done by forming boxes around the words and the distance between these boxes was calculated.

Usha Tiwari et al [10], compared OCR, Neural network, Intelligent Character Recognition (ICR) and Intelligent word recognition (IWR). The following conclusions were produced in this study: OCR is good for just character recognition not for comparing and concluding (analysis) a data. Neural network finds the similarity with the training images and then conclude the result based on similar factors. Neural networks have a high tolerance for noise.

Table 1. Comparative Study of Literature Survey

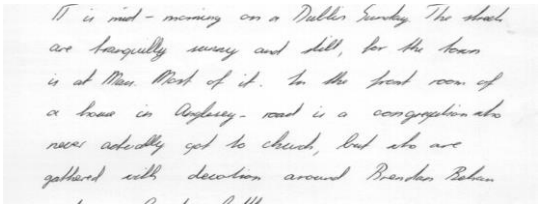
Method	Features	Accuracy
Skew Normalistion	Line space, word space, character space	63
Hidden MarkovModel, Neural	Margin value, word expansion, character sizes, line space, word	76

Network	space, word tilts, horizontal to vertical ratio of characters	
Image processing MATLAB	Baseline, slant, size, Word spacing, Title over I, Page Margin	95
SVM Classifier	Printed, handwritten text	98
Rule Based, Bounding box	Left margin, right margin, word spacing	90
OCR, ANN, ICR, IWR	character sizes, line space, word space,word tilts	85
CNN	Baseline, Word Space, Slant	Not mentioned

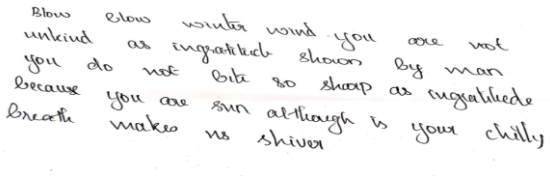
III. MATERIALS AND METHODS

A. Dataset

The dataset included is two types. First Dataset-1 contains 1533 images of the scanned text of calligraphy. It is the IAM Handwriting Database of Research Group on Computer Vision and Artificial Intelligence INF, University of Bern, Switzerland. These images are cropped and saved as PNG images to avoid the printed text in the images. On analysing IAM dataset the features baseline, slant and wordspace show only slight variation which may affect accuracy so a new dataset, Dataset-2 is created inorder to overcome the problems faced in dataset-1. The dimension of these images is 850 pixels width and the height is taken accordingly to the width.



(a)



(b)

Figure 1. (a)descending baseline-1,(b)descending baseline-2

The Figure 1 shows two images with (a) showing descending baseline example of Dataset-1 and (b) showing descending baseline example of Dataset-2.It is observed that Dataset-2 show extreme descending baseline feature than Dataset-1.

B. Features

1) Baseline: The baseline is the invisible line between the upper and lower zones of script.The feature show how well the personality the influences from intellectual,social and instinctual aspects.Here we are considering the main types of baseline.

a. Ascending Baseline
b. Descending Baseline
c. Straight Baseline

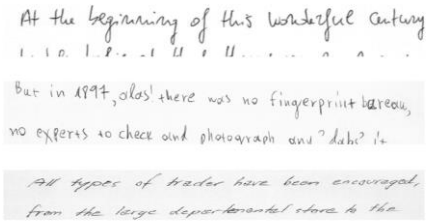


Figure 2. Image of various baselines

2) Top Margin: The blank space left at top of a page when a writer begins writing.

a. Narrow margin
b.Wide margin

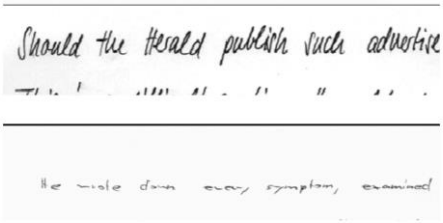


Figure 3. Image of various top margins

3) Pen Pressure: Different persons pen pressure or writing pressure can be classified into 3:

a.Heavy
b.Light
c.Medium

4) Letter size: It is the size of the letters,for this the middle zone letters are on focus. 1/8th of an inch is considered as standard lettersize for normal copy-book category.Therefore above 1/8th inch is considered larger than normal and smaller than 1/8th is held smaller than normal.

a. Large Letter Size
b.Normal Letter Size
c.Smaller Letter Size

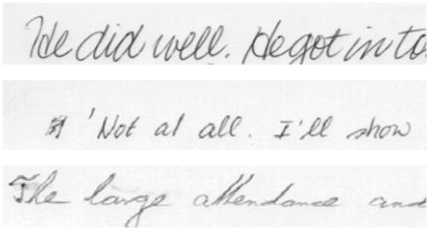


Figure 4. Image of various letter sizes

5) Line Spacing: Space between the lines the writer leaves while writing gives a view to his level of order and thinking clarity,and also the amount of interaction with his/her environment.

a.Normal spacing
b.Narrow spacing
c.Wide spacing

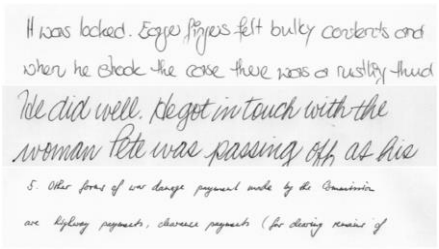


Figure 5. Image of various line spacing

6) Word Spacing: The amount of space writer leaves between the words indicates the distance he would maintain between himself and society.The need of a persons emotional comfort with others can be seen in the distance between the words.

a.Large spacing
b.Small spacing
c.Average spacing

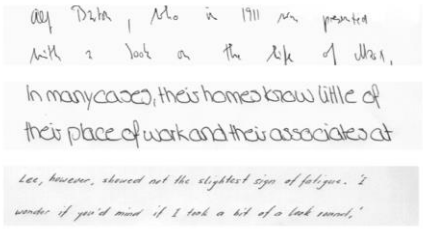


Figure 6. Image of various word spacing

7) Slant: The slant of letters of a writers calligraphy.

a.Normal slant
b.Right slant
c.Left slant

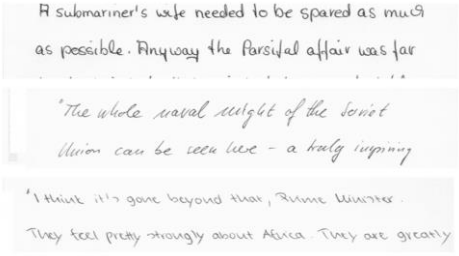


Figure 7. Image of various slants

C. Feature Extraction

1) Extraction of Baseline: First convert image to binary by applying inverted binary thresholding then it is dilation is applied and a horizontal segment is obtained from this.Discard the contours less than 20 pixels height since they cannot form a written line.The rest will be a single line or group of written lines,from this each contour the corresponding angle is obtained.Baseline angle is obtained by taking the average of these angles.

2) Extraction of individual lines: The horizontal projection list is scanned top to down.The non-zero list value represent pixel row with at least one contour.Each contour is scanned to extract individual lines.Set threshold to identify overlapping rows.The hpList is scanned from top and we can see it increases and then decreases while scanning from top of each line to its bottom. On continuing this process for each contour obtain the starting and ending indices of all lines.

3) Extraction of Letter Size: Scanning horizontal projection of each extracted lines give us an estimate on the letter size.The rows with projection value that is greater than the threshold is counted and the average of all lines give the letter size. Only the size of midzone is estimated in this process.

4) Extraction of Line Spacing: Let x be the total number of rows whose horizontal projection is zero,except the top margin and y be the upper and lower zones of the lines whose horizontal projection list will have value less than a threshold.

Let the total number of extracted lines be n

$$a = \frac{x+y}{n} \quad (1)$$

The value 'a' gives the average space between lines. The final space between the lines is obtained by dividing a by the letter size.

5) Extraction of Word Space: The vertical projection of individual line is computed. Let x be count of vertical projection with zero.Let y be non-zero column,the number of words or letters that are disconnected.

$$a = \frac{x}{y} \quad (2)$$

The average of a's are found,let it be b.The final space between the words is obtained by dividing b by the letter size.

6) Extraction of Top Margin: Scan the horizontal projection of the image and obtain the first rows of 0's.The height of the top margin will be the number of 0's divided by the letter size.

7) Extraction of Pen Pressure: First we invert the image using formula:

$$dst[a][b] = 255src[a][b] \quad (3)$$

If src(a ,b) is lower than threshold which is 100,inverted binary thresholding is applied and dst(a,b) will be set to 0.The pen pressure will be the average of all non-zero pixels.

8) Extraction of Letter Slant: A shear transformation is applied and histogram is calculated for 9 different angles(-4,- 30,-15,-5,0,5,15,30 and 45 degree).

$$V(v) = \frac{h(v)}{y(v)} \quad (4)$$

V(v) is the vertical density in column *v* and *y(v)* is the distance between lowest and highest column pixel. *V(v)* = 1, if column *v* contains a continuous stroke else

$V(v) \in [0,1]$. The following function is calculated, for the shear transformed image,

$$S = \sum h(i)^2 \quad (5)$$

D. Algorithms

1) Convolution Neural Network: CNN, a powerful set of techniques for learning in neural networks.It is a class of machine learning algorithms that uses multiple layers to progressively extract higher level features from the raw input. For example, in image processing, lower layers may identify edges, while higher layers may identify the concepts relevant to a human such as digits or letters or faces. These networks have been applied to fields including computer vision, speech recognition, natural language processing, where they have produced results comparable to and in some cases superior to human experts.

2) Multi Layer Perceptron: A multi layer perceptron (MLP) is a class of feed forward artificial neural network (ANN). The term MLP is used ambiguously, sometimes loosely to refer to any feedforward ANN. An MLP consists of at least three layers of nodes: an input layer, a hidden layer and an output layer. Except for the input nodes, each node is a neuron that uses a nonlinear activation function. MLP utilizes a technique for training purpose which is a supervised learning technique known as backpropagation .Its multiple layers and non-linear activation distinguish MLP from a linear perceptron.

E. Standard Measures

- Accuracy: Accuracy can be calculated in terms of positives and negatives as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (6)$$

- Precision: Precision is defined as follows:

$$Precision = \frac{TP}{TP + FP} \quad (7)$$

- Recall: Recall is defined as follows:

$$Recall = \frac{TP}{TP + FN} \quad (8)$$

- F1 Score: It can be calculated as follows:

$$F1score = 2 \times \frac{Recall \times Precision}{Recall + Precision} \quad (9)$$

IV. METHODOLOGY

As a first step or phase we are preprocessing the images. For the IAM dataset the unwanted printed text fields are cropped out and the image is saved in PNG format. Then bilateral filter is applied and thresholding is performed. Thus image is converted into an array of pixels which is necessary for the neural networks to work[5]. Now feature extraction is performed on these preprocessed images.

In feature extraction process the significant features of calligraphy are extracted as mentioned in materials and methods. From these extracted 7 features, baseline, wordspace and slant are the three features we use to compare as the output in both models. In CNN the images in the dataset are given as input and in MLP seven features are given as input and finally the output of both CNN and MLP are concatenated and given to dense layer with 64 nodes and this model is again given to a dense layer with 10 nodes.

Here for comparing personality traits in CNN and MLP we are considering 10 features ie 3 types of baseline, 3 types of word space and 4 different slants.

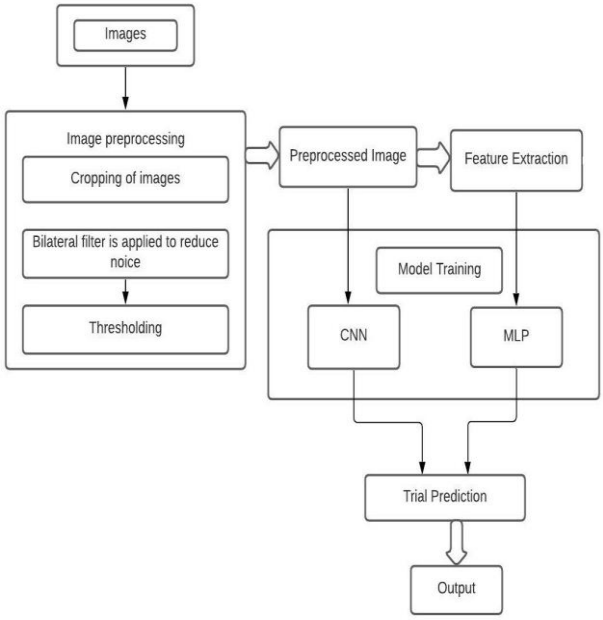


Figure 8. Proposed Methodology

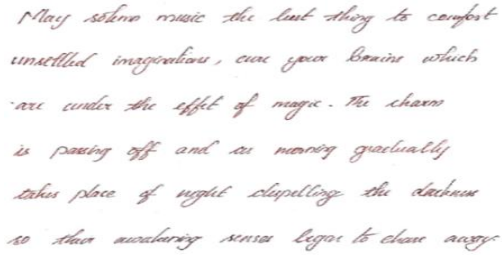


Figure 9. Uploaded Image

Fig. 9 shows the image that we selected and Fig 10 shows the figure of the extracted features from the given image.From the given image various values of the seven considered features are taken. So based on these values we can analyse a secondary character of the person and is displayed in another table.

Features	Value	Type
Baseline	-0.23	STRAIGHT
Top Margin	4.58	MEDIUM OR BIGGER
Letter Size	15.5	MEDIUM
Line Spacing	4.27	BIG
Word Spacing	1.51	MEDIUM
Pen Pressure	182.46	HEAVY
Slant	45	EXTREMELY INCLINED

Figure 10. Extracted Feaures

Personality Based on Features	Prediction
Emotional Stability	Not Stable
Will Power	High
Modesty	Observed
Personal Harmony & Flexibility	Not Harmonius
Lack of Discipline	Not Observed
Poor Concentration Power	Not Observed
Non Communicativeness	Not Observed
Social Isolation	Observed

Figure 11. Secondary Features

Fig.11 shows the secondary character of a person which is analysed based on the obtained features after feature extraction.Now we enters to the final phase ie predicting characters ,primary characters by the defined model consisting of CNN and MLP.

Personality Based on CNN Model	Prediction
Pessimistic (Descending Baseline)	0.233
Optimistic (Ascending Baseline)	0.164
Balanced (Straight Baseline)	0.573
Good Taste & Independent (Wide Spacing)	0.027
Poor Taste & Independent (Narrow Spacing)	0.484
Social Maturity (Balanced Spacing)	0.550
Shy & Reserved (Left Slant)	0.000
Pragmatic & Impulsive (Right Slant)	0.994
Self Reliant (Straight Slant)	0.000
Moody & Unsettled (Irregular Slant)	0.005

Figure 12. Primary characters predicted by defined model

From the obtained results of model in fig.12 we can conclude that the person has a balanced character,social maturity is also high since balanced spacing is observed in his writing and also the person is Pragmatic and Impulsive since right slant is shown more in calligraphy.

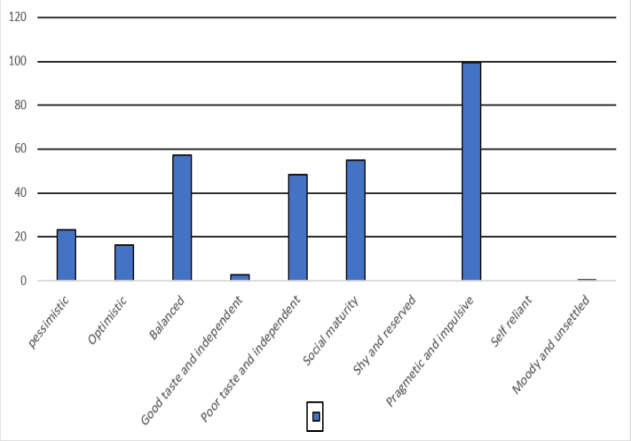


Figure 13. bar chart showing final results

Fig 13 shows the bar chart of the final results. From the graph the first 3 personality traits ie, pessimistic ,optimistic and Balanced are determined by baseline .If writer has descending baseline then he is a pessimistic person(a person who habitually expects bad things to happen or thinks things are bad),or if he has a ascending baseline then the person is optimistic(hopeful and confident about the future),or if he has straight baseline then he is balanced(one in which our personality traits are of average intensity (i.e., normal) needs work and is not easily achieved).

The next 3 features are determined by word space. If writer has a wide spacing then he has a good taste and is independent. If writer has a narrow spacing the he has poor taste and is independent, if it's a balanced spacing then he has social maturity.

The last 4 features are determined by slant. If writer has right slant then he is pragmatic (pragmatist usually has a straightforward, matter-of-fact approach and doesn't let emotion distract them) and impulsive, if writer has left slant then he is shy and reserved, if it is straight he is self-reliant (means that you're able to come up with solutions to problems with as little direct outside help as possible) and if its irregular slant then he is moody & unsettled (Emotionally unstable personality). We can conclude that the person has a balanced character, social maturity is also high since balanced spacing is observed in his writing and also the person is Pragmatic and Impulsive since right slant is shown more in calligraphy.

V. RESULTS AND DISCUSSION

The proposed system is to identify personality of human, we apply combined model both CNN and MLP. Both models are fed with different inputs. In phase 1 IAM dataset is applied and an accuracy of 83% is obtained. In phase 2 the Dataset-2 is applied and 92% accuracy is obtained.

Table 2. Comparing the Dataset

Dataset	Accuracy	Validation Accuracy
1	83%	82%
2	93%	82%

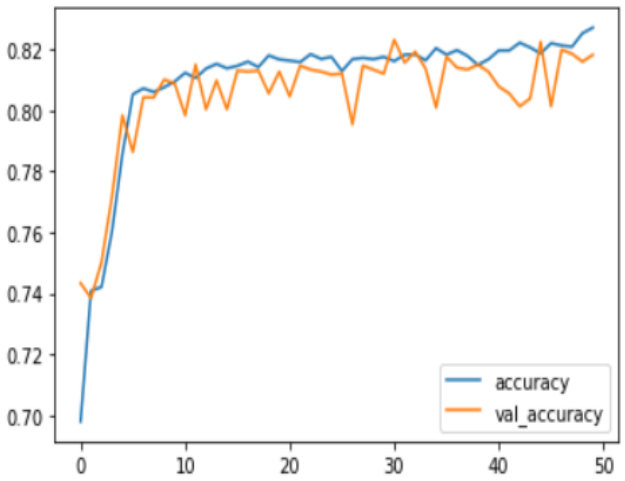


Figure 14. ROC curve of dataset 1

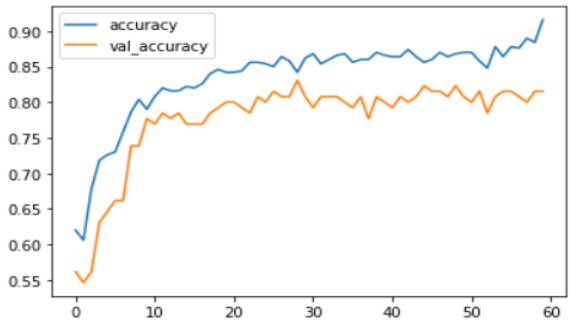


Figure 15. ROC curve of dataset 2

Fig 14 shows the plotting of accuracy and validation accuracy of Dataset-1.Its shows the accuracy as 83% and validation accuracy as 82% is obtained. Fig 15 shows the plotting of accuracy and validation accuracy of Dataset-2.Its shows the accuracy as 93% and validation accuracy as 82% is obtained.

Table 3. Results of training in dataset-1

Features	Precision	Recall	F1-score
B_0	0.83	0.88	0.86
B_1	0.86	0.96	0.91
B_2	1.00	0.29	0.44
W_0	0.86	0.89	0.87
W_1	0.73	0.67	0.70
W_2	1.00	0.75	0.62
S_0.0	0.94	1.00	0.97
S_1.0	1.00	1.00	1.00
S_2.0	0.00	0.00	0.00
S_3.0	1.00	1.00	1.00

Table 4. Results of training in dataset-2

Features	Precision	Recall	F1-score
B_0	0.40	0.67	0.50
B_1	0.71	0.71	0.71
B_2	0.00	0.00	0.00
W_0	0.83	0.62	0.71
W_1	0.25	1.00	0.40
W_2	0.00	0.00	0.00
S_0.0	1.00	0.80	0.89
S_1.0	0.88	1.00	0.93
S_2.0	0.00	0.00	0.00
S_3.0	1.00	1.00	1.00

Table 3 and Table 4 shows the precision, recall and f1-score of training and testing data of dataset-2 in which B_0, B_1, B_2 are the baseline with descending, ascending and straight property, W_0, W_1, W_2 are the word space with big, small and medium property, S_0.0, S_1.0, S_2.0, S_3.0, S_4.0 are the slant with right, left, straight, irregular respectively. The proposed method as shown in Table V reveals the accuracy as 83%, validation accuracy 82%, precision 90%, recall 85% and f1-score 86%.

Table 5. Results Of Proposed Method

Accuracy	Val-accuracy	Precision	Recall	F1-score
92%	82%	90%	85%	86%

A. Comparision of Results

On comparing the existing system with the results obtained from proposed system,in the first paper the features character space,size was analysed using 0CR (optical character recognition), ANN (artificial neural network), ICR (intelligent character recognition), IWR (intelligent word recognition) and 85% accuracy was obtained .In the next paper features baseline, word space, slant was analysed using CNN. In the proposed system we are considering seven features baseline,words pace, letter size, pen-pressure, top-margin, line space, slant. Here CNN and MLP combined model are used and an accuracy of 92% is obtained.

Table 6. Comparing Results

Components	Existing methods	Proposed methods
Methods	OCR,CNN,ICR	CNN and MLP
Accuracy	85%	92%

The proposed system is much better because in existing system CNN was used and only single sentences was analysed also number of features taken was limited. Here in the proposed system 2 types of datasets were used, Dataset-1 which is the IAM dataset and in order to overcome faults of Dataset1 a created Dataset-2 was formed. Seven specific calligraphic features were also considered. Another advantage of using the proposed system is that its able to analyse a secondary and primary character. Accuracy is also better for the proposed method also it is systematized and cost effective. Therefore the proposed system yields accurate results and efficiently forecasts personality.

VI. CONCLUSION

In this project, personalities or traits are detected by performing a calligraphy analysis on the input image. Here we are using 2 datasets in order to compare results. The input images are preprocessed firstly using various techniques and then passed on to extract the various mentioned features. Using the extracted features, system is able to predict a secondary character of the writer. For predicting the primary character of the writer, the extracted features along with the input image is passed to the combined trained model. The system compares the input image and features with the combined model and predicts writers personality. The key feature of this project is exacting all the possible traits using combined model (CNN and MLP).

- Multinational companies can utilize this work on employee recruiting process to check whether the candidate have a criminal background. In that way we could reduce terrorist activity.
- The system can be used in forensic science to solve crimes, to know the personality of the persons.

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