

## **AUTOMATED HANDWRITING ANALYSIS FOR HUMAN BEHAVIOR PREDICTION**

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### **ABSTRACT**

Handwriting Analysis or Graphology is a study of the physical traits and patterns of handwriting, implying the psychological state of the writer at the time of writing. Handwriting is the reflection of each individual's personality. The writer leaves their identity in the subtle characters of their writing. Handwriting Analysts study the handwriting and predict the behavior of a person based on their skills. To make this more accurate, proposed methodology focuses on computer assisted handwriting analysis by considering 9 features such as size, slant of the words, space between words, breaks in writing, pressure, margin, baseline, loop of 'e' and the distance between title(dot) and stem of 'i'. The estimation accuracy of 93.77% is achieved.

**KEYWORDS:** Graphology, Cognitive, Brain Writing, Feature Extraction, Behavioural Prediction

### **INTRODUCTION**

Handwriting Analysis or Graphology is a scientific method of recognizing, appraising and understanding personality through the strokes and patterns revealed by handwriting [12]. It is well suited to cognitive psychology as handwriting relies upon the same principles as cognitive psychology [14]. Everything that is part of the brain is expressed in many ways, one way being handwriting; hence it is called as 'brain writing'. Thus brain print is left on the paper. What is written at the moment is an instant photo of how the person thinks, feels and behaves [1]. In other words brain or subconscious mind actually forms the characters as a result of habit. Graphology is a very old and respected science developed 3,000 years ago by Chinese [13]. Professional examiners of handwriting called Graphologists predict the personality of a person examining the handwriting sample. Besides deducing a complete personality profile of an individual, many other things can be revealed like mental status, schizophrenia and high blood pressure.

Computer assisted handwriting analysis is efficient and accurate compared to visual inspection. The present work emphasizes on the development of an automated system for ascertaining the behavioral traits of a person through image processing. Analysis is done for specific features of the samples such as pressure, margins, breaks in writing, size, slant of words, baseline, spacing between words, loop of 'e' and distance of title from the stem in 'i'. The system is designed to indicate the behavior of the person from the extracted traits. The performance is measured by comparing the results with the ideal manual analysis obtained by graphologist.

### **LITERATURE RECAPITULATION**

Graphology has been exercised since centuries and by now, there are more than 2,200 documented works on

handwriting analysis. The first known published book on handwriting analysis appeared in the year 1622 by Camillo Baldi. The term “Graphology” was coined by a Frenchman, Jean Michon, in 1870s. Since then, profound studies have been done in this field. A study by the American Psychological Association's annual convention revealed that graphology - conducted with the aid of computer - can be a reliable tool for determining traits such as emotional stability, honesty, substance abuse risk and judgement [2].

A paper named “Development of an automated Handwriting analysis system” by Vikram Kamath and others have proposed a new method for an automated behavioral analysis using Automated Handwriting Analysis System (AHWAS). This paper focuses on the prime features of writing such as slant, size, pressure, baseline, number of breaks, margins. This work limits its scope to macro analysis of writing. Micro features like alphabets, loop of letters are not considered here[3].

Another paper discusses about computer aided handwriting analysis i.e. Personality analysis based on handwriting where the system is trained to perform the analysis without the human intervention. Major features like margins, baseline and zones are considered and are mapped to existing personality theories given by Briggs and Kersey's. Features such as strokes, pen pressure variations are not considered in this paper [4].

Authors Prachi Joshi and others have discussed a novel approach of machine learning technique in order to implement the automated handwriting analysis and to increase the speed of analysis in their work. Various algorithms and techniques like polygonalization, thresholding algorithm, template matching, artificial neural networks were used. Their work was limited to a set of four features – baseline, margin, height of t-bar and slant of words [5].

Champa and others have implemented an artificial neural networks by considering limited features like pen pressure, baseline and height of t-bar as found in individual's writing by polygonalization, templating matching. Features such as margins, size are not considered in this paper [6].

## **PROPOSED METHODOLOGY**

Graphologists analyze the handwriting manually which is written on the paper. The graphologist's interpretation skill depends on their psychological art of interpreting the particular blend of handwriting features. But, it is costlier and prolonged. The proposed methodology focuses on developing a system with the minimum aid of human intervention by analyzing both micro and macro features of handwriting. The flow diagram of the proposed methodology is shown in the figure 1. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

### **Image Acquisition**

The handwritten images are taken from IAM Handwriting Database. The database contains forms of handwritten English text. It contains forms of unconstrained handwritten text, which were scanned at a resolution of 300dpi and saved in portable network graphics format with 256 gray levels as shown in Figure 2[8].

### **Image Pre-Processing**

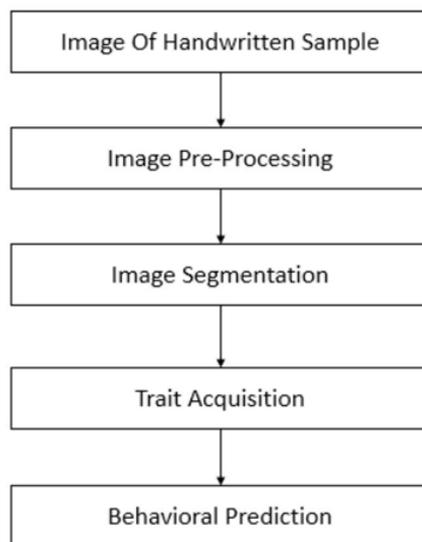
Image pre-processing is the technique of enhancing the images prior to computational processing in order to remove the background noise, normalising the intensity. The image is pre-processed by applying a threshold to remove the background noise.

## Image Segmentation

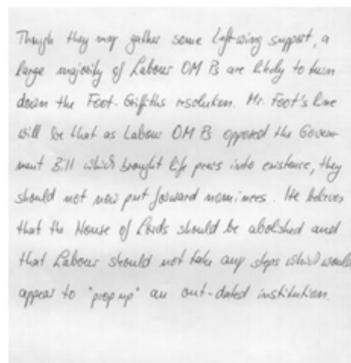
In handwriting image segmentation, digital handwriting is segmented into three different parts for efficient analysis, i.e. line segmentation, word segmentation and letter segmentation.

## Feature Extraction

Feature Extraction is a technique of dimensionality reduction from a high dimensional input data [15]. In our work, features are the nine important factors on which a graphologist predicts the personality of the person. These features are explained in detail below.



**Figure 1: Flow Diagram**



**Figure 2: Handwritten Sample**

## Pressure

It is the weight of the handwriting. Precisely how much energy is available to the person at the time of writing is evident in the pressure [9]. Based on the pen pressure, writer can be classified into light, medium and heavy writer [14]. To measure this, a simple thresholding technique is used by taking the intensity of the foreground pixels in the image. Physical and mental level of a person is revealed by pressure in the writing.

## Margin

Margin is the space left while writing either to the left or to the right. This feature reveals the exquisite

temperament, adjustment and social interaction of the person with the society. It is obtained by applying bounding box method as shown in the Figure 3.

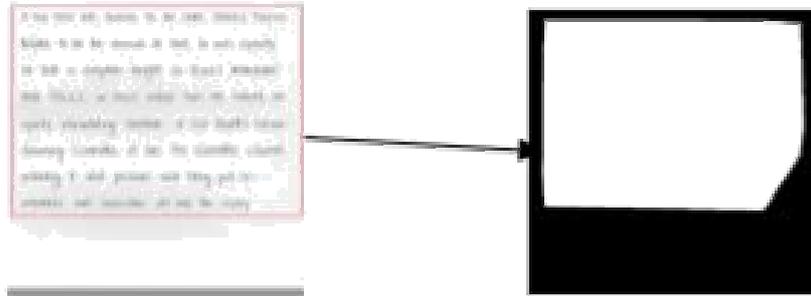


Figure 3: Margin

**iii. Breaks**

This represents the connectivity within a word in the handwriting. A person can write a word continuously without any break, or sometimes he connects 2-3 letters in a word, or he gives break after every letter. Each way of writing reflects different personality of an individual. It is determined by the total number of breaks by total number of words in the given sample. Number of breaks is obtained by applying the bounding box method for each word as shown in the Figure 4.

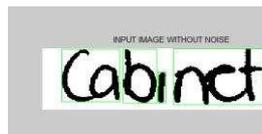


Figure 4: Breaks in Writing

$$\text{Average Breaks in Writing} = \frac{\text{Total Number of Breaks}}{\text{Total Number of Words}}$$

**Size**

Size has its own significance in the process of handwriting. Size is an unfixed trait [10]. It tells whether the writer is extrovert or introvert, the writer’s present capacity for concentration. It is determined by the average height of the word. To get the average height, image of the word is scanned column by column to find the first black pixel and the last black pixel (get the mean over every column).

**Space between Words**

Spacing refers to how far one word is placed from the other. It shows how much distance one want to keep from people around them. This handwriting feature in a sample is obtained by the number of white pixels between the end of the one word and the start of the next word as shown in Figure 5.



Figure 5: Space between Words

**Baseline**

The imaginary line on which the writer writes on the blank paper is called ‘baseline’. It determines the emotional

control and reliability of the writer. The three most fundamental baselines are straight, uphill and downhill. It is obtained by inverse tangent function which is given by

$$\text{Angle} = \tan^{-1} \left( \frac{y_2 - y_1}{x_2 - x_1} \right)$$

### Slant

Slant of the writing indicates emotional interactions of the author. Three classes in slant are vertical, rightward and leftward slant it is obtained by finding the mean angle of an image by looking for maximum projection values and transforming the image according to the geometric transformation.

### Area of Loop of 'E'

The letter 'e' is contemplated to be the ears in the art of graphology since it tells us how different people communicate and their reactions when they hear something in this materialistic world. The area is obtained by computing the roundness metric.

### Dot Distance in 'I'

It is a surprising fact that dot in the 'i' can disclose a lot about writer's personality and character. As a general rule, the closer the dot, the writer pays extra attention to details and on the contrary, the farther away the dot, it reflects the writer's trait of having less attention to details [11]. The distance of dot is calculated by Euclidean distance.

$$\text{Distance}(x, y) = \sqrt{(y_1 - x_1)^2 + (y_2 - x_2)^2}$$

### Behavioral Prediction

The classifier used here is a simple n-class classifier ( $n > 1$ ). Depending upon the class, the behavior is predicted in reference to table 1.

**Table 1: Handwriting Traits and Behavioural Explanation**

	Small	Introvert
Size	medium	Social
	large	extrovert
Pressure	Light	sensitive to atmosphere
	Medium	Emotional
	Heavy	takes things seriously
Margin	Left margin	Exhibits courage in facing
		life
	Right margin	Less risk taker
Breaks	Connected	Good Analytical thinking
		power
	Disconnected	Sensitive
Space between words	Narrow	Dependent
	Even	caring
	Wide	Independent
Baseline	Downward	Negative
	Straight	Consistent
	Upward	Active and busy
Slant	Left	self-reliant
	Right	Moody

	Vertical	Practical
Loop of	closed	less acceptability
'e'		
	wider	Open minded
Distance	close	Extra attention to details
of dot in	far	Less attention
'i'		
	Just above	Accuracy and perfection

## RESULTS

The experimentation is conducted for around 80 samples and the results are compared with the manual analysis obtained by graphologist. It is observed that the efficiency of all the traits exceeds 80% as shown in table 2. In our system, the discriminating features are breaks, size, space between words, baseline and loop of 'e'. A weighted average is computed by giving 90% weightage for discriminating features and 10% for the remaining.

The handwriting traits and their corresponding behavioural explanation is shown in the table 1.

**Table 2: Accuracy Table**

Features	Percentage Accuracy
Pressure	86.15
Margin	98.46
Breaks	92.3
Size	90.76
Space	98.46
Baseline	93.84
Slant	83.76
Loop of e	95.38
Dot distance	93.38

## CONCLUSIONS

A relatively simpler method has been proposed to anticipate the personality of a person by exploring various handwriting features. The system considers five discriminating features such as breaks, size, space between words, baseline, loop of 'e' and few other features like pressure, margin, slant and dot distance in 'i'. The proposed system can be used as a twin tool by graphologist to improve the accuracy and anticipate the behavior of a person faster. The estimated weighted accuracy of 93.77 % is achieved.

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