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A Study of Personality Traits from Handwriting using Digital Image Processing

[*1]Sethi Ganesh Kumar, [2]Sharma Harmohan & [3]Komal

[*1]*Assistant Professor, Department of Computer Science, Multani Mal Modi College, Patiala, Punjab, India*
[2]*Assistant Professor, Department of Computer Science, Multani Mal Modi College, Patiala, Punjab, India*
[3]*Research Scholar, Department of Computer Science, Punjabi University, Patiala, Punjab, India*

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[*]Corresponding Author
Email: ganeshsethi147@gmail.com

ABSTRACT

Handwriting is one of the unique traits to represent what individuals carry in their minds. Handwriting reveals the true personality of a person including character behavior, self-esteem, emotional outlay, imagination, anger, honesty, fearlessness, defenses, and many other personality characteristics. Handwriting analysis is commonly known as Graphology which is the scientific process for recognizing, investigating, and comprehending a writer's personality through the styles and patterns in words in the handwriting. In this review paper, we have tried to summarize all earlier works reported in the development of automated handwriting script analysis for the prediction of character behavior and personality of the individuals. It has been observed in this review paper that most of the researchers have employed techniques of image processing in MATLAB and machine learning techniques in the development of automated handwriting analysis systems. This paper throws light on handwriting analysis, characteristics of handwriting, its associated personality traits, and a thorough literature survey of the earlier reported works on automated handwriting analysis systems.

1. Introduction

Graphology or Handwriting Analysis is a scientific process of identifying, investigating, and understanding an individual's personality through his/her handwriting pattern or strokes. The handwriting of an individual is often regarded as a reflection of his/her brain or mind writing. Different kinds of Handwriting strokes, pressures, patterns, and spaces used by human beings at the time of writing can help in predicting specific personality characteristics or traits [1]. A true personality such as honesty, cowardly, fears, boldness, behavior among many others can be determined by Handwriting. The professionals in graphology called graphologists or Handwriting examiners investigate many traits or features of handwriting samples to identify the writer's personality traits exploiting their knowledge and gained experiences. Therefore, the results of the analysis might vary among graphology examiners.

If an automatic tool is available for handwriting analysis, naive users may use it for handwriting analysis. Handwriting analysis acts as an efficient and trustworthy indicator of human behavior and personality. The handwriting of an individual is representative of his/her mental condition and handwriting analysis can be a projection method as being the body motions that profile an individual's behavior in different areas of social achievements, social skills, work habits, or thinking styles [2]. Handwriting also depicts the possible alternatives for a person's transactions with the handling of stress. Handwriting analysis is a study of frozen graphical written structures that are outcomes of the author's brain and therefore are depicted on the paper inside a printed or cursive handwriting pattern or style that may vary from other authors performing comparative analysis on their personalities and their ability to solve problems.

The concept of graphology is not newer to the world. Almost 400 years ago, people developed an interest in handwriting analysis. Camillo Baldi, known as the father of graphology, brought the idea of graphology carrying out systematic observations as well as studying the handwriting styles and manners and summed up his observations into a first graphological essay in 1622. In 1897, Abb Jean-Hippolyte Michon officially coined the "graphology" term by amalgamating two Greek words "graphein" (to write), and "logos" (science) [3].

2. Motivations

According to an American Management Association survey, 39% of corporate houses added personality testing as an essential component of their recruitment process [4]. Lawyers utilize personality testing in analyzing and investigating criminal behavior, litigation profiling, examining witnesses, and selecting the jury. Employers can minimize their turnover rate and saving themselves from economic losses incurred by people subjected to thievery, emotional disorders, drug abuse, or disturbances at the workplace. Understanding human behavior [5] becomes a key issue for people working for others. This is the best-case scenario when everybody seeks to bring the best out of employees, allocating the appropriate jobs to the deserving people and evolving them. Employees possessing software engineering abilities are more preferred. [6].

3. Applications of Graphology or Handwriting Analysis

- **Psychological Analysis:** Counsellors, Psychologists, and Psychotherapists clinically use Graphology for assessing the psychological behavior of the persons but not for confinement.
- **Employment Profiling:** Graphology is becoming an essential component for hiring employees in many companies. Background details and working skills of the persons are assessed using graphology in conjunction with other tools.

- **Curbing Terrorism:** Various government agencies make use of handwritten samples of terrorists to assess and investigate the tendency of destruction, killings, bombings, etc. Their handwriting reveals inconsistent textures, not clear or blurred strokes, pressure, etc. that are useful for predicting their character behavior.

In the addition, handwriting analysis is also widely used in many diverse fields such as medical diagnosis, forensics studies, and author identification etc.

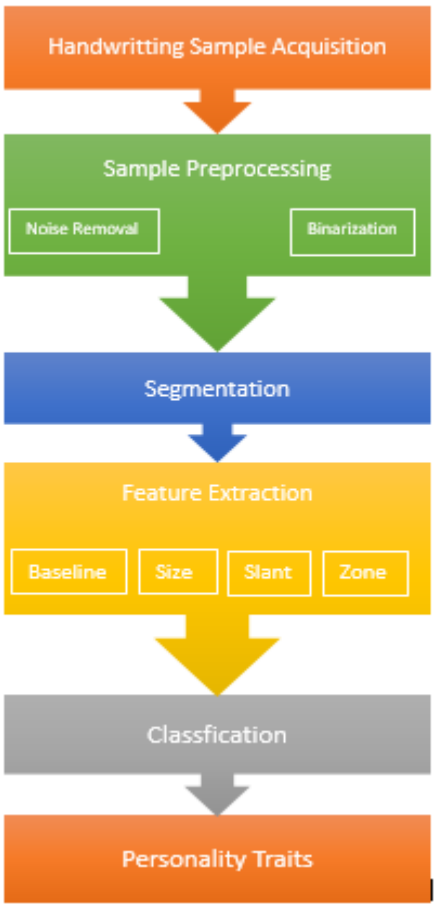

Figure 1. Block Diagram of Handwriting Analysis Process

4. Handwriting Features and Personality

To identify and evaluate the personality traits of the individual, there are diverse features of handwriting that can be used. Handwriting features include baseline, size, zone, slant, margin, spacing, etc. that are illustrated below:

4.1 Zones: The handwriting is divided into three parts as Upper, Middle and lower. The personality and behavior of an individual can be assessed by investigating these three handwriting zones.

- Upper Zone indicates an upper body, future, conscious, intellectual, cultural, and spiritual aspirations, concepts, mental logic, and fantasies.
- Middle Zone indicates a middle body, present, practical, realistic, and social expression of the ego, expressive emotions.
- The lower Zone indicates a lower body, past, unconscious drives, memory, basic drives, sensual ideas, and biological requirements.

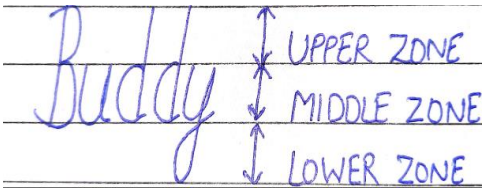

Figure 2. Various zones of characters

4.2 Baseline: The baseline of the handwriting can be partition ascending, descending; straight can be shown in Fig.3. The baseline of handwriting is used to access the emotional nature of an individual. Ascending Style indicates the person is Active, Hopefulness, Optimistic, & cheerful, choleric behavior, and Excitability whereas descending style represents pessimism, mentally exhausted, having digestion problems. Straight style represents disciplined and stable behavior, realism, straightness.

Figure 3. Various types of baseline

4.3 Slant: The slant of the handwriting means the direction of the letter slope. The slant represents emotions, sentiment, and emotional control of the person. The various slants are shown in Fig. 4.

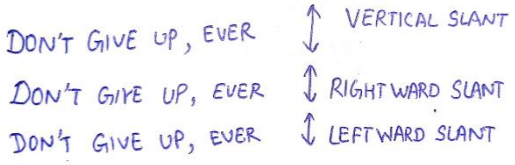

Figure 4. Various types of slant

4.4 Size: Vertical height of the letters is used to measure the size of the handwriting. It can be large, small, and medium. The size can be large, medium, or small. Size represents the importance writer gives to himself (herself) and his/her actions.

Figure 5. Various size of handwriting

4.5 Pressure: The pressure of the pen means the application of the amount of force while writing. Pressure can be light, heavy, or medium and indicates the mental energy of the individual.

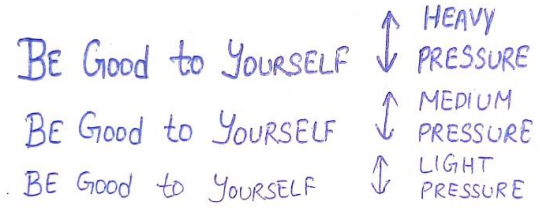

Figure 6. Various types of pressure

4.6 Word Spacing The space present between two words is called word spacing. It indicates the distance. The person would like to have between himself and other people.

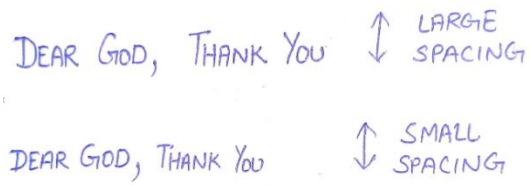

Figure 7. Various types of spacing

4.7 Margin: Margin is the amount of space present at the top or bottom of the page and right or left side of the page. It defines future and past, intelligence, adjustment, truthfulness, and fastness.

5. Reported Work

Ricard et al. [7] presented an automatic tool to facilitate HR professionals in recruitment drives in companies to predict the attitude of job applicants. The proposed model suggested linking extracted features from handwriting samples to several personality traits used to assess job applicant aptitudes in a particular hiring scenario. They focused on determining the active personality and leadership of the individual. The features like letter size, layout configuration, shape, slant, baseline and skew angle of lines, etc. are extracted and passed to a neural network for classification for predicting the personality of the writer. Some features such as the roundness factor and frequency analysis of a word's core region could be very beneficial in other fields as identification of the author.

Shitala et al. [2] reported the development of an automatic method using SVM machine learning algorithm to find the personality of a person by using handwriting sample. The proposed algorithm accepts input in the form of the letter size, baseline, pen pressure, letter as well as word spacing and focusing more on the letter and word slant in a document, and predicts their psychological behavior of each person as the output. The techniques of trigonometry and thresholding are used to calculate the different various parameters. This is a real-time writer-independent handwriting analysis system. The system was experimented on different handwriting samples collected from 100 different writers and produced a 94% of accuracy rate with RBF kernel.

Vikram et al. [8] presented "an automated behavioral analysis using Automated Handwriting Analysis System (AHWAS)". The proposed model identified the psychological characteristics in the handwritings like letter size, slant and pen pressure, baseline, margins, number of breaks, writing speed, and letter as well as word spacing. The handwriting analysis is performed through Image Processing in MATLAB. The proposed system identified a handwriting sample closely which is not in reach of a graphologist to analyze. The proposed system is a real-time system and makes less use of image preprocessing. The proposed system produced more than 80% accuracy rate and manual analysis is used to calibrate. The proposed model can also be used for different applications of handwriting such as detecting diseases such as Parkinson's disease and cancer.

Abdul et al. [9] implemented a writer-independent, offline handwriting analysis system "HABIT (Handwriting Analysis Based Individualistic Traits Prediction)" to predict the personality and behavioral traits of a person automatically from features extracted from a handwritten scanned image of the person accepting as input. The system results in producing a set of personality characteristics as output. The extracted features include baseline, pen pressure, letter size, letters slant, and size of letters. Eclipse-Indigo and Java are used as implementation tools in the system.

Esmeralda and Risna [10] proposed a hybrid approach of handwriting and signature using structured algorithms and several artificial neural networks (ANN) for predicting more personality and behavior. They used a mixed image of signature and handwriting to be classified by ANN based on the different feature sets. Multi-structure algorithms produced an accuracy of 87-100% using eight features and ANN produced 52-100% accuracy using six features. The system was experimented on 100 sets of data testing after training with 25-75 data using backpropagation. The implementation of the system has been performed with the software to be useful to classify personality from automatically scanned handwriting styles.

Esmeralda et al. [11] reported the development of an automatic method using a hybrid approach of digit of the character of application form and signature using structured algorithms and several artificial neural networks (ANN) for predicting more personality and behavior. They used a combined image of signature and digit of the character of the application form to be classified by ANN based on the different feature set. The ANN classified signature area based on five features and produced a 56- 78% accuracy rate. The multi-structure algorithm classified signature using four features and resulted in 87-100% accuracy. The Learning Vector Quantization technique when applied on application form digit area produced 43% accuracy. The system was experimented on 100 sets of data testing after training with 10-25 data.

Ankur et al. [12] suggested a novel method for predicting the behavior of an individual using automated script analysis. The proposed system classified psychological individuality in the handwriting such as slant, size, baseline, pressure, margins, number of breaks, word spacing, and writing speed. Image Processing in MATLAB is used to analyze the written script and the behavioral pattern of the writer is identified from the above individuality of the script. The developed system predicts handwritten script and is a real-time system and makes less use of image preprocessing. The proposed system produced more than 80% accuracy rate and manual analysis was used to calibrate.

Ashish and Ajit [13] In their work reported the development of an automated human behavior information system that classifies the scripts of the writers and able to identify the personality traits and career of an individual automatically. They considered different parameters of handwriting such as

pen pressure, baseline, size, word spacing, slant, line spacing, lower zone loops, upper zone loops, page margins, etc. over the sets of characters to predict the personality characteristics associated with an individual helping to decide the career of that person.

Syeda and Shubhangi [14] presented a novel regression line-based orientation algorithm to predict personality traits and human behavior of a person. The proposed algorithm was used to find the direction of orientation of lines. They considered the three most desired features in direction of orientation of lines such as uphill, downhill, and constant line. Feature extraction was carried out using bounding boxes and an Edge histogram. Several recognized machine-learning classifiers like ANN and support vector machines (SVM) were utilized to train the system and a comparative analysis of results was performed. SVM and ANN produced 98% and &70% accuracy rates respectively. The SVM produced a 99% accuracy rate using a testing dataset from the standard dataset.

Ankur and Nikkoo [15] in the present study proposed an Image Processing method to predict the character behavior of a person through handwriting analysis automatically. Image Processing in MATLAB was used for the prediction of behavior. Different attributes from handwriting samples like pen pressure, letters, and words, word spacing, letter spacing, and size of letters, slant, and baseline were extracted using the segmentation method. The SVM processed these different parameters and predicted the character behavior of the individual. The SVM produced around a 90% accuracy rate using the Redial Kernel function with additional training datasets. They observed larger datasets can produce more accurate results.

Prachi et al. [16] proposed the development of an automated handwriting analysis tool using the approach of machine learning technique for predicting the character behavior of a person. The personality traits revealing from features like baseline, size, margin, word slant, and height of t-bar of a writer's handwriting. These features are extracted from the scanned handwriting images into feature vectors to compare with an initially trained network, and then directly mapped to the corresponding class with associated personality characteristics. Polygonalization and vertical scanning are used to evaluate baseline and margin respectively. Template matching is used to match the slant of the words and the stem of the alphabet 't' is used for the height of the t-bar.

Subham et al. [17] proposed a model for the detection of skew and normalizing the skew in writer's handwriting to determine behavior based on spatial analysis. The various image preprocessing steps are performed on collected handwritten samples on plain paper. Then segmentation of line, words, and characters are performed and normalization is applied for finding space between characters, words, and lines in sample images. At the last, the mean of the space present in all the closed loops of the characters is found out and matched with the word spaces to assess the character. The developed system experimented on images of the IAM database that can find the exact space in between words, characters, and lines before and after skew normalization of a given document. The system produced an accuracy rate of more than 63%.

Akshita et al. [18] proposed a method to predict the personality behavior of an individual using the letter slant and various letters present in handwriting script. The various image-preprocessing steps like noise removal, binarization, normalization, etc., and segmentation steps like edge detection, thresholding, etc. are performed on collected handwritten samples on plain paper. These extracted parameters are passed to the Artificial Neural Network as input for the prediction of the behavior of the writer.

Anamika and Harsh [19] implemented an automatic system in their work to predict character behavioral analysis. The extracted features are analyzed and provided a detailed analysis following the principles of Graphology. Six various handwriting features are extracted using image processing in MATLAB. For each feature, a novel technique was designed. The proposed system experimented on 75 handwriting samples collected from subjects in the age group of 20-40. The proposed system produced 95% accuracy in the identification of the handwriting features and mapping equivalent traits according to principles of Graphology.

Syeda and Shubhangi [20] proposed an automated model for personality trait identification using a machine learning approach. A big five-factor model is employed to detect individual differences. To predict whether a person is an extrovert or introvert, letter and word spacing present in the handwriting are considered. Some specific patterns and styles of handwriting are chosen, that shows personality feature of an individual, then with help of techniques of image processing the patterns and styles can be feature extracted, made noise-free and then segmented and recognized using support vector machine or ANN. The Correlation is shown between the pattern and the psychological trait. The support vector machine produced 90% accuracy.

Mihai and Nicolae [21] proposed the first-ever non-invasive three-layer architecture using neural networks that are employed to measure the Big Five personality traits of a person by performing comparative analysis on his/her handwriting. They also developed the first-ever database linking the Big Five personality type with the handwriting features acquired from 128 subjects containing both random and predefined texts. The proposed architecture was experimented on the developed database and revealed that more value can be added with predefined texts in the training stage if enforced on persons and offered 84.4% accuracy in intra-subject tests. The architecture produced 80.5% accuracy in inter-subject tests on the random dataset. The system obtained the highest prediction accuracy (over 84%) for Extraversion, Openness to Experience, and Neuroticism and prediction accuracy (77%) for Agreeableness and Conscientiousness.

6. Conclusion and Future work

At present, Handwriting Analysis or Graphology is an ever-advancing field for recognizing the personality of individuals. The different techniques for personality analysis can be experimented with to predict accurate personality characteristics and behavioral information. Although graphology or handwriting analysis is established science, human errors, and ambiguity present in the handwritten samples lead to correct estimation of handwriting analysis around 90% accuracy level. Automated personality or character behavioral identification through graphology or handwriting analysis will be a beneficial and helpful system to

detect the personality traits of individuals. This review paper throws light on the system built using image processing techniques and artificial neural networks technology. It has been observed mostly researchers have considered small testing datasets for experimentation with their system and developed system are mostly limited domain-specific in the field of the hiring process. In the future, automated personality traits identification systems can be built especially in the fields of personnel recruitment drives, in fields of medicine, marketing, and counseling, and also forensics studies, biometrics, etc. The accuracy of these systems can be enhanced using larger training as well as testing datasets using techniques of machine learning and deep learning.

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