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APPROXIMATION OF PERSON'S AGE AND GENDER FROM CERTAIN HANDWRITING CHARACTERISTICS - A REVIEW

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Abstract:
Handwriting examination is used in forensic work to help investigators identify a particular writer. Handwritten characteristic identification for age, gender, and handedness prediction is an intriguing study challenge for researchers, as there has been little research done in these areas. Handwriting changes with time and is influenced by a number of factors including writing experience, physical and mental health, gender, and age. Previously, several characters like handwriting slant, letter size, alignment, tremors, and connecting strokes in handwriting have been used by the researchers to identify age and gender of the writer to an extent. This review aims to understand the research work done in the area of age and gender determination by certain handwriting characteristics as performed by various scholars.

Keywords: Handwriting, Handwriting Characteristics, Factors influencing handwriting, age and gender determination.

I. Introduction

In Forensic Science, handwriting and its traits are utilized to assist investigators who are focusing on the identification of the writer in cases of disputed handwriting [1]. Given the paucity of prior research in this field, handwritten character recognition, approximate age and gender estimation, and handedness prediction from handwritten documents present an interesting research challenge for researchers. The language of culture and the written speech is commonly referred as handwriting [2]. Researchers describe handwriting as "Written Speech" to the fact that we write down what we say [3]. Writings are typically what people are known for, and writing styles are what civilizations are known for [4].

There is a strong connection between the hand and the brain. Lundborg (2003) states that "In functional terms, the hand moulds the mind—we should rather see the brain as an extension of the hand into our mind investigating and exposing the secrets of the surrounding world". Writing with your hands is therefore difficult without the proper coordination with brain [5]. It is thought that exposure to more challenging situations causes brain cells to enlarge, hence increasing an individual's intellect.

Sull (2012) stated that there was a "Golden Age of Ornamental Penmanship" that lasted from 1850 to 1925. Further, he builds the emotional connection of the handwriting in his research. The researcher emphasized that “writing scribbles demonstrate the power of the hand, which develops into

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a means of expressing ideas through drawings and other mediums" [6].

To imprint the form of a letter in long-term memory, a child must process the letter's form through multiple senses. When a child's hand is moved by someone else during verbalization or guided hand demonstration, the child's perception of the movement is not always connected to the letter shape; as a result, the child does not develop muscle memory for the letters because writing and reading are two separate brain processes [7]. The researchers found that the right hemisphere of the brain is responsible for cursive writing, whereas the left hemisphere is responsible for manuscript printing or reading [8].

In copying act, a person cannot successfully replicate all the peculiarities of someone else's handwriting by simply duplicating the letter designs, as handwriting is more complex than simple letter drawing [9]. Because all the characteristics and components are unique to an individual writer those are produced as a result of acquired and learned characteristics since childhood. A person's handwriting will always have some distinctive characteristics that serve as the foundation for a valid identification and authentication [10].

The flow of handwriting is determined by a number of factors, including writing pressure, pace, rhythm, pen position, shading, writer competence, and line quality [11]. The significance of the sample for the comparison of the questioned documents cannot be overstated in disputed cases of authorships. The exemplars are usually gathered under identical conditions to those under which the questioned document was written, and ideally they originated from the same time period. The handwriting variations in the specimen collected and the questioned document are evaluated, and a range is established for each to determine whether the natural variations are within the range of genuine handwriting or outside that range. If the analyzed variations for both fall within the same range, they are considered to be written by the same individual [12].

The early phases of handwriting development, when a person begins to establish his or her handwriting by adhering to a precise pattern found in books, are roughly associated with handwriting training. Since they follow the same format as the other students, there aren't much of distinctions between the students' work at this point, and it's difficult to pick them out right away on the basis of characteristics identification [13]. However, as the training progresses and the student moves up to more advanced classes, they begin to stray from the so-called copy book style after establishing a foundational writing pattern and a particular line quality. This departure from the students' copybook style serves as the foundation for the development of their extremely individualistic handwriting [14]. The primary explanation for this is that the growth and uniqueness of the writing habit are derived from the interaction between mental motion and the musculature of the hands and fingers. Gradually, the way an individual holds the pen also changes. Over the time, they develop different pen grip techniques. Due to this difference in pen hold, it results in different letter shapes and slants.

In recent years, one of the most fascinating and challenging areas of study in image processing and pattern recognition has emerged as a tool in handwriting identification. It greatly advances the development of an automated process and can enhance human-machine interaction in a range of applications. Numerous researches have been carried out to investigate novel approaches and procedures that can shorten processing times while improving recognition precision in handwriting authorship determination [15].

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On the other hand, an individual's sex plays a significant role in the formation of their handwriting [16, 17]. Because men and women have diverse outlooks on life and distinct life experiences, they develop distinct handwriting habits too [17]. According to certain studies, women develop handwriting with ornamented letters because they are more influenced by ornamentation and adornment. Similarly, a man who is gruff and busy demonstrates these traits by focusing on finishing a piece of writing that is reasonably readable rather than placing considerable emphasis on letter adornment [17, 18].

The research and investigations carried out by different researchers to establish a connection between the writer's age and sex based on specific handwriting features are elaborated in the present review. It also discusses the validity of these age and sex determination techniques as well as whether or not they may be effectively applied in the future to ascertain an individual's age and sex from their writing.

2. The Literature

2.1 Type of the letters affecting handwriting at an early age: According to Longcamp, et al. (2005), hand gestures are important while drawing letters. To find out if teaching kids to type letters before they write them has any impact on how they understand written language; researchers studied 76 preschool-aged kids. The pupils were split up into two groups, one of which was given typing instruction and the other, writing instruction. Compared to the typing group, the handwritten group's results were noteworthy in affecting the handwriting [19].

2.2 Emphasis of Motor Skills on Handwriting: Since handwriting involves multiple processes at once, including "synthesis of cognition, visual perception, motor skill, integration of memory, problem solving, organization, reading and language ability, ideation, and graphomotor function," Tennyson (2006) describes handwriting as a complex process. Consequently, writing may be viewed as a type of creativity training that calls for a variety of thought processes [20]. According to the research, it is possible to deduce from that an individual's handwriting will be influenced by their age and the abilities they have acquired. As a result, an individual's handwriting will change as they age. However, this can theoretically reverse due to poor neuro-muscular coordination in old age.

2.3 Determination of Writer's Age Using English Handwritten Documents with the Help of Generalized Coding Method: Shubhangi D.C. et al., 2010 conducted a research on determining the age of writers using handwritten English papers. Authors tried using multiclass support vector machines to analyze handwritten documents for human age. They stated that an individual's writing style evolves with age. They employed a novel Generalized Chain Code (GCC) technique. Using some statistical techniques, distinctive properties for every character was derived from the normalized GCC values. A multiclass SVM classifier processes the codes and characteristics to create the hyperplane. The multiclass hyperplane is used to plot the values of test pictures. A total of five age categories were taken into account. Because there is no linear relationship between the document image and age, the efficiency of almost 84.54 percent for age group 1, 79.52 percent for age group 2, 80.67 percent for age group 3, 82.58 percent for age group 4, and 90.467 percent for age group 5 was achieved. The feature set utilized in the suggested approach offers insightful data that conventional chain coding is unable to provide, and this data can be utilized to determine the writer's age from English handwritten documents [21].

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2.4 Automated Prediction of Age of the Writer in Demographic Category with Certain Feature Extraction: Somaya Al Maadeed and Abdelaali Hassaine (2014) focused on the automatic identification of country, age, and gender in offline handwriting. They stated that there are numerous uses for classifying handwriting into different categories based on factors including age, gender, and nationality. According to the study, a demographic category can be assigned to handwriting through two methods: feature extraction and categorization. The feature extraction process affects a system's performance since it identifies the writers through feature descriptions. The authors employed a variety of geometric parameters that they provided in their work to characterize handwritings and then categorized the handwritings according to age, gender, and nationality. Features were integrated using kernel discriminant analysis (KDA) and random forests (RF) methods. Gender prediction rates rise to 74.05 percent, age range prediction rates to 55.76 percent, and nationality prediction rates to 53.66 percent when all writers wrote the identical handwritten content. Gender prediction rates rise to 73.59 percent, age range prediction rates to 60.62 percent, and nationality prediction rates to 47.98 percent when every writer produces unique non-related handwritten content. Experiments revealed that chain code-based features performed better in predicting age range and that geometric characteristics performed better in distinguishing gender and nationality than other features. When compared to other scripts, Arabic handwritings generally produced better prediction results in the experiments. They have recommended that in subsequent research, the suggested attributes to be integrated together with additional classifier algorithms. The authors also came to the conclusion that in future, handedness of the writer may be predicted using the suggested qualities [22].

2.5 Age Determination Using Certain Handwriting Characteristics in Different Age Groups:

Male writers' ages were ascertained by Shruti Gupta et al. (2015) using distinguished handwriting characteristics. An individual's handwriting changes progressively and consistently over time. A number of variables, such as the writer's age, physical and mental well-being, and length of writing experience, will affect how much of a change occurs. For the study, a total of 90 handwriting samples from male Indians between the ages of 10 and 50 were acquired. Each participant was given an A-4 blank sheet of paper and instructed to create a "London letter" as a prescribed text. The distinct class and individual aspects of the study were identified by analyzing the handwriting samples. For class features, a coding scheme was created in order to standardize and share the results. The percentage proportions of the class traits were ascertained. Class characteristics including slant, alignment, writing speed, spacing, and tremors differ in proportion for different age groups. Based on the study's findings, the age was estimated, though not with absolute or whole accuracy. The writers feel that some qualities can be used as supporting evidence and a point of inclusion in identifying an individual and their estimated age because they had a significant association with the writer's age [23].

2.6 Identification & Characterization of the Type of Tremors in Handwriting and Their Significances:

Handwriting tremors were identified and characterized by Choudhary, et al., (2016). According to the authors, tremor is an organic, rhythmic muscle movement characterized by oscillations (to and fro) of one or more body parts. It is defined as an unanticipated departure of a line from its intended path that results in difficulties in the execution of fine motor abilities. For document experts, determining the source of such non-rhythmic handwriting strokes is never an easy task. Forensic document examiners are inclined to infer fraud when they comes across wobbly line writings; however this isn't always the

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case. These irregularities can even be found in the handwriting of certain well-respected writers, such as those who are ignorant, elderly, or suffering from health problems. The primary goal of the study was to identify and highlight the essential characteristics of handwriting that are vital for differentiating and identifying the kinds and origins of tremors that manifest in handwriting. In order to differentiate between various types of tremors, the authors have also included condition-specific tremor characteristics. Authors have also stated that how tremors may indicate the forgeries as well as age factor while examining the handwriting [24].

2.7 Sex Determination Through Handwriting Characteristics: Upadhyay et al; in 2017 saw progress on the sex determination through handwriting characteristics. A total of 130 handwriting samples from women of different ages were gathered and evaluated. A total of sixty-five male and female participants, aged eighteen to thirty, were selected. All samples had their macro and micro properties analyzed using z-tests and feature extraction techniques. According to the authors, certain aspects may be categorized as gender identifying features that could help determine the writer's gender based on the z-test score. Among the main characteristics examined were line quality, hand movement, alignment, margins, hesitation marks, connecting strokes, slant, speed, writing aptitude, and word spacing. According to the research, women in the 20–30 age range exhibited smooth line quality with wrist and forearm movement, a forward slant in most cases, even spacing between words, and a significantly faster tempo. They found that the line quality in the 30-40 year-old age range is still smooth, with most of them having narrow spacing, garlanded strokes, and even margins. Another important factor that diminishes with age is the distance between words. The decline in writing abilities and line quality among those over 50 has also been noted by authors. Lastly, they opine that these attributes may have some utility in approximating the age of a female writer [25].

2.8 Age Determination Through Handwriting Characteristics in Female Writers: Upadhyay et al., in 2017 used handwriting characteristics to analyze the age of female writers. The study found that handwriting changes over time and is impacted by a number of factors, such as age, gender, writing experience, and physical and mental health. The study suggests that handwriting samples may be somewhat useful in determining the writer's projected age. It has been demonstrated that slant, alignment, spacing, hesitation marks, tremor, and speed are all highly instructive and useful in estimating age [26].

2.9 Age-Related Variation in Feminine: The study "Age-Related Variation in Feminine Handwriting Among Population Groups in Delhi, India" was conducted by Deepani and associates in 2018. Their primary objective was to observe the effects of aging on the handwriting characteristics of female authors from different socioeconomic backgrounds in Delhi, India. The research indicates that the writer's age significantly affects the macro- and micro-features of handwriting. Pen pressure, handwriting height, and handwriting connectedness were examined by researchers in an effort to address age-related handwriting variance. Moreover, there was notable age variations observed in every one of the handwriting micro-features that this study looked at [27].

3. Discussion

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Several writers and handwriting specialists have addressed the handwriting characteristics those could be effectively used as an indicators of age and gender. The most important aspect that was examined were:

3.1. Tremors in Handwriting- Writings by elderly people who suffer from weak neuromuscular conditions develop tremors. The writings were written slowly, tremoring at various points, and in some cases at the beginning and ending strokes. Despite these deteriorations, the writer's internal consistency is still clearly visible [28]. The writing remains rhythmic but with slight wavering, and there are broken stroke formations as well. While handwriting tremors can occur naturally as a result of aging, pathological illnesses, illiteracy, physical and mental disorders, and other factors, they can also indicate the presence of forgeries, as the tremors are evident in writings that are carefully and slowly produced [29]. A forger having anxiety and fear since they are aware of the wrongdoing they are about to commit. In addition, his or her moral character forbids them from participating in any immoral behavior, which causes tremors that may be differentiated from real tremors by their reluctant handwriting. In addition to forgeries, the researchers think that one feature that can be utilized to determine the age of the writer is the existence of tremors [30].

3.2. The Line Quality- The standard metric of handwriting smoothness, fluency, and rhythm is called line quality. In authentic handwriting, line quality may reveal the writer's age, even though it may be a deviant characteristic resulting from a fake. Generally speaking, the line quality is smoother and better in the early years and to some extent till age 50, but as age advances, it begins to decline even more [29, 30].

3.3. Word And Letter Spacing – The letter spacing is uneven at a very young age. It becomes more even in the mid 30s and 40s, and as people age the studies indicate, the spacing becomes smaller and more irregular between the age groups of 50 and 60 [31]. However, additional research is required to confirm this, as there might be other contributing elements.

3.4. The Connecting Strokes - The strokes that link the letters within a word (intra-word connectives) or between words are called connectives or connecting strokes. These connecting strokes are incredibly distinctive and unique to each person. As previously mentioned, a number of research have focused on using the connecting stroke analysis to infer an author's age and gender from their handwriting [32]. A writer can be recognized by their size, form, angularity, spread, direction, simplification, or even absence of connecting strokes. In one of the study [23] it was observed that in the age group 15–20 years, 50% of the samples had garlanded connecting strokes, 30% had arched connecting strokes, and only 13% had angular strokes and of all the people in the age group of 30 to 40 years old, 46% had arches, while only 26% had garlands and angles. In the age group of 50 years and older, 73% had arches, while 13% had garlands and angles [23, 32].

3.5. The Writing Slant - A writer may occasionally and purposefully makes a different slant. Alternatively, someone may unintentionally begin writing with a certain viewpoint due to natural habit.

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However, the degree of a slant becomes more or less permanent if it is adopted and utilized for an extended period of time [33]. Numerous experts have noted how the tilt varies with age and gender. It was discovered by researchers in the studies conducted that females had greater slant on the right side of their writing than males, males had more slant on the left and vertical positions [23, 33]. Though, once again further researches are required to validate these findings.

3.6. Diacritic Placement - With time, certain actions become subconscious, such as the positioning of punctuation marks, dots over the letters "i" and "j," cross bars to the letters "f," "t," and "x," underscore lines, top lines, or writing the date next to the signature [34, 35]. They don't catch the writer's interest. He or she has no idea how big or how shaped they are, or where to put them. These seemingly with little nuances become ingrained in the writer's subconscious habits. The placement is written in the same repetitive rhythm. The extremely distinctive design aids in identifying the writer. Age-related changes in handwriting attributes may be associated with a decline in performance, speed degeneration in neuromuscular function affecting hand strength, speed and coordination object manipulations, dexterity abilities, and impaired perceptual motor skills, all of which are linked to sensory processing [35, 36].

4. Conclusion

On the cumulative impact of all the previously mentioned research and conclusions, it is feasible to determine the approximate age of the writer. During the study, it was demonstrated that slant, alignment, spacing, tremor, and speed were all very helpful in determining the approximate age and the sex of the writer. Based on extant literature, these attributes have a significant correlation with the writer's age, making them useful both as confirmatory evidence and as a point of inclusion when establishing an individual's age. According to some studies, chain code-based features work better than other features for recognizing gender whereas, geometric features work better than other features for estimating age. The handwriting's macro- and micro-features differed greatly depending on the writer's age. Age differences were evident in pen pressure, handwriting height, and handwriting connectivity. Age and illness have a substantial impact on a person's handwriting. The handwriting of the elderly and those suffering from Parkinson's disease has substantially declined, resulting in a completely different appearance of writing than that of a comparable piece of normal writing. The document examiner needs to be cognizant of this fact when examining such cases and determining the estimated age or gender based on handwriting samples. Furthermore, a number of other factors, such as a decline in performance and speed degeneration in neuromuscular function, which affects hand strength, coordination, object manipulation, and impaired perceptual motor skills—all of which are related to sensory processing—may also be associated with age-related changes in handwriting characteristics. The substantial results of all the experiments suggest that some traits determine the writer's age and gender, but more investigation is required with bigger samples and different writing scripts to confirm the findings.

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