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MatLab based GUI tool to establish relationship among handwriting of family members: a computational study

Abstract

In this research paper an attempt has been made to analyze the similarity in handwriting of closed genotypic family members statistically. Handwriting specimens were taken from 500 different families having four members (Parents and Offspring) who have sufficient writing experience and were examined macroscopically as well as computationally and classified into class characteristic and individual characteristic of letters and bigram "th". A statistical technique Pearson Chi-squared ($\chi 2$) test was performed to determine the relationship between Parents handwriting traits combination with the normal habits of offspring handwriting. The study showed that handwriting among genetically related family members has strong resemblances in their general characteristics. However the writing of every individual is same but a strong family likeness can be established.

Keywords: familial likeness, inherited handwriting, genetic similarities

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Introduction

Handwriting is a unique & individual style of person's neuromuscular activity where the hand moves on a surface with any writing instrument, what appears is an impersonal and formalized writing style. Cursive handwriting has been reported as the prominent style of writing, but imitating print letter shapes or using capital letters are more prevalent among children. The manner of writing is individual and characteristic to every writer. The style of handwriting varies among every individual and the style of handwriting is unique and has its own personalized touch. Handwriting is a movement habit that is very strong and individual. Brien,[1] stated that it is a mixture of what we have been taught and our personality. Hilton[2] has reported that handwritings fall into two general groups; class and individual characteristics. Class characteristics are actually common characteristics such as basic type of handwriting, slope of writing, line position and word spacing and suggested that handwriting show variation resulting from such influences. The first published article on possibility of handwriting similarities within genetic relationships was on December 2, 1911 in the issue of Scientific American that reports an article by R. H. Chandler. Earlier in an issue of Knowledge, it was published describing Family Likenesses in Handwriting. The article illustrated cases which have some general similarity between genetically related family members, but the similarity is not so great that current and competent examiners would be easily deceived. Comments on this topic by other authors are rare, however. Even Osborn omitted it. Hedrick[3] quoted that Munch reported the case about similarity in the writings of a mother and daughter. The questioned material was limited to three sets of initials. Since there were disparities between the questioned and admitted writings they were not considered consistent and they could not have been attributed to natural variations, if the examination and study was not fastidious. Muehlberger et al.,[4] suggested that there is a lack of statistical data or any database concerning the specific handwriting characteristics and the occurrence frequency of combinations of particular handwriting characteristics, the identification of handwriting and the examination of questioned document becomes a more difficult task. The forensic document examiners tend to assign the probative values to specific handwriting characteristics and their combinations while the judgments are often based almost entirely on their experience and power recall. Handwriting identification is a scientific pursuit, statistical data concerning common handwritings characteristics among family members seems to offer assistance to document examiner to establish a link between writing and writer especially in cases pertaining to family dispute or in cases of anonymous letters.

Methodology

Collection of samples

Handwriting Samples were collected from a 500 family of four members; (viz Father, Mother offspring); for the purpose of study of effect on handwriting of persons related genetically. The samples were collected randomly in accordance with the principle that if samples are taken randomly it ensures an approximate equal participation of each and every member of a civilization. The sample was obtained by contacting the persons in personnel and a repetitive statement was made them to write without telling them the real purpose. The writer was provided with Photocopier, 70 GSM and 210mm x 297mm paper with control text typed on it along with a format to fill in the writer information. This method was applied to ensure that writing sample obtained remains unaffected from any kind of psychological and sociological effect. Samples of their original writing were also collected from them as their admitted handwriting.

Computational analysis

Data acquisition

Handwriting samples collected were scanned and saved as image files for the purpose of computational analysis. Letter combinations were determined and characteristic for each letter combinations were examined. In the next step snippets of letter combination images were extracted.

Image pre processing

In this step the scanned images of the handwriting samples are digitally uniformed by equalizing histogram and reducing various

noises, such as unwanted dust speckles, which may hinder the accurate measurement and may also affect the final results, by Linear Filtering using Gaussian filters.

Image segmentation

The preprocessed handwriting sample images were segmented using Otsu method, resulting in threshold of image, to minimize the intra class variance of the black and white pixels. In this stage, first, the input image is binarized using a global threshold. Secondly, the following operations are performed on the binarized image.

I=imread ('rhs.jpg'); % reads the image rhs.jpg

level = graythresh (I); % Threshold the image

BW = im2bw(I, level); % binarized the image

imshow(BW)

The command level = graythresh (I) computed a global threshold (level) which converted the intensity image to a binary image with im2bw. The level is a normalized intensity value that lies in the range (0, 1).

Computation of features

Handwriting features of combination of letters were calculated on the basis of formulas of co- ordinate geometry. In this phase the basic features such as slant, size of letters, alignment and angle of strokes were estimated mathematically (Table 1).[5]

Table 1 Features selected for the study with their computational formula

Sr. No	Characteristic observed	Formula used for calculation	Classified as
1	Slant	$\theta = (y1-y2)/(x1-x2)$	Right Slant if Θ > 90 Left Slant if Θ < 90 Vertical Slant if Θ = 90
2	Size of letters	$Size = \sqrt{(x_1-x_2)^2+(y_1-y_2)^2}$ Average Vertical distance of letter on x,y plane calculated by distance formula	Small Medium Large (Based on number of Pixel)
3	Alignment	Tan Θ = Base/Hypotenuse The angle between a line and the x-axis is measured counterclockwise from the part of the x-axis to the right of the line.	Horizontal if Θ =180° Uphill if Θ < 180° Down Hill if Θ > 180°
4	Spacing	Average Horizontal Distance between letters, words and lines on x,y plane calculated by $Space = \sqrt{(x_1-x_2)^2+(y_1-y_2)^2}$	Moderate Narrow Wide (Based on number of Pixel)
5	Angle of Strokes	$\theta = tan-1(m_2-m_1)/1+(m_2*m_1)$	Acute if Θ < 90 Obtuse if Θ > 90 Right Angled if Θ = 90

Statistical approach

Observed characteristics were then statistically evaluated using the Chi-Square method. Chi-square is a statistical test used to compare observed data with data one would expect to obtain according to a specific hypothesis. This method is employed to know about the "goodness to fit" between the observed and expected values. It explains the deviations, i.e. differences between observed and expected, in between the result were due to chance or were they due to other factors. Chi-square test is purposefully used for scrutinizing the null hypothesis, which states that there is no significant difference between the expected and observed result. The Chi Square ($X2$) test employed for the purpose is shown in Equation 1.

$$x^2 = \sum_{i=1}^{n} \frac{(O_i-E_i)^2}{E_i} \ldots\ldots\ldots\ldots\ldots\ldots Equation\,1$$

O_i = Pearson's cumulative test statistic, which asymptotically approaches x^2 distribution.

O_i = an observed frequency;

E_i = an expected (theoretical) frequency, asserted by the null hypothesis;

n = the number of cells in the table.

The Chi square test using MATLAB statistical toolbox was performed with the syntax

stats::

$$csGOFT(x1, x2,\ldots, [[a1, b1], [a2, b2], \ldots], CDF = f \mid PDF = f \mid PF = f)$$

The hypotheses, relating to the study of similarities in handwriting characteristics of parents and their offspring's, considered during this study are as follows:

I. Null hypothesis as various combinations doesn't significantly affect the handwriting of offspring.

II. An alternative hypothesis different combination of parent's style of writing does significantly affect the handwriting of offspring.

Results

The results reported in Table 2 describes the chi square value for the observed frequency of writers of family, the results were computed as per Pearson chi square test with an alternate hypothesis that different handwriting combinations of parent has a significant effect on child's handwriting, the table shows the chi-square

value (Tabulated & Computed), the Degrees of Freedom (2 for all features) and interpretation. The results are supported with graphical representation; in form of Bar chart labeled Figure 1.which shows the chi square distribution among different writing parent (Table 2 & Figure 1).

Table 2 Chi Square Distribution of Different handwriting combinations of parent

Sr. No.	Feature Identified	Parent Combination	No of Samples	Chi Square Value	Tabulated Value	S/NS
		RHS X RHS	60	20.8	5.9	S
		RHS X LHS	60	7.6	5.9	S
		RHS X VS	60	25.2	5.9	S
		LHS X LHS	60	9.7	5.9	S
1	Slant	LHS X VS	60	11.1	5.9	S
		VS X VS	60	25.9	5.9	S
		UH X UH	60	21.9	5.9	S
		UH X DH	60	17.1	5.9	S
		UH X P	60	27.3	5.9	S
2	Alignment	DH X DH	60	12.4	5.9	S
		DH X P	60	9.1	5.9	S
		P X P	60	22.8	5.9	S
		C X C	60	8.4	5.9	S
		C X P	60	17.5	5.9	S
3	Writing Style	P X P	60	23.7	5.9	S
		TT X TT	60	8.1	5.9	S
		TT X TH	60	8.1	5.9	S
		TT X ETH	60	7.6	5.9	S
		TH X TH	60	12.4	5.9	S
		TH X ETH	60	6.3	5.9	S
4	Bigrams	ETH X ETH	60	6.7	5.9	S
		T X T	60	9.5	5.9	S
5	Size	T X S	60	3.8	5.9	NS
		T X R	60	4.1	5.9	NS
		S X S	60	3.3	5.9	NS
		S X R	60	4.1	5.9	NS
		R X R	60	5.6	5.9	NS
		Co X Co	60	17	5.9	S
		Co X R	60	6.5	5.9	S
		Co X W	60	3.1	5.9	NS
		R X R	60	7.8	5.9	S
6	Spacing	R X W	60	6.5	5.9	S
		W X W	60	10.8	5.9	S
		G X G	60	9.1	5.9	S

Table Continued

Sr. No.	Feature Identified	Parent Combination	No of Samples	Chi Square Value	Tabulated Value	S/NS
		G X A	60	12.5	5.9	S
		G X UC	60	21.5	5.9	S
7	Connecting strokes	A X A	60	5.6	5.9	NS
		A X UC	60	4.6	5.9	NS
		UC X UC	60	14.6	5.9	S
		L X L	60	7.6	5.9	S
		L X S	60	0.4	5.9	NS
		L X Ab	60	6.7	5.9	S
		S X S	60	3.6	5.9	NS
8	Initial strokes	S X Ab	60	20.8	5.9	S
		Ab X Ab	60	32.5	5.9	S
		L X L	60	8.4	5.9	S
		L X S	60	0.4	5.9	NS
		L X Ab	60	3.1	5.9	NS
		S X S	60	4.3	5.9	NS
9	Terminal strokes	S X Ab	60	7.6	5.9	S
		Ab X Ab	60	1.3	5.9	NS

Legends: RHS, right hand slant; LHS, left hand slant;VS, vertical slant; UH, uphill; DH, downhill; P, parallel, C, cursive; P, printed; TT, taller T; TH, taller H; ETH, equal TH; T, tall; S, short; R, regular; Co, constricted; W , wide; G, garland; A, arcade; UC, unconnected; L, long; Ab, absent; S/NS, significant/non significant

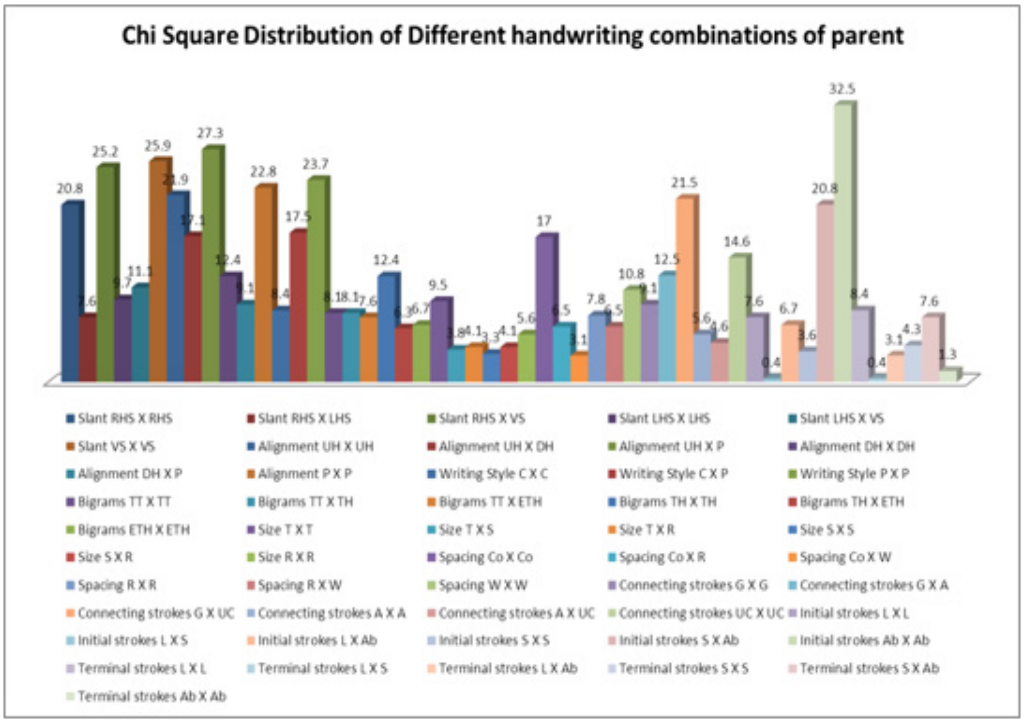

Figure 1 Graphical representation for chi square distribution of different handwriting combinations of parent.

Conclusion

The present study was based on critical examination of the handwriting from 500 Families, having ample writing experience; the features selected for study were analyzed manually as well as computationally using a tool designed on MatLab for the study. On detailed examination it was observed that Handwriting of every individual is unique in its own way however, there are significant similarities within the class characteristics of handwriting among the genetically related bloodlines. The features were statically analyzed by Pearson Chi Square test to check whether the different writing combination of parents affect the writing of their child or not. The study revealed that some of the handwriting features like slant, alignment, writing style, and bigrams have a strong resemblance in parents and their offspring's handwriting. The study is an attempt to help document expert for examination of Anonymous letters where it is generally difficult to identify the source or author of the letter, by comparing the general writing trends a strong family likeness can be ascertained to link the writer with the suspected exhibit.

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Conflicts of interest

The author declares that there is no conflict of interest.

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