

Automated Tool Based on Statistical Study for Predicting Probable Dexterity of Writers



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Submission: December 20, 2017; **Published:** January 08, 2018

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Abstract

Establishing handedness of writer in suspected document is a critical task and is often encountered by the Forensic Document Examiners. The present paper lays emphasis on estimating the probable dexterity of writers, based on statistical validation of features observed in 400 handwriting samples using chi square test. The frequency of features in samples was computed and relative probability was calculated. A computational tool is proposed here by using C++, which computes the input values given by user and suggests the probability of writer being dextral. The tool was validated by 50 unknown samples and found to be 89.14% accurate.

Keywords: Handwriting; Probable Dexterity; Automated Tool

Introduction

Handwriting is a highly complicated motor skill which involves together neurological, physiological and sensory impulses. Comprehension of form, acuity, visual perception, central nervous system pathways, and physiology and anatomy of the muscles and bones of the arm and hand are the factors which combine to generate the output as desired result [1,2]. Handwriting is affected by various internal and external features like handedness, gender, age, educational level of the writers. Classification of offline handwriting based on various attributes like handedness, age, gender and medium of education has a vital role in forensic document examination, it may help in minimizing the suspect list and hence the accuracy of positive identification in less time could be achieved. A similar classifier has been developed by Nigam et al. [3] for predicting the probability of female authorship.

Document experts rely on visual observation of handwriting features and sometimes their manual measurements, a computational approach which may measure the desired features of handwriting may assist the document expert in examination of document with higher accuracy level within less time consumption. Previous studies have reported many computational methods which are based on high level programming and personal models which are majorly based on optical character recognition, and no such classifier is

proposed which may serve the document expert to categorize the handwriting into certain groups. Different character (micro-features) have been found to be powerful for hand writing discrimination, however, their capability in identifying the attributes like gender, handedness, age, etc. has not yet been evaluated [4]. The present paper lays emphasis on estimating the probable dexterity of writers, based on statistical validation of features observed in 400 handwriting samples using chi square test.

Methodology

Handwriting samples of 400 writers (319 Dextrals and 81 Sinistrals) were randomly collected from different regions of Uttar Pradesh of age range between 18 to 60 years without letting them know the purpose of the study. The participants were requested to copy the control passages in the unlined space of the same make of paper using the pen provided. They were requested to copy the passage for in handwriting specimen forms in their normal handwriting. The writings were preserved for further analysis. The digital image processing of the scanned handwritten samples were performed in several steps as followed:

Image Acquisition: The handwriting samples were acquired in a digital format by using High resolution HP LASERJET M1005

scanner at 1200 DPI and a dataset of 400 offline handwritings was prepared by compiling the scanned handwritten images and storing in memory of the system used.

Noise Removal: The noise appeared during image acquisition resulting from a number of factors, which affect the intensity of actual image, is removed using Range filters.

Image Segmentation: Noise free image is subjected to Otsu method for the segmentation of the pre processed image which chooses the threshold to minimize the intra class variance of

black and white pixels [5].

Feature Selection: The image is further segmented to extract the features and the frequency of these features were statistically computed using chi square test and compared with the tabulated value to prove the alternate hypothesis that there is significant variation in dextral and sinistral handwriting as mentioned in Table 1. These features were then framed to use in the Program designed to calculate the probable dextrality of writer mentioned in Table 2 and (Figures 1A & 1B).

Table 1: Total Features Studied for Handedness based Classifier.

S. No.	Characteristics Observed			Dextral	Sinistral	χ^2	Interpretation
1	Left to Right Direction of Stroke of "t"	Present	Observed	319	0	400	Significant
			Expected	254	65		
		Absent	Observed	0	81		
			Expected	65	16		
2	Left to Right Direction of Stroke of "f"	Present	Observed	319	0	400	Significant
			Expected	254	65		
		Absent	Observed	0	81		
			Expected	65	16		
3	Left to Right Direction of Stroke of "A"	Present	Observed	319	0	400	Significant
			Expected	254	65		
		Absent	Observed	0	81		
			Expected	65	16		
4	Left to Right Direction of Stroke of "l"	Present	Observed	319	0	400	Significant
			Expected	254	65		
		Absent	Observed	0	81		
			Expected	65	16		
5	Left to Right Direction of Stroke of "E"	Present	Observed	319	0	400	Significant
			Expected	254	65		
		Absent	Observed	0	81		
			Expected	65	16		
6	Left to Right Direction of Stroke of "F"	Present	Observed	319	0	400	Significant
			Expected	254	65		
		Absent	Observed	0	81		
			Expected	65	16		
7	Forward Slope in "l"	Present	Observed	313	14	256	Significant
			Expected	261	66		
		Absent	Observed	6	67		
			Expected	58	15		
8	Forward Slope in "t"	Present	Observed	313	11	300	Significant
			Expected	258	66		
		Absent	Observed	6	70		
			Expected	61	15		
9	Forward Slope in "d"	Present	Observed	278	10	179	Significant
			Expected	230	58		
		Absent	Observed	41	71		
			Expected	89	23		

10	Forward Slope in "f"	Present	Observed	271	3	198	Significant
			Expected	219	55		
		Absent	Observed	48	78		
			Expected	100	26		
11	Forward Slope in "g"	Present	Observed	16	79	305	Significant
			Expected	76	19		
		Absent	Observed	303	2		
			Expected	243	62		
12	Forward slope in "y"	Present	Observed	29	79	256	Significant
			Expected	86	22		
		Absent	Observed	290	2		
			Expected	233	59		

Note: At 5% degree of freedom, $F_{tab} = 1.96$

Table 2: Features Selected for Automated Tool

S. No.	Features	Demonstration	Probability of being Dextral
1.	Forward Slope in "l"		12.80%
2.	Forward Slope in "t"		12.75%
3.	Forward Slope in "d"		11.40%
4.	Forward Slope in "f"		11.10%
5.	Forward Slope in "g"		0.71%
6.	Forward Slope in "y"		1.21%
7.	Direction of Strokes Left to Right		50%

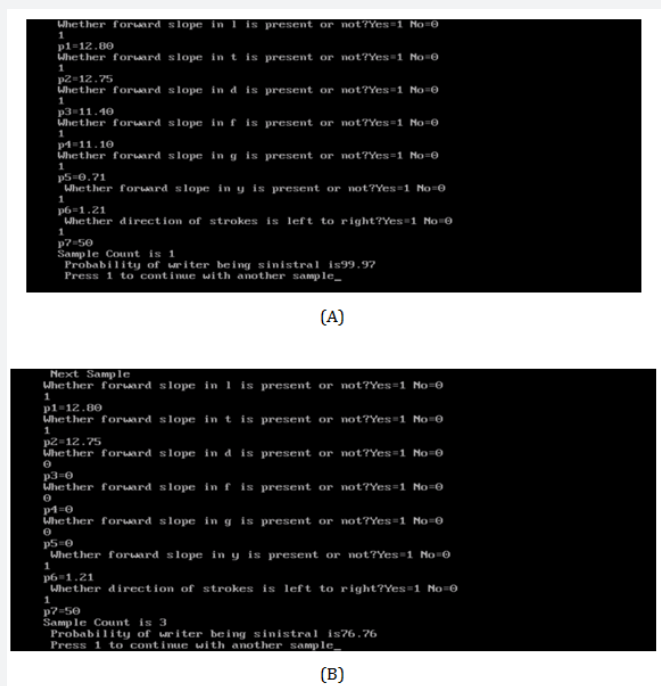


Figure 1A & 1B: Screen shots of tool developed to check probable Dextrality of Author.

Result

The proposed tool is based on the observation of features in handwriting samples, the examiner carefully examines the handwriting sample and enters the value 0 or 1 for the presence or absence of the features in that sample respectively. The tool then computes the values and displays the overall probability of

the writer being dextral. The tool was formulated on statistical observation of 400 samples and them validated by 50 unknown samples. The False Acceptance rate (FAR) was highest in cases of forward slope in 'l' 8% whereas the False Rejection Rate (FRR) was maximum in case forward slope in 'g' 9% as mentioned in Table 3. The tool has showed an accuracy of 89.14%.

Table 3: Validation of Tool.

Features	False Acceptance Rate	False Rejection Rate	Accuracy
Forward Slope in "l"	8	4	88%
Forward Slope in "t"	4	6	90%
Forward Slope in "d"	7	5	88%
Forward Slope in "f"	6	4	90%
Forward Slope in "g"	5	9	86%
Forward Slope in "y"	6	5	89%
Direction of Strokes			
Left to Right	3	4	93%

Conclusion

The above mentioned features proved to be highly significant in differentiating the dextral writings. Along with this each feature is associated with its fixed probability value on the basis of their relative occurrence in the samples analyzed. Thus, a combination of different features will give a different probability of the handwriting being written by a dextral writer. The tool proposed in this paper will help the forensic document

examiners to estimate the handedness of the writer of any anonymous document in a comparatively lesser period of time with greater accuracy.

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DOI:10.19080/JFSCI.2018.07.555703

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