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FORENSIC DOCUMENT EXAMINATION: TO DELINEATE THE DIFFERENCE BETWEEN GENUINE AND FAKE SEAL

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Abstract

Questioned documents may comprise ID cards, contracts, wills and deeds, seals, stamps, bank checks, manually written correspondence, machine-created records, money, and electronic reports. This study attempts to distinguish between the genuine seal sample and forged seal sample by evaluating the individual and class characteristics. The research design is an experimental structure within the research study is undertaken. For this study, 7 different seals were taken, and from each sample, 10 imprints were obtained. The obtained genuine seal impressions were replicated by two different techniques, namely crude and scanning methods. In each technique, 70 seal impressions were obtained, a total of 210 seal impressions were collected, including both admitted and disputed seals. The disputed seal impressions were made by two different techniques, namely simple technique, and scanning technique. Since the disputed sample is the replica of the admitted sample, the class characteristics were found to be similar. Whereas the individual characteristics appeared to have commonness between the genuine and disputed but the nature of the seal impressions is evident; the replicated impressions were not genuine. To compare, the same chi-square test was performed, which indicates that the calculated value of admitted, disputed crude, and scanning sample are 96.02, 56, 86.83, respectively, which is higher than the table value 7.81, and it signifies that the source of seal impressions can be determined. Hence, even though the class and individual characteristics are similar to admitted seal impressions, examining the nature of the seal impressions would help establish their source of origin.

Keywords: *Seal impression, questioned documents, forgery seal, genuine seal, individual characteristics, class characteristics.*

INTRODUCTION

A seal is a method for making an impression on paper, or on any documents, including an embossment on paper, and is also the impression thus made (Dr. G.S. Sodhi). In the olden days, seals played a vital role to validate the documents, and it has worth studying the authentication of Seals for questioned document examination (Rose, 2016). Seals are used both in the government and private sectors for authentication. In the government sector, seals are used to certify essential records such as birth certificates, marriage licenses, and death certificates as legal documents, while the private sector uses the seals to affix their organization name on official transcripts. In Forensic Document Examination (FDE), the seal impressions are compared for the characteristics influenced by the die material, surface of the seals, and type of paper and wear and tear of the die material. The seals are classified into 4 different types they are the hand seal, the self-inking seal, the pre-inked seal, and the flat-die seal based on the location of the ink source (Jan Seaman Kelly, 2006). The spatial arrangement of seal content was detected by the multi-oriented and multi-scale text character recognition method to generate the local spatial information to classify the seal, and it is the efficient method to locate the shape of the seal orientation in documents (Roy, 2010). Likewise, the edges of the seal impression were analyzed in Chinese seal impressions using the Hough transformation method, and the inputs were fed into a support vector machine (SVM) to verify the seal imprints (Su, 2019). A study was done to validate the seal impressions by (Lang 2012) to detect the novel seal forgery method based on local feature matching and geometric consistency. The experimental results showed that this method was effective and found a substantial geometric difference between the genuine and forged seal. In the above literature, all the seal impressions were analyzed using automated machines instead of other manual visual examinations. The visual examination is done with the help of a stereomicroscope or digital microscope to analyze the disputed seal impressions. In this research, the seal impressions were analyzed using

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Auslese TM USB digital microscope (50 to 1000x). Therefore, this study aims to examine the different types of forged seal impressions to establish their source and genuineness.

MATERIALS AND METHODS

Research Design

The research design is an experimental structure within the research study is undertaken. The preparation of such a design facilitates research to be as effective as possible yielding maximum information.

Sample collecting technique

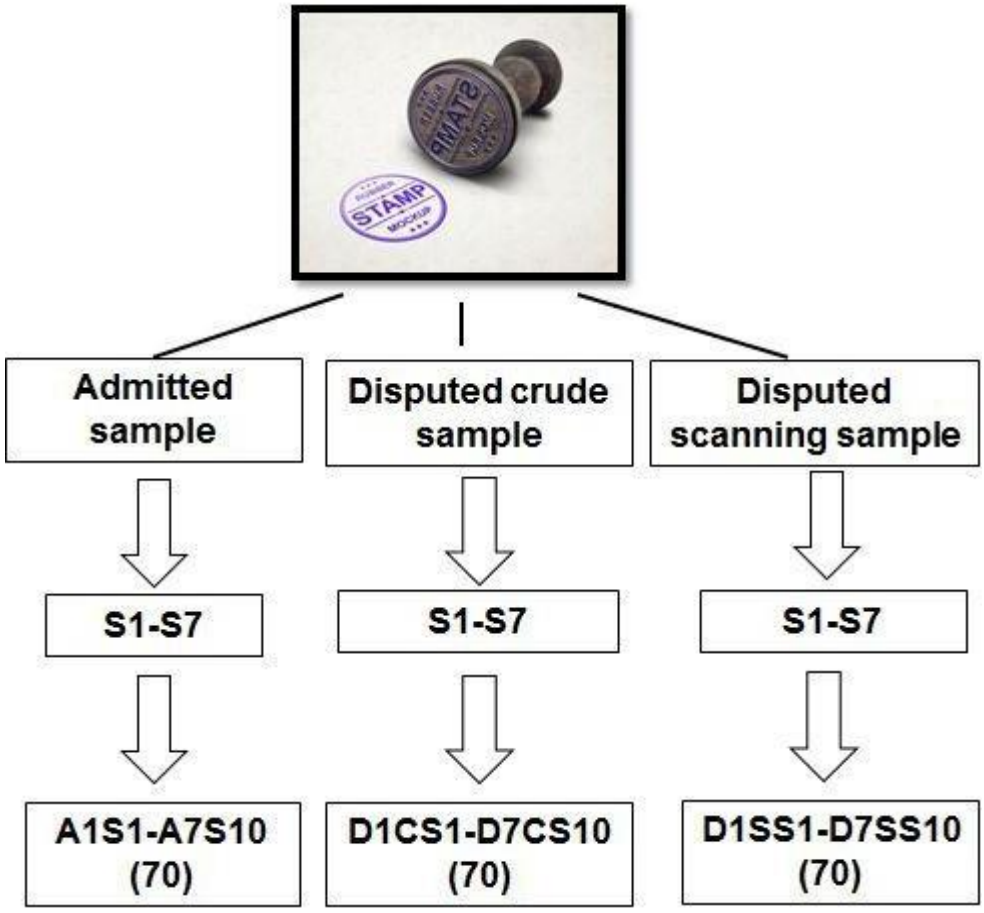

Figure.1 Flow Chart Representing the Sample Size

The researcher has used seven different genuine seals for creating the sample. From each seal, 10 impressions were obtained; the researcher has tried to duplicate the genuine seal impression by using two different techniques, namely crude and scanning technique. Therefore, the researcher has obtained a total of 210 seal impressions for the examination, including admitted samples shown in figure 1.

Hypothesis

Null hypothesis (H_0): There is no significant difference between the genuine and disputed seal.

The alternate hypothesis (H_A): There is a significant difference between the genuine and disputed seal.

Operational definition

Impression void- A gap or void present in the seal impression.

Blemish- An unwanted mark that makes the seal impression looks imperfect.

The sharpness of the font- The formation of sharp and well-defined edges of the characters of the seal impressions.

Wear and tear- It is referred to as the cut marks or worn off any character in the rubber stamp due to repeated usage of the seal.

Data collection procedure

For this study, 7 different seals were taken, and from each sample, 10 impressions were obtained, which is then coded as Admitted Sample (A1S1-A7S10). The Admitted seal impressions were then duplicated by scanning and obtaining the printout from an inkjet printer (Epson L350) of the same stamp pad ink color to give an original

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pictorial effect, which is coded as Disputed Scanning Sample (D1SS1-D7SS10). The last technique that the researcher has used to duplicate the genuine impressions was of crude method, and the investigator has successfully duplicated the genuine impressions, which are then coded as Disputed Crude Sample (D1CS1-D7CS10). Hence from each seal 10 impressions were obtained, which sums up to 70 impressions from the genuine seal, and the same is repeated for the other two forging techniques. Hence a total of 210 impressions were obtained for analysis.

Analysis

For analysis, Auslese TM USB digital microscope (50 to 1000x) was used to examine the class and individual characteristics. The class characteristics that are considered for this study are the shape, size, alignment, dimensions such as length and breadth of the seal, the interspace between the lines, and between the words. The individual characteristics such as wear and tear, impression void, and reproducible blemishes were identified, and the same is coded scientifically into MS Excel and is statistically analyzed.

ANALYSIS

Class characteristics

Table 1. Class Characteristics of the Admitted Sample

Admitted Sample							
Sample no	**Length (Cm)**	**Breadth (Cm)**	**Interspace b/w words (Cm)**	**Interspace b/w lines (Cm)**	**Alignment**	**Shape**	**Size**
A1S1	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S2	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S3	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S4	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S5	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S6	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S7	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S8	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S9	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A1S10	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A2S1	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S2	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S3	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S4	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S5	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S6	4.2	1.5	0.05	0.5	Straight	Rectangle	Small
A2S7	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S8	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S9	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A2S10	4.2	1.5	0.05	0.5	Straight	Rectangle	small
A3S1	3.8	1	0	0	Straight	Rectangle	small
A3S2	3.8	1	0	0	Straight	Rectangle	small
A3S3	3.8	1	0	0	Straight	Rectangle	small
A3S4	3.8	1	0	0	Straight	Rectangle	small
A3S5	3.8	1	0	0	Straight	Rectangle	small
A3S6	3.8	1	0	0	Straight	Rectangle	small
A3S7	3.8	1	0	0	Straight	Rectangle	small
A3S8	3.8	1	0	0	Straight	Rectangle	small
A3S9	3.8	1	0	0	Straight	Rectangle	small
A3S10	3.8	1	0	0	Straight	Rectangle	small
A4S1	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S2	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S3	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S4	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S5	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S6	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S7	5.4	1.6	0.1	0.15	Straight	Rectangle	small

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A4S8	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S9	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A4S10	5.4	1.6	0.1	0.15	Straight	Rectangle	small
A5S1	4	0.4	0	0	Straight	Rectangle	small
A5S2	4	0.4	0	0	Straight	Rectangle	Small
A5S3	4	0.4	0	0	Straight	Rectangle	small
A5S4	4	0.4	0	0	Straight	Rectangle	small
A5S5	4	0.4	0	0	Straight	Rectangle	small
A5S6	4	0.4	0	0	Straight	Rectangle	small
A5S7	4	0.4	0	0	Straight	Rectangle	small
A5S8	4	0.4	0	0	Straight	Rectangle	small
A5S9	4	0.4	0	0	Straight	Rectangle	small
A5S10	4	0.4	0	0	Straight	Rectangle	small
A6S1	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S2	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S3	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S4	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S5	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S6	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S7	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S8	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S9	3	1.4	0.05	0.2	Straight	Rectangle	small
A6S10	3	1.4	0.05	0.2	Straight	Rectangle	small
A7S1	2.6	0.4	0	0	Straight	Rectangle	small
A7S2	2.6	0.4	0	0	Straight	Rectangle	small

A7S3	2.6	0.4	0	0	Straight	Rectangle	small
A7S4	2.6	0.4	0	0	Straight	Rectangle	small
A7S5	2.6	0.4	0	0	Straight	Rectangle	small
A7S6	2.6	0.4	0	0	Straight	Rectangle	small
A7S7	2.6	0.4	0	0	Straight	Rectangle	small
A7S8	2.6	0.4	0	0	Straight	Rectangle	small
A7S9	2.6	0.4	0	0	Straight	Rectangle	small
A7S10	2.6	0.4	0	0	Straight	Rectangle	small

The class characteristics consist of length, breadth, the interspace between words and lines, alignment, size, and shape. There are 7 different types of seals that were used to obtain the impression. Each seal has a unique class characteristic, and it is not similar to each other. The length, breadth, interspace between words and lines of A1S1-A1S10 is 5.4, 1.6, 0.1, 0.15cm respectively followed by A2S1-A2S10 is 4.2, 1.5, 0.5, 0.5cm respectively followed by A3S1-A3S10 is 3.8, 1, 0, 0.15cm respectively followed by A4S1-A4S10 is 5.4, 1.6, 0.1, 0.15cm A5S1-A5S10 is 4, 0.4, 0, 0cm respectively followed by A6S1-A6S10 is 3, 1.4, 0.05, 0.2cm & A7S1-A7S10 is 2.6, 0.4, 0, 0 15cm respectively. The size, shape, and alignment of all the 7 admitted seal samples were the same, i.e., small, rectangle & straight is shown in table 1.

Table 2. Class Characteristics of Disputed Crude Sample

Disputed Crude Sample							
Sample no	**Length (Cm)**	**Breadth (Cm)**	**Interspace b/w words (Cm)**	**Interspace b/w lines (Cm)**	**Alignment**	**Shape**	**Size**
D1CS1	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS2	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS3	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS4	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS5	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS6	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS7	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS8	5.4	1.6	0.1	0.15	Straight	Rectangle	small

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D1CS9	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1CS10	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D2CS1	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS2	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS3	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS4	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS5	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS6	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS7	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS8	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS9	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2CS10	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D3CS1	3.8	1	0	0	Straight	Rectangle	small
D3CS2	3.8	1	0	0	Straight	Rectangle	small
D3CS3	3.8	1	0	0	Straight	Rectangle	small
D3CS4	3.8	1	0	0	Straight	Rectangle	small
D3CS5	3.8	1	0	0	Straight	Rectangle	small
D3CS6	3.8	1	0	0	Straight	Rectangle	small
D3CS7	3.8	1	0	0	Straight	Rectangle	small
D3CS8	3.8	1	0	0	Straight	Rectangle	small
D3CS9	3.8	1	0	0	Straight	Rectangle	small
D3CS10	3.8	1	0	0	Straight	Rectangle	small
D4CS1	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS2	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS3	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS4	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS5	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS6	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS7	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS8	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS9	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4CS10	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D5CS1	4	0.4	0	0	Straight	Rectangle	small
D5CS2	4	0.4	0	0	Straight	Rectangle	small
D5CS3	4	0.4	0	0	Straight	Rectangle	small
D5CS4	4	0.4	0	0	Straight	Rectangle	small
D5CS5	4	0.4	0	0	Straight	Rectangle	small
D5CS6	4	0.4	0	0	Straight	Rectangle	small
D5CS7	4	0.4	0	0	Straight	Rectangle	small
D5CS8	4	0.4	0	0	Straight	Rectangle	small
D5CS9	4	0.4	0	0	Straight	Rectangle	small
D5CS10	4	0.4	0	0	Straight	Rectangle	small
D6CS1	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS2	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS3	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS4	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS5	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS6	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS7	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS8	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS9	3	1.4	0.05	0.2	Straight	Rectangle	small
D6CS10	3	1.4	0.05	0.2	Straight	Rectangle	small
D7CS1	2.6	0.4	0	0	Straight	Rectangle	small
D7CS2	2.6	0.4	0	0	Straight	Rectangle	small
D7CS3	2.6	0.4	0	0	Straight	Rectangle	small
D7CS4	2.6	0.4	0	0	Straight	Rectangle	small
D7CS5	2.6	0.4	0	0	Straight	Rectangle	small

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D7CS6	2.6	0.4	0	0	Straight	Rectangle	small
D7CS7	2.6	0.4	0	0	Straight	Rectangle	small
D7CS8	2.6	0.4	0	0	Straight	Rectangle	small
D7CS9	2.6	0.4	0	0	Straight	Rectangle	small
D7CS10	2.6	0.4	0	0	Straight	Rectangle	small

Table 3. Class Characteristics of Disputed Scanning Sample

Disputed Scanning Sample							
Sample no	**Length (Cm)**	**Breadth (Cm)**	**Interspace b/w words (Cm)**	**Interspace b/w lines (Cm)**	**Alignment**	**Shape**	**Size**
D1SS1	5.4	1.6	0.1	0.15	Straight	Rectangle	Small
D1SS2	5.4	1.6	0.1	0.15	Straight	Rectangle	Small
D1SS3	5.4	1.6	0.1	0.15	Straight	Rectangle	Small
D1SS4	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1SS5	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1SS6	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1SS7	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1SS8	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1SS9	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D1SS10	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D2SS1	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS2	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS3	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS4	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS5	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS6	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS7	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS8	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS9	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D2SS10	4.2	1.5	0.05	0.5	Straight	Rectangle	small
D3SS1	3.8	1	0	0	Straight	Rectangle	small
D3SS2	3.8	1	0	0	Straight	Rectangle	small
D3SS3	3.8	1	0	0	Straight	Rectangle	small
D3SS4	3.8	1	0	0	Straight	Rectangle	small
D3SS5	3.8	1	0	0	Straight	Rectangle	small
D3SS6	3.8	1	0	0	Straight	Rectangle	small
D3SS7	3.8	1	0	0	Straight	Rectangle	small
D3SS8	3.8	1	0	0	Straight	Rectangle	small
D3SS9	3.8	1	0	0	Straight	Rectangle	small
D3SS10	3.8	1	0	0	Straight	Rectangle	small
D4SS1	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS2	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS3	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS4	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS5	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS6	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS7	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS8	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS9	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D4SS10	5.4	1.6	0.1	0.15	Straight	Rectangle	small
D5SS1	4	0.4	0	0	Straight	Rectangle	small
D5SS2	4	0.4	0	0	Straight	Rectangle	small
D5SS3	4	0.4	0	0	Straight	Rectangle	small
D5SS4	4	0.4	0	0	Straight	Rectangle	small
D5SS5	4	0.4	0	0	Straight	Rectangle	small
D5SS6	4	0.4	0	0	Straight	Rectangle	small
D5SS7	4	0.4	0	0	Straight	Rectangle	small
D5SS8	4	0.4	0	0	Straight	Rectangle	small

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D5SS10	4	0.4	0	0	Straight	Rectangle	small
D6SS1	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS2	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS3	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS4	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS5	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS6	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS7	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS8	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS9	3	1.4	0.05	0.2	Straight	Rectangle	small
D6SS10	3	1.4	0.05	0.2	Straight	Rectangle	small
D7SS1	2.6	0.4	0	0	Straight	Rectangle	small
D7SS2	2.6	0.4	0	0	Straight	Rectangle	small
D7SS3	2.6	0.4	0	0	Straight	Rectangle	small
D7SS4	2.6	0.4	0	0	Straight	Rectangle	small
D7SS5	2.6	0.4	0	0	Straight	Rectangle	small
D7SS6	2.6	0.4	0	0	Straight	Rectangle	small
D7SS7	2.6	0.4	0	0	Straight	Rectangle	small
D7SS8	2.6	0.4	0	0	Straight	Rectangle	small
D7SS9	2.6	0.4	0	0	Straight	Rectangle	small
D7SS10	2.6	0.4	0	0	Straight	Rectangle	small

The genuine seal impressions were then forged by two different techniques such as simple technique, and the class characteristics are given in table 2, and another one is the scanning technique given in table 3. Since the disputed sample is the replica of the admitted sample, all class characteristics were found to be similar as genuine.

Individual characteristics of the seal

Table 4. Blemish Present in Admitted and Disputer Samples

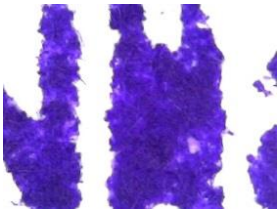
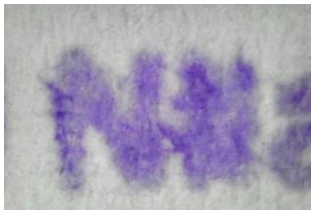
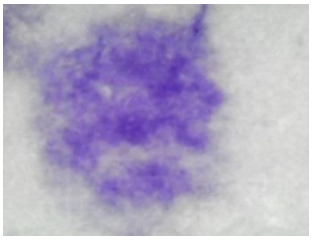
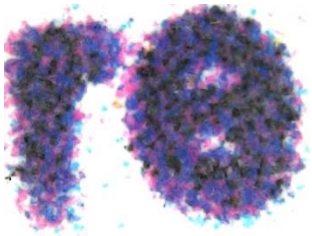
SI.No.	Blemish		
	Admitted sample	**Disputed crude sample**	**Disputed scanning sample**
1.	A1S1 	D1CS1 	D1SS1 
2.	A2S1 	D2CS1 	D2SS2 

Table 4 represents the blemish present in the seal samples. In the admitted sample A1S1, the blemish was found between the characters such as 'i' & 'l' of Nilaya. When it is compared with the disputed sample such as D1CS1 and D1SS1 were found the same blemishes at the exact location. In admitted seal sample A2S1, the blemish was

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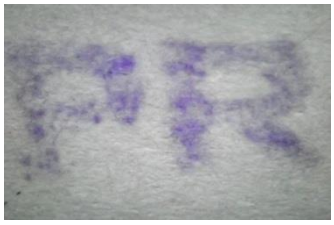
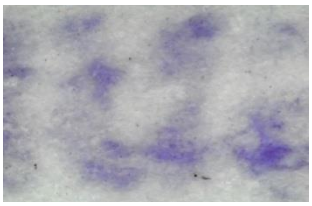
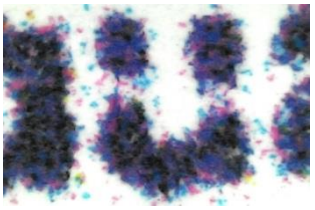
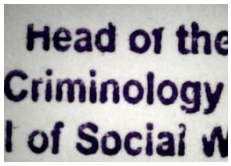
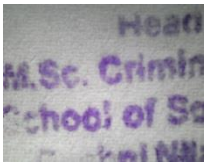
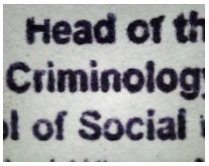
found in character 'e' of 'Mangalore.' When it is compared with the disputed sample such as D2CS1 and D2SS1, blemish was found to be the same. Though the replication of the blemish in the disputed samples was achieved, the nature of the seal impression would reveal that the source of reproduction is disputed.

Table 5. Impression Void Present in Admitted and Disputer Samples

SI.No.	Impression Void		
	Admitted Sample	**Disputed Crude Sample**	**Disputed scanning sample**
1.	A3S1 	D3CS1 	D3SS1 
2.	A4S2 	D4CS2 	D4SS2 

In the admitted sample A3S1, the impression void was found in character 'R' of 'APPROVED.' Compared with the disputed sample such as D3CS1 and D3SS1; the same impression was found to be void at the exact location. In admitted seal sample A4S2, the impression void was found in the character 'U' of 'Graduate.' When it is compared with the disputed sample such as D4CS2 and D4SS2, the presence of impression void was found to be the same. Though the replication of the impression void in the disputed samples was achieved, the nature of the seal impression would reveal that the source of reproduction is disputed is represented in table 5.

Table 6. The sharpness of the Font Present in Admitted and Disputer Samples

SI.No.	The sharpness of the font		
	Admitted Sample (AS)	**Disputed Crude Sample (DCS)**	**Disputed scanning sample (DSS)**
1.	A1S1 	D1CS1 	D1SS1 

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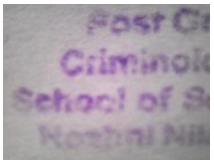
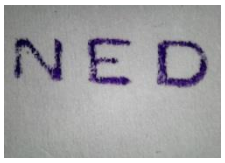
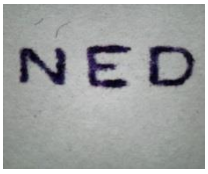
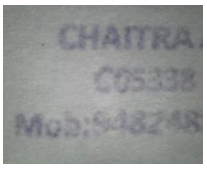
2.	A2S1 	D2CS1 	D2SS1 
3.	A3S1 	D3CS1 	D3SS1 
4.	A4S1 	D4CS1 	D4SS1 
5.	A5S1 	D5CS1 	D5SS1 
6.	A6S1 	D6CS1 	D6SS1 
7.	A7S1 	D7CS1 	D7SS1 

In admitted samples A1S1-A7S10, since the impressions seals were off from the genuine seals, the impressions were having a sharp and clear finishing of edges. In D1SS1-D7SS10, though the impressions of the seal found to be having precise finishing of the fonts, the presence of the spray pattern of the ink indicates that the source of the impression was from the inkjet printer. In D1CS1-D7CS10, the impressions were found to be having round and smudged edges, indicating the source of the impression is disputed.

Table 7. Wear and Tare Present in Admitted and Disputer Samples

SI.No.	Wear and tear		
	Admitted Sample (AS)	Disputed Crude Sample (DCS)	Disputed scanning sample (DSS)

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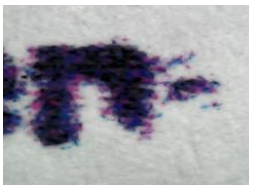
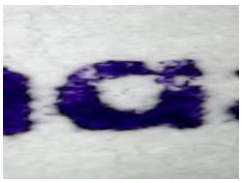
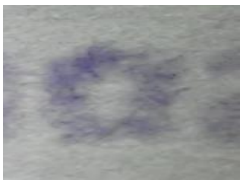
1.	A1S1 	D1CS1 	D1SS1 
2.	A4S1 	D4CS1 	D4SS1 

Table 7 shows the wear and tear present in the seal samples. In the admitted sample A1S1, the wear and tear were found in character 'n' of 'Department.' Compared with the disputed sample such as D1CS1 and D1SS1, the same wear and tear were found at the exact location. In admitted seal sample A4S1, the wear and tear were found in character 'g' of 'Mangalore.' When it is compared with the disputed sample such as D4CS1 and D4SS1, the presence of wear and tear was found to be the same. Though the replications of the wear and tear in the disputed samples were achieved, the nature of the seal impression would reveal that the source of reproduction is disputed.

CHI-SQUARE TEST:
The formula for chi-square is

$$x^2 = \sum \frac{(Oi - Ei)^2}{Ei}$$

x^2 – Chi-square
Oi – Observed Frequency
Ei – Expected Frequency
Admitted sample
Table 8. Chi-square table for the admitted sample

	Wear and tare		**Blemish**		**Impression void**		**Sharpness of the font**		**Spraying pattern**	
	Oi	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***
Present	20	37.5	20	37.5	40	37.5	70	37.5	0	0
Absent	50	32.5	50	32.5	30	32.5	0	32.5	0	0

$$x^2 = \sum \left\{ \frac{(20-37.5)^2}{37.5} + \frac{(20-37.5)^2}{37.5} + \frac{(40-37.5)^2}{37.5} + \frac{(70-37.5)^2}{37.5} + \frac{(50-32.5)^2}{32.5} + \frac{(50-32.5)^2}{32.5} + \frac{(30-32.5)^2}{32.5} + \frac{(0-32.5)^2}{32.5} \right\}$$

x^2 = 8.166 + 8.166 + 0.166 + 28.166 +9.423 + 9.423 + 0.192 + 32.5
x^2= 96.02
Disputed crude sample
Table 9. Chi-square table for the disputed crude sample

	Wear and tare		**Blemish**		**Impression void**		**Sharpness of the font**		**Spraying pattern**	
	Oi	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***
Present	20	20	20	20	40	20	0	20	0	0
Absent	50	50	50	50	30	50	70	50	0	0

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$$x^2 = \sum\left\{\frac{(20-20)^2}{20} + \frac{(20-20)^2}{20} + \frac{(40-20)^2}{20} + \frac{(0-20)^2}{20} + \frac{(50-50)^2}{50} + \frac{(50-50)^2}{50} + \frac{(30-50)^2}{50} + \frac{(70-50)^2}{50}\right\}$$

$x^2 = 0 + 0 + 20 + 20 + 0 + 0 + 8 + 8$

$x^2 = 56$

Disputed scanning sample

Table 10. Chi-square table for the disputed scanning sample

	Wear and tare		**Blemish**		**Impression void**		**Sharpness of the font**		**Spraying pattern**	
	Oi	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***	***Oi***	***Ei***
Present	20	44	20	44	40	44	70	44	70	44
Absent	50	26	50	26	30	26	0	26	0	26

$$x^2 = \sum\left\{\frac{(20-44)^2}{44} + \frac{(20-44)^2}{44} + \frac{(40-44)^2}{44} + \frac{(70-44)^2}{44} + \frac{(50-26)^2}{26} + \frac{(50-26)^2}{26} + \frac{(30-26)^2}{26} + \frac{(0-26)^2}{26}\right\}$$

$x^2 = 13.09 + 13.09 + 0.36 + 15.36 + 22.15 + 22.15 + 0.62 + 0$

$x^2 = 86.83$

The chi-square (x^2) values of admitted sample, disputed crude sample, disputed scanning sample were 96.02,56, 86.83, respectively. According to the presence and absence of individual characteristics in the different seal impressions, the chi-square value has given in the above tables 8,9 & 10. The chi-square table value for admitted, disputed crude sample, disputed scanning the sample with the degrees of freedom 3 for the level of significance 5% ($\alpha = 0.05$) is 7.82. Since the calculated value is higher than the table value, it indicates that the null hypothesis is rejected, and the data is statistically significant since p <0.05.

RESULTS

Based on the analysis of class characteristics of seal samples, the researcher found out there are similarities between both admitted and disputed seal samples (Table.1 & 2). The reproducible blemishes were compared between admitted, and disputed samples; the researcher has found that the blemish present in character between the 'i' & 'l' of 'Nilaya' of admitted sample A1S1 is found to be similar in the disputed crude sample D1CS1 and disputed scanning sample D1SS1. Though the presence of blemish is precisely similar, it could be easily identified by the nature of the seal impressions that D1CS1 and D1SS1 were not obtained from the genuine seal. The reproducible blemishes were compared between admitted and disputed samples; the researcher has found that the blemish present in character between the 'e' of 'Mangalore' of admitted sample A2S1 is found to be similar in the disputed crude sample D2CS1 and disputed scanning sample D2SS1. Though the presence of blemish is precisely similar, it could be easily identified by the nature of the seal impressions that D2CS1 and D2SS1 were not obtained from the genuine seal. The impression voids were compared between admitted and disputed samples; the researcher has found that the impression void present in character 'R' of 'APPROVED' of admitted sample A3S1 is found to be similar in the disputed crude sample D3CS1 and disputed scanning sample D3SS1. Though the presence of impression void is precisely similar, it could be easily identified by the nature of the seal impressions that D3CS1 and D3SS1 were not obtained from the genuine seal. The sharpness of the fonts present in admitted samples A1S1-A1S10 was compared with disputed scanning samples D1SS1-D1SS10 and disputed crude sample D1CS1-D1CS10. The admitted seal impressions were having sharp finishing of the characters, but whereas the disputed scanned samples, though the impressions of the seal found to be having precise finishing of the fonts, the presence of the spray pattern of the ink indicates that the source of the impression was obtained from the inkjet printer. In disputed crude sample D1CS1-D7CS10, the impressions were found to be having round and smudged edges, indicating the source of the impression is disputed. The wear and tear were compared between admitted and disputed samples; the researcher has found that the wear and tear in character 'n' of 'Department 'of admitted sample A4S1 is found to be similar in the disputed crude sample D4CS1 and disputed scanning sample D4SS1. Though the presence of wear and tear is precisely similar, it could be easily identified by the nature of the seal impressions that D4CS1 and D4SS1 were not obtained from the genuine seal. The wear and tear were compared between admitted and disputed samples; the researcher has

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found that the wear and tear in character 'g' of 'Mangalore 'of admitted sample A4S1 is found to be similar in the disputed crude sample D4CS1 and disputed scanning sample D4SS1. Though the presence of wear and tear is precisely similar, it could be easily identified by the nature of the seal impressions that D4CS1 and D4SS1 were not obtained from the genuine seal. The chi-square table value for admitted, disputed crude sample, disputed scanning the sample with the degrees of freedom 3 for the level of significance 5% ($\alpha = 0.05$) is 7.82. Since the calculated value is higher than the table value, it indicates that the null hypothesis is rejected, and the data is statistically significant since $p < 0.05$.

DISCUSSION

Initially, FDE experts were determined the age of the document by using the absorbance ratio method. Simultaneously, by using the same method, the age of ink or other writing materials could be determined, but there is no possibility to delineate the seal impressions (Ouyang *et al*., 2019). Based on Hough transformation, morphological operations, and regression analysis, the seal impression was verified using the SVM-based techniques and found the similarities between the admitted and disputed imprints (Yu-Chen s *et al*., 2019). Other than these techniques, the FDE experts are currently using the advanced automated seal imprint verification system (ASIV) by using the Video Spectral Comparator 6000 (VSC 6000). However, the before-mentioned techniques are sophisticated and need specialized people to perform the tests. However, in this study, the methods used to dispute and analyze the seal impressions are less costly and need basic handling skills to perform the examination. The limitation of this research is only two different techniques were used to replicate the genuine seal impressions. In the future, for duplicating the seal impressions, various other methods can be adopted. For further correspondence, the investigator can also use other types of seals such as pre-inked or self-inking stamps and so forth.

CONCLUSION

The main aim of the study is to differentiate the genuine seal impressions from the disputed ones. In this study, the researcher carried out two different techniques to replicate the genuine seal impressions for the forgery analysis. For analysis, the class and individual characteristics of the seal impressions were compared, and it is found that the class characteristics were the same as that of admitted seal impressions. Whilst comparing the individual characteristics, it is found that the disputed seal impressions were similar to admitted seal impressions, as these disputed seal impressions were the replication of admitted seal samples. However, the nature of the disputed seal impressions would indicate that the source of its origin is not from the genuine seal. The disputed seal impressions D1SS1-D7SS10 were having spraying of ink pattern which indicates that its source of origin is from an inkjet printer, whereas the disputed seal impressions D1CS1-D7CS10 were having round and smudged finishing of the fonts, which indicates that water is used as a solvent and by using the crude method the genuine impressions were transferred to the required documents. The observations were scientifically coded, and for statistical analysis, the chi-square test was used. The calculated value of chi-square for admitted disputed crude and scanning samples were found to be 96.02, 56, 86.83, respectively, which is higher than the table value 7.81, indicating that the null hypothesis is rejected. Hence, even though the class and individual characteristics are similar to admitted seal impressions, examining the nature of the seal impressions would help establish its source of origin.

ABBREVIATION

FDE- Forensic Document Examination
AS- Admitted Seal
DCS- Disputed Crude Sample
DSS- Disputed Scanning Sample
SVM- Support Vector Machine
Oi – Observed Frequency
Ei – Expected Frequency

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