

# An Empirical Investigation of Human Handwritings and Imitational Software Based Digital Machine Writings: A New Category of Forgery Christened as “Hybrid Forgery” in Questioned Documents

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## Abstract

Varieties of writing instruments are available in the market. The history and development of writing instruments, impact printers, non-impact printers, scanners and auto-pens are very interesting subjects to create new challenges for document scientists. The available literature suggests that the mechanical typewriter could be the first writing machine and digital printers are the latest machines that are still used for typing and printing processes. There is a paucity of works of literature on machine writing as questioned documents. A new innovative, imitational software based digital writing machine i.e., the ‘Drawing CNC machine with XY Plotter’ is introduced into the market which can be utilized to imitate writings, signatures as well as drawings which mimic natural patterns of human handwriting. Such an imitational digital writing machine is capable of creating customized written samples by imitating pen movement, good line quality of letter formations, rhythmic connecting strokes, pen pressure and a combination of letter formations. Identifying the difference between machines generated writing and human handwriting is biggest task for questioned document scientists in the present digital era. The research on such writing machines is very useful for the questioned document scientists, law enforcement agencies, police administrations, vigilance and surveillance departments, banks etc.

**Keywords:** Forensic science • Questioned documents • Handwriting examination • Imitational digital writings machine • Hybrid forgery

## Introduction

Handwriting is brain writing which is complex loco-motor ability with neuro-muscular co-ordination. This is the combination of neurological, sensory and physiological impulses with the action of the brain [1,2]. Once a person grasps mature writings, it never changes in life but some minute variations are always present which are known as natural variations [3]. Natural variations are the minute variations in handwriting, signatures and such variations are signs of genuineness [4]. The identification of the handwriting or signatures are based on the principle of handwriting i.e., no two persons write exactly alike twice [5]. From the scientific examination point of view, it is very difficult, almost impossible to repeat on paper the natural flow of the writings, individuality of one’s writing by another person [6,7].

Literature and surveys reveal the presence of multiple technologies of writing instruments like pencils, fountain pens, ballpoint pens, gel pens, roller ballpoint

pens, felt tip pens, high tech ink pens etc. [8]. Writing instruments’ functions were substituted by typewriters and different technology printers. Typewriters have now been in existence well over 300 years and the first recorded patent for such a writing machine was granted to ‘Henry Mills’ in London, the U.K. in 1714 [9-11]. Famous American inventor ‘Thomas Alva Edison’ obtained the first patent for an electric typewriter in 1872 [12]. Mechanical writings date back to the eighteenth century when writing machines imitated genuine signatures of individuals as important as the President of the United States of America. In 1760 ‘Friedrich von Knauss’, a German clockmaker and an inventor developed the first writing doll. Such writing doll could write up to 107 different words [13]. An interesting development in writing technology was the making of ‘The Writer Automata’ or ‘Mechanical Writing Doll’ [14,15]. After some years an autopen called ‘The Signature Machine’ was a tool developed for the programmed signing of a mark or signature with the assistance of a writing instrument. During the 1930s an early form of the ‘Autopen’ was invented [16,17]. In 1942 ‘Robert De Shazo Jr.’ built the first monetarily fruitful autopen. Such autopen could utilize any kind of writing instrument, fluctuate the speed of its execution and take into account some variety of the line quality [18]. Recently certain manufacturers have developed technologies to facilitate mechanical writing and have introduced digital software based mechanical writing instruments to imitate genuine human handwriting [19-22]. In the present digital era, an imitational software based digital writing machine can be used by fraudsters to copy/replicate human handwritings or signatures easily. In our research work we utilized one such machine called the ‘Drawing CNC (Computerised Numerical Control) machine with XY Plotter’ [23,24].

In this research work we introduced the empirical investigation of genuine human handwriting and imitational software based digital machine writing. Such machine writing will be visible too perfect and unnatural to a questioned document scientist, might create several problems of forgeries and non-genuine documents. Such forged documents may be much less detectable. This will

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affect future courtroom testimony and impact the opinions of questioned document examiners. As such questioned document scientists must familiarize themselves with such type of technology and modus operandi of frauds. The proposed research work aims to resource questioned document scientists in recognizing the trace characteristics of a new innovative imitational software based digital machine writing. The main goal of such a study was to identify the difference between genuine human natural handwriting and its replication by an imitational software based digital machine.

### Aim and objective of the present study

The proposed research aims to help questioned document scientists in perceiving the trace characteristics in the writings by a new innovative imitational software based digital writing machine. The objective of the proposed research was to determine whether the questioned document scientists can make the distinction between genuine human handwriting and its replication by **imitational software based digital writing machine** i.e., the 'Drawing CNC machine with XY Plotter'.

## Materials and Methods

### Materials and instruments

In the present research work we utilized three questioned documents as well as three specimen human handwritten documents for the comparison point of view. In our research work we used the 'Drawing CNC (Computerised Numerical Control) machine with XY Plotter' which is digital software based mechanical writing instrument manufactured by NoEnName\_Null®, China.

Such imitational software based digital writing machine has specific design capabilities, a writing head which moves vertically making it feasible to draw or write on any object. It allows one's laptop to copy handwritings, signatures and writes it by using an actual writing instrument like a pen or a pencil etc. which appears as genuine human handwriting perfect with unmistakable appearance. The entire equipment size is (490 mm × 390 mm × 70 mm) connected with a power supply of 12V, 2A. The 'CNC machine with XY Plotter' is ideal for writing on A4 (210 × 279 mm) paper size. The list of materials that are used to perform the experiment are described in Table 1. The list of writing instruments and papers which are used to perform experiments are described in Table 2. The list of scientific instruments which are used to perform the experiments are described in Table 3.

### Sample preparation

In the proposed research work, we prepared human natural handwriting samples using (i) Rorito Fibre point felt tip pen with 0.5 mm tip with green ink (ii) Uni-ball AIR MICRO pen with blue ink and Rorito Robomax pen with a Hovertech roller with a 0.5 mm tip in blue ink. We also prepared the questioned writing and signature samples using the 'Drawing CNC machine with XY Plotter' on an A4 sized printer's white paper. In preparing such samples, we used (i) Uni-ball AIR MICRO pen with blue ink (ii) BE-108 Zebra PENCILTIC rollerball pen with 0.5 mm tip with red ink (iii) Pilot V10 Grip Hi-TechPoint pen with 1.0 mm tip with black ink (iv) Rorito Fibre point felt tip pen with 0.5 mm tip with green ink and (v) Rorito Fibre point felt tip pen with 0.5 mm tip with black ink. Such written documents prepared using the 'Drawing CNC machine with XY Plotter' are indicated with the red enclosed circle and marked as Q1 to Q3.

Such human handwritten documents in natural handwriting are indicated

**Table 1.** The list of materials that are used to perform the experiment.

Material	Description	Brand
Drawing CNC machine with XY Plotter (Figure 1)	Imitational software-based digital writing machine with size (490 mm × 390 mm × 70 mm (L × W × H))	NoEnName_Null®, China
Power supply via an adapter	12V, 2A, and 50/60Hz	Anonymous, China
Inkscape®	Software	Inkscape®, USA
Universal Gcode Sender® (UGS)	Software	UGS®, USA
Laptop of ASUS VivoBook®, UX	Facilitated with intel CORE™ i5, Windows® 10	ASUS®, Taiwan
Drawing CNC machine with XY Plotter	Connected with Window® 10 and software run under Java® environment	Microsoft® and Java®
Scanner – L2541DW	1200 dpi	Brother®, Japan

**Table 2.** The list of writing instruments and paper which are used to experiment.

Writing instruments & paper	Description	Manufacturers
Rorito® Robomax®	Hovertech roller blue ink pen with 0.5 mm tip pen	G. M. pens International PVT. Ltd.®, India.
Uni-ball AIR MICRO®	Hovertech blue ink pen with 1.0 mm tip	Mitsubishi pencil Co. Ltd.®, Japan.
Pilot® V10 Grip	Hi-tecpoint black ink pen with 1.0 mm tip	Luxor®, Japan.
BE-108, Zebra PENCILTIC®	Rollerball red ink pen with 0.5 mm tip	Zebra, imported by Camlin International Ltd, India.
Rorito® Fiberpoint	Felt tip green ink pen with 0.5 mm tip	G M pens International PVT. Ltd.®, India.
Rorito® Fiberpoint	Felt tip black ink pen with 0.5 mm tip	G M pens International PVT. Ltd.®, India.
A4 size printer white papers	(82 gm/m <sup>2</sup> , 210 × 279 mm)	TNPL®, India.

**Table 3.** The list of scientific instruments which are used to experiment.

Instruments	Description	Manufacturers
Mini hand magnifying glass with Ultraviolet lamp	Corning, with 09 V–50 Hz mini 10X Magnifying glass.	Pia Internationals®
Compound microscope vision-2000®	With 100X magnification.	Labomed®

with the blue enclosed circle and marked as S1 to S3 respectively. The blue enclosed specimens of human handwritten signatures reading as 'Chayal' are marked as S1 and S2. The blue enclosed specimens of human handwritings reading as 'forensic science' is marked as S3. All the signatures and writing samples were submitted for document examination to the Forensic Questioned Document Examiners and Researchers of this work. Authorship of the documents were not disclosed.

**Working process of human natural handwriting (signatures and writings) converting into G-code (Figure 1)**

All the test samples (S1 to S3) were scanned in 1200 dpi using a L2541DW scanner manufactured by Brother®, Japan in (.jpg) file format. Thereafter we opened the Inkscape® software and opened scanned files (S1 to S3) in such software in a laptop ASUS Vivo Book® UX, with Window® 10 operating system with Java® environment for UGS (Universal Gcode Sender) version 1.0.7 software. The submitted handwriting was then digitally designed into an author's "handwriting font" using the 'Drawing CNC machine with XY Plotter' with particular handwriting software. As an ordinary strategy of manufacture, the 'Drawing CNC machine with XY Plotter' uses this software to modify the submitted handwriting without conceding the font of the writing. Some modifying systems obscure strokes, complete fragmented letter formation and do baseline correction. This is done with an end goal to make it all the more aesthetically pleasing. Supported by a human operator, the software creates

a 'render'. A render is an adaptation of a person's writing habit consisting of substitute types of letters, figures, marks, signs, symbols, numerals and images. The render is then changed over into Universal Gcode Sender a digital code i.e., Gcode.

**Working process (Figure 2) of new innovative imitational software based digital writing machine i.e., the 'drawing cnc machine with xy plotter' 2.5**

Such obtained G-code samples are conveyed to the 'Drawing CNC machine with XY Plotter' which deciphers the code to produce an imitated hard copy of the sample handwriting.

The 'Drawing CNC machine with XY Plotter' is fitted with a mechanical holder or a grip to hold a writing instrument such as a pen, a pencil etc. This mechanical holder is fitted on a mechanical head which moves vertically. A platen is also fitted to the machine. A writing surface i.e., a paper can settle on the platen and on which the document can be written. The 'Drawing CNC machine with XY Plotter' works by reading the Gcode and moving the mechanical holder of the writing instrument along with X and Y axes. The joined utilization of every one of the three axes incorporates pen lifts, pen drops and imitates the movements of human handwritings. As the writing instrument attached to mechanical head of the 'Drawing CNC machine with XY Plotter' travels through the two linear and the vertical axes and writes letters,

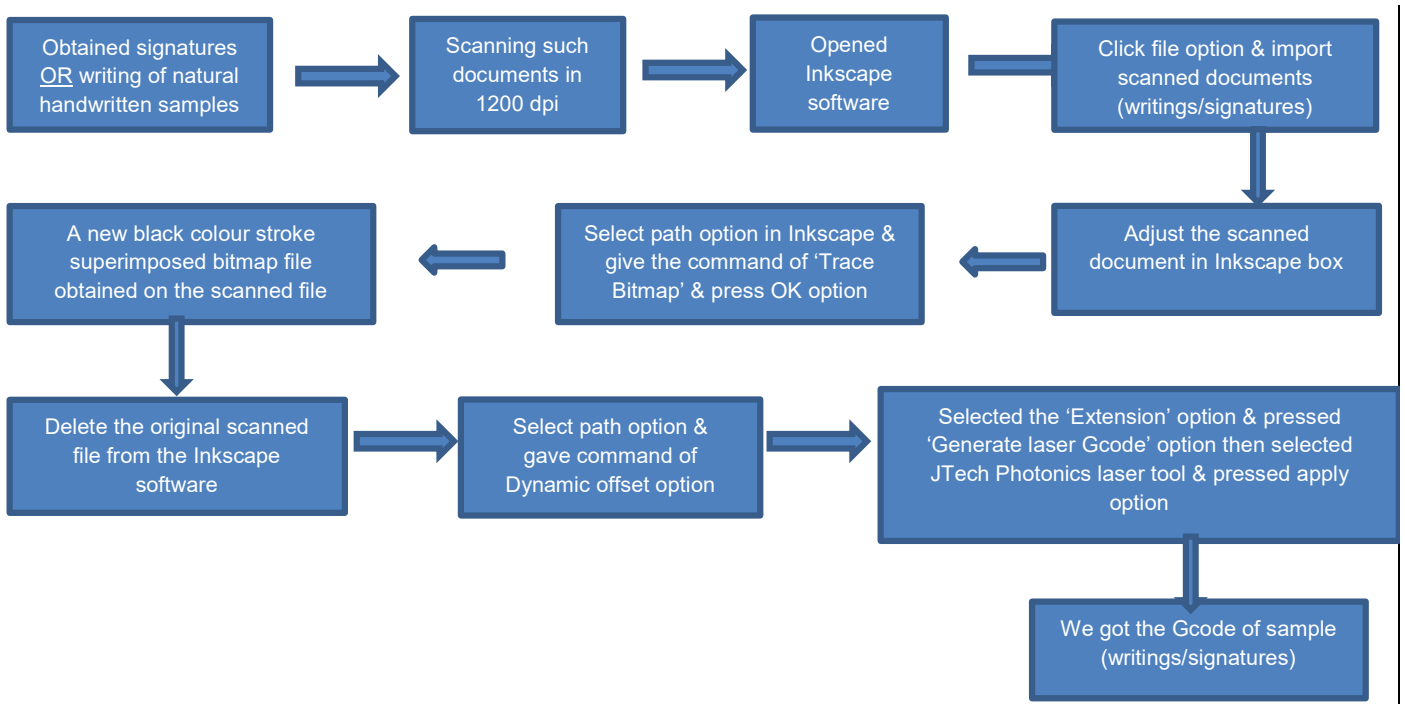


Figure 1. Working process of natural handwriting (signatures & writings) to G-code.

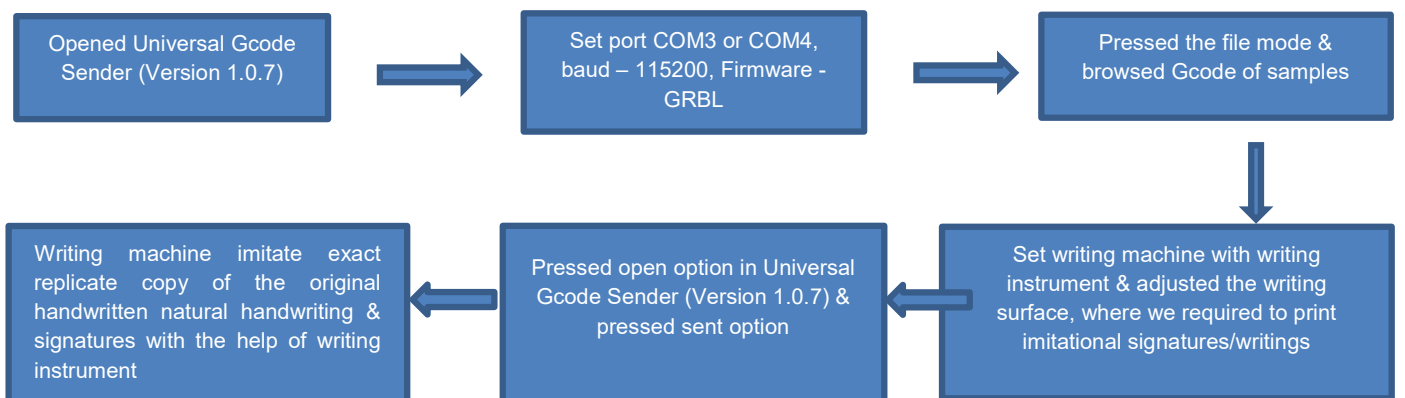


Figure 2. Working process of a new innovative imitational software-based digital writing machine.

words, marks, figures, signatures, drawings, sentences, paragraphs etc. on the writing surface. Like this a written document is produced and the procedure is finished.

The produced writing with the help of the 'Drawing CNC machine with XY Plotter' was considered as a replicate writing of human natural handwritings with good pen pressure, pen pose, pen lift and rhythm. The 'Drawing CNC machine with XY Plotter' machine arrangement might be liable for even pen pressure, blunt strokes, lack of tapered strokes and shading effect in the writing.

**Methods of development**

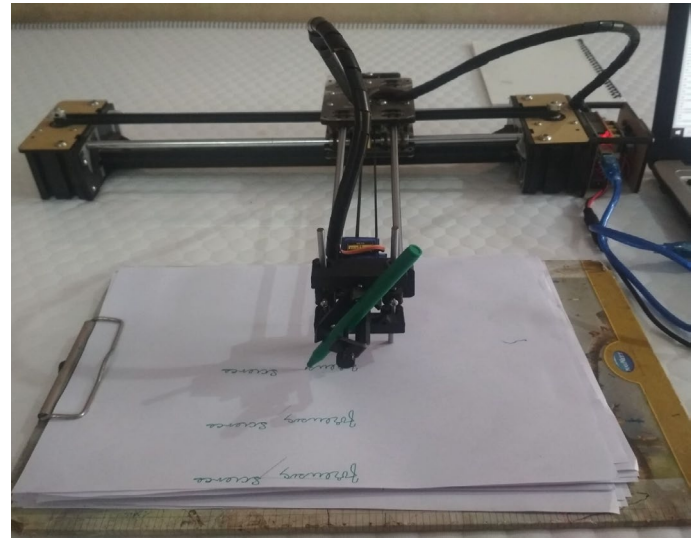
In the proposed research work modified ACEVE (Analysis, Comparison, Evaluation, Verification and Examination) methodologies were used to analyze the questioned as well as specimen human handwritten documents. Such methodologies are accepted in different divisions of forensic disciplines including questioned documents. The use of the ACEVE techniques was intended to decrease predisposition in the investigation and to comprise the accompanying successive procedure. In the examination period of ACEVE, we investigated the imitational software based digital machine questioned writing and signatures marked as (Q1 to Q3) and specimen human hand-writings and signatures marked as (S1 to S3). During the investigation, we identified the highly peculiar and inconspicuous features which are fragments of the highly individual characteristics of handwriting habits resulting from pen impulse movements and that repeat consistently at the same contextual location of the writings. In the comparison stage, the recognizing features from the red enclosed imitational software based digital machine questioned writing and signatures marked as Q1 to Q3 and the blue enclosed specimen of human handwritings and signatures marked as S1 to S3 were inspected and compared with the side-by-side mechanism. Comparisons incorporated imitational software based digital machine questioned writings and signatures marked as S1 to Q3 and specimen of human handwritings and signatures marked as S1 to S3 at the same contextual location of the writings. In the evaluation stage, we assessed the significance of any similarities or dissimilarities and also observed the comparison process during the examination procedure to conclude. In the verification stage, the red enclosed imitational software based digital machine questioned writings and signatures marked as Q1 to Q3 and blue enclosed specimen of human handwritings and signatures marked as S1 to S3 were verified. In the examination stage, the red enclosed questioned writings and signatures marked as Q1 to Q3 were compared with the blue enclosed specimen of human handwritings and signatures marked as S1 to S3 with the help of scientific instruments to give the scientific opinion.

**Results**




















Figure 3 is a photograph of a new innovative imitational software based digital writing machine i.e., a 'Drawing CNC machine with XY Plotter'.

Figure 4 is a photograph of a genuine natural human handwritten signature and it reads as 'Chayal'. Such a signature is written with the help of Rorito Fibre point felt tip green ink pen and marked as S1 in the blue enclosed circle. The blue enclosed handwritten signature in green colour ink and the red enclosed imitational software based digital machine signatures in blue, red and black colour inks are described in Figure 4. The blue enclosed handwritten signature in blue colour ink and the red enclosed imitational software based digital machine signatures in red and black colour inks are described in Figure 5. The blue enclosed handwritten writings in blue colour ink and the red enclosed imitational software based digital machine writings in black and green colour inks are described in Figure 6.

Figure 4 is the photograph of the signatures written by imitational software based digital machine i.e., the 'Drawing CNC machine with XY Plotter' which are marked as Q1 in the red enclosed circle. The questioned signatures marked as Q1 are prepared using imitational software based digital writing machine i.e., the 'Drawing CNC machine with XY Plotter' in blue, red and black colour inks. During the sample preparation, we utilized different technology writing instruments with different colours inks on an A4 size (82 g/m<sup>2</sup>, 210 ×



**Figure 3.** Imitational software-based digital writing machine/CNC machine with XY Plotter.

Specimen of Human Signature Marked as S1	Imitational Software Based Digital Machine Signatures Marked as Q1		
			
			
			
			
			
			

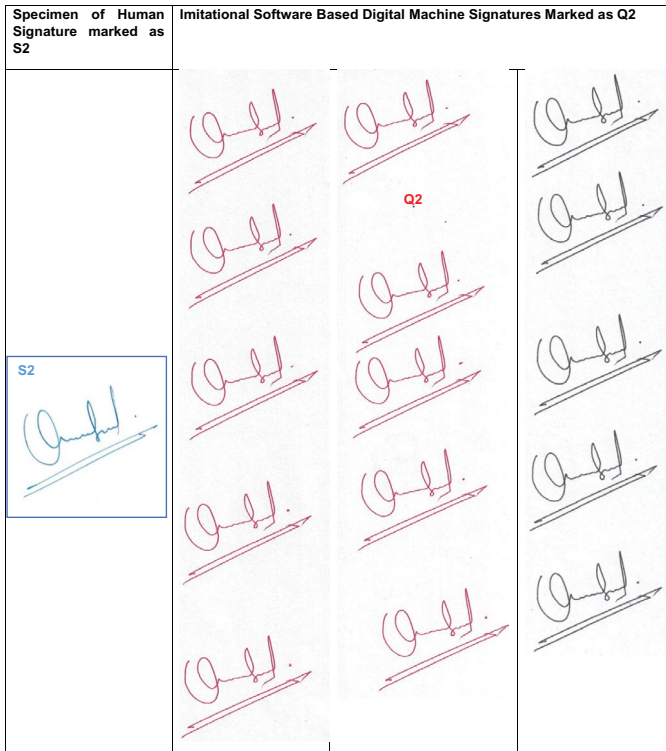
**Figure 4.** The blue enclosed handwritten signature with green colour ink and the red enclosed imitational software based digital machine signatures with blue, red and black colour inks.

279 mm) printer white paper. The questioned signatures marked as Q1 look like normal signatures and seem almost written by human hands.

Figure 5 is a photograph of different models of a genuine natural human handwritten signature and reads as 'Chayal'. Such signatures are written using a Uni-ball AIR MICRO pen having a Hovertech roller 0.5 mm tip in blue ink and marked as S2 in the blue enclosed circle.

Figure 5 is the photograph of the signatures written using an imitational software based digital machine i.e., the 'Drawing CNC machine with XY Plotter' in red and black inks which is marked as Q2 in the red enclosed circle. The questioned signatures marked as Q2 are prepared using an imitational software based digital writing machine i.e., the 'Drawing CNC machine with XY Plotter'. Figure 6 is the photograph of a different model of a genuine natural human handwriting which reads as 'forensic science'. Such writing is written using a Rorito Robomax pen with a Hovertech roller with a 0.5 mm tip in blue ink and marked as S3 in the blue enclosed circle.

Figure 6 is a photograph of writings produced by imitational software based digital writing machine i.e., the 'Drawing CNC machine with XY Plotter' in black and green inks which is marked as Q3 in the red enclosed circle.



**Figure 5.**The blue enclosed handwritten signature with blue colour ink and the red enclosed imitational software based digital machine signatures with red and black colour inks. Prominent nature of even emphasis present on all strokes.



**Figure 6.** The blue enclosed handwritten writing with blue colour ink and the red enclosed imitational software based digital machine writings with black and green colour inks.

The questioned signatures marked as Q3 are prepared with the help of an imitational software based digital writing machine i.e., the ‘Drawing CNC machine with XY Plotter’.

## Discussion

Here we implemented a modified ACEVE (Analysis, Comparison, Evaluation, Verification and Examination) methodology which is to analyse the questioned as well as specimen of human handwritten documents.

### Samples examination and opinion

**Questioned:** The red enclosed signatures reading as ‘Chayal’ which are

marked as Q1 and Q2, the red enclosed writings reading as ‘forensic science’, which is marked as Q3 respectively on A4 size printer white papers.

**Standards:** The blue enclosed specimen of human handwritten signatures reading as ‘Chayal’ which are marked as S1 and S2. The blue enclosed specimen of human handwritings reading as ‘forensic science’, which is marked as S3.

All the documents were carefully and thoroughly examined with the scientific instruments such as a mini hand magnifying glass with Ultraviolet lamp and compound microscope vision-2000 ® under different lighting conditions and we are of the opinion that the examinations of comparative specimen signatures marked as S1 and S2 shows that they are freely written, in good speed and flow among themselves. On the other hand, the questioned simplified signatures marked as Q1 and Q2 are slow and drawn in execution in comparison to that of specimen of human handwritten signatures marked as S1 and S2. Questioned signatures marked as Q1 and Q2 also show hesitations, tremors, defective and poor line quality which are an act of imitation. Besides this, divergences are also observed between questioned signatures marked as Q1 and Q2 and specimen of human handwritten signatures marked S1 and S2 in the execution of various characters and parts of characters such as – prominent extended nature of commencement of letter appearing as ‘C’, manner of its trough, manner of the joining of letter ‘C’ with subsequent letter appearing as ‘h’. Sharp nature of movement at the curved at terminal body part of letter ‘C’ and its subsequent connection with the garlanded strokes, their depth, terminal stroke of letter ‘h’. Commencement of letter ‘h’ forming slight large in nature and without tremulous nature of curved body part while forming the compressed nature of elongated loop, tilted and curved nature of vertical staff, movement in the execution of curved body at the bottom, nature and location of angularity/hump on the body shoulder while forming letter ‘a’ with simplified manner. Manner of the formation of letter appearing as ‘y’, bold and compressed elongated nature of eyelet at the top of the body part, nature and shape of the bulb at the lower body part while forming the subsequent letter ‘a’ with simplified manner. Manner of the execution of simplified letter ‘a’ connected with the subsequent letter ‘l’, simplified letter ‘a’ appearing as letter ‘u’, manner of its trough, manner of the formation of letter ‘l’, extended nature of the vertical staff, compressed nature and shape of eyelet at the top of the body part, prominent nature of emphasis present on certain strokes while forming the extended nature of the terminal stroke along with nature and direction of its finish. Nature and location of underscoring and placement marks are differently observed in imitational software based digital machine questioned signatures. The same are also differently observed in specimen of human handwritten signatures with similar variation at one or other places. The aforesaid divergences are fundamental in nature and beyond the range of natural variations. This indicates that the person who wrote the blue enclosed specimen of human handwritten signatures marked as S1 and S2 did not write the red enclosed questioned signatures marked as Q1 and Q2.

The examination of comparative specimen of human handwritings marked as S3 shows that they are freely written, in good speed and flow among themselves. On the other hand, the questioned writings marked as Q3 is slow and drawn in execution in comparison to that of specimen and questioned writing also show hesitations, tremors, defective and poor line quality which are an act of imitation. Besides this, divergences are observed between questioned writings marked as Q3 and specimen of human handwriting marked as S3 in the execution of various characters and parts of characters such as – slight short nature along with tapered commencement of the letter ‘f’, movement in the execution of the curved body part, manner of its ridge while forming the slight short nature of the vertical staff, movement in the execution of curved body part, slight expanded nature of eyelet at bottom body part while forming horizontal bar. Manner of the combination of letter ‘f’ with letter ‘o’. Nature and shape of the body oval visible as expanded and oval shape. Nature and position of closing while forming the subsequent letter ‘r’, movement in the execution of curved body part, small nature of body oval at the top of the body part while forming the body shoulder of letter ‘r’ along with nature and direction of its finish. Manner of the formation of letter ‘r’ connected with the subsequent letter appearing as letter ‘e’. Expanded nature of eyelet at the top

of the body part, manner of its trough, movement in the execution of the curve body part along with nature and direction of its finish. Manner of the execution of letter 'e' connected with subsequent letter appearing as 'n'. Manner of the formation of letter 'n', shape and movement while making its body part and direction of its finish and its connection with the subsequent letter appearing as letter 's'. Nature of the commencement of letter 's', shape, size of its body movement at the base and its connection with subsequent letter 'i', nature and relative location of i-dot (.) at top of the body part. Manner of the formation of subsequent letter 'c', nature and location of retraced at the top of the curvature body part, movement in the execution of curved body part while forming the extended nature of terminal stroke, no ticked/downward stroke observed at the terminal stroke in word 'forensic'.

Tapered nature of commencement of letter 'S', movement in the execution of curved body part, nature and location of diagonal stroke at the middle body part while forming the terminal stroke, slight compressed nature of letter 'c', manner of its trough, manner of the execution of letter 'i', straight ward nature of vertical staff, nature and relative location of i-dot (.) at top of the body part, manner of the execution of letter 'n', manner of its trough, nature and location of angularity at lower and body shoulder, manner of the formation of letter 'e', absence of eyelet at the terminal stroke along with nature and direction of its finish in word 'Science' as observed in imitational software based digital machine questioned writings are also differently observed in specimen of human handwriting with similar variation at one or other places. The aforesaid divergences are fundamental in nature. This indicates that the person who wrote the blue enclosed specimen of human handwriting marked as S3 did not write the red enclosed questioned writings marked as Q3.

Some erasable magic inks are also used for fraudulent purposes in forensic questioned document science [6,25]. Handwriting forensic forgeries are classified into several categories i.e., simple forgery, imitational/simulated forgery, trace forgery, digital forgery, mechanical forgery and disguise [26-29]. The proposed research work is a combination of imitational forgery, mechanical and digital forgery. For this reason, we christen it as 'Hybrid Forgery'. In such a system of forgery, several mechanical parts are under control electrically, electronically and work together as a human arm, imitate the writing or signatures as a human hand does and all processes are under the control of particular software and a computer system. We distinguished indications of unnatural writing by the 'Drawing CNC machine with XY Plotter' dependent on our experience and handwriting investigation principles. One of these handwriting identification principles is that nobody can write similarly twice. Because of natural variations, different executions of letter formations can't be made to coincide precisely. In genuine human handwritings, due to motion of the human hand, the writing ink fluid will create written strokes showing lightness and darkness of the upstrokes and the downstrokes as the pen moves quickly over the paper which is highly individual characteristics of human handwriting and such characteristics are produced due to strength of the muscles and brain control. The 'Drawing CNC machine with XY Plotter' doesn't emulate human handwriting with respect to the complex writing movement of the human hand and the directionality of building the strokes of the letters or figures. The 'Drawing CNC machine with XY Plotter' might be liable for even pen pressure, blunt strokes, lack of tapered strokes, extended strokes and shading effect in the writing. The superimposition of characters observed, such as overall precise spacing, is likely the result of computer programmed imitational software-based writing.

We as questioned document scientists should be aware of machine writing to recognize the trace characteristics of the imitated writing and signatures produced by the imitational software based digital writing machine/ the 'CNC machine with XY plotter'. The blue enclosed specimen of human handwritings and signatures which are marked as S1 to S3 are freely written having smooth strokes. The imitational software based digital machine questioned writings and signatures marked as Q1 to Q3 appear being slowly written and drawn in the execution with a lack of natural variations in comparison to that of the specimen of human handwritings and signatures marked as S1 to S3. Whereas genuine handwritings and signatures show normal consistency, natural variations, smooth line quality, rhythm, skill, no hesitations, fine

commencement and terminal strokes and pressure gradient i.e., uneven pressure at the strokes, emphasis etc. which are acts of genuineness. Handwriting is the most inimitable habit which is developed with lots of effort, practice and then to create mature writings or master pattern and reflects the dynamic characteristic of genuine human handwriting.

When reporting the findings, we as questioned document scientists may opine whether the writing and signatures are human handwritings or are written by imitational software based digital machine? A recommended configuration of this announcement may be - "The questioned writings and signatures display bizarre even pen pressure present on up and down strokes, drawn in movement with drag strokes, lack of rhythm and smoothness/sharpness in strokes and curves, poor line quality, no change in pressure gradient, faint tremors and hesitations, blunt strokes and absence of tapered strokes and defects in minute and inconspicuous features proposing the questioned writings and signatures were not freely and uninhibitedly written. The aforesaid divergences are fundamental in nature. The manner of execution proposes simulation and accordingly, the questioned writings and signatures marked as Q1 to Q3 might not have been written by the writer of specimen of human handwritings and signatures marked as S1 to S3."

## Conclusion

Genuine writings and signatures show normal consistency, natural variations, smooth line quality, rhythm, skill, no hesitations, fine commencement and terminal strokes and pressure gradient i.e., uneven pressure at the strokes, emphasis etc. which are acts of genuineness. The questioned writing and signatures produced by the imitational software based digital writing machine display bizarre even pen pressure present on up and down strokes, drawn in movement with drag strokes, lack of rhythm and smoothness/sharpness in strokes and curves, poor line quality, no change in pressure gradient, the faint tremors and hesitations, blunt strokes and absence of tapered strokes and defects in minute and inconspicuous features proposing the questioned writing and signatures were not freely and uninhibitedly written. Writings produced by an imitational software based digital writing machine can be distinguished from freely written genuine human handwritings and signatures because such imitated writings do not have natural variations as compared with human writing and signatures which have natural variations. The proposed research serves to an empirical new challenge for questioned document scientists with everchanging and evolving writing technology.

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## Conflict of Interest

The authors state no conflict of interest.

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