Identifying Personality Traits, and Especially Traits Resulting in Violent Behavior through Automatic Handwriting Analysis

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ABSTRACT

Handwriting analysis is a process that has been carried out for centuries. But its effectiveness when analyzing the behavior and personality of an individual is still a debate. Is it possible to detect potential deviant behavior and personality traits of an individual by carrying out an analysis of his/her handwriting? There are two methods of handwriting analysis: Graphology is the method of psychological analysis, while forensic document examination or handwriting identification which is the examination of documents and writing samples by a known source, or person. In this paper we have carried out research of the various state of the art technologies available in analyzing an individual's behavior based on their handwriting and the effectiveness of predicting the character and personality of that individual. We also wanted to determine if we can uncover handedness, authorship and gender through analysis. Apart from working on Lewinson-Zubin method of analyzing handwriting, various online tools are also available for handwriting analysis, such as: NEURO SCRIPT, WANDA, CEDAR-FOX, and Gaussian Mixture Model.

I. INTRODUCTION

Handwriting analysis is also known as graphology which is a method of identifying the traits related to an individual. It helps in understanding personality traits through the strokes and patterns revealed by handwriting. It can reveal traits such as emotional and mental instability, which can further lead an individual to engage in deviant behavior.

Handwriting is unique to every individual, regardless of the word formation of an individual's handwriting; the shape of the character is will remain the same. This is applicable to all languages.

Forgery of another person's handwriting can easily be identified by proper forensic examining characteristics like pen pressure and shakiness. Theoretically, it is difficult to determine personality especially when it is related to forensics. This is because current automated systems are preprogrammed by humans. Another reason why it may be difficult to accurately examine handwriting samples is the fact that there is no threshold or scale available which can accurately provide the results of the analysis. The automated pattern recognition system also may need training on few samples so that they can get the scale and do the analysis for the next available scanned samples.

Determining handwriting and signature through forensic examining has been successful to some degree. However there have been many instances in handwriting analysis where a forensic handwriting expert will compare handwriting on the basis of clear sets of characteristics and cannot make any relation between the handwriting characteristics and the personality traits because accuracy is the major issue in such forensic examining.

The main focus of this study is to examine known technology that can identify or predict personality traits, as well as those technologies that identify and authenticate handedness, authorship, gender using handwriting samples. What do experts say on how accurately handedness and gender can be determined from handwriting? And what can be said about determining from handwriting samples whether a person will commit violent crimes?

We will also reference several implementations of the different methodologies/technologies and techniques, which shows some degree of significance in the assessment of one's personality.

The technologies discussed in the latter part of the study demonstrate that despite the algorithms applied in attempt to aid handwriting analysts in their study, they all seem to lack a complete vision and may only linearly approach the problem, particularly, the strategy used to produce the best possible results, none of the tools were capable of accurately predicting deviant behavior. Handwriting analysis is not a science where inputs into any system will produce a 100% accurate output.

Different aspects of the analysis must be taken into consideration, such as the time the questioned document was written, and the individual's state of mind whilst writing the letter may have been compromised by anger. These factors play an important role. However, they are hard to determine while carrying out an analysis.

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II. LITERATURE REVIEW

In our literature review we will focus on forensic technique which can play a key role in providing evidence, especially in fraud, identity theft, and murder cases and how forensics experts determine authorship, handedness, amongst other traits.

Research has shown that handwriting analysis can tell a lot about an individual from their handwriting.

Forensic investigators use handwriting technology to determine personality traits of an individual. Different companies use graphology (handwriting analyzing) to check "job applications, recruitment, marriage compatibility, and career guidance, motivate workers, and child development". [9].

It is also stated that an individual's, social status, environment, psychological health, and cognitive development are also a part of an individual's motives to participate in deviant behavior. Some biological, psychological, and sociological theories have been used as principal classifications to explain interpretations of deviant behavior.

Researchers such as DeLisi and Conis recommend that when using individual factors to explain deviant behavior, experts must take into consideration the individual's personality construction, level of self-control, disposition, and overall level of psychopathic disposition. An individual's social development is said to be one of the biggest element in predicting violent criminal behavior [4].

A link between substandard social dispositions for causation of criminal behavior can also be evaluated by examining the socializing practices and the social ties that is formed within the unconventional or conventional systems of an individual's society setting.

To determine handwriting traits that correspond to particular characteristics, experts study large portions of handwriting samples from known and unknown sources. Apart from human analysis to examine handwriting samples, there have been numerous technologies developed recently to assist handwriting experts with carrying out this tedious task. Various studies have validated handwriting analysis as a method of personality assessment, using experiments and scientific techniques.

In our study we examined the current state of technology and how useful these methods can assist handwriting experts when assessing one's personality. Moreover, even though these technologies are available, handwriting assessment will not be fully replaced by an automated system. Human interactions are still needed to carrying out the digitization/processing of the scanned documents to be evaluated.

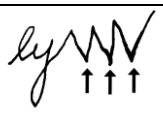
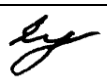
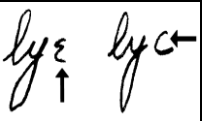
III. OTHER VIEWPOINTS

In determining violent behavior we can also look at criminal behavior from a standpoint such as ecological factors, genetics, social behaviors, biological, bio psychosocial, socio-culture, and even environmental. One's environment can seriously impact deviant behavior. These characteristics are minimal compared to the big picture. We will point out some of the traits in the upcoming tables. We have highlighted a small portion of how forensic experts manually and electronically examine handwriting samples.

Table 1 shows some examples of different personality traits, the writing style of an individual, and the explanation of the traits of one's handwriting. Each trait described in the table can be examined individually and within a group to clarify hints between traits [21]. Akers, et al states that considering an individual's psychological composition in relation to their sociological structure may provide better findings whether personality variables are a major cause of criminal and delinquent behavior [1]. Individuals may choose to participate in deviant behavior for a various amount of reasons and it can be erroneous to attribute the causation of crime solely to the effects of one's personality traits.

A number of Forensic experts use different methodologies to assist in finding statistical information about a person's sex and handedness. For example, Huber and Headrick have identified 21 discriminating elements in handwriting. [9]

TABLE I
EXAMPLES OF PERSONALITY TRAITS

ANALYTICAL THINKING v-wedges for m, n-bottom baseline intersections	*sorts and separates information in assessing their value, evaluates information and supporting patterns*	
BLUNT increasingly heavy downward and forward middle final	*brings matters to a conclusion and thrusts it upon others*	
CONCENTRATION small writing	*focuses attention on one activity ignoring all other influences*	
CULTURAL REFINEMENT middle letter is printed with a capital letter	integration and discrimination of creative artistic and structural systems into one's mode of living	

In forensics, examining the variant shapes of each letter, also known as an allograph can be useful, but sometimes word formation is

TABLE 2
FEMININE HAND WRITING [22]

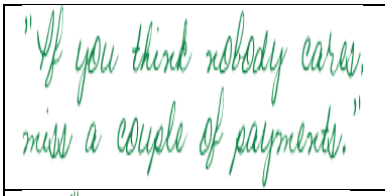
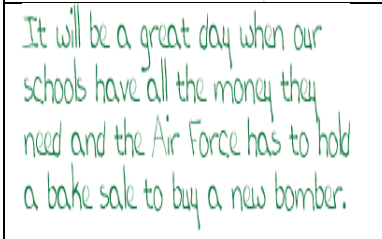
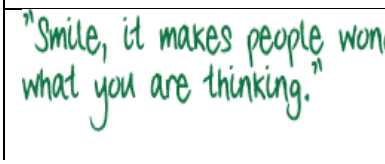
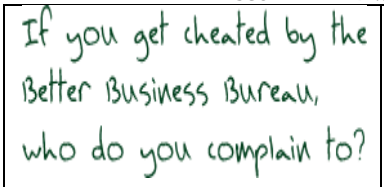
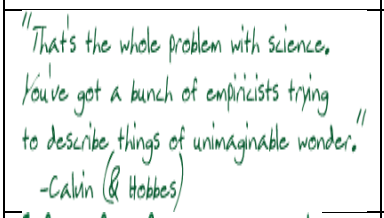
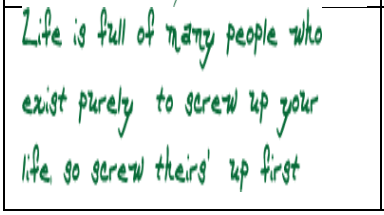
	Noted are the elegant shape of the **o** and **s**, and the fullness of the **counters.**
	There are rounded open **counters** on all the **vowels**. Some letters **slant** backwards, which is considered "feminine" because of the curves and size.
	casual style and has a "feminine" feel because of the **y**, **g**, **n** and **h** letters

TABLE 3
MASCULINE HAND WRITING [22]

	the **m** and **n** shapes have sharp corners rather than arches. The **h** has the same form. The lowercase letters have altered heights and, the letters using circles have different **x-heights**.
	Look at the **a** and **e** shapes on this sample: the **counter** of the **a** and the restricted loop of the **e** can be considered "masculine."
	The additions that start the **m**, **n**, **u**, **y**, and **w** and the straight lines give the handwriting sample a "masculine" assumption.

equally more important for investigating information such as gendering a writer based on their handwriting. Word formations can carry more individuality and patterns than individual letter shapes. There are three basic categories to consider when examining handwriting:

1. **Incline** (slant to the left or right)
2. **Shape** (evenness of letter size)
3. **Form** (roundness)

Current studies show that most English-speaking countries tend to characterize "feminine" handwriting as well-organized, arranged, rounded, petite, decorative and well-proportioned, versus handwriting from "masculine" subjects often gets described as rushed, not lengthy, disordered, sharply irritating, and very bold. Another study suggests that some of these stereotypes cross over into other cultures and writing systems [4]. One early study examined "males who write with handwriting judged to be feminine and vice versa" and concluded their handwriting "is not reliably associated in these studies with femininity or with sexual orientation" [11].

After gather handwriting samples from men and women; we found that women are more careful not to make mistakes and include more information in their answers to certain questions. They are more careful with grammar then males. Males on the other hand write big and answer with one word sentences. Men write much faster and do not put as much care into the documents they are writing. Most men do not care if the message they are writing about is conveyed correctly. However, later studies suggest that most people can discriminate a writer's sex, rather than showing accuracy. A study of handwriting samples from 73 men and 168 women found handwriting tidiness score for men was lower than women. "Masculine Gender role predicts 'sloppy' penmanship and Feminine Gender Role predicts tidy writing, independent of the writers' biological sex"[12].

Another study found that students were able to discern a writer's sex at a higher accuracy level. "It was suggested that sex or gender is present in handwriting in much the same way as it is present in movement of the whole body"[8].

IV. HANDEDNESS, SEX, AND PERSONALITY

Active biometrics techniques such as voice and handwriting have achieved a new role in user authentication systems. Past research has introduced two new methods of analyzing active biometric methods; voice and handwriting, in context of metadata. In handwriting recognition, texts are analyzed by using "global image features and image indexing by automatic page analysis and separation" [18].

Biological metadata describes soft biometrics [2]. Soft biometrics includes hair and eye color or tattoos, clothes and accessories [2] Aspects such as handedness, especially the context of handwriting, the age and the gender are collected using a software interface. The biological metadata can be used to research the physical effects of the handwriting data. The cultural portion of the Meta data collects the background of a person's development.

Other methods of analyzing handwritten documents regarding aspects of an individual's characteristics such as gender or ethnic background have been introduced. For example, handwriting samples of individuals of Indian ethnicity were analyzed for identification and quality based on demographical information about the writer using biometrics [3].

Some ways of measuring handedness is by emulating women and men's handwriting of a certain age and then conducting a comparison of their writing samples. This will give you a look into what forms are used at a certain age or the differences between left handed writers and right handed writers. The personality of a writer subject can also affect the

way someone writes.

According to Niels et al, handwriting can also be divided into writer-specific sub-categories which include gender, handedness, age and ethnicity [15].

V. CURRENT STATE OF TECHNOLOGY

The current state of technology is an expanding topic. Many examiners are looking for new software to get more accurate readings from handwriting examinations. Agencies in the private sector and the public sector are willing to pay top dollar for any software that can do an analysis and have accurate readings. Handwriting identification and analysis has become a norm to the information technology and forensic field.

The technology is used by forensic teams in all law enforcement agencies, by document examiners, and by private companies as well. The available tools are used to help find out the identity of the writer. The questioned documents are used to find forgeries, similarities and dissimilarities of documents, sign of alteration and the authorship of a given document. There are also few software that use handwriting samples to ascertain known personality traits.

Unfortunately there are only a handful of systems to showcase at the present time. With technology growing the numbers are bound to get higher and as the need arises to authenticate one's identity, that has sparked more interest within the forensics community to create accurate automated systems that will aide in the identification process; whether it is to determine gender, age, handedness and authorship and identify personality traits.

A. WANDA

WANDA is a software tool that is used to compare handwriting on the basis of well-defined characteristics and on the knowledge and experience of a forensic expert [10].

Handwriting samples are digitized by the use of an optical device such as a digital camera or scanner or by using an electronic writing tablet or an electronic pen. WANDA involves a set of tools for pre-programmed scanned images, semi-automatic and manual feature extraction, database management, and writer identification analysis. Using the WANDA allograph matcher, the users can manually copy/draw the lines of a scanned handwriting image.

The concept of the WANDA framework is inspired by a number of characteristics such as the need for longitudinal use of forensic annotated handwritten samples that requires a stable and open data representation Extended Markup Language (XML) which has emerged as an ideal format [10].

Numerous attempts were made to acquire a trial copy of the software, but all our attempts were ignored. Doing further research, we have uncovered individuals who have actually bought the software and have done handwriting assessment experiments, as per fig.2.

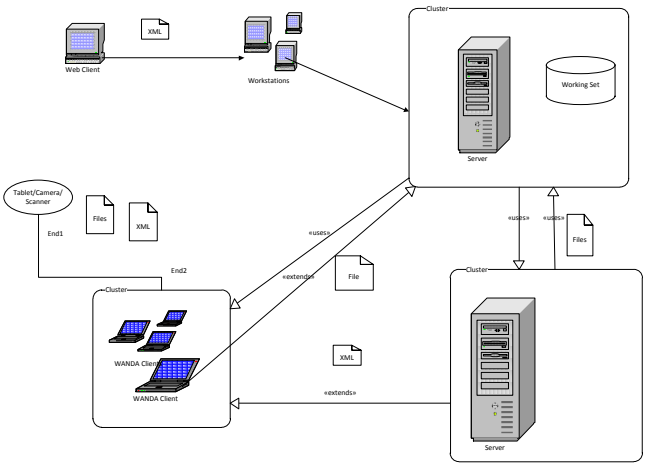


Fig. 1. Plug-In concept for WANDA user interface

B. MovAlyzeR

Fig.2. Screen shot of the WANDA workbench: a prototype system for writer identification. Source: [10]

MovAlyzeR is used to process handwriting images. It can record different paragraphs of writing, segmenting into words, up and down-strokes, pen-lifts and pauses. Each stroke is defined by spatial and dynamic features. Forensic document examiners use MovAlyzeR for comparisons of questioned versus known samples of handwriting. The software also provides tools for handwriting analysts to collect and analyze handwriting movements and assess handwriting performance.

We used a trial version of the MovAlyzeR. The software is broken down into several window panes. The tree view is where the user will interact with the objects and the data. The output pane presents messages while an experiment is being run [23]

In MovAlyzeR, everything revolves around the experiment. The analysis chart provides a look into the result of our experiment. It is a visual representation of the features that were calculated during the processing of the samples. Including, vertical and horizontal sizes, slant, velocity, acceleration, including others [23].

C. Foster and Freeman VSC 6000/HS Desktop Video Spectral Comparator

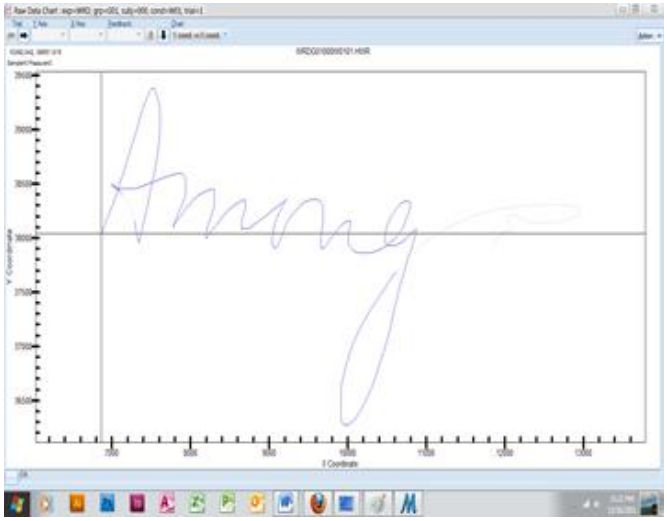


Fig.3. Raw Data of the sample handwriting.

Examining and comparing documents by examiners can be quite diverse and may involve any of the following:
excellent eyesight or the use of a hand lens/loupe: this is used for closer examination of written documents stereomicroscope electrostatic detection device: An electrostatic detection device, or EDD, is a specialized piece of equipment commonly used in questioned document examination to reveal indentations or impressions in paper which may otherwise go unnoticed.

It is a non-destructive method (i.e. the machine will not damage the evidence in question) which allows further testing to be carried out. The technique process is very sensitive and is capable of detecting shifts on pages that are a few layers below the top of the page.

Video Spectral Comparator is the NEW VSC 6000/HS desktop video spectral comparator is a complete digital imaging system providing the questioned document examiner with an extensive range of facilities for detecting irregularities on altered and counterfeit documents [24].

D. CEDAR-FOX

CEDAR-FOX is a system for analyzing scanned, handwritten documents. It is also used for searching repositories of handwritten documents, writer verification/Identification, document properties, and Signature Verification of Questioned Document Examination. The system can help experts' measure features from a questioned document or documents in a database, by increasing the image quality of a document and marking the written text [20].

CEDAR-FOX help experts decrease the number of possible writers that need to be inspected. Identification of the writer of a questioned document, based only on a handwriting sample can be a challenging task, especially for pattern recognition. Recently, the use of automatic methods for writer identification discriminated by forensic examiners [20].

Additionally, image processing technology, tools for pattern recognition and raw computing power have evolved to a higher extent where computer use in this field has become a seamless possibility.

Fig.4. The NEW VSC 6000/HS desktop video spectral comparator Source [25].

E. GMM and SVM Methods

On-line handwriting means that sequential information about the handwriting is available. Two classifiers can be applied to the gender and the handedness classification problem.

The first classifier uses Gaussian Mixture Models (GMMs) to model the classes, while the second approach is based on Support Vector Machines (SVMs). Both classifiers are trained using the same set of features extracted from the handwriting [22].

The ability to identify sub-categories through the handwriting assessment systems may provide analysts with the ability to analyze and compare samples in different regions or languages. The analysis of handwriting, for such purposes of determining gender and handedness, could be applied seamlessly.

F. Lewinson Zubin Scales

Lewinson-Zubin analysis represents four special characteristics of handwriting-vertical, horizontal, depth and composition. Each letter can be analyzed by the above-mentioned characteristics.

The questioned documents are scanned into the analyzer. The L-Z scale system should fill out the different scales automatically. However, the scales were done manually.

In order to analyze each letter of the scanned documents, we cropped the image and removed the unwanted noise (white noise) from the document to be analyzed. Based on the cropped image, the characteristics will be analyzed based on the following: analysis type, one character, one word, two words and line.

The system, after clicking the "run analysis" button, a pop up window must show the results of the scale. However, we were unable to complete the scale analysis. The tools for running the automated system were unavailable. We are

confident that the right programming candidate with enough time can write a code that will allow the L-Z Scale Generator

to function completely. Nevertheless, previous studies have shown that meaningful contents extracted from the L-Z scales provides information about an individual's personality.

Feature extraction and analysis allows a trained professional to look into the disposition of existing personality traits. The

L-Z analysis can help determine different personality traits such as: rational, social-emotional, and the instinctual [15].

G. ForensicXP

Fig. 6. L-Z Scale Generator cropping the intended part of the handwriting sample.

ForensicXP is a digital forensic imaging spectrograph for large-scale document examination used for determining the different types of documents and handwritings using imaging technology. By detecting alterations, forensicFX can reveal the original writing/writer by Luminescence and Reflection spectrum differences [7].

H. FLEX-Tracker

The FLEX-Tracker is handwriting biometric software. The word means Foreign Language Exploitation for Handwritten Documents. It utilizes the graph-based pattern matching technique, which compares dimensions on similar objects across different handwriting samples to identify unique traits of an individual writer. These characteristics include pen strokes, loops, crossed lines, and size which can be analyzed and then explained using a mathematical characterization or "identifier" for each writer [22].

I. U.S. Secret Service FISH

The Forensic Information System for Handwriting (FISH) is a computer-based system that allows document examiners to scan, digitize, measure and store questioned and known handwriting for the purpose of searching the handwriting against previously stored material within a short space of time. The FISH handwriting recognition system is used for searching letters with the intent to threaten, from previously submitted material. It is also used to identify individuals or groups that may pose a threat to elected members, such as members of Congress, and Supreme Court Justices; the Secretary of State, U S. Ambassadors and U.S. Embassies; and state governors. The Secret Service's mission is to provide protection and perform criminal investigations, so it is crucial to have a system such as FISH in place to aide them in the operations.

When the Secret Service receives inputs from Federal, State and local government they will run them through the FISH system. The examiner scans and digitizes an extended portion of the handwriting, which is then plotted as arithmetic and geometric values. If the correspondence is of a threatening nature; it is stored in a vault for future review. A master file is kept and those files refer to threats made to the all past and present President's, Vice President's, and people under the Secret Service Protect order. These stored document samples have been fruitful in identifying criminals who repeatedly make threats and are tied with militant organizations.

Searches are made on images in an offline database, producing a list of probable candidate matches. The questioned writings, along with the nearest matches, are then submitted to the Document Examination Section for validation [17].

In addition to the capability of recognizing authorship, the USSS has related technologies available to help link documents through paper and ink comparisons. A database is maintained with paper specimens that can determine how the paper was processed, what the paper was made from, amongst other characteristics [17].

J. FLASH ID

It is an automated system Approach using Handwriting as a Biometric Identifier. FLASH ID is an FBI handwriting biometric software. FLASH ID is an automated process for extracting graphical data from handwritten documents, and then analyzes the data using well-known statistical methods then matches the documents based on likeness of the denoted writing.

The system extracts features graphically from the written documents from individual letters and characters. The extracted features can be writer-dependent [17].

FLASH ID is able to act on any unknown sample of handwriting and can return the nearest value in its handwriting database and provides the closest match to the questioned writing sample. The FLASH ID's technology is language independent [7].

The ability to allow forensic document examiners harness the power of handwriting assessment system to influence the effectiveness of handwritten documents from different sub-

classes could provide the ability to analyze and compare writing samples, showcasing the similarities that can lead to the identification of the author, across different region or language, could provide an immeasurable benefit to the entire forensic science community.

This system is currently being used by a leader in graph based pattern technology called Gannon Technology Group.

K. WriteOn

This software was created to search, collect, dissect, and manage enormous amounts of document. WriteOn was meant to assist forensic document examiners (FDE) in analyzing handwriting, but now has tools that help all professionals in cataloguing and collecting many types of documents [21].

Enforcement agencies use it to collect, report, tabulate and report on evidence. The Forensic document examiners also use the software to review, assess, dissect, and look at variations in handwriting. Once they receive the information they report their findings.

The software makers note that Write-On is not an optical character recognition (OCR) application, and it does not compare documents through metrics. This design was not intended to replace expert witness.

VI. CONCLUSION

A study was done for the purpose of identifying personality traits through automatic handwriting analysis and the current technology available for such process. Identification of personality traits through handwriting samples can be done both by humans and by machines.

In this study we covered topics that can be determined from handwriting samples-gender, handedness, education, age, country, all of which are useful in forensics- by using different current state-of-the art technologies.

Our work has employed different handwriting features some used in forensics. Unfortunately, we unable to automate the Lewinson-Zubin scales for testing of handwriting samples for the purpose of uncovering traits which may lead to deviant behavior.

During the research process we manually gathered multiple samples of criminals who were violent and compared them to non-violent felons. This process uncovered characteristics that were the same and those that differed. The comparisons were helpful in determining if an individual had the potential to further commit violent crimes. One could argue that a carefully manicured handwriting analysis software program with the ability to input characteristics of the subject in question can be fruitful in determining one's potential to commit violence. The software can have background history, race, birthplace, genes, social status, religious beliefs, etc. as categories to look for.

There is a need for an automated handwriting system that evaluates personality traits extend the research presented in this paper, because the current state of technology is insufficient, and human research in the field could be further validated with this solution.

VII. FUTURE WORK

The ultimate point of the research is to Identify Personality Traits, and Especially Traits Resulting in Violent Behavior, through Automatic Handwriting Analysis. More work can be done on the Lewinson–Zubin handwriting analyzer by making it fully functional and allowing the analyzer to automatically take the scale based on the scanned image.

Extending the program will analyze samples and find characteristics in an individual's handwriting. Coupled with analysis done in the application, we should be able to determine if there are any characteristics which demonstrate a potential for violence.

Finding the Slant of the letters which plays a major role in determining the personality traits of an individual is also a major challenge which can be done as a future part of the project. From that, we should be able to establish conclusions on whether we feel this is a possible method for personality assessment.

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COLLECTION OF VARIOUS
-> HINDUISM SCRIPTURES
-> HINDU COMICS
-> AYURVEDA
-> MAGZINES

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