

# Scanned Images:

How Well Do They Depict  
the Subtle Features in  
Handwriting?

For Presentation at the  
**Measurement Science and Standards in  
Forensic Handwriting Analysis Conference**

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NIST Campus  
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Janet Fenner Masson  
Forensic Document Examiner  
908 Town and Country Blvd., Suite 120  
Houston, TX 77024

713-973-7552

This project is not intended to be an inquiry into parameters document examiners should use in scanning documents for their own records. Rather, it studies digital images captured by companies and agencies in maintaining records – images that are sometimes submitted for examination.

# Changes in Technology Present New Challenges

Historical changes and/or improvements in  
document production and preservation

- 1) Originals
- 2) Carbon Copies/NCR Copies
- 3) Photostats
- 4) Photocopies
- 5) Fax Copies
- 6) Storage as Digital Files

What is the best evidence to examine when the original has been destroyed? Is a digital file better than a photocopy?

# Some Definitions:

## PPI vs. DPI

often used interchangeably

PPI - pixels per inch, measures image resolution (i.e., resolution on the screen)

DPI - dots per inch, measures output resolution (i.e., resolution on the print)

# Lossless file formats v. Lossy file formats

Files scanned for document preservation are typically stored as tiff (tif) or pdf files, both of which are lossless.

At the time the majority of this research was conducted (late 2010 through 2011), I found no companies or agencies that routinely scanned documents for storage in parameters other than black and white or at resolutions higher than 200 ppi.

Since that time, some organizations have upgraded the parameters used for scanning.



Documents stored by Harris County (Texas) are now scanned as black-and-white images at a resolution of 300 pixels per inch, are stored as tiff files, and are not compressed.

(Prior to mid-2012, their documents were scanned at a resolution of 200 ppi.)

Bank personnel I contacted were all unsure of the scan resolution used by their facilities, but scanning was generally outsourced.

Banking industry literature suggests that the scans are at 200 ppi or less and are in black and white.

Many organizations and companies have this task done off-site and by a company that specializes in scanning (called outsourcing).

Official records for Harris County, Texas (the county in which Houston is located) are scanned in-house.

# The Project

# Writing Instruments Used

Uni-ball Vision Rollerball w/blue ink  
Zebra F301 ballpoint pen w/black ink  
Zebra F301 ballpoint pen w/red ink  
Sanford Sharpie marker w/brown ink  
Sanford Sharpie marker w/black ink

## **Paper Used**

- Plain white bond paper
- Ruled yellow legal-pad paper

## **Scanner Used**

- Hewlett- Packard Pro 8500 flatbed scanner

# Procedure

- Two sample sheets were prepared.
- Each was scanned in color, in grayscale, and in black-and-white mode at resolutions of 100 ppi, 200 ppi, and 300 ppi and each scan was stored as a tif file.
- The scanning process was repeated and each scan was stored as a pdf file.
- Each black-and-white image was attached to an e-mail and sent from one e-mail address to another, where it was stored. The newly-stored image was then attached to a new e-mail and was transmitted again.

# Characteristics Examined

- Lightly-written connections or upstrokes
- Stroke directions
- Initial and terminal strokes
- Diacritical marks and punctuation marks
- Replication of overall line quality
- Letter designs
- Replication of internal proportions of letters
- Height and spacing relationships



# Two Sample Sheets

Unihell Vision Blue

Zebra F301 Black BP

Zebra F301 Red BP

Sanford Sharpie Brown

Sanford Sharpie Black

ABCDEFGHIJK

Our London Business is good

ABCDEFGHIJK

Our London Business is good

ABCDEFGHIJK

Our London Business is good

ABCDEFGHIJKL

Our London Business is good

ABCDEFGHIJK

Our London Business is good

~~Unihell~~ Unihell Vision Blue

Zebra F301 Black BP

Zebra F301 Red BP

Sanford Sharpie Brown

Sanford Sharpie Black

Our London Business is good

Our London Business is good

Our London Business is good

Our London Business is good

Our London Business is  
ABCDEFGHIJK <sup>good</sup>

ABCDEFGHIJK

ABCDEFGHIJK

ABCDEFGHIJK

ABCDEFGHIJK

Color  
300 ppi, pdf file



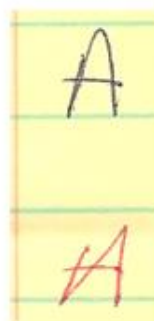
Color  
300 ppi, tif file



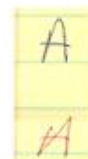
Color  
200 ppi pdf file



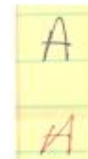
Color  
200 ppi tif file



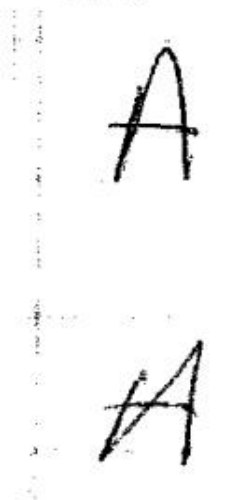
Color  
100 ppi pdf file



Color  
100 ppi tif file



B&W  
300 ppi, pdf file



B&W  
300 ppi, tif file



B&W  
200 ppi pdf file



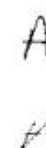
B&W  
200 ppi tif file



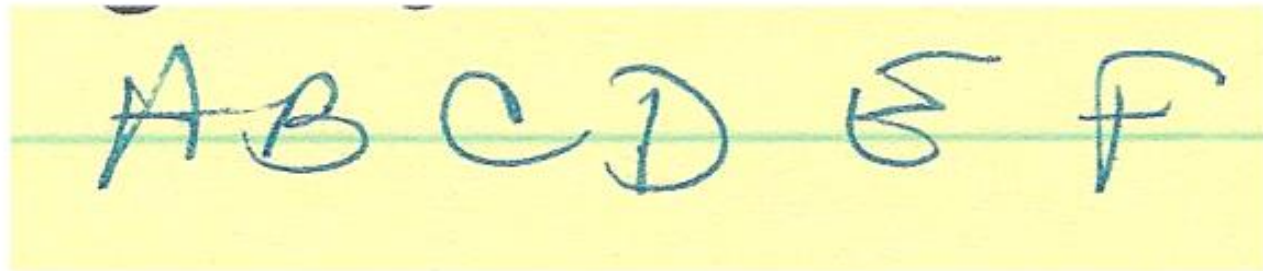
B&W  
100 ppi pdf file



B&W  
100 ppi tif file



Color Scan - at 300 ppi



B&W Scan - at 300 ppi



Color Scan - at 200 ppi

A color scan of a piece of yellow paper with a horizontal green line. The letters 'A', 'B', 'C', 'D', 'E', and 'F' are handwritten in blue ink. The scan is at 200 ppi. The letters are clearly defined against the yellow background.

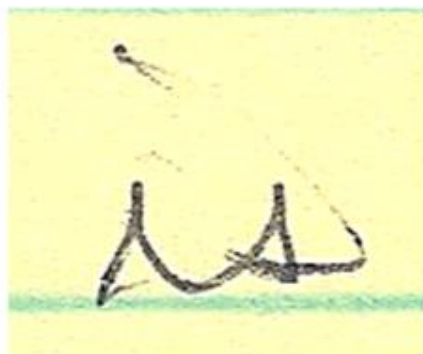
A B C D E F

B&W Scan - at 200ppi

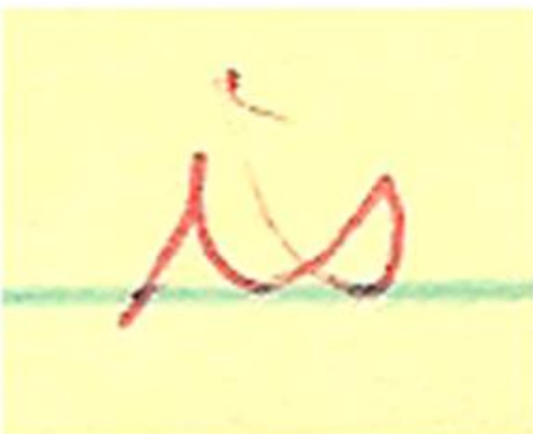
A black and white scan of the same handwritten letters 'A', 'B', 'C', 'D', 'E', and 'F' on a yellow background. The scan is at 200 ppi. The letters are rendered in black, and the background is white, showing some noise and artifacts from the scanning process.

A B C D E F

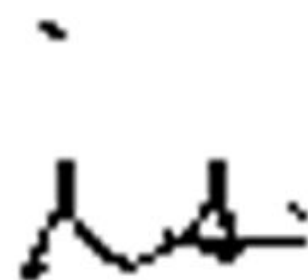
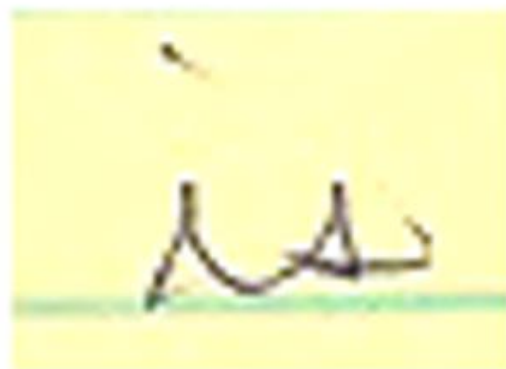
300 ppi



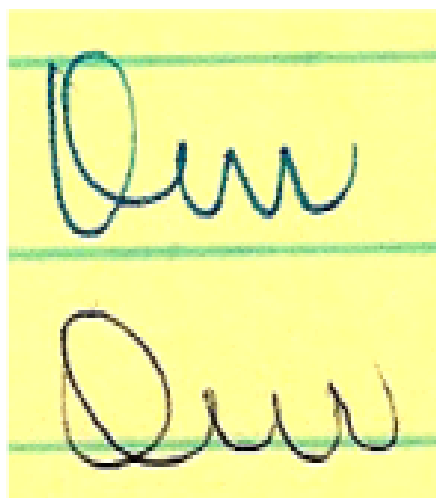
200 ppi



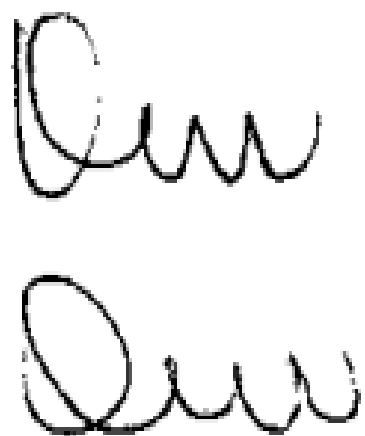
100 ppi



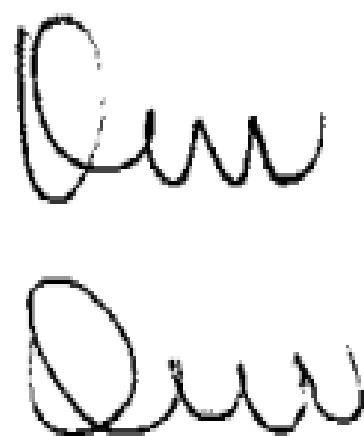
Color - 200 ppi  
tif file



B&W - 200 ppi  
pdf file



B&W - 200 ppi  
tif file





*Dear London Business*

Black & White Scan  
200 ppi

*Dear London Business*

Grayscale Scan  
200 ppi

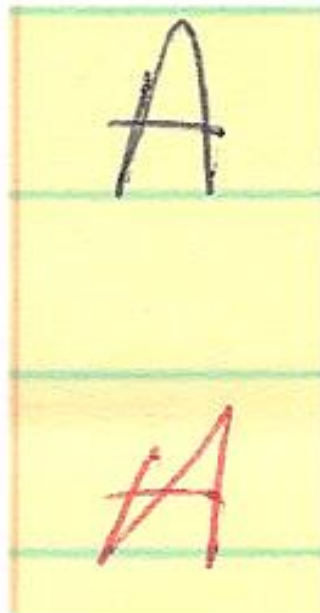
*Dear London Business*

Color Scan  
200 ppi

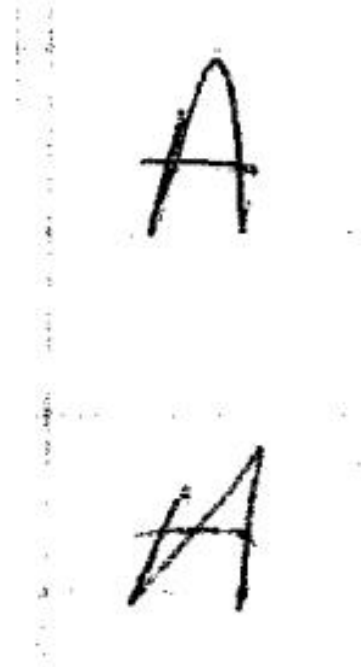
Color  
300 ppi, pdf file



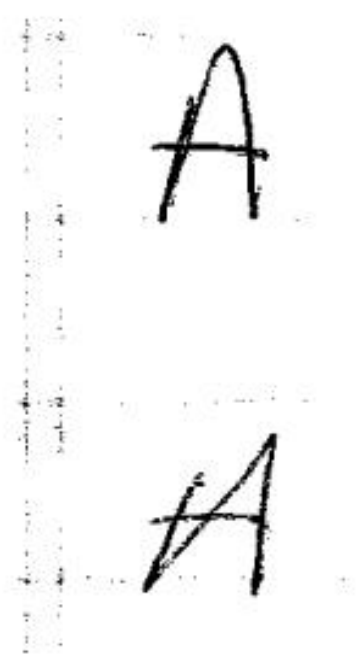
Color  
300 ppi, tif file



B&W  
300 ppi, pdf file



B&W  
300 ppi, tif file



Vision

Blue

100 PPI

Vision

Blue

200 PPI

Vision

Blue

300 PPI

Color  
300 ppi  
Bond paper - pdf



B&W - 300 ppi  
Bond paper - pdf file



After 1 e-mail  
transmission



After 2 e-mail  
transmissions



First Generation  
Photocopy made  
on HP Officejet Pro 8500

25  
PAY  
TO THE  
ORDER OF ABFDE

Two hundred fifty

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TEXAS  
wellsfargo.com

FOR Annual Fee #221

Copy of image from  
bank, enlarged to  
duplicate size of  
copy above

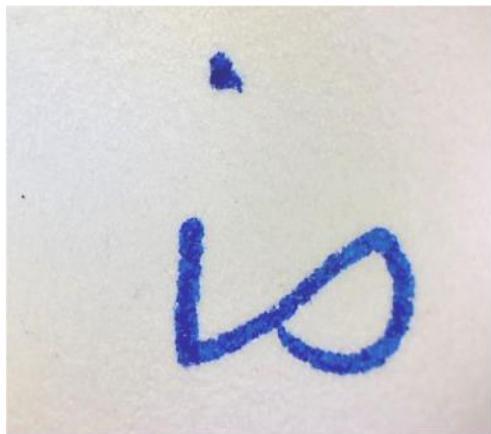
PAY  
TO THE  
ORDER OF ABFDE

Two hundred fifty

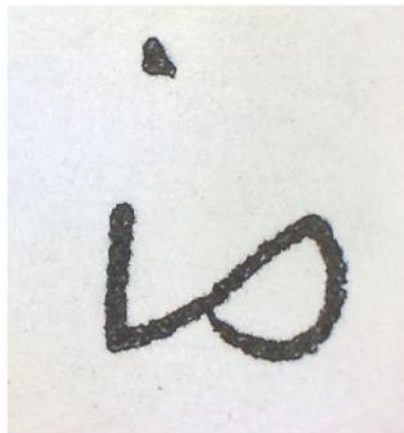
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TEXAS  
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FOR Annual Fee #221

Original



1st Generation  
Photocopy



B&W Scanned Image  
300 ppi



# The Results

- 1) Features such as letter designs, internal proportions of letters, and height/spacing relationships were typically accurately depicted, even on images scanned at low resolution.
- 2) Black-and-white scans often have deficiencies in their replication of subtle writing features, including lightly-written strokes, the presence of connections between letters, the character of initial and terminal strokes, diacritical marks, and line quality.

- 3) The lower the resolution, the worse the image. Images scanned in color are consistently significantly better than those scanned in black-and-white mode.
- 4) Images of documents scanned using grayscale parameters are better than those scanned in black and white, but not as good as those scanned in full color.
- 5) Features of the paper, such as ruled lines and folds in the paper, are often not well-depicted in images scanned in black and white.



- 6) No differences in the reproduction of handwriting features were found between the images of handwriting stored as tif files and those stored as pdf files when the two scans were made at the same resolution and using the same mode.
  
- 7) No noticeable deterioration was found in the scanned tif and pdf files as a result of sending them as attachments to e-mail.

# Recommendations

- The original document is always the best evidence.
- If the original is not available, but a photocopy was made directly from the original, obtain it.
- The closer you can get to the original, the better. Receiving the digital image as an e-mail attachment is likely going to provide more information than a print made from that digital image.
- Remember what may be missing.

Images of documents captured by scanning often provide useful information about the handwriting.

When the original has been destroyed or is not available for examination, the digital image of the document should not be disregarded.

While there are limitations inherent in the examination of scanned images, in many instances these images (especially images scanned in color and/or higher-resolution scans) are sufficient for a reliable evaluation of the handwriting.