

## TECHNICAL NOTE

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# Color Separation of Signature and Stamp Inks to Facilitate Handwriting Examination

**ABSTRACT:** The questioned documents laboratory often encounters cases where handwriting that is to be examined intersects with some interfering factor such as a rubber stamp, typewriting or background printing. In these cases, line direction, beginning and ending features of letters and other fine details of the handwriting may be lost in the “noise” of the intersecting ink. The purpose of this paper is to show several new digital photography methods that may be used to “subtract” the effect of the intersecting ink, thereby enhancing that of the handwriting ink in order to enable the document examiner to conduct a complete examination. These methods have the advantage of being fast and do not involve the use of expensive material or equipment.

Several new methods are described that may be used to separate the colors of the handwriting ink from that of the intersecting ink: the analog method and several digital methods such as RGB-HSB-CMYK, L\*a\*b color, and color separation using the Channel Mixer function of Adobe Photoshop.

Successful application of these color separation methods to specific handwriting ink/rubber stamp ink color combinations shows that the effect of the intersecting ink may indeed be minimized if not canceled altogether.

Application of the suggested methods may well make the difference between a nonconclusive handwriting examination and a full analysis of the questioned handwriting.

**KEYWORDS:** forensic science, questioned documents, Adobe Photoshop, digital photography, color models, channels, RGB, HSB, CMYK, L\*a\*b, channel mixer, rubber stamp inks, intersecting lines, handwriting, signatures

In many signed documents such as checks, the signature is often partially hidden by a rubber stamp impression. In order to conduct a handwriting examination of the signatures and compare them with known exemplars, the signature ink must be visually separated from that of the stamp impression, when possible. The photolaboratory’s objective in this case is to filter out the color of the stamp and enhance that of the signature. To this aim, analog methods have been used for many years but have proved only partially successful in separation of very specific color combinations. More recently, the value of digital image processing in questioned document analysis has shown itself useful through various applications in an abundance of questioned document cases (1,2). To the best of our knowledge, however, there are no reports to date of how these image-processing methods can be applied to the separation of rubber stamp inks intersecting with handwritten signatures.

The various combinations of colors of inks and stamps can be categorized as follows: Usually the stamp colors are either black or

purple and the signature ink is usually blue or black. These are the four most common color combinations that will be discussed here. Four methods for dealing with these combinations will be discussed: (1) a traditional analog method, (2) digital methods using the “RGB-HSB-CMYK” models, (3) the digital L\*a\*b color method that is principally useful for separating blue, red or green writing inks from various stamp inks, and (4) the digital method using the “Channel Mixer” function.

### Theory

Much of the theoretical information given below is based on material taken from Adobe® Photoshop’s® ‘Help’ and User’s Guide (3,4).

Dyes and inks that are used with stamps, and those used for signatures, usually contain different color pigments that can be distinguished, “pushed” and subtracted using different color modes and models in Adobe Photoshop.

A color mode in Photoshop determines the color model used to display and print Photoshop documents. Photoshop bases its color modes on established models for describing and reproducing color. Common models include RGB (red, green, blue); CMYK (cyan, magenta, yellow, black); HSB (hue, saturation, brightness); and CIE L\*a\*b\* (Commission Internationale d’Eclairage; lightness and “a” and “b” components). Photoshop also includes modes for specialized color output such as indexed color and duotones.

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Received 23 Dec. 2002; and in revised form 29 April 2003; accepted 10 June 2003; published 25 Sept. 2003.

### RGB Mode

A large portion of the visible spectrum may be described mixing different quantities and intensities of red, green and blue light. Overlap of these colors produces cyan, magenta and yellow.

“Photoshop’s RGB mode uses the RGB model that assigns an intensity value to each pixel ranging from 0 (black) to 255 (white) for each of the RGB components in a color image. For example, a bright red color might have an “R” value of 246, a “G” value of 20, and a “B” value of 50.

When the values of all three components are equal, the result is a shade of gray. When the value of all components is 255, the result is pure white; when the value is 0, pure black” (3); for this reason these colors are known as additive colors. This system is used for lighting, video and computer monitors.

“RGB images use three colors to reproduce up to 16.7 million colors on-screen.” RGB images are three-channel images, so they contain 24 ( $8 \times 3$ ) bits per pixel. RGB is the default mode for all digital images and also for new Photoshop images. Digital cameras and scanners always generate image files using the RGB mode and computer monitors always display colors using the RGB model. Consequently, when working in color modes other than RGB, such as CMYK, Photoshop temporarily converts data into RGB data for display on-screen.

### CMYK Mode

“In Photoshop’s CMYK mode, each pixel is assigned a percentage value for each of the process inks. The lightest (highlight) colors are assigned small percentages of process ink colors, the darker (shadow) colors have higher percentages. For example, a bright red might contain 2% cyan, 93% magenta, 90% yellow, and 0% black. In CMYK images, pure white is generated when all four components have values of 0%” (3).

The CMYK model is based on the light-absorbing quality of ink printed on paper. As white light strikes translucent inks, part of the spectrum is absorbed and part is reflected. The part that is reflected is the “color” the eye observes.

In theory, pure cyan (C), magenta (M), and yellow (Y) pigments should combine to absorb all color and produce black. For this reason these colors are called subtractive colors. Because all printing inks contain some impurities, these three inks actually produce a muddy brown and must be combined with black (K) ink to produce a true black. (“K” is used instead of “B” to avoid confusion with blue.) Combining these inks to reproduce color is called four-color process printing.

The subtractive (CMY) and additive (RGB) colors are complementary colors. Each pair of subtractive colors creates an additive color, and vice versa.

### HSB Model

“Based on the human perception of color, the HSB model describes three fundamental characteristics of color:

- Hue is the color reflected from or transmitted through an object. It is measured as a location on the standard color wheel, expressed as a degree between 0 and 360. In common use, hue is identified by the name of the color such as red, orange, or green.
- Saturation, sometimes called “chroma,” is the strength or purity of the color. Saturation represents the amount of gray in

proportion to the hue, measured as a percentage from 0% (gray) to 100% (fully saturated). On the standard color wheel, saturation increases from the center to the edge.

- Brightness is the relative lightness or darkness of the color, usually measured as a percentage from 0% (black) to 100% (white)” (3). Although the HSB model in Photoshop can be used to define a color in the ‘Color Palette’ or ‘Color Picker’ dialog box, there is no HSB mode available for creating and editing images.

### L\*a\*b Model

The L\*a\*b color model is based on the idea proposed by the *Commission Internationale d’Eclairage* (CIE) in 1931 as an international standard for color measurement. In 1976, this model was refined and named CIE L\*a\*b.

L\*a\*b color is designed to be device independent; it creates consistent color whatever the device (such as monitor, printer, computer, or scanner) used to create or output the image.

L\*a\*b color consists of a luminance or lightness component (L) and two chromatic components: the “a” component (from green to red) and the “b” component (from blue to yellow). It is for this reason that this method is most useful for separating blue, red or green writing inks from interfering stamp inks utilizing the “a” or “b” channels accordingly.

### Automating Tasks

#### Using the Actions Palette

When processing numerous documents of similar composition with Adobe Photoshop, it is preferable to standardize the working process and to automate it as much as possible after the image file of the document has been opened. It is understandable that the process cannot be entirely automated, and in some cases it is necessary to make minor manual corrections.

Adobe Photoshop allows one to automate tasks by grouping a series of commands into a single action. In the work described here, an ‘Action’ may be prepared for applying a standard set of tasks to the rubber stamp and signature inks.

For example, in many cases large quantities of documents are signed with the same ink. It is best to automate the process for separating the signature ink from that of the rubber stamp by using the ‘Actions’ function of Photoshop.

The documents should be digitally photographed or scanned and after determining the photographic conditions, such as aperture and exposure, an ‘Action’ can be built (recorded).

After opening the ‘Actions’ function, the first document is processed step-by-step manually. Each stage is registered and when the best result is achieved the ‘Action’ should be saved (“Atn” format of Photoshop). Subsequently, when the next document is processed, one need only apply the ‘Action’ and not go through each stage manually as with the first document. As long as the current document is indeed similar in color composition to the first, a satisfying result should be achieved with minimal input from the user. Note that ‘Actions’ work best when applied to a group of similar documents, as achieved with the ‘Batch’ function. Once the whole series of documents have been photographed, the recorded ‘Action’ is applied using the File-Batch-Automate functions.

Similarly, each file may be processed separately, examined and corrected if necessary, after using the ‘Action’ function.

### Practical Examples

The examples given below were effective for specific cases of signature and rubber stamp inks involving certain shades of color. Therefore, these are *not* absolute values, but provide a guideline as to which functions should be used, in which order, and at which approximate value. Each case should be treated individually with a trial and error approach plus fine tuning around the values given.

### Analog Method

#### *Method 1: Separation of a Purple Stamp from Blue or Black Writing Ink, Figs. 1, 1a*

This was the traditional way of separating a blue or black ink signature from a purple stamp by an analog method. A dark red filter (e.g., R70) is used with a black and white panchromatic film (e.g.,



FIG. 1—Combination of purple ink stamp and a blue ink signature.



FIG. 1a—Photograph taken through a dark red filter (analog method).

Technical Pan 25 ISO). For this purpose any light source may be used; the exposure time is measured automatically by the camera (e.g., Aperture priority-A).

### Digital Methods

Methods 2–7 describe digital processes that may be applied in order to separate various ink color combinations. Note that the values given were those that worked best for the particular inks examined. As mentioned above, the user should base his color separation attempt on the guidelines given below with respect to order of the functions and approximate levels. Fine-tuning and a trial and error approach are necessary in order to achieve optimum results.

#### Color Separation Using the RGB-HSB-CMYK Models (Methods 2–5)

This method may be successfully used to separate all four combinations of stamp and signature colors as mentioned above, black:black, black:blue, purple:blue and purple:black. It has also been successfully used in other aspects of forensic science such as photography of latent fingerprints (5).

Before processing the image on the computer, it should be scanned or digitally photographed. When scanning the document, a 600 dpi resolution is preferable at a 1:1 scale and using the RGB model. Scanning conditions should be fixed so that the image is not too dark; in this case the stamp would block out the signature.

Incorrect scanning conditions will at best lead to an incomplete separation of the inks' colors, or actually fail to separate them at all.

After scanning, an image is received in RGB mode. The image should be saved in a TIF format or a Photoshop PSD format.

If digitally photographed it is best to use a "Hi" mode setting (for example as appears on the Fuji FinePix S1Pro™ digital camera) with an uncompressed TIF format; a high quality JPEG format can also be used, although use of a low quality JPEG will cause a high compression and unwanted color changes.

All functions of image processing are performed over the whole image surface to protect its integrity.

In the HSB model, the saturation should be increased to around 90% in order to decrease the amount of noise in the image and to increase the color component of the signature. In the next stage, the hue is changed by trial and error in order to separate the signature from the stamp by substituting the original colors with new shades.

As a next step, the file is transferred from an RGB model to a CMYK model in order to achieve maximum separation. The CMYK model includes the black "K" channel, while the CMY channels remain clear of unwanted information. One of the CMY channels should contain information from the signature in gray tones. If no channel produces clean information of the signature, one should return to the RGB model by canceling transfer to CMYK, increase the saturation of the signature ink in the HSB model and reduce the saturation and the brightness of the stamp ink.

Once the channels have been separated and a suitable channel saved as a separate file, the brightness and contrast can be adjusted using the 'Levels' or 'Replace color' function to enhance the signature.

The following section details step-by-step methods for separating four different rubber stamp ink/signature ink combinations based on the color models described above. The stages are shown as they are recorded by Photoshop's "Actions" function.

#### Method 2: Filtering Out of a Black Ink Stamp from a Black Ink Signature, Figs. 2, 2a

Filtering out a black ink stamp from a black ink signature. The files have been named with respect to the colors of the stamps and the signature inks.

##### BLACK-BLACK

###### ▼ Action 1

---

###### ▼ Hue/Saturation

Without Colorize  
Adjustment: hue/saturation adjustment list  
hue/saturation adjustment  
Hue: -180  
Saturation: 86  
Lightness: 10

---

###### ▼ Convert Mode

To: CMYK color mode

---

Select yellow channel

---

###### ▼ Levels

Adjustment: levels adjustment list  
levels adjustment  
Channel: current channel  
Input: 42, 237

---

Split Channels

---

###### ▼ Close

Saving: no

---

###### ▼ Close

Saving: no

---

Select previous document

---

###### ▼ Close

Saving: no

---

###### ▼ Levels

Adjustment: levels adjustment list  
levels adjustment  
Channel: current channel  
Input: 117, 255  
Gamma: 2.18

---

###### ▼ Levels

Adjustment: levels adjustment list levels adjustment  
Channel: current channel  
Input: 51, 191  
Gamma: 1.55

---





FIG. 2—Combination of black ink stamp and a black ink signature

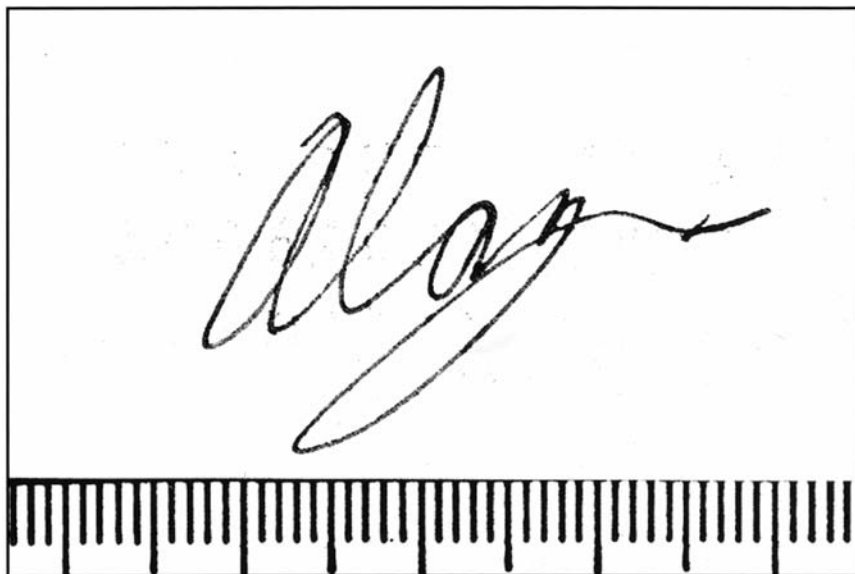


FIG. 2a—Filtering out of a black ink stamp from a black ink signature.

*Method 3: Filtering Out of a Purple Ink Stamp from a Black Ink Signature, Figs. 3, 3a*

## PURPLE-BLACK

## ▼ Action 1

## ▼ Convert Mode

To: CMYK color mode

Select CMYK channel

## ▼ Set Selection

To: all

Select black channel

Delete

Select CMYK channel

## ▼ Set Selection

To: none

## ▼ Hue/Saturation

Without Colorize

Adjustment: hue/saturation adjustment list

hue/saturation adjustment

Local Range: 6

Begin Ramp: 250

Begin Sustain: 280

End Sustain: 315

End Ramp: 345

Hue: 109

Saturation: 34

Lightness: -55

Split Channels

## ▼ Close

Saving: no

## ▼ Levels

Adjustment: levels adjustment list

levels adjustment

Channel: current channel

Input: 80, 220

Gamma: 1.03

Select black channel

Delete

Select magenta channel

Select CMYK channel

Select magenta channel

Select CMYK channel

## ▼ Hue/Saturation

Without Colorize

Adjustment: hue/saturation adjustment list

hue/saturation adjustment

Local Range: 6

Begin Ramp: 231

Begin Sustain: 261

End Sustain: 315

End Ramp: 345

Hue: 0

Saturation: 0

Lightness: 100

## ▼ Convert Mode

To: grayscale mode

## ▼ Levels

Adjustment: levels adjustment list

levels adjustment

Channel: current channel

Gamma: 1.54

## ▼ Set Selection

To: none

## ▼ Replace Color

Fuzziness: 20

Minimum: grayscale

Gray: 15.29

Maximum: grayscale

Gray: 15.29

Lightness: 67

## ▼ Levels

Adjustment: levels adjustment list

levels adjustment

Channel: current channel

Input: 135.255

*Method 4: Filtering Out of a Purple Ink Stamp from a Blue Ink Signature, Figs. 4, 4a*

## PURPLE-BLUE

## ▼ Action 1

## ▶ Convert Mode

Select yellow channel

## ▼ Set Selection

To: all

Delete

*Method 5: Filtering Out of a Black Ink Stamp from a Blue Ink Signature, Figs. 5, 5a*

Blue ink signatures may be separated from black ink stamps using several methods with different degrees of success. Three methods are detailed below that give similar results and may be applied according to the operator's choice; the same source is shown, Fig. 5, with three resultant separations, Figs. 5a, 6a and 7a. It should be noted that the Channel mixer method is the most universal and flexible method, applicable for most if not all of the possible ink color combinations.



FIG. 3—Combination of purple ink stamp and a black ink signature.

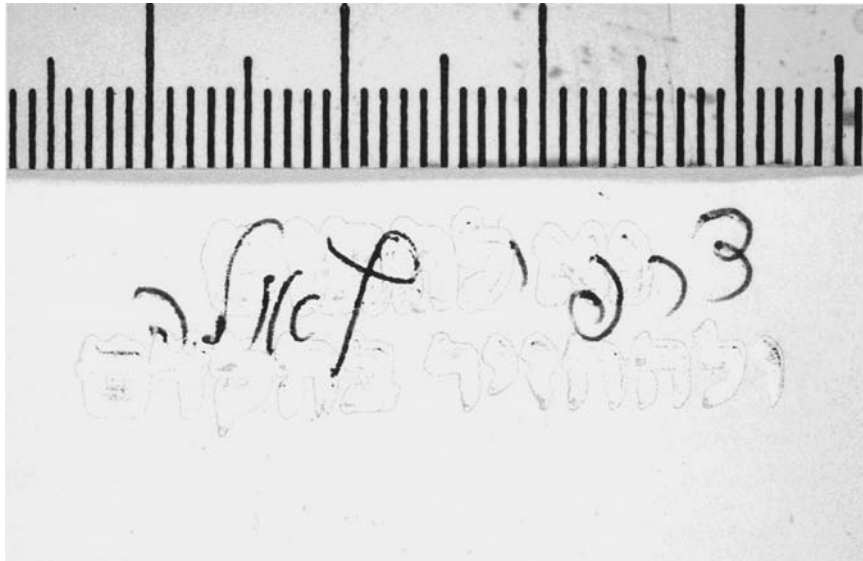


FIG. 3a—Filtering out of a purple ink stamp from a black ink signature.



FIG. 4—Combination of purple ink stamp and a blue ink signature

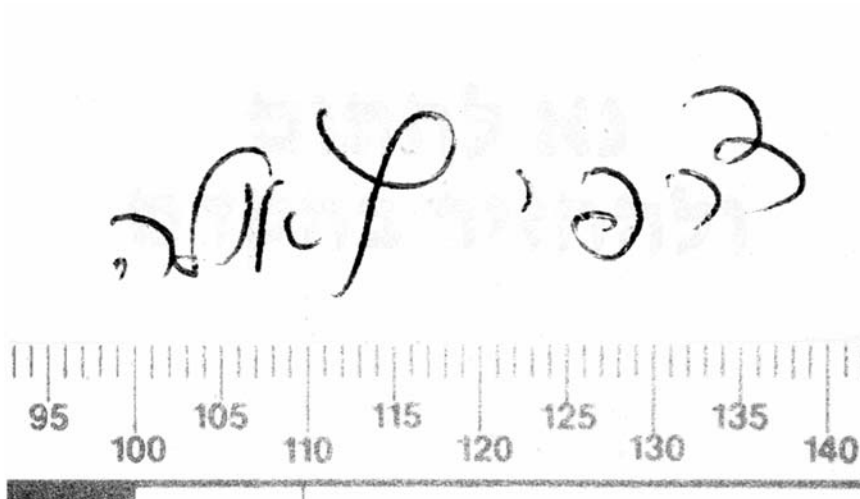


FIG. 4a—Filtering out of a purple ink stamp from a blue ink signature.



FIG. 5—Combination of black ink stamp and a blue ink signature

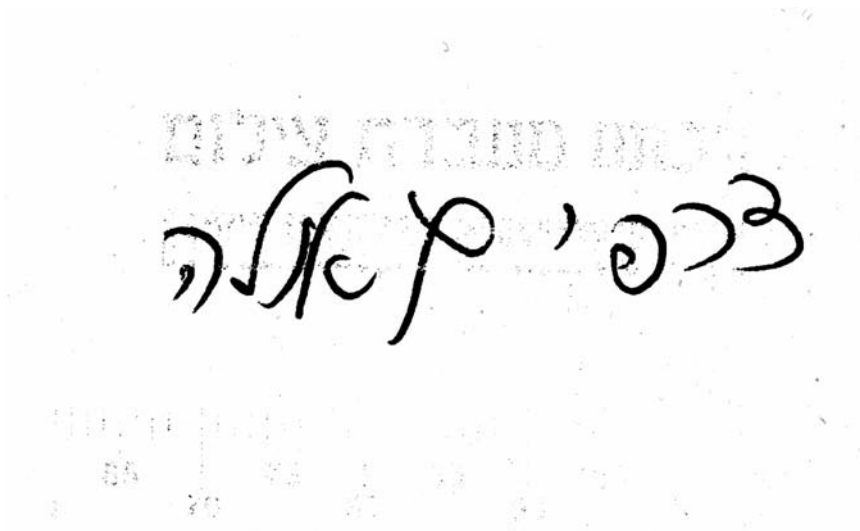


FIG. 5a—Filtering out of a black ink stamp from a blue ink signature.



BLACK-BLUE

- ▼ Action 1
 

---

  - ▼ Hue/Saturation
 

---

 Without Colorize  
 Adjustment: hue/saturation adjustment list  
 hue/saturation adjustment  
 Hue: -180  
 Saturation: 86  
 Lightness: 10
  - ▼ Convert Mode
 

---

 To: CMYK color mode
  - Select yellow channel
  - ▼ Levels
 

---

 Adjustment: levels adjustment list  
 levels adjustment  
 Channel: current channel  
 Input: 42, 237
  - Split Channels
  - ▼ Close
 

---

 Saving: no
  - Select previous document
  - ▼ Close
 

---

 Saving: no
  - Select previous document
  - ▼ Close
 

---

 Saving: no

*Color Separation Using the L\*a\*b\* Color Method*

This is a simple and efficient method for separating *blue* signatures from stamps, based on the L\*a\*b\* color model.

This model is based on a lightness channel (luminance) and two color channels (chromatic): a=green-red axis, b=blue-yellow axis (3).

*Method 6: Filtering Out a Black Ink Stamp from a Blue Ink Signature Using the L\*a\*b\* Color Model, Figs. 5, 6a*

BLACK-BLUE Lab color

- ▼ Action 1
 

---

  - ▶ Levels
 

---
  - ▶ Convert Mode
 

---

 Select b channel
  - Split Channels
  - Select previous document
  - ▶ Close
 

---

 Select previous document
  - ▶ Close
 

---
  - ▶ Levels
 

---

*Separation Using the Channel Mixer*

The use of the channel mixer function has been well recorded in the field of enhancing fingerprint evidence (6).

This method may also be used to successfully separate any of the given signature/stamp combinations. The “Channel Mixer” is

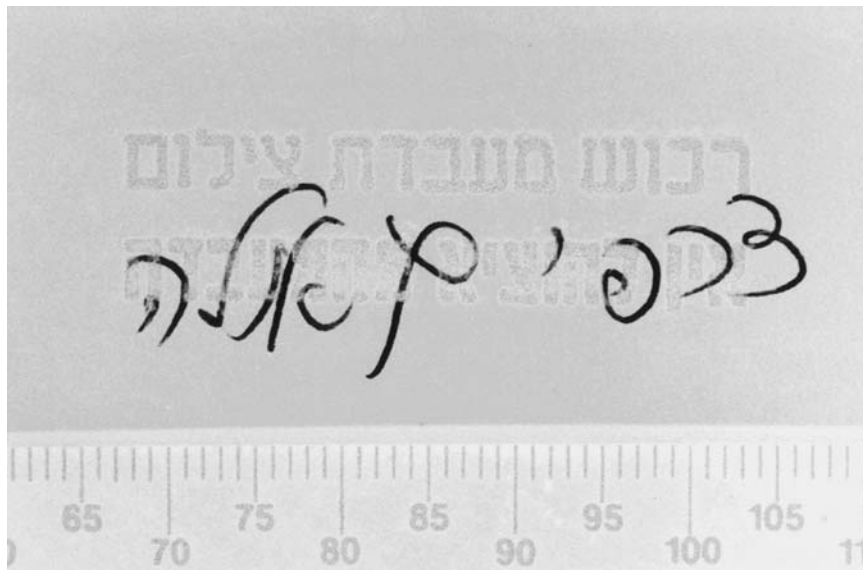


FIG. 6a—Filtering out of a black ink stamp from a blue ink signature using the L\*a\*b\* Color model.

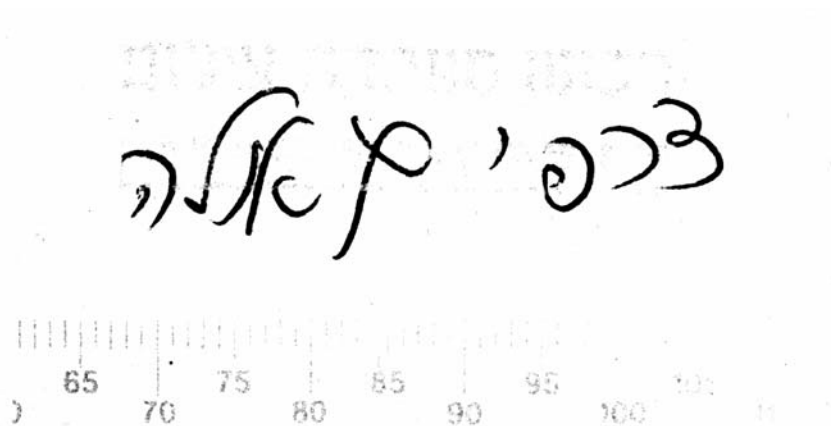


FIG. 7a—Filtering out of a black ink stamp from a blue ink signature using the Channel Mixer.

meant for accurate color fixing. The principle of its function is to mix information by percentage, from  $-200\%$  to  $+200\%$  of all channels in the RGB and CMYK models.

*Method 7: Filtering Out of a Black Ink Stamp From a Blue Ink Signature Using the Channel Mixer, Figs. 5, 7a*

#### BLACK-BLUE Channel Mixer

##### ▼ Action 1

##### ▼ Convert Mode

To: CMYK color mode

##### ▼ Channel Mixer

With Monochromatic

Output Black: is a mixture of

Cyan: 200

Magenta:  $-64$

Yellow:  $-142$

Black: 54

##### ▼ Convert Mode

To: grayscale mode

##### ▼ Levels

Adjustment: levels adjustment list

levels adjustment

Channel: current channel

Input: 60, 255

Gamma: 1.04

#### Equipment

1. Digital camera (minimum 3 mega pixels) or scanner with 600 lpi (lines per image) optical resolution.
2. Adobe Photoshop software, version 5.0
3. Quality printer using continuous shade technology or digital minilab.

#### Conclusions

When using analog technology in the photographic separation of an inked signature from the ink of a rubber stamp, one is confined to the use of certain light sources, filters and films. Furthermore, the photographer can only assess the success of the photograph once it has been developed, a process that demands time and use of material.

Digital photography and image processing software enable the photographer to view the resultant photograph in real time. An unsuccessful image can be discarded at the touch of a button with little waste of time and effort, whereas a quality photograph can be enhanced and processed using different color models and functions as described above, thereby enabling the document examiner to complete a handwriting comparison that previously would have been highly limited and confined.

Whereas using the analog method, only very specific combinations of colored ink may be separated, using digital photography and software such as Adobe Photoshop, most, if not all of the common ink color combinations can be successfully separated. Each case should be approached individually until a satisfactory separation is achieved using one of the color models mentioned above. It should be noted that the Channel Mixer method has been found to be the most universal.

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