With the primary color separations of the input document stored as described above, color differences can be detected by combining two or more of the color separations into a resulting monochromatic image and then enhancing the resulting color differences. The combination of the separations exposes small color differences that are not detectable in any of the individual separations, thus enabling the photocopier signature to be detected.

In particular, with reference to FIG. **4**, the image processing unit **24** includes a controller **30** that i) parses the RGB color separations on a pixel-by-pixel basis, ii) performs mathematical operations on the corresponding pixels of the color separations to generate at least one output image, and iii) enhances the output image before it reaches the image output terminal **26**.

The controller generates at least one output image by calculating the differences between corresponding pixels of various combinations of the RGB color separations. In the embodiment being described, a first monochromatic output image **34** is generated by subtracting the video values of the green separation from the video values of the blue separation on a pixel-by-pixel basis. That is, the output image **34** is generated from:

$$D1_{m,n}=B_{m,n}-G_{m,n},$$

where $D1_{m,n}$ is the resulting video value of the nth pixel in the mth row of the output image **34**, $B_{m,n}$ is the video value of the nth pixel in the mth row of the blue separation bitmap, and $G_{m,n}$ is the video value of the nth pixel in the mth row of the green separation bitmap.

The pixel values of the output image **34** can mathematically fall within a range of -255_{10} to $+255_{10}$. However, because the pixel values of the output image **34** represent a difference between corresponding pixels of the color separations, the values of the pixels fall together within a much smaller range. As a result, the scale can be significantly expanded around the grouping of pixel values without losing a significant amount of information. One way to keep the difference values within the same range as the individual separations is to simply discard the few pixels values that fall outside of the range of -128_{10} to 127_{10} are simply discarded. Another way is to simply divide $D1_{m,n}$ by 2. With the first method, some pixel values are lost at the extremes of the dynamic range, and with the second method, dynamic range resolution is lost overall. However, either method works fine for this purpose.

Applying known histogram equalization and/or histogram stretching techniques to the output image enhances the contrast of the output image **34**. In the embodiment being described, a simple histogram stretch of the minimum value to 0 and the maximum value to 255 provides satisfactory results. The image processing unit **24** then outputs the contrast-enhanced image to one or more of the printer, the visual display and/or the image storage device.

The dot patterns representing the photocopier-specific information may not be seen in the monochromatic output image **34**, depending upon the color(s) of the dot patterns, the document substrate, and the photocopied image. Accordingly, it may be necessary to generate a second monochromatic output image **36** by combining the color separations in a manner different from that of the first output image **34**. For instance, the second output image **36** can be generated by subtracting the pixel values of the red separation from the pixel values of the blue separation on a pixel-by-pixel basis. That is, the output image **36** is generated from:

$$D2_{m,n}=R_{m,n}-B_{m,n},$$

where $D2_{m,n}$ is the resulting video value of the nth pixel in the mth row of the output image **36**, $R_{m,n}$ is the video value of the nth pixel in the mth row of the red separation bitmap, and $B_{m,n}$ is the video value of the nth pixel in the mth row of the blue separation bitmap.

In addition to generating the first and second monochromatic output images **34**, **36**, the controller can generate additional output images **38**, etc. based on some or all of the various other combinations of RGB color separations. Some additional combinations of the color separations include R−G; (R+G)/2−B; (R+B)/2−G; (G+B)/2−R; etc. The contrast between the dot patterns and the document substrate and photocopied color image, should be large enough in one or more of the plurality of output images to permit accurate identification of the photocopier-specific information.

It is contemplated that the controller can automatically generate any number of different output images **34**, **36**, **38**, etc. from different combinations of the color separations. A user of the system **20** can selectively display and/or print individual monochromatic output images to determine on which output image the dot patterns are most visible. Alternatively, all of the output images that are generated can be automatically or selectively printed and/or displayed for inspection.

It should be appreciated that the method for detecting copier tracking signatures of the present invention can also be used to authenticate documents produced by color photocopiers. In particular, an input document can be authenticated by analyzing the dot patterns on the input document in the same manner as described above.

The invention has been described with reference to the preferred embodiment(s). Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

For instance, the method for detecting copier tracking signatures of the present invention can be implemented in hardware, software, firmware, or any combination thereof. Further, any number of hardware buffers or software buffers may be used to accomplish the method of detecting copier tracking signatures of the present invention.

Further, it is contemplated that any number of different difference combinations between the various color separations can be utilized to detect the dot patterns.

Having thus described the preferred embodiment(s), the invention is now claimed to be:

1. A method of detecting a latent photocopier tracking signature printed in yellow on a document produced by a color photocopier, the method comprising:

generating a plurality of color separations that digitally represent the document wherein each of the plurality of color separations are defined by a plurality of pixel values;

generating an output image based on differences between corresponding pixel values of a blue color separation and a green color separation; and

displaying the output image to view the photocopier tracking signature.

2. An image processing system comprising:

an input terminal that supplies digital image data representing an input document produced by a color photocopier, the digital image data including a plurality of pixel values grouped together to form a plurality of