Automated Optimization of Void Pantograph Settings

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Void pantographs (VPs) have been an important part of the security printing toolkit for several decades. When crafted for a specific printing technology, VPs provide an almost "magical" effect - they are nearly invisible in the original print and then stand out strikingly when they are copied. However, this effect comes at an expense - VPs have historically been designed only for a specific printing technology, and so cannot be extended to a mobile-printing world, where the VP needs to be supported by a wide range of printers.

In this paper, we describe an automated process for optimizing the VP settings. These are the background and foreground pattern used in the VP - the background "disappears" when copied and the foreground "bolds". VP test sheets are created using the ranges of background and foreground settings necessary to guarantee identification of at least one "readable" pair of settings. This can be automated by writing the VP as a readable mark for example, a barcode that can be read (or not read) by a barcode reader; text that can be read (or not read) by an optical character recognition (OCR) engine; or even a face that can be recognized by a face recognition engine. The successful VPs will not be readable (using camera images to prevent a "copying" effect) when originally printed but accurately readable (using a camera) after a single copy, or print-scan, cycle.
Automated Optimization of Void Pantograph Settings

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Introduction

Void pantographs are used to create copy-evident backgrounds for a variety of security documents. Perhaps most prominently, void pantographs are used as backgrounds for checks, sometimes for example displaying “void” or “copy” on the faces. Reproduction of the VP image yet be visually perceptible in the original. One of the first embodiments of the VP, the void pantograph (VP) involved the use of two dot patterns on the substrate, one creating a background pattern and the other creating a foreground pattern. The little dots are sized below the optical resolution and the large dots are sized above it. The VP is produced by using differential dot placement. We emphasize that our approach to construct the VP pattern is purely binary. That is, all dot patterns are rendered as pure black on a pure white background.

The test sheet used in our approach is constructed of nine rows of 9 columns of a test pattern at varying foreground and background intensities. For 600 dots per inch (dpi) printers, we used 2x2 pixel dots (foreground) and 1x1 pixel dots (background) for the test pattern. The test pattern is printed on all target printers with a statically chosen anti-copy pattern and the variable content is subsequently embedded into the substrate. The printed test sheets are then compared to the original printed sheets to identify the settings which effectively hide the VP test pattern when printed but reveal the test pattern when copied.

Methodology

1. Settings Determination

Our approach to implementation of the VP involves the following steps. We briefly list the steps to give the reader an overall sense of our approach and then go into further detail below. (1) A test sheet is a digital image generated that is comprised of multiple instances of the VP to examine a range of possible settings. (2) The test sheet is printed on all target printers with the user wishes to deploy the VP pattern. (3) The printed test pages are photocopied to examine whether the anti-copy pattern is visible. (4) The copy of the test sheet is then compared to the original printed test sheet to identify the settings which effectively hide the VP test pattern when printed but reveal the test pattern when copied.

The void pantograph is produced by using differential dot sizes and different black pixel concentrations. For 600 dots per inch (dpi) printers, we used 2x2 pixel dots (foreground) and 1x1 pixel dots (background) for the test pattern. The test pattern is printed on all target printers with a statically chosen anti-copy pattern and the variable content is subsequently embedded into the substrate. The printed test sheets are then compared to the original printed sheets to identify the settings which effectively hide the VP test pattern when printed but reveal the test pattern when copied.

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background intensity is computed relative to the value of the foreground. Each row is assigned a multiplier value (ranging from 0.40 to 1.60 in Figure 1) and the background intensity is computed as the product of the foreground and the multiplier value. Dots are then randomly placed within the foreground or background to achieve the target percentages. Figure 3 shows an example test cross enlarged for better visibility, created from the above process.

Figure 1. Same black pixel density (10%), different dot cluster size (2x2 at 600 dpi in lower left, 1x1 at 600 dpi in rest of image).

The test page is then printed on each target printer to be examined. The printed pages are subsequently copied using either an all-in-one multi-function printer or a commercial copier. The nominal set of foreground/background values will result in the test cross being only minimally visually perceptible in the original print, but highly prominent once copied. Inspection of both the printed test sheet and copied test sheet allows one to identify these settings. In some cases the initial range of foreground and background intensities may be too broad to fully elicit the VP effect. In this case one may use the first sheet as a “coarse” calibration to identify a smaller range of settings from which to produce a second test sheet for finer granularity.

Figure 3. Original image of a VP test pattern enlarged for legibility.

2. Pattern Detection & Recognition

After the void pantograph deployment candidates are chosen, the actual patterns to be used are chosen. Different shapes will be used for different workflows, as described below. The void pantographs are then printed as a background to whatever the foreground is (of course, the parts to be read should not be obscured, or “hidden”, by whatever else is printed in addition to the void pantograph).

After scanning, the void pantograph stands out (Figure 4) to the human eye, and is a loss easily identified with existing segmentation software. Selecting the latter option to identify the VP enables the use automated workflows. Once the pattern is identified, the pattern can, in the case of OCR, be read and acted upon based on the content in the text. The steps for enabling these options are further detailed in steps 3 and 4.

When utilizing an automated machine vision approach for identification, the steps to form the void pantograph patterns from the scanned image are as follows:

a. Threshold the image (this “binarizes” it, leaving the ink areas black and the non-ink areas white).

b. Perform erosion of the resulting connected components. This completely erases the small dots and shrinks, but does not erase, the large dots. Generally, 1-pixel boundary erosion suffices for this step (even if a few small dots are not erased completely, they will not result in substantial regions of interest in Step 4 below.)

Figure 4. Digital camera photograph of a copied test pattern enlarged for legibility. Note how the cross stands out from the background after copying.
depending on the printer, scanner and substrate (paper) type. We and scanning). The effectiveness of this approach is variable, produces the most distinct region of interest after copying (printing copied.

d. Form regions of interest from the remaining dots. Here, run length smearing [5] (by the square root of the inverse of the black percentage of pixels) is used to cluster the dots left over into their original associated shapes or forms.

3. Region Analysis

These regions of interest are then analyzed based on their typing. If classified as text, for example, OCR (optical character recognition) is used for interpretation. If classified as shapes, shape analysis (such as Freeman, or chain coding [6]) is used for interpretation, etc. Any type of pattern recognition suitable for the embedded pattern can be used at this stage.

We are experimenting with the use of multiple very dense patterns. The first is where different regions of interest are encoded with different “foreground” specifications—e.g. different relative percent blacks: if the document contains a certain amount of black content, the foreground will appear more distinct over a lighter background—e.g. if the foreground is 50%, 60%, 70%, 80%, 90%, and 100% over a background of 50%. On one type of printer, the 100% foreground will show best against the background; on another, the 50% foreground will show best against the background.

The use of multiple regions of interest allows one to deploy a single VP with multiple messages, each being calibrated to a specific make and model printer. For example, the left-hand side of an image may reveal the message “print on A” when printed on printer A and copied, but when printed on printer B, reveals no message. The converse can also be configured such that at the right-hand side of the VP will reveal a different message when printed on printer B, but not on A. Obviously, some analysis of the VP settings is required to find the ideal mix of settings which allow messages to be hidden by both printers prior to copying and also correctly reveal the target message when printed on printer A and copied, but not on printer B. Only the variable void pantograph associated with the correct copy will not instantiate this workflow.

2. Differential downstream image pipeline/restoration
dependent on the type of printer. In this case, the void pantograph sheet is the first sheet printed and inspected in a test run, and is used to determine the settings for the background (has the best OCR or shape matching score) is read and used to determine the settings for the rest of the inspection-related printing job.

Three other uses, such as imposing differential security, privacy, biometric, etc. policies depending on the type of copier (which is automatically determined from the image), etc. are available. The VP is easily understood at this point.

4. Workflow Design

In the last step, the information read sets into motion the correct workflow. This step can be automated on a copier, since the “copied” image is directly scanned by definition during the copy process. With more and more commercial copiers containing network functionality, a number of options are available. Applications readily amenable to setting automated workflows into motion include: document routing, document indexing, and support for network functionality, a number of options are available.

1. Authentication workflow: if the document is not intended to be copied, the variable void pantograph will pop up with a denial of copying message (and could send an appropriate alert). Only the variable void pantograph at a associated with the correct copier will not instantiate this workflow.

2. Differential downstream image pipeline/restoration dependent on the type of printer. In this case, the void pantograph sheet that best stands out from the background (has the best OCR or shape matching score) is read and used to determine the settings for the rest of the inspection-related printing job.

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Discussion and Conclusions

The use of calibration test sheets allows for rapid testing of multiple printers to be used in deployment. Since technologies and print engines vary between models and brands of printers, it is a necessary step to determine optimal settings for each printer to be used in a workflow. Similarly, looking at the differences between thermal ink jet (TIJ) and dry electrophotography (DEP) printers (i.e. laser printers) when printing on the same substrate illustrates this point. See Figure 5 for an example. Unlike laser printers, TJ printers will have increased ink spread on pulped substrates. This spread will affect which combination of settings best results in the VP effect. Other differences, including the amount of ink or toner deposited, will affect the density of the patterns and the subsequent contrast differences. Similarly, if more than one type of substrate is to be used, calibration sheets should be printed for each substrate. Usual differences b etween DEP and TTI printers, different substrates may have different surface chemistries which alter how the ink or toner diffuse or adhere to it.

In addition to the copy-evident patterns that void pantographs are known for, there is a clear utility in the V P when incorporated into workflows. As an alternative to the barcode, the VP can carry additional image payload which is specifically calibrated to a target message when printed on the same printer. If a document contains a VP that is printed on a unauthorized model printer, the VP pattern will be treated as noise and not recognized. Unless laser printers, TIJ printers will have increased ink spread on pulped substrates. This spread will affect which combination of settings best results in the VP effect. Other differences, including the amount of ink or toner deposited, will affect the density of the patterns and the subsequent contrast differences. Similarly, if more than one type of substrate is to be used, calibration sheets should be printed for each substrate. Usual differences between DEP and TTI printers, different substrates may have different surface chemistries which alter how the ink or toner diffuse or adhere to it.

While void pantographs are not the most robust of security deterrents available today, there is a system in place where a botnet could be used to degrade the image. Studies have shown that security systems are often not robust enough to withstand a coordinated attack. The VP is valuable in security and automated workflows.

Figure 5. Two VP test crosses with the same foreground and background intensity settings. The left image was printed on an inkjet printer and the right image was printed on a laser printer. Both images were taken with the same digital camera.
References


Author Biography
Jason Aronoff received his MS in Computer Science from Colorado State University in 2008. He has been working full time for HP Labs since the beginning of 2007 when he joined what has now become the Security Printing and Imaging group. His work has focused on deterrent qualification and functional printing as applied towards anti-counterfeiting techniques. He is a member of IS&T, IEEE, and ACM.