Showthrough and Strikethrough print defect detection using histogram equalization based computer vision method

ABSTRACT

This paper presents a comparatively simple approach for showthrough and strikethrough print defect detection using computer vision method. Showthrough and strikethrough are common printing problem and are typically functions of a paper's opacity. Under normal lighting condition the visibility of printing on the reverse side of printed paper is termed as showthrough whereas the penetration of ink to the other side is termed as strikethrough. Moreover the intensity of showthrough pixel is extremely low thus it is difficult to identify the showthrough pixel from the printed area. On the other hand strikethrough is the result of penetration of ink through paper and depends on the absorbent nature of paper. Comparatively the intensity of the strikethrough pixel is higher than that of the showthrough but due to similar intensity of the ink of the printed pixel and strikethrough pixel, both overlapped with each other in the foreground of the image. These print defects can degrade the image quality as well as print production. In this study, the detection of these two print defects achieved using histogram equalization technique, to enhance the contrast between foreground and back ground pixels. A global thresholding algorithm was applied on a histogram equalized image to segment the printed area from the background of the image. Pixels in the background which are considered as showthrough and strike through pixels are identified by image subtraction. The pictorial representations of the results show the remarkable potential of the proposed technique which can be possible alternative of present subjective measures of showthrough and strikethrough.

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Introduction

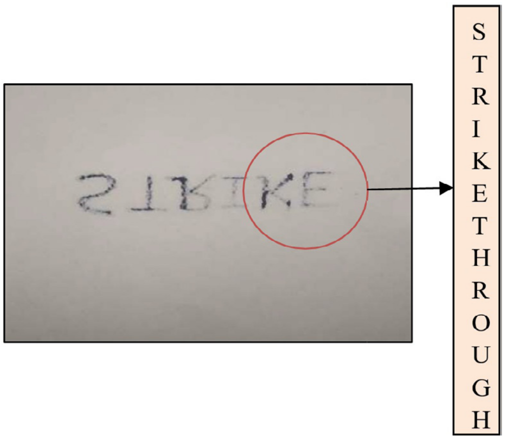
Showthrough is a common print defect that is generally found in offset lithography. Paper opacity is responsible for this type of phenomenon while ink absorption and penetration through the paper results in the visibility of printing on the reverse side of a sheet of paper under normal lighting conditions termed as showthrough (Leach & Pierce, 1988). This printing problem occurs in thinner papers with less pulp to create opacity. In both side coated paper there is a polished clay surface on both the sides (Smyth, 2009). Less fiber makes the paper more transparent. The main reason behind the showthrough problem is the combination of ink and paper. Tackiness of ink and excessive acidity of dampening are reasons for many type of print problems (Leach & Pierce, 1988). Strikethrough is similar to the showthrough print problem where the main reason is the penetration of ink through the paper or the substrate. Generally, in porous or uncoated paper this type of problem arises because of the excessive absorbent nature of paper which allows the ink vehicle to penetrate. Moreover, it can also occur when the refractive index of the ink vehicle is close to that of cellulose, making the printed area more transparent. The only remedy to avoid strike-through is to use less absorbent substrate or porous paper, usage of quick set ink and maintain the printing pressure. The ink setting speed is very important criterion to avoid strikethrough as well as showthrough. Moreover, excessive printing impression pressure causes bleeding of the printed object through the paper (Smyth, 2009).

The choice of resin and oil determines the wetting characteristics of ink vehicle. In newspaper printing an asphaltum complex solution in mineral oil with the correct addition (2 or 3%) is used which helps to avoid excessive strikethrough in printing (Smyth, 2009). Filler increases paper opacity, brightness, whiteness and smoothness and reduces ink strikethrough and showthrough by controlling ink absorption (Eldred, 2001). The most common fillers used for this purpose are calcium carbonate, titanium dioxide etc.Paper sizing is one of the most common methods to control the penetration of ink through the paper. Rosin is common sizing agent (Eldred, 2001) that provides significant resistance to wetting paper by ink.

Here in Figure 1 and Figure 2 showthrough and strike-through defected printed sample image is shown respectively. These samples are collected using different offset presses.

» **Figure 1:** *Sample image of Showthrough*

Previously studies in the domain of showthrough printing defect identification are: simplified linearized mathematical model with an adaptive linear filter used to detect the showthrough in the scanned document (Sharma, 2001). Self-Organizing Map (SOM) and Independent Component Analysis (ICA) were implemented to separate the showthrough print defect from a scanned document: (Zhang, Lu & Yahagi, 2007). In another study Non-negative Matrix Factorization methods were applied to remove the showthrough print problem (Merrikh-Bayat, Babaie-Zadeh & Jutten, 2011). Two layer bi-directional neural networks have been proposed to create a cancellation model for showthrough in printing or scanned handwritten samples (Oda & Miyajima, 2014).



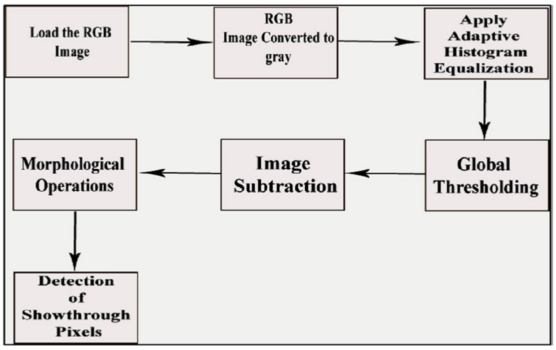
» **Figure 2:** *Sample image of Strikethrough*

The aim of this presented approach of showthrough and strikethrough defect detection is to make much easier procedure in terms of computational load. However, in terms of print quality assessment it is necessary to identify this type of defects using a less expensive procedure. The main purpose of the proposed method is to make the identification procedure of showthrough and strikethrough print defect to be less manual and comparatively less time consuming with an automated detection process.

Presented method

The steps of proposed approach for detecting showthrough and strikethrough print defects are shown in the flow chart in Figure 3. First, defective print samples were collected from various commercial offset presses. Next thickness and porosity of those collected substrate were measured. Thickness of the substrate was measured using micrometer (S.C.Dey & co.). Porosity of the samples was measured by Gurley Densometer. Paste ink and liquid ink were used for showthrough and strikethrough samples respectively.

Digital form of those samples was obtained using an imaging device. Mobile camera with 12 megapixel resolutions in D65 illumination used for the digitalization of all samples. Then the captured original RGB image was converted into a gray scale image. As the gray color space intensity value of pixel ranges from 0(black) to 1(white) and any fractional values in between, it is much easier to perform any image processing operations as it simplifies the algorithm and reduces the computational load. Moreover, the RGB color space is device dependent; as a result pixel information varies from manufacture to manufacture or device to device. Therefore, the gray color space was chosen for further operations. Next, the converted gray image contrast was enhanced by applying histogram equalization method (Mustafa & Abdul Kader, 2018; Kong, 2013; Patel, Yogendra & Sharma, 2013).

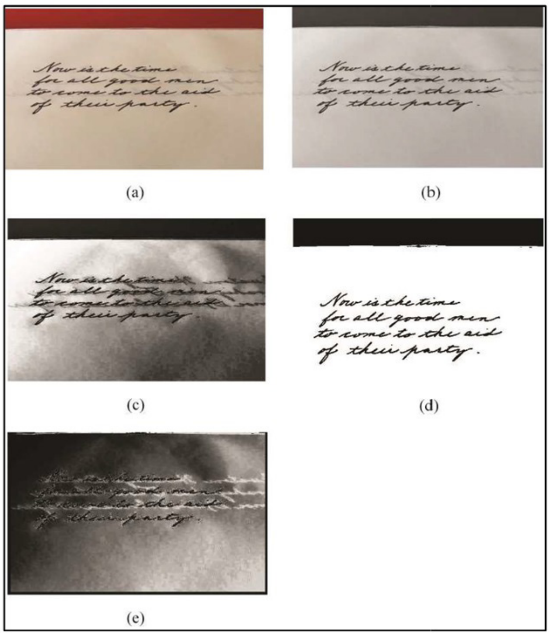


» **Figure 3:** *Flowchart of presented method*

In this study contrast enhancement adaptive histogram equalization was used to enhance the contrast of foreground and background images while maintaining the subsequent number of details of the entire image. This step was needed for the segmentation on and detection of showthrough pixels in background as it has low intensity values. To segment the foreground image from showthrough pixel global thresholding algorithm was applied in next step. Selecting a reasonable threshold value was the most difficult task in this step. In global thresholding (Lee, Yoon Chung & Park, 1990) method threshold value was selected by maximizing the class variance. Pixels with a gray level greater than the global optimal threshold value were considered as foreground pixels. However, in the case of showthrough pixel detection, thresholding is not sufficient to detect or segregate the pixels from foreground. Therefore, subtraction algorithm was applied where thresholded image and histogram equalized image were subtracted to obtain the background image that contains showthrough pixels. Morphological operations such as erosion and dilation were performed on the subtracted image to detect the showthrough pixels in the background of the image. The same steps were followed for strikethrough as well. As these two print defects are similar in terms of their causes, the proposed method was applied same manner for strikethrough and showthrough. The intensity of strikethrough pixels are higher than showthrough pixels and due to penetration of ink, strikethrough pixel overlapped with print pixel or other occurring defects such as scumming pixels or tinting pixels. Therefore it becomes difficult to identify and segregate strikethrough pixels from print pixel in the image.

Results and discussion for Showthrough

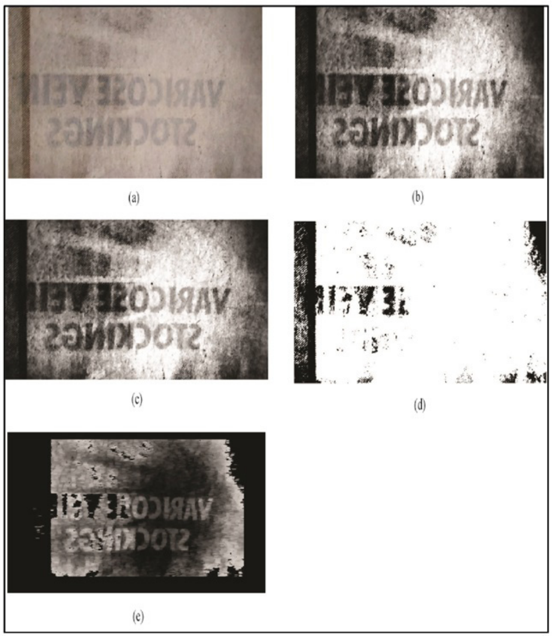
The presented method was tested with numerous samples collected from offset presses and a mobile camera was used to capture the digital form of these samples. The pictorial results for the four samples are shown in Figure 4, Figure 5, Figure 6 and Figure 7.



» **Figure 4:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Showthrough Pixels.*

In Figure 4a original digital image of sample is shown. In this image showthrough is clearly visible in the background and is overlapped with the foreground text which degrades the quality of printed document. Moreover it becomes difficult to identify and segregate the showthrough pixels from foreground text because the showthrough pixel has low intensity. Figure 4b shows the converted gray image of the original RGB image. Figure 4c shows the histogram equalized image of the converted gray scale image. It is shown that after histogram equalization, the showthrough pixels are clearly visible which helps in further operations to detect the pixels in background. After applying the global thresholding In Figure 4d the segmentation of foreground image is shown where it can be seen that only the text to be printed coming as absolute black. Figure 4e shows the showthrough pixels in background image appears in white which ideally should not be present in a good copy.

In Figure 5a it is shown in the original image that the foreground image has some scum pixels which are very difficult to segregate from show through pixels. Therefore as per the proposed method, image is first converted into gray scale is shown Figure 5b Histogram equalized image is shown in Figure 5c. In Figure 5d and Figure 5e the foreground and background image containing showthrough pixels are shown respectively. It is difficult to segregate scum pixels from showthrough pixels in background of the image. The appearance of scum pixels can be considered as a limitation for these images. The limitation can be overcome with the help of image processing tool and post processing operation.

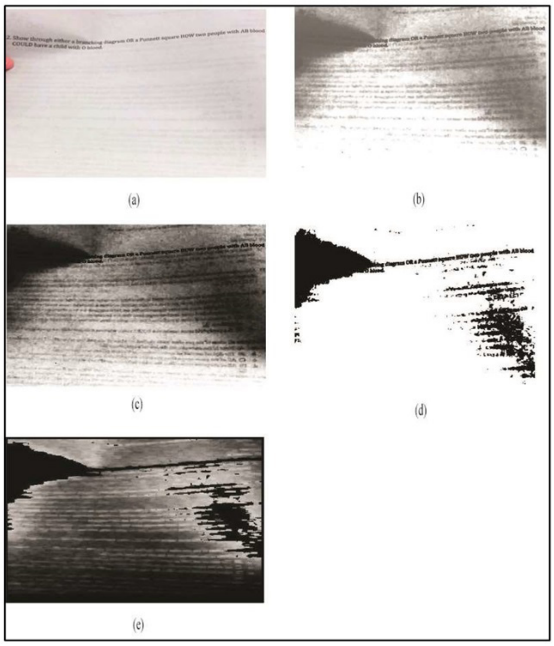


» **Figure 5:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Showthrough Pixels*

Images of another sample are shown in Figure 6. The main difficulties for this sample arise because of the lighting condition and the presence of other print defects.

» **Figure 6:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Showthrough Pixels*

The final output image in Figure 6e shows the detected showthrough pixels in white. However, the appearance of scum pixel cannot be ignored and can possibly remove by post processing operations. In case of sample shown in Figure 7 the original image degraded with shadow and showed showthrough pixels. Moreover the intensity of showthrough pixels is extremely low which makes the detection procedure more challenging. Therefore, it is necessary to increase the contrast to detect the pixels in background. After histogram equalization of the gray scale image the contrast is increased and the background pixels are clearly visible in Figure 7c. In Figure 7e the white pixels in background are detected as showthrough pixels and the appearance of shadow can be removed by post image processing operations.



» **Figure 7:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Showthrough Pixels*

In Table-1 the values for porosity and thickness of the showthrough samples are given.

Table 1

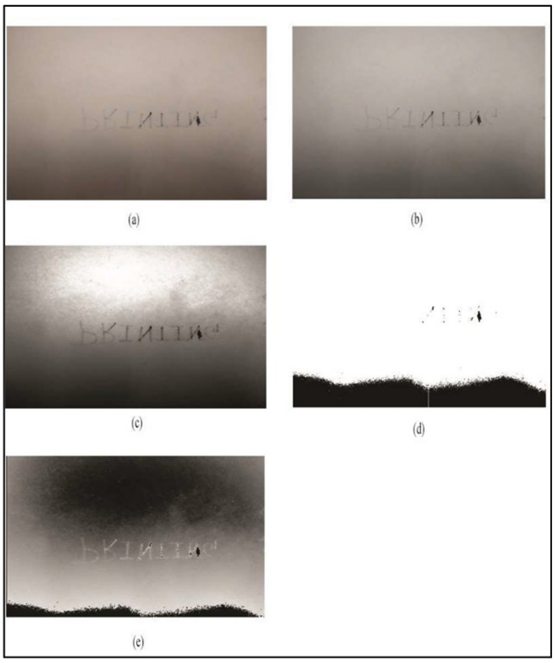
Porosity and thickness of Showthrough substrates

Sample	Thickness (mm)	Porosity (sec)
Sample1 (Figure 4)	0.058	52
Sample 2 (Figure 5)	0.088	40
Sample 3 (Figure 6)	0.055	47
Sample 4 (Figure 7)	0.084	46

According to the measurement sample 2 has the maximum porosity whereas sample 1 has the lowest porosity. The order of porosity (high to low) can be arranged as- Sample 2> Sample 4>Sample 3> Sample 1. Showthrough print defect in Sample 2 is more than other samples as the porosity is high. Sample 1 is less porous and the identification of showthrough pixels in sample 1 is little bit difficult as it is having lower intensity value. According to the intensity of the showthrough pixel it is clearly visible that Sample 2> Sample 3> Sample 1> Sample 4. It is also observed that though the porosity is less in case of Sample 3, but as the thickness of substrate is lowest, showthrough is more as compared to Sample 1 and Sample 4.

Results and discussion for Strikethrough

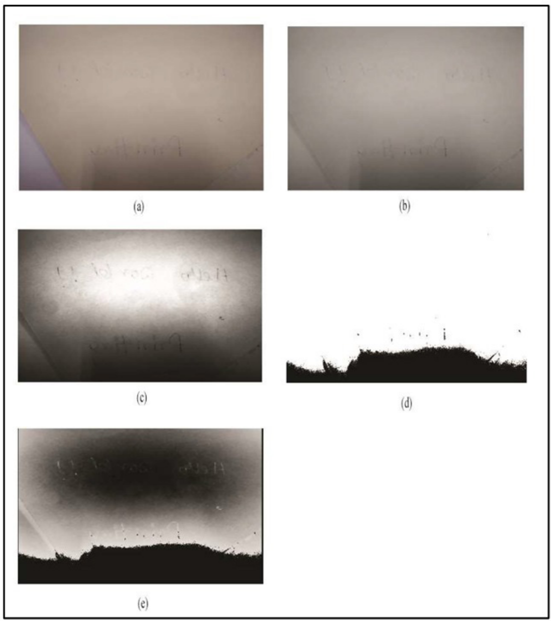
The same proposed method of showthrough detection is followed for strikethrough print defect detection as well. The pictorial representation of the results also proves its strength. In case of strikethrough print defect, the presented method is also tested with no. of samples. Figure 8, Figure 9, Figure 10 and Figure 11 are some of the results of strikethrough detection.



» **Figure 8:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Strikethrough Pixels*

In Figure 8 (a) the original digital image of strikethrough sample is shown and it is captured using mobile camera only. Here the ink penetrated through the paper fibre and became visible in the foreground of image. However the intensity of the strike through pixels are more compare to showthrough pixels which facilitates the detection procedure. However the presence of other unwanted appearance cannot be ignored and can be removed by further post processing. In this sample presence of shadow made the detection of strikethrough pixels difficult. In Figure 8 (d) in foreground image, the portion of ink that bleeds through the paper is detected. Finally in Figure 8(e) the strikethrough pixels in background are shown in white.

The next sample in Figure 9, because of illumination it is very difficult to identify strike through pixels. Here histogram equalization is required to increase the contrast of background strikethrough pixels for proper detection. The histogram equalized image is shown in Figure 9 (c). Here also the shadow part degrade the image and can be ignored by further image processing operations. Fig. 9 (d) shows the foreground image is shown and Figure 9 (e) shows the strikethrough pixels detected in background.



» **Figure 9:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Strikethrough Pixels*

The sample in Figure 10 shows that the strikethrough pixels are clearly visible and the presence of unwanted summing pixels makes the segregation of strikethrough pixels difficult. The foreground image in Figure 10 (a) shows the penetrated strike through pixels from reverse side of the paper and the scumming pixels.

To segregate the strike through pixels from scum pixel and print pixel, a proper choice of threshold value is very much important, otherwise scum pixels or print pixels can also be identified as strikethrough pixels, as the intensity value of scum and print pixel is nearly similar to strikethrough pixels. The threshold value was selected by maximizing the class variance of the pixel of the entire image. Pixels with a gray level greater than the global optimal threshold value were considered as foreground pixels. The final result in Figure 10 (e) shows the detected strikethrough pixels in background only and depicts the strength of segmentation of scum pixels and print pixels from the strikethrough pixels.

» **Figure 10:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Strikethrough Pixels*

In the fourth sample in Figure 11 (a), ink mostly penetrates from the reverse side and is detected in the foreground image in Figure 11 (d) after thresholding operation. Ideally the foreground image should be blanked but here the ink bleeded through the fibre and appears in foreground. The strikethrough pixels detected in white are shown in Figure 11 (e).

» **Figure 11:** *(a) Original image (b) RGB to Gray Converted image (c) Histogram Equalized Image (d) Foreground Image (e) Detected Strikethrough Pixels*

In case of Strikethrough pixel the substrates used for all the samples were same and the liquid ink was used. The porosity of strikethrough sample is 6 sec and the thickness is 0.059mm.

Conclusion

Image quality can be degraded if showthrough or strikethrough pixels merged with the background and as well as foreground image. So this is a very much important task to detect this kind of print defect and remove it in terms of quality control of print job. Generally this defect detection is done manually in press which makes the job very much time consuming and dependent as this varies with man to man ability of detection. So it becomes a popular research direction to detect these defects with the help of image processing tool that can be less manual and less time consuming. As the showthrough and strikethrough are almost same type of defects caused by ink penetration or absorption, a common method of detection is proposed in this paper. A major limitation of this study is appearance of scummimg, tinting which make the detection a little bit noisy. Post processing operations can be a solution to overcome this problem. Moreover exploring detection process in different color space can be further extended by reconstructing of image removing the showthrough pixel.

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