Correcting Photometric Distortion of Document Images on a Smartphone

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Abstract

This paper presents efficient and robust methods for correcting photometric distortion on document images caused by moiré pattern noise and specular highlight in smartphone. Our algorithm uses separated smoothing process for moiré pattern removal on recaptured document image from LCD monitor. Furthermore, contrast of characters in specular highlight area is enhanced using subtraction and noise removal technique.

1. Introduction

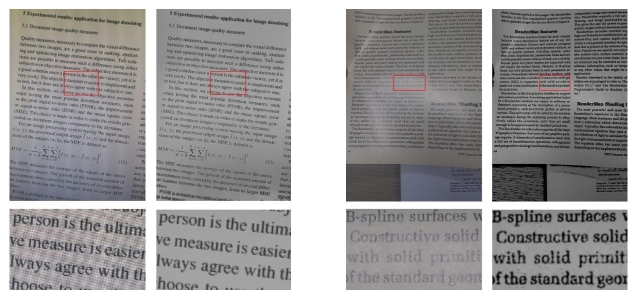
The accuracy of OCR application is usually degraded due to various distortions especially photometric distortion. When using camera in smartphone, the moiré pattern noise problem is often observed when recapturing a document image from LCD monitor and strong specular light exists when a document image is captured from glossy paper reflecting the illumination as shown in Fig. 1.

2. Moiré Pattern Noise Removal

2.1. Foreground Extraction

In foreground extraction, the adaptive thresholding [1] is employed to obtain the binary image (B_I). The noise pattern appears in B_I, so run-length histogram [2] is utilized vertically and horizontally to remove the patterns with elimination applied to the most frequent stroke width and lesser than it denoted as B_L.

It is necessary to check whether the run-length filtering technique runs correctly without eliminating plentiful text area. Text area is obtained by using erosion upon image after run length filtering, which is denoted by B_E. The eliminated pattern $B_P(= B_I - B_L)$ are used to select the fore-



(a) (b)

Figure 1. Photometrically distorted document images and the result of applying the proposed algorithms. (a) Moiré pattern. (b) Specular highlight.

ground. E_0 (number of eliminated pixels inside text region) and E_1 (number of eliminated pixels outside text region) are defined as follows.

$$E_0 = \sum_{x,y} [B_E(x,y) = B_P(x,y)] \quad (1)$$

$$E_1 = \sum_{x,y} [B_E(x,y) \neq B_P(x,y)] \quad (2)$$

Mask extracting foreground image is obtained described in (3). After $M(x,y)$ is obtained than the final foreground image (I_{FF}) is formed using this mask with its 8-neighbors.

$$M(x,y) = \begin{cases} B_L & \text{if } \frac{E_1}{E_0} > \tau \\ B_I & \text{if } \frac{E_1}{E_0} \leq \tau \end{cases} \quad (3)$$

2.2. Background Extraction

The foreground mask $M(x,y)$ is used again to create the background I_B (without text area) image. Adaptive thresholding is applied to I_B and E denotes the set of pixels in boundary edge. The result of thresholding is used as mask for I_B with 0 value area to be filled with mean of pixels around it which are not 0 to obtain background image(I_{FB}).

$$I_B(x,y) = \begin{cases} \frac{1}{N}\sum_{(x',y')\in E} I(x',y') & \text{if } M(x,y)=0 \\ I(x,y) & \text{if } M(x,y)=1 \end{cases} \quad (4)$$

2.3. Image Blending

The output image is obtained by merging the final background (I_{FB}) and foreground image (I_{FF}).

3. Contrast Enhancement in Specular highlight Area

3.1. Background Extraction and Candidate Image Generation

The pixels in the text area are replaced by pixels in the background area using the dilation process denoted as D. Then, candidate image is obtained by $I_C(x,y) = D(x,y) - I(x,y)$.

3.2. Hole-Filling with Noise Removal

Hole-filling is a process to fill the text area which is not detected by the dilation process. Firstly, the binary image (I_B) is obtained by using adaptive thresholding [1]. After that, pixel value of I_C at the position of the text area of I_B is set to maximum, yielding the hole-filled image I_H.

The candidate image may contain some noise especially in the background area. The minimum value in the background which does not represent text affects the value from subtraction process. To remove the noise, the local contrast (LC) is computed by finding the maximum and minimum value in 3×3 block in the input image as follows.

$$LC = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \quad (5)$$

Then, the average value ($\bar{\mu}$) of the local contrast from all pixels is computed. Pixels in the candidate image which have local contrast less than $1/3 \times \bar{\mu}$ are set to zero. After that, the noise removed hole-filled image (I_{NR}) is obtained as follows.

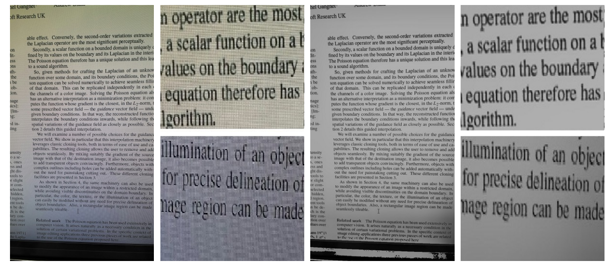
$$I_{NR}(x,y) = \begin{cases} I_H(x,y) & \text{if } LC(x,y) > 0 \\ 0 & \text{if } LC(x,y) = 0 \end{cases} \quad (6)$$

3.3. Reconstruction

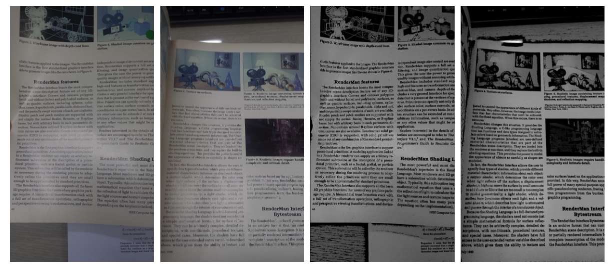
Finally, the input image (I) is subtracted by the noise removed hole-filled image (I_{NR}) to produce the contrast enhanced image with the specular highlight suppressed.

4. Experimental Results

In this work, the proposed methods for moiré pattern and specular highlight are applied in the smartphone environment using Samsung Galaxy S4 with processing speeds 0.7 and 1.0 second respectively. The results and improvement can be seen as shown in Fig. 2 and the Table 1. Note that moiré pattern and specular highlight appear locally on the image, so it only improves a few percents.



(a)



(b)

Figure 2. Result images. (a) Left : Input image with moiré pattern noise and its zoomed images. Right : Output image. (b) Left : Input image with specular highlight. Right : Output image.

Table 1. Accuracy on OCR application (*OPTICAL READER* in Galaxy S4)

Proposed Method	Accuracy		
	Before	After	Improvement
Moiré Pattern Removal	78.1%	82.6%	4.5%
Specular Highlight Removal	73.7%	81.5%	7.8%

5. Conclusion

In this paper, fast and robust methods were proposed to restore the text from a photometrically distorted document image. They were developed to enhance the text visibility in the specular area and to remove the moiré pattern noise.

Acknowledgement

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References

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