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SEGMENTATION OF COLOUR REGIONS FROM PRINTING SHEETS

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Abstract: The print characteristics of optical density, dot area and ink trapping are suitable to control of printing process. To evaluate the print characteristics on the basis of scanned micro-samples of printing sheets, it is necessary to carry out the segmentation of colour regions, printed with process inks. The accuracy of the evaluation of these print characteristics strongly depends on the sufficient accurate segmentation of colour regions involved in the print sample. This paper describes the thresholding method of segmentation, combined with edge detection between colour regions.

Keywords: Colour print, control of print, print characteristics, region segmentation

1. Introduction

The control of optimal colouring of printing sheets in the inking unit is the standard function, which is implemented in the printing press. Utilization of this function in the printing process needs the measuring of printing parameters optical density, dot area, ink trapping and colour differences. The method described in this paper enables measuring of theses parameters from segmented colour regions in halftone areas of printing sheets. The application of this method in printing process control increases the quality of the print.

Colour publications are printed with using four process inks – yellow (Y), magenta (M), cyan (C) and black (K) by various technologies of industrial press, such as digital screening - Green (1995). The results of such printing method are halftone dots of various sizes printed with these four process inks (fig. 1).

We can measure and evaluate the basic printing characteristics, which determine quality of the print, with various methods. How to obtain them from the halftone colour samples is described in this work.

Fig. 1 Three-colour print sample with digital screening (scanned with zoom about 100)

The basic print characteristics used to examine of print quality, measured in the solid and halftoned areas by densitometry are - Mortimer (1991):

Optical density of the ink layer (determines quality of ink printing on the paper)

$$D = \log \frac{L_W}{L_R} \qquad (1)$$

where L_W is the intensity of light reflected from the white region of the paper, and where L_R is the intensity of light reflected from the process ink region printed on the paper.

Geometrical Dot Area in percents

$$\Phi_G = \frac{S_{PD}}{S_T} \qquad (2)$$

where S_{PD} is the surface of the printed dot, and where S_T is total surface of the halftone cell.

Ink trapping (determines quality of ink printing to ink layer printed first)

$$T = \frac{D_{12} - D_1}{D_2} \qquad (3)$$

where D_{12} is the density of the overprint, where D_1 is the density of the first printed colour, and where D_2 is the density of the second printed colour.

These parameters can be evaluated also from the regions of halftone dots of colour samples scanned with a CCD camera. The usual practice is to perform the segmentation of an individual process colour and their overprint regions from the colour sample, and then evaluate the print characteristics by the method of the image analysis. In this case the print characteristics are: optical density inside the segmented regions, ink trapping evaluated from these densities and area of segmented region – Fribert (2002).

Optical densities inside halftone dots of cyan, magenta and yellow, evaluated by image analyses method are:

$$D_c = \log \frac{L_w N_p}{\sum_{i,j} r_{i,j}} \qquad D_m = \log \frac{L_w N_p}{\sum_{i,j} g_{i,j}} \qquad D_y = \log \frac{L_w N_p}{\sum_{i,j} b_{i,j}} \qquad (4)$$

where $L_w = \frac{\sum_{i,j} (r_{i,j} + g_{i,j} + b_{i,j})}{3N_w}$ is light intensity reflected from the white reference sample, N_p is number of pixels inside segmented colour region, N_w is number of pixels inside white reference sample and where $r_{i,j}$, $g_{i,j}$, $b_{i,j}$ are colour components of light reflected from the segmented colour region or from white reference sample.

The crucial point of successful evaluation of print characteristics is the accurate segmentation of the colour regions in the print sample. There are many methods, how to improve accuracy results of segmentation – Sonka et al. (1993), Russ (1999). The combination of thresholding grey level image, gained from separation process, and edge detection applied on original colour image, can be used for this purpose.

2. Separation of colour regions

This proposed segmentation method is based in the first step on the process of colour separation of the print sample image into grey level image. After separation has the region of separated colour minimal brightness. The separation process is based on the evaluation of colour differences between colours included in the print sample.

$$D_{i,j} = \sqrt{(R_{i,j} - R_r)^2 + (G_{i,j} - G_r)^2 + (B_{i,j} - B_r)^2} \qquad (5)$$

where D_{ij} is colour difference in the pixel i,j, $R_{i,j}$, $G_{i,j}$, $B_{i,j}$ are components of the pixel i, j involved in the sample, and R_r, G_r, B_r are the reference values of the colour, that is to be separated from the sample.

There was proposed equation for the gray level brightness *BR* of the separated colour – Fribert (2005). The function *MAX* is applied for all possible values *i, j* in the image:

$$BR_{i,j} = 255 \cdot \frac{\sqrt{(R_{i,j} - R_r)^2 + (G_{i,j} - G_r)^2 + (B_{i,j} - B_r)^2}}{MAX\sqrt{(R_{i,j} - R_r)^2 + (G_{i,j} - G_r)^2 + (B_{i,j} - B_r)^2}} \qquad (6)$$

On the fig. 2 are presented images of blue and yellow separations created by application of eq. 6. The motives of this colours has the minimal brightness in comparison with other colours.

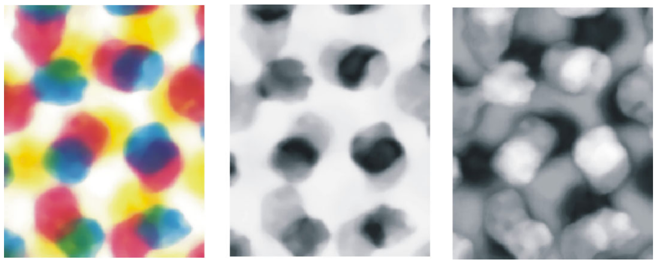

Fig. 2 Separations of blue and yellow regions

The segmentation of specific colour regions is based on using the monochromatic images obtained after described separation process.

The simplest segmentation method in the image of the grey-level separation is the thresholding. As was proven by many acts of measuring and evaluating, the optimal threshold always exists for images gained by the described method of the separation - Böhm (2001), Fribert (2002). The usual determination of threshold value from the brightness histogram of the separation is impossible in most cases, because of the inexpressive maximum or not-sharp valley in this histogram (fig. 3). Then the proposed method of the combination of the thresholding and edge detection is suitable for this purpose.

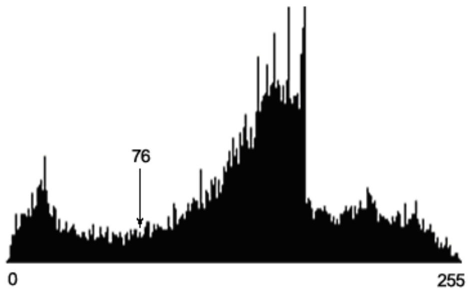

Fig. 3 Histogram of yellow separation and optimal threshold, the value 76 was gained by proposed method.

This method is based on the assumption that the border of the particular colour region lies in the middle of the edge of the colour changeover from the first to the second colour. This border can be obtained by the edge detection process. We can calculate significant edges of the specific colour from the original colour image by using of any standard edge detectors. The coordinates of the edge pixels determine the various threshold values in the image of separation. The average of these threshold values is the optimal threshold for the segmentation of the specific colour region.

3. Edge detection of colour regions

The edge detection method used in this work is based on the colour differences between the specific colour region and its neighbourhood. The statistical parameter variance of the colour value Hue in this neighbourhood indicates the location and size of the edge. For the correct segmentation it is necessary to determine edges only on the borders of colour

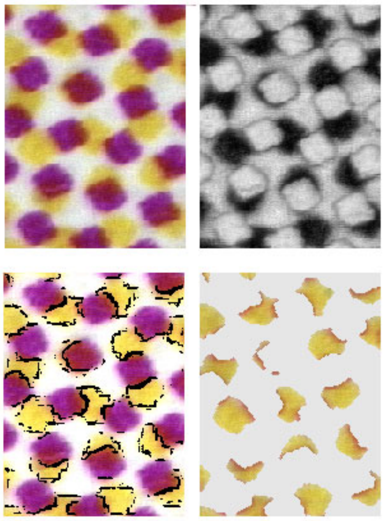

Fig. 4 Original image, its yellow separation, yellow edges and yellow regions segmented with optimal threshhold

regions, that are to be segmented. On the fig. 4 are presented the original colour image, the image of its yellow separation, original image with significant edges of yellow regions and the resulting image of the yellow region segmentation.

The pixel coordinates gained from the image of yellow edges were used as the pointers to the image of yellow separation to evaluate optimal threshold. As a result of segmentation process is the segmentation mask and after masking of the original image with this mask we get the resulting segmentation of yellow regions.

On the fig. 5 are presented images of cyan-magenta sample and the separations of cyan, magenta and blue regions. The corresponding optimal threshold values for cyan, magenta and blue separations, calculated with help of the edge detection process, were 78, 88 and 74.

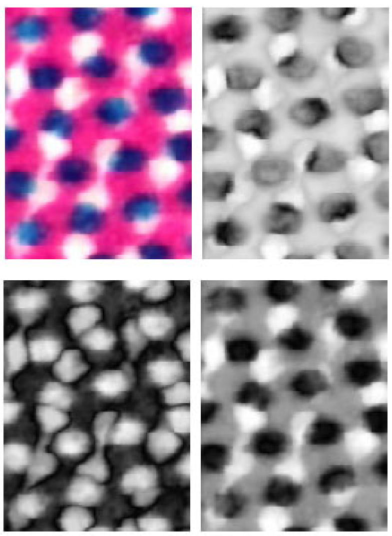

Fig. 5 Separations of colour regions included in the cyan-magenta sample

4. Accuracy of segmentation

The effect of the segmentation error can be demonstrated on evaluation of colour regions areas from the two-colour samples. In these two-colour samples were segmented all colours including white background. The sum of the colour regions areas would have to be 100 %. The difference from the 100 % determines the segmentation error.

On the fig. 6 are presented the images of segmentations gained from previous cyan-magenta sample. These segmentation images were processed by thresholding of separation images with optimal threshholds and with subsequent masking of the original image. The sum of all segmented colour region areas, including white, was 97.11% segmentation error is then in this case 2.89 %.

The proposed method was check on three tested sheets with two-colour halftone motives Cyan-Magenta, Cyan-Yellow and Magenta-Yellow with various values of the parameter dot area. There were scanned and processed by the proposed method 5 image samples from each sheet. The sheets were printed on the press Heidelberg Quickmaster QM-42 in the department of graphics arts of the University of Pardubice.

By verifying of the proposed method the achieved maximal error was less then 5% in the case of the offset print samples. In the offset print, in comparison e.g. with flexography print, the edges of halftone dots are blurred.

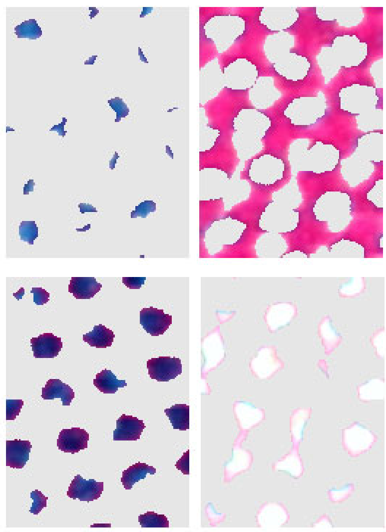

Fig. 6 Segmentations of cyan, magenta blue and white regions

4. Conclusions

There were processed many image halftone samples from printing sheets in the department of graphic arts. The segmentation has been performed usually with the standard thresholding. The accuracy of segmentation was always under 10% in the case of the offset print. The proposed method is approximately twice more accurately.

The improving the segmentation accuracy has the positive effect on the successful evaluation of all important print characteristics, especially of the dot area parameter. The dot area parameter enables the measuring of the dot gain value (spreading of halftone dots), which causes the main distortion in the colour reproduction - colour shift.

The contemporary production printing needs measure, evaluate and control the print characteristics with sufficient accuracy. The method described in this work can benefit to this purpose, but it can be used also in the other areas of image processing.

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