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CALCULATION OF DOT AREA WITH IMAGE ANALYSIS METHOD

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Image analysis is a suitable method to calculate the basic print characteristic from print samples, because of the possibility of scanning geometrical and colour characteristic at the same time. This paper deals with the calculation of the dot area print characteristic. Before the evaluation of dot area parameter, the segmentation of halftone dots from the print sample must be done. The paper describes an algorithm of dot area calculation based on the segmentation and presents the results obtained with processing one-colour and two-colour print samples. Finally the resuts of the image analysis method and densitometric method are compared.

Introduction

The standard method of measuring and calculation of the print characteristic dot area is the densitometric method [1,2]. The dot area value in the halftone print is determined as the geometrical effective ink surface coverage

$$F = \frac{S_p}{S_p + S_u} \cdot 100 \qquad [\%] \qquad (1)$$

where S_p is printed area and S_u unprinted area of the halftone print sample.

The densitometric dot area can be calculated using Murray–Davies formula from measurement of solid (D_s), halftone densities (D_a) and substrate (D_0)

$$F_d = \frac{1 - 10^{-(D_a - D_0)}}{1 - 10^{-(D_s - D_0)}} \cdot 100 \qquad [\%] \qquad (2)$$

The image analysis method evaluates the dot area in accordance with the first equation. The main advantages of the image analysis method for the purpose of the dot area evaluation are

- the possibility to evaluate the dot area from any suitable part of printed image and not only from the control strip
- the possibility to evaluate the dot area after separation process from multicolour print samples.

Method of Evaluation

The method of the dot area evaluation from multicolour print sample consists of two steps. In the first step the halftone dots separation of evaluated printing ink is proccesed. In the second step the image segmentation of separated halftone dots is processed [4,6].

The process of separation is based on the evaluation of the colour differences between colours included in the print sample. This process enables halftone dots separation of specific printing ink from multicolour print sample.

The equation of the separation model for the one-colour region for the pixel i,j [9]

$$BR_{i,j} = 255 \frac{\sqrt{(R_{i,j} - R_r)^2 + (G_{i,j} - G_r)^2 + (B_{i,j} - B_r)^2}}{MAX\sqrt{(R_{i,j} - R_r)^2 + (G_{i,j} - G_r)^2 + (B_{i,j} - B_r)^2}} \qquad (3)$$

where $BR_{i,j}$ is the brightness of the converted pixel i,j, $R_{i,j}$, $G_{i,j}$, $B_{i,j}$ are the colour components of the pixel i,j involved in the sample and R_r, G_r, B_r are the reference components of the colour, which are to be separated from the sample.

The equation of the separation model for the two-colour region (e.g. one primary colour and the overprint colour) [9]

$$BR_{i,j} = k\frac{BR1_{i,j}BR2_{i,j}}{255} \tag{4}$$

where $BR1_{i,j}$, $BR2_{i,j}$ are brightness values of the first colour separation, second colour separation and $BR_{i,j}$ brightness of the pair colour separation in the pixel i,j, k is a constant.

The second step — the segmentation of individual colour regions is based on the processing of the monochromatic image which is obtained by the separation process described above. The simplest segmentation method is thresholding in the image of monochromatic separation [3]. It was proved by many measurement and evaluations, that the optimum threshold always exists for the image obtained by the described method of separation.

The standard determination of threshold value from the separation image brightness histogram is impossible in some cases, because of the inexpressive maxima or unsharp valley in this histogram. Various methods of optimum threshold determination were tested. One of them is the method of interactive manual detection of the optimum threshold value [9]. The result of segmentation from the monochromatic separation is the image of segmentation mask, which is used to masking of the original colour image.

Figure1 presents the result of segmentation process: segmentation mask and final segmentation of the pair magenta-blue from the two colour sample. Final segmentation, obtained with masking of the original image, is actually the image of the magenta halftone dots in this case.

The value of the dot area is then [4]

$$F = \frac{N_p}{N_p + N_u} 100 \qquad [\%] \tag{5}$$

where N_p, N_u are numbers of pixels in the printed and unprinted area in the image of segmentation mask or in the image of final segmentation.

Two sets of prints patches were prepared: a one-colour set and two-colour set. The one-colour set was the wedge from 10 % to 90 % covering the process inks C,M,Y,K. The two-colour set was patches with colour couples with various combinations of covering values [7,8].

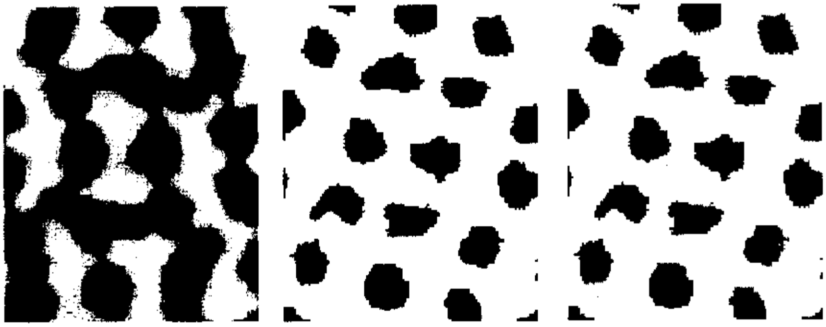

Fig. 1 Segmentation of the mangenta halftone dots

The print samples were obtained by scanning from these patches at the image analysis workplace. The workplace includes a microscope Technival 2 from Askania-Werke, a colour CCD Camera JVC TK-1070E and computer with frame grabber MM/VGA 32K from Matrox with the support software. The scanned samples were processed with help of the image analysis program package Anatis 2, which was developed for the purpose of calculation of print characteristics.

The following functions were used in the calculating procedure for every sample:

- colour cast removing and contrast enhancement,
- reference values calculation of specific colour,
- calculation of separation image of specific colour,
- calculation of segmentation image of specific colour regions,
- calculation of the dot area value.

Results

1. Dot area values in the one-color samples of cyan, magenta, yellow (coated paper) [7]

Table I Dot area of Cyan

Reference value	10	20	30	40	50	60	70	80	90
Densitometer	17.8	32.7	45.1	57.6	67.6	75.5	82.4	88.5	94.2
CCD camera	9.44	20.2	29.5	38.3	56.6	63.6	73.3	82.7	91.7
Correlation factor	0.9879								

Table II Dot area of Magenta

Reference value	10	20	30	40	50	60	70	80	90
Densitometer	17.9	34.4	49.2	63.0	78.9	81.4	87.8	93.5	97.8
CCD camera	13.3	23.1	35.1	49.5	65.7	74.9	80.4	88.3	95.3
Correlation factor	0.9899								

Table III Dot area of Yellow

Reference value	10	20	30	40	50	60	70	80	90
Densitometer	19.8	29.2	41.7	53.7	63.7	71.9	76.6	87.1	94.7
CCD camera	13.1	22.1	34.6	47.3	64.8	70.7	75.5	88.9	93.5
Correlation factor	0.9965								

2. Dot area values in the two-color samples of cyan, magenta, yellow (coated paper) [8]

Table IV Dot area of Cyan

Reference value	10	20	30	40	50	60	70	80
CCD camera	9.5	25.2	32.6	35.7	43.5	58.7	64.5	74.5
Correlation factor	0.9903							

Table V Dot area of Magenta

Reference value	10	20	30	40	50	60	70	80
CCD camera	7.9	21.4	31.3	46.9	53.7	56.2	69.2	84.4
Correlation factor	0.9901							

Table VI Dot area of Yellow

Reference value	10	20	30	40	50	60	70	80
CCD camera	8.6	23.1	25.4	39.7	45.7	65.8	74.6	81.9
Correlation factor	0.9911							

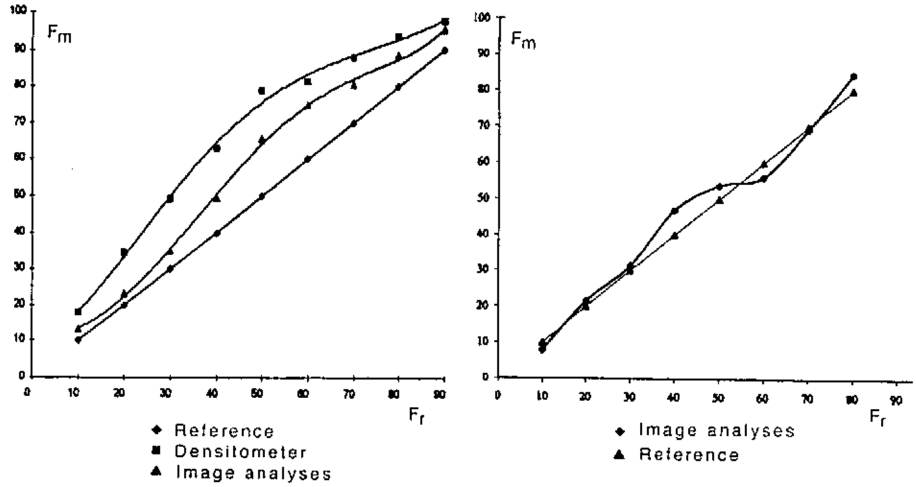

Fig. 2 Comparison of mangenta dot area between one- and two-colour samples

Figure 2 presents two charts of the dot area of colour magenta, one for one-colour samples, the other for two-colour samples. F_r is the reference and F_m is the measured value.

Conclusion

The results of the image analysis method were compared with the results of densitometric method, which is established and generally accepted. The values of densitometric method for one-colour samples are approximately about 10 % larger because of the side lighting.

Correlation coefficients were calculated between two sets of values corresponding with these two methods. The values of these correlation coefficients are presented in the above tables. The correlation coefficients are all grater than 0.98, which is a good result. It can be concluded that the image analysis method corelates very well with the densitometric method and is suitable for the calculation of the dot area print characteristic.

The densitometric values of the dot area are not given in the results presented from two-colour samples. This is due to the impossibility of densitometric measurements of the dot area in the multicolour samples. The results of the image analyses method are then compared with the reference values (specified with print patches).

The waveforms of the dot area value in the case of two-colour samples have not the typical shape, as in the case of one-colour samples. It is evident from Fig.

2 and it is similar for the other colours. With the high probability, the reason is, the lower accuracy of segmentation in the case of two-colour samples. An important conclusion follows from this fact: a successful calculation of the dot area needs a high accuracy of segmentation.

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