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An Approach towards Measurement of Color Shifting in Misregistration Print Defect using Euclidean and Manhattan Distance Metrics

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Abstract- Misregistration print defect occurs during offset printing affects the visual appearance of printed image. Registration refers to the proper superimposition of colors whereas improper alignment or shifting of colors is resulted as blurred image. Generally registration marks is used in printed sheet to detect this kind of print problem manually. In the presented study a computer vision technique is applied to detect and quantify the problem. Euclidean distance and Manhattan distance measurement method is applied for quantification of color shifting. Therefore this presented study is a novel approach in printing industry which can be a substitute of the usual human perception based method.

Keywords: Misregistration, Print Defect, Image Processing, Euclidean Distance, Manhattan Distance, Computer Vision

I. INTRODUCTION

Misregistration is a common print defect which occurs during offset print production for various applications like newspaper, magazine, book printing, packaging etc. while printing with four colors (CMYK) this print problem can happen due to misalignment or improper superimposition of colors. As a result the printed image becomes blurred or fuzzy which can affect the visual quality of production. Generally in printing industry registration marks is used to check the misalignment of colors and according to that perception the particular color unit is adjusted for proper alignment. Fig. 1 shows the image of registration marks where Fig. 1(a) depicts perfect registration and Fig. 1(b) is for misregistration. Misregister can happen due to various press conditions like improper adjustment of lithographic press units, changes in moisture content of paper, unsatisfactory paper [1].

In lithography printing process if the paper stacks are left in a damp atmosphere it will develop wavy edges and creases in sheets will also occur near the edges during printing. This distortion can cause misregistration in printed sample [2]. Mostly in lithographic press, when the paper travels through the first unit, it rolls out and stretches.

In the mean time if the first unit does not print shorter than subsequent units it may cause misregister [1]. In screen printing process, before printing, screen has to be mounted and stretched on a frame with proper tension, otherwise misregistration can happen [2]. To get register on the following units, the press operator packs the press so that the first unit prints shorter than subsequent units [2]. In the halftone process register of colors with each other is very much important in order to get successful color combinations [2]. Reels must be stored correctly on end to avoid this kind of print problem otherwise reel out of round causes variation in tension that may be responsible for misregistration [3]. In case of proper ink trapping the overlap between two colors used in printing ensures that there is no white space appearing between them as a result of paper movement and poor registration [3]. This kind of print problem is very much unwanted and should be optimized to get a better quality end product. As of now, largely the detection procedure of this defect in most of the presses depends on human's ability of identification. There is no other standard procedure where the shifting can be measured or quantified without human intervention. Here in this presented study computer vision based approach is presented to detect the misregistration and how much color is shifted has also been measured by using Euclidian distance measurement method. Therefore this presented

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method is a novel proposal in printing industry with less manual and less time consuming approach.

Some of the relevant work that had been done in this domain are: impact of misregistration of images on detection of changes in land cover [4], effect of image misregistration on the accuracy of remotely sensed change detection[5], quantitative evaluation of misregistration induced color shifts in color halftones [6], image misregistration error in change measurements [7], the impact of misregistration on SRTM and DEM image differences[8], analysis of Euclidean distance and Manhattan distance measure in face recognition[9].

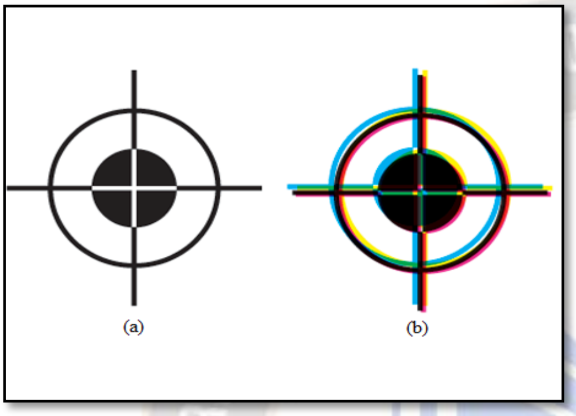

Figure 1. Registration Marks (a) Perfect Registration; (b) Misregistration

II. PRESENTED METHOD

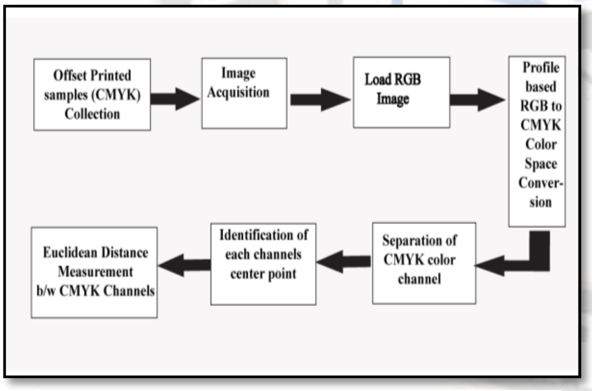

Figure 2. Flow chart of presented method

The presented method of identification of misregistration print defect has several steps tested with numerous sample collected from offset printing press. Fig. 2. shows the flow chart of presented method of detection procedure. Matlab programming software platform is used for this purpose. First of all digital copy of all offset printed samples are taken by using an imaging device. Here mobile camera with 48 megapixel resolution in D65 illumination is used for the digitalization of all samples. Now the RGB samples are converted into CMYK color space. Here the conversion to CMYK color space cannot be done so easily as because there is a real risk of degradation of color values during the conversion process. Therefore, a profile based conversion has been done to convert the RGB color into CMYK color space. According to the International Color Consortium (ICC), the color management system uses device profiles that contain the information of color for a specific device in the form of look-up tables, matrics etc [10]. This helps to translate color data between devices (input, output and display device). ICC profiles first co-ordinate transformations where device color code values relate to colorimetric code values in the PCS (Profile Connection Space). Next while color rendering, it changes the colorimetry of an original to some specific better suited reproduction medium [11]. So here to convert the RGB color data into CMYK color space without losing any information, two profiles are needed. One is monitor profile (RGB) that is source color space and the other one is printer profile (CMYK) that is destination color space. Now the conversion has been done by creating color transformation structure. After converting into CMYK color space, separation of each color channel has been performed to get the information of each channel individually. After the separation of CMYK channel, each channels center point is identified. In a registered image, the four color channel will be superimposed so that there will be no color shifting between them. Now to check whether the tested sample images are registered or not, euclidean distance is measured form the center point of each color channel. Euclidean distance between two points is the absolute difference value of their co-ordinates. Here for each channel a center point is found out which can be imagined as the Cartesian coordinates. In Fig. 3, four separate color channel is shown and Let's assume that C-channel has the center point P (p1, p2) and similarly M-channel has the center point Q(q1, q2). Then the Euclidean distance [9] between P and Q can be measured as:

$$yd(P,Q) = \sqrt{(q_1 - p_1)^2 + \ (q_2 - p_2)^2} \quad (1)$$

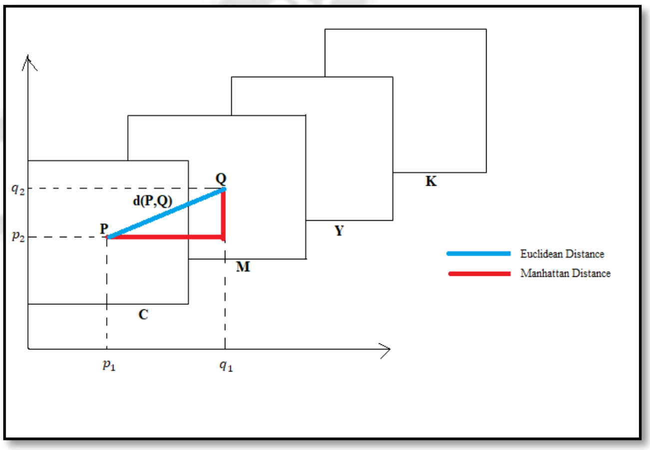

Figure.3. Euclidean distance measurement between channels

Similarly the distance with other channels is also measured like the distance between MY, YK, CK, CY and MK. If the tested image is properly registered then the

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distance between these channels will be zero or else the resulted distance shows how much color is shifted from each other.

Manhattan distance metrics [9] is also applied to measure the color shifting in printed image samples. Manhattan distance is also called 'city block distance' and it measures the absolute value of sum of the difference of two points. The Manhattan distance between the two points (P,Q) in Fig. 3 can be measured as:

$$md(P,Q) = |q_1 - p_1| + |q_2 - p_2| \quad (2)$$

III. RESULTS AND DISCUSSION

The presented method is tested with various sample collected from offset press. Distance between CMYK channels has been calculated according to the proposed method. Some of the tested samples result with pictorial representation is presented here. Three misregisterd samples are shown in Fig. 4, Fig. 5 and Fig. 6.

For sample1, the original RGB image is shown in Fig. 4(a) and the converted image in CMYK color space is shown in Fig. 4(b). Fig. 4(c), 4(d), 4(e) and 4(f) depicts the separated color channels of the sample in CMYK color space consecutively. Though visual appearance of this image does not depict any color shifting but if tested with linen glass tester it shows the misalignment of colors. This fact is also supported by the results calculated by Euclidean distance and Manhattan distance between the color channels shows in Table 1 and Table 2 respectively. Though color shifting can be noticed (by linen glass) in this image but the measure of color shifting cannot be quantified visually. The result (Table 1 and Table 2) shows that all the four channels, except cyan and magenta, are not aligned properly with each other. The Euclidean and Manhattan distance between cyan and magenta is zero which proves that this two color channels are overlapped. But the others have distance in between. The distance measured by Euclidean and Manhattan shows how much shifting is occurred.

For sample 2, the original RGB image is shown in Fig. 5(a). Misregistration of these images generally detected through the linen glasses as because it's not possible to trace the defect with naked eyes. The computed result in table 1 and table2 shows the shifting of colors. In this sample none the four colors are aligned with each other. This much of color shifting is not acceptable in any way and the color units must be adjusted according to the result. For Sample 3 (Fig. 6) the euclidean distance result depicts that magenta and yellow channel superimposed but black and cyan channel are misregisterd. Manhattan distance metrics also supported this fact. In this image the amount of color shifting is more than other samples which affects the visual appearance and readability as well.

Fig. 7, Fig. 8 and Fig. 9 are the sample of registered image of Sample 4, Sample 5 and Sample 6 respectively and considered as a good copy. Table 3 and 4 shows the calculated distance of CMYK color channel for these registered samples. However the result shows that there is some misregistration present in black channel that is negligible to some extent. The other channels which are cyan, magenta and yellow channels are properly superimposed. The visual appearance of these images are not affected that much. Therefore it can be said that though there is some misregistration in black channel but as the other channels are properly aligned with each other, visually the image appears as good and considered for quality output.

Figure. 4. Misregistered Sample 1: (a) Original Image; (b) Converted CMYK Image ; (c) Image in C-channel; (d) Image in M- channel; (e) Image in Y-channel; (f) Image in K-channel.

Figure. 5. Misregistered Sample 2: (a) Original Image; (b) Converted CMYK Image ; (c) Image in C-channel; (d) Image in M- channel; (e) Image in Y-channel; (f) Image in K-channel.

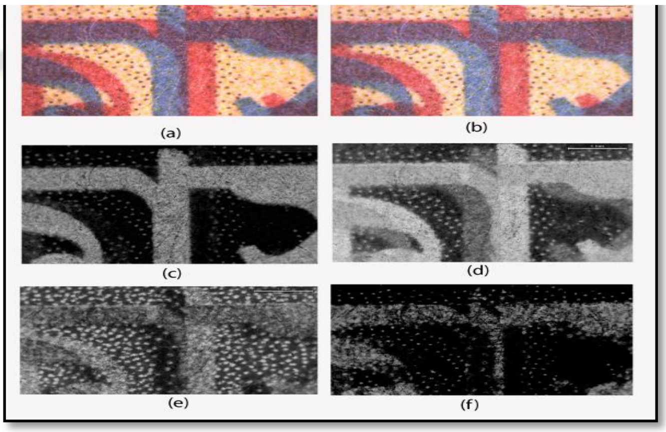

Figure. 6. Misregistered Sample 3: (a) Original Image; (b) Converted CMYK Image ; (c) Image in C-channel; (d) Image in M- channel; (e) Image in Y-channel; (f) Image in K-channel.

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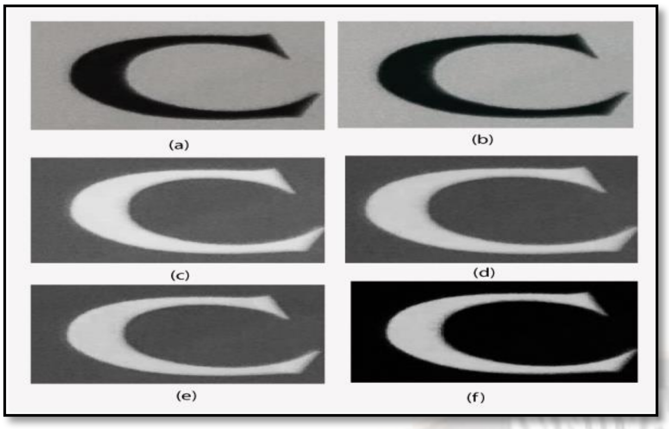

Figure 7. Registered Sample 4: (a) Original Image; (b) Converted CMYK Image ; (c) Image in C-channel; (d) Image in M- channel; (e) Image in Y-channel; (f) Image in K-channel.

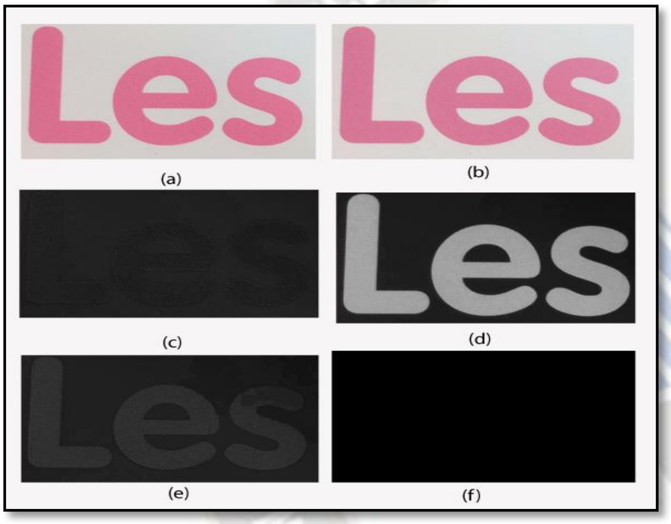

Figure 8. Registered Sample 5: (a) Original Image; (b) Converted CMYK Image ; (c) Image in C-channel; (d) Image in M- channel; (e) Image in Y-channel; (f) Image in K-channel.

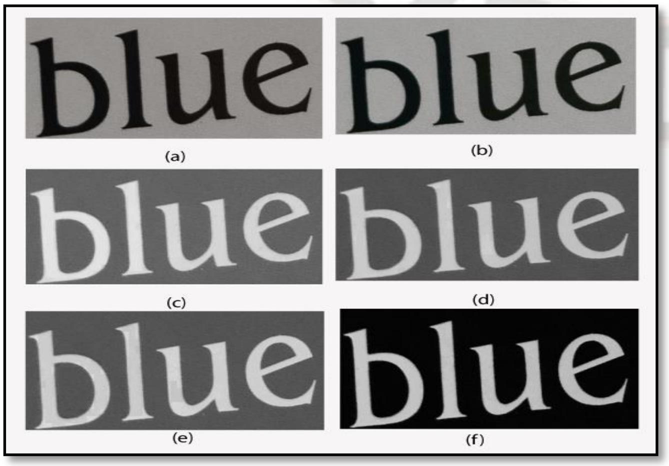

Figure 9. Registered Sample 6: (a) Original Image; (b) Converted CMYK Image ; (c) Image in C-channel; (d) Image in M- channel; (e) Image in Y-channel; (f) Image in K-channel.

TABLE1: EUCLIDEAN DISTANCE BETWEEN COLOR CHANNELS IN CMYK COLOR SPACE FOR MISREGISTERD SAMPLE

Sample	CM	CY	CK	MY	MK	YK
Sample 1 (Fig.4)	0	12.16	73.76	12.16	73.76	61.68
Sample 2 (Fig.5)	10.198	3.605	146.932	7	155.438	148.929
Sample 3 (Fig.6)	22.825	22.825	94.366	0	116.481	116.481

TABLE2: MANHATTAN DISTANCE BETWEEN COLOR CHANNELS IN CMYK COLOR SPACE FOR MISREGISTERD SAMPLE

Sample	CM	CY	CK	MY	MK	YK
Sample 1 (Fig.4)	0	14	91	14	91	77
Sample 2 (Fig.5)	12	5	193	7	201	194
Sample 3 (Fig.6)	31	31	113	0	144	144

TABLE 3: EUCLIDEAN DISTANCE BETWEEN COLOR CHANNELS IN CMYK COLOR SPACE FOR REGISTERED SAMPLE

Sample	CM	CY	CK	MY	MK	YK
Sample 4(Fig.7)	0	0	0.5	0	0.5	0.5
Sample 5(Fig.8)	0	0	133.66	0	133.66	133.66
Sample 6(Fig.9)	0	0	0.7	0	0.7	0.7

TABLE 4: MANHATTAN DISTANCE BETWEEN COLOR CHANNELS IN CMYK COLOR SPACE FOR REGISTERED SAMPLE

Sample	CM	CY	CK	MY	MK	YK
Sample 4(Fig.7)	0	0	0.5	0	0.5	0.5
Sample 5(Fig.8)	0	0	154	0	154	154
Sample 6(Fig.9)	0	0	1	0	1	1

IV. Conclusion

This paper presents an approach of misregistration print defect detection by quantifying the amount of misregistration by using Euclidean distance and Manhattan distance measurement in CMYK color space. Identification of misregistration is still depends on manual intervention in most of the presses. Whereas this proposed method can be a potential alternative for less manual approach with a proper quantification of this print problem. Artificial intelligence application can be the future scope of this work. Moreover it is identified that to some extent there are negligible misregistration present in good copies also. But it can be ignored if the visual appearance in terms of readability is not affected that much. This presented method is a novel approach to quantify misregistration. Therefore it can be concluded that proposed approach has the better potential in terms of automatic detection process of misalignment of colors without human intervention. The main aim of this work is to make the procedure of detection and quantification of misregistration less manual and less time consuming as well.

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