

# Colour to colour register on the spot

**This article is about: 'The effect of register measuring equipment on colour to colour registration'. We will use the measuring of register variation as an example on how the measuring system variation must be accounted for in the process evaluation. By Wilbert Streefland.**

We often believe that when using measuring equipment, especially when digital equipment and computers are used, that the measurement is absolute. However the measuring equipment has variation, just like the process evaluated with the measuring equipment. The variation due to the measuring equipment used for measuring a property must be a magnitude less than the variation for that property of the process evaluated. We will not discuss the quantum effects that measuring systems have on the process evaluated but yes the measuring already effects how the process behaves thus has influence.

## The problem

We begin by explaining that the measuring system has variations when measuring and that this can influence the judging of the measured process variation. We can't judge the variation of the process if the variation of the measuring system is similar or larger than the variation of the process measured.

We assume that the measuring system for collecting colour to colour register data produces a normally distributed data set and the same applies for the process. In that case we can apply 'normal' statistical analysis.

## Measuring colour to colour register using a CCD camera

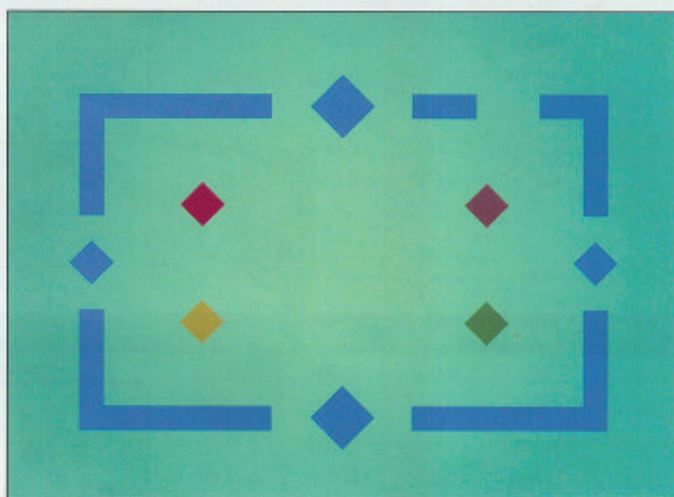
When measuring colour to colour register it is meant that we measure the deviation in distance between a reference printed colour and the other individual colours printed. These are in print direction and in cross print direction. Preferably we do this on a number of positions in the printed image. During testing I always take six measurements in one printed image, three measurements in print direction on the operator side

and three on the drive side and repeat this for at least 10 consecutive images printed. Thus I collect 60 measurements in print direction and 60 in cross print direction. All these data points are then shown in one graph. This graph will give an indication of the colour to colour register variation.

For the measuring of colour to colour register we can use a CCD camera connected to the computer using 'Firewire'.

In our case the colour to colour register element used looks as presented in figure 1. The total actual size of the image is: 44.5 x 33.5 mm. The resolution of the camera used is 640 x 480 pixels. The result is that one pixel is 0.07 mm. Thus the resolution of the camera is in this case 0.07 mm per pixel. Remember this might not be accurate because the software used will decide which pixel it is and it might thus be a few pixels off. This is because of the light source or the gloss interference of the surface printed on.

Using clever software solutions as sub pixel definition allows increasing the resolution of the measuring system. It is what was used when collecting the data for this report. So what are we going to do to determine how well the camera is measuring the register? For this case we do four tests using two similar images one printed on a glossy paper and one on a matt paper. We do two series of measurements on each paper one holding the camera steady



Register element.

and one series where we move the camera between each measurement. This simulates the moving of the sheet or paper web. However we still use the same image so we are looking at a stable process. All of this is done for five colours individually printed.

To analyse the data we will calculate the standard deviation of the data collected per colour in print direction and in cross print direction. You can calculate the total standard deviation using the following equation:

$$\sigma_{tot} = \sqrt{\sigma_{PD}^2 + \sigma_{CPD}^2}$$

$\sigma_{tot}$  = Total standard deviation

$\sigma_{PD}$  = Standard deviation in print direction

$\sigma_{CPD}$  = Standard deviation in cross print direction

## Test results

The following table shows the results for the four tests done (all values in mm). It can be seen from the results that two different images for the glossy and the matt paper are used. We have not off set the data to



Test	Colour	Stat	Spd	Scpd	Image
Camera still on glossy paper	ALL	0.006	0.004	0.005	
	Yellow	0.009	0.005	0.007	
	Magenta	0.006	0.004	0.005	
	Green	0.007	0.004	0.005	
	Cyan	0.005	0.003	0.004	
	Black	0.006	0.004	0.004	

Test	Colour	Stat	Spd	Scpd	Image
Camera moving on glossy paper	ALL	0.011	0.008	0.007	
	Yellow	0.014	0.010	0.010	
	Magenta	0.009	0.005	0.008	
	Green	0.011	0.009	0.006	
	Cyan	0.007	0.004	0.006	
	Black	0.012	0.009	0.007	

Test	Colour	Stat	Spd	Scpd	Image
Camera still on matt paper	ALL	0.006	0.004	0.004	
	Yellow	0.006	0.004	0.004	
	Magenta	0.006	0.004	0.004	
	Green	0.007	0.005	0.005	
	Cyan	0.005	0.003	0.004	
	Black	0.006	0.004	0.004	

Test	Colour	Stat	Spd	Scpd	Image
Camera moving on matt paper	ALL	0.009	0.006	0.007	
	Yellow	0.011	0.007	0.008	
	Magenta	0.008	0.005	0.006	
	Green	0.011	0.009	0.006	
	Cyan	0.008	0.004	0.006	
	Black	0.008	0.006	0.006	

the centre so you can see the variation of the individual colours.

If you look at the variation data then you see that there is not a large difference for print and cross print direction. This was expected because we are looking at the capability of the camera and not the printing equipment.

Also notice the scaling difference in the images for the coated and matt paper. This is due to the difference in off set between the colours in the measured images for the glossy and matt paper.

The increase in variation when start-

ing to move the camera is also visible.

Let us now compare the images using the same scale (3 x 4 mm) with data collected from two print tests and the camera data:

The data of the two machines shown was for a corrugated post printer with vacuum transport and direct drive and an older pre-print machine. This data shows a greater register variation in print direction than in cross print direction.

## Discussion

The question we need to ask is: does the measuring variation of the cam-

era have a significant influence on the result of the print tests?

Let us first take a closer look at the camera variation. It shows a total variation of 0.011 for the moving camera on a coated surface. If we apply normal statistics then this means that 99.97% of all measurements are within a radius of  $3 \times 0.011 = 0.033$  mm. Careful! It is six sigma but we only look at half the normal distribution when talking about a radius. The diameter of the circle would be 0.066 mm. This value is very close to the size of one pixel (0.070 mm). We can conclude that the resolution and the error are identical in this case.

The difference in variation found for the two machines compared with the camera variation is  $0.149/0.011 = 13.5$  for machine 1 and  $0.190/0.011 = 17.3$  for machine 2. This is large enough to allow us to judge the machines using the camera.

The results show that the machines can hold register within a circle with a radius of 0.447 mm and 0.570 but this is not including the mounting of the plates and the adjustments made by the operators. Thus what is supplied to the customer will be significantly larger. If the end result is within 1mm then the job done is still excellent.

## Conclusions and recommendations

- If you intend to buy equipment for register control on your machine then it is wise to test it independently of the machine it will control. The variation of the controlling equipment might affect the quality of the print if the resolution is inadequate for to what you want to achieve in print register.

- Printing equipment does not become more stable or better when installing register controlling equipment. It might result in hunting a moving target. It is not right to assume that the next image can be corrected in register using the data derived from the previous image printed. Systematic errors only can be corrected.

- If tests show that your machine is stable in terms of register variation then mostly that is enough. Digital register controlling/measuring equipment might then be useful only during set-up and for the providing of evidence towards the quality produced in terms of colour to colour register. ■