Line Quality Analysis in Digital Printing

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Abstract

In this study, the line quality defects in digital printing will be evaluated and analyzed. The design of a line quality analysis system will be described in some detail. The attributes of line qualities have been defined in the ISO13660 standard. Among them, the line width, raggedness and blurriness are used to reflect the edge features of lines. The analysis of line quality can be applied to evaluate both text and line quality. Using carefully designed test targets, it can also be used to evaluate other printing problems like inter-color bleed, positional errors from a device, and color registration problems. By using digital printer with different imaging mechanisms or different types, the three attributes, line width, edge raggedness, and edge blurriness, which best present the digital printing quality, are measured and analyzed. The measurement of the line quality attributes is made through the line tool in analysis system. The evaluation and analysis of line quality in digital printing provides a basis to solve the line quality measurement in current digital prints, and offers a practical technology for quality controlling of digital prints.

Introduction

The high prints quality is the ultimate goal for the print to pursue and the fundamental guarantee for printing enterprises to survive in the market. Digital printing technology has its own printing quality defects, such as the raggedness and blurriness of line edges [1].

Image quality evaluation is divided into two major categories of subjective evaluation and objective evaluation. The line quality evaluation of digital prints is still placed in the subjective evaluation. The results of subjective evaluation affected by many factors, such as visual geometrical conditions, light source, past experience and eye fatigue, and so on. Therefore, the evaluation result is poor in reproducibility, and is not good for printing quality control. The results of objective evaluation are indicated in digital form with good reproducibility because they based on instrument measurements. Then, the correct and stable judgments can be made easily based on this. In this study, the line quality defects which caused by the characteristics of papers in digital prints were evaluated and analyzed, based on the measurements of line attributes [2].

Objective Attributes of Line Quality

The attributes of line qualities have been defined in the ISO13660 standard. Among them, the line width, raggedness and blurriness are used to reflect the edge features of lines, providing a method for the evaluation and analysis of the quality of digital prints.

Line width is the average stroke width, where the stroke width is measured from edge threshold to edge threshold along a line normal to the centre line of the image element, as seen in Figure 1(a). The line width needs to be calculated by sampling at a rate of at least 600 points per inch, along the center line perpendicular to the direction of the line.

Line raggedness is the appearance of geometric distortion of an edge from the ideal position, as shown in Figure 1(b). The ragged edges appear rough or wave rather than smooth or straight. The measurement of raggedness is the standard deviation of the residuals from a line fitted to the edge threshold of the line, calculated perpendicular to the fitted line. The raggedness evaluation is optimized for use with edges containing a periodic noise.

Line blurriness shows the appearance of being hazy or indistinct in outline, the noticeable transition of blackness from background to character, as shown in Figure 1(c). The measurement of blurriness is the average distance between the inner and outer boundary edges.

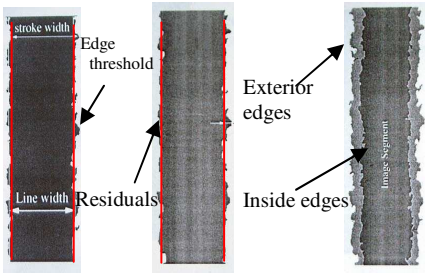

Figure 1. *Three attributes of line*

In the following experiments, we choose five types of papers which have different gloss, roughness and absorbency. The impact of different paper properties to the attributes of line quality was tested.

Table 1 Paper properties

Pattern number	Basis weight (g/m^2)	Gloss (TAPPI, 75°)	Roughness (1MPa, μm)	Absorbency (60s, g/m^2)
# 1	103.4	5.4	3.48	40.37
# 2	120.1	51	3.19	28.4
# 3	148.9	43.4	2.09	35.5
# 4	167.2	58.7	1.07	33.9
# 5	195	45.9	1.34	53.7

Designing Test Diagram

Digital prints were produced by the horizontal and vertical imaging mechanism, according to quality characteristics in the digital printer of different imaging mechanism and types. Designing a test diagram, which consists of lines oriented in horizontal and vertical direction respectively and with different width (from 0.035 mm to 0.245 mm), and then outputting them by digital printer. All the lines were black lines on white paper background. Designed test diagram was completed in Indesign software and was transformed into PDF format for outputting, in order to ensure the consistency with original when outputting the diagram in the digital printer [3]. It could be seen from Figure 2.

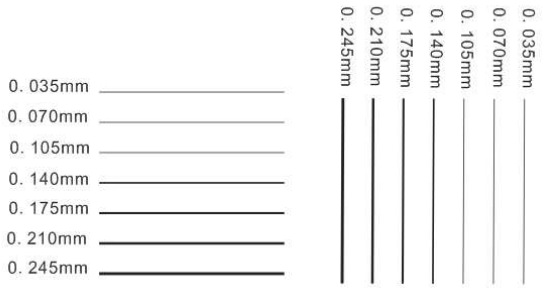

***Figure 2**. Horizontal and vertical lines in designed test diagram*

Measurement and Analysis of Results

Line Width

Line width is a basic attribute of line quality. Epson7800 inkjet printer was selected to output the test diagram. Ideally, the designed and output lines are the same in width. But the case is not this in fact [4]. In this part, the increased value of output lines, which were the output value of line width minus the designed line width, was used to show the difference in the vertical direction clearly. It could be seen in Figure 3.

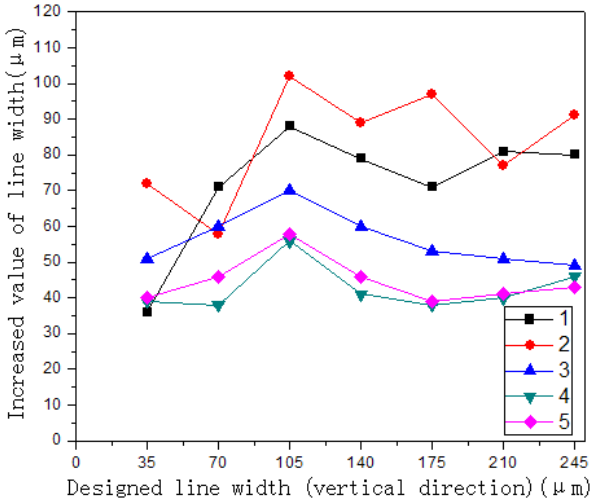

***Figure 3**. The increased value of line width of different papers in vertical direction*

The increased value of line width in horizontal direction performance derived from our experiments could be seen in Figure 4.

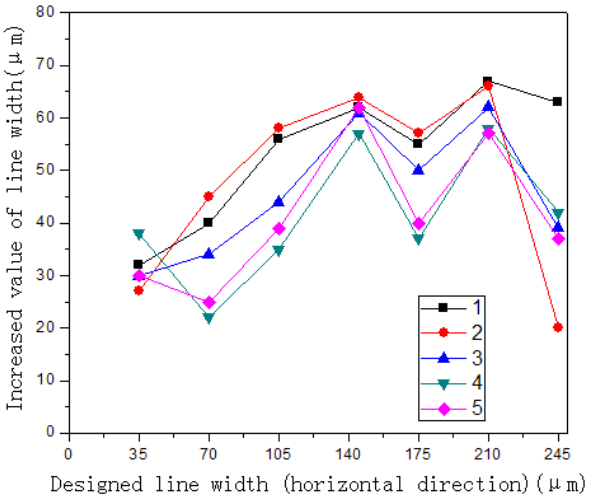

***Figure 4**. The increased value of line width of different papers in horizontal direction*

It could be seen from Figure 3 and 4, the order trend of the increased value of line width of different papers in vertical direction and horizontal direction were same as the paper roughness. The greater roughness of paper, the greater increased of line width. In addition, the increased of line width in vertical direction were bigger than horizontal direction.

It could be explained that the different paper roughness cause the different degrees of ink diffusion on papers, which will cause different changes in line width. The absorption and diffusion degree of ink on paper is related to the paper roughness. The different increased of line width in vertical and horizontal direction. It could be explained that the line width also affected by the moving direction of inkjet head and papers.

Line Raggedness

According to the definition of the line raggedness, the line raggedness and line width are independent from each other [5]. Ideally, the line edge is absolutely smooth; the raggedness value should be zero. On the opposite, it shows be rough, jagged or fan-shaped in edges.

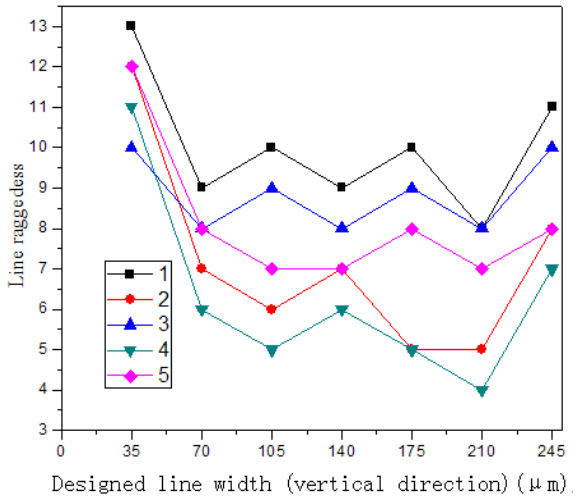

***Figure 5**. Average line raggedness in vertical direction*

The 5 different papers and the Epson7800 were used to output the test diagram; the vertical line raggedness is shown in Figure 5.

The line raggedness in horizontal direction performance derived from our experiments could be seen in Figure 6.

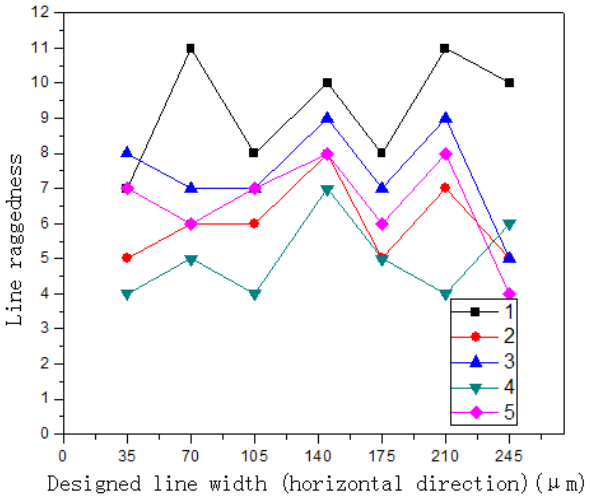

Figure 6 *Average line raggedness in horizontal direction*

It could be seen from Figure 5 and 6, the order trend of the line raggedness of different papers in vertical direction and horizontal direction were same as the paper gloss. The greater gloss of paper, the smaller line raggedness. In addition, the line raggedness in vertical direction was bigger than horizontal direction. The line edge raggedness appear uneven jagged or waves, deviating from the ideal smooth edges. The line raggedness values fluctuated with the width increasing of designed lines. And the raggedness fluctuates in different ranges with widening of the designed lines. Therefore, the raggedness values of vertical lines were the larger than the horizontal lines.

It could be explained that the different paper gloss cause the different degrees of dot expand, which will cause different changes in line raggedness.

Line Blurriness

When the inkjet to the paper surface, it will be absorbed by the paper fibers and appear a phenomenon called ink diffusion. The degree of absorption and diffusion is related to the characters of papers and ink itself. Owing to these traits, inkjet line edge appears to be blurry [6].

The 5 different papers and the Epson7800 were used to output the test diagram. The vertical line blurriness is shown in Figure 7.

The line blurriness in horizontal direction performance derived from our experiments could be seen in Figure 8.

It could be seen from Figure 7 and 8, the order trend of the line blurriness of different papers in vertical direction and horizontal direction were same as the paper absorbency. The greater absorbency of paper, the smaller line blurriness.

It could be explained that the different paper absorbency cause the different degrees of ink spreading, which will cause different changes in line blurriness. The ink drying rate will be slow to a less absorptive of paper. If the ink strength is light, the spreading of ink will be serious.

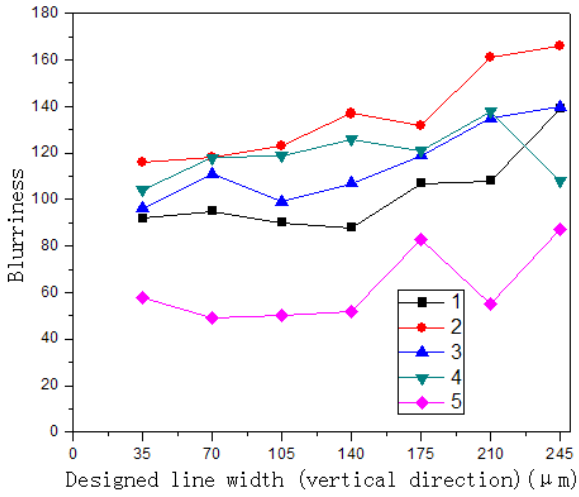

Figure 7 *Average line blurriness in vertical direction*

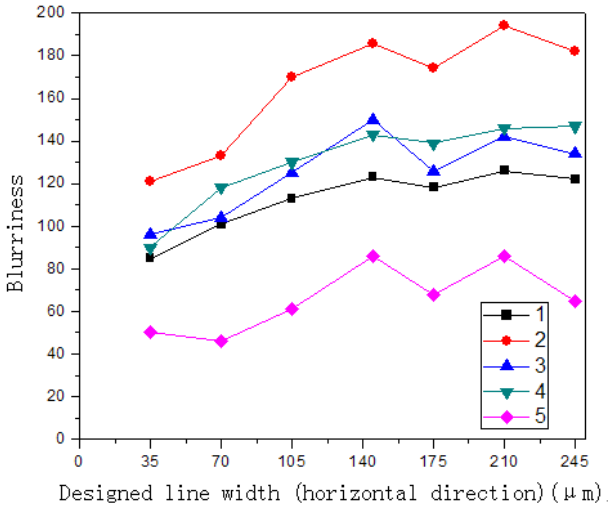

Figure 8 *Average line blurriness in horizontal direction*

Conclusions

In this study, by using digital printer with different papers, the three attributes, line width, line edge raggedness, and line edge blurriness, which best present the digital printing quality , are measured and analyzed.

The line width in digital printing was affected by the roughness of paper. The greater roughness of paper, the greater increased of line width.

The line raggedness in digital printing was affected by the gloss of paper. The greater gloss of paper, the smaller line raggedness.

The line blurriness in digital printing were affected by the absorbency of paper. The greater absorbency of paper, the smaller line blurriness.

During the printing process, small roughness and high gloss paper with large absorptive can be chosen for digital printing to improve the fineness of the lines and print quality.

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