Beyond Density and Color: Print Quality Measurement Using a New Handheld Instrument

John C. Briggs and Ming-Kai Tse
QEA, Inc.
755 Middlesex Turnpike, Unit 3, Billerica MA 01821 USA
Tel: (978) 528-2034 · Fax: (978) 528-2033
e-mail: info@qea.com
URL: www.qea.com

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John C. Briggs and Ming-Kai Tse

Quality Engineering Associates (QEA), Inc.
Burlington, Massachusetts 01803, USA

Abstract

Good print quality is the result of achieving high quality for a large number of attributes including color (color gamut and reproduction accuracy), density, tonal quality (tone reproduction and details in highlight, shadow and mid-tone), gloss, line quality (width, blurriness, raggedness,), text quality, adjacency (e.g. inter-color bleed), micro-uniformity (graininess), macro-uniformity (mottle), effective resolution (MTF), and many others. While for many people in the digital printing world, good print quality is synonymous with accurate reproduction of color, it is by no means the only attribute affecting the perception of print quality. One reason why the quantification of most print quality attributes other than color is neglected has been the lack of convenient instrumentation for objective evaluation of these attributes. In this paper, we will introduce a novel handheld instrument that is capable of measuring a wide range of print quality attributes. We will provide examples of many print quality defects common in digital "photo" printing such as ink coalescence, graininess and mottle, inter-color bleed, misdirected jets, satellites, etc. and show how these defects can be quantified quickly, objectively and reliably.

Introduction

It should be made clear, right from the start of this paper: accurate color and tone reproduction are important aspects of print quality. Perhaps they are the most important aspects, particularly when pictorial images are involved. But there are other, often neglected, attributes that affect the perception of print quality (PQ) as well.

Lists of PQ attributes are available in numerous technical papers. One such list[1] shows six attributes beyond color, density and gloss.

- Line Quality (e.g. raggedness)
- Text Quality (e.g. serif deletion)
- Adjacency (e.g. intercolor bleed)
- Micro uniformity (e.g. graininess)
- Macro uniformity (e.g. mottle)
- Effective Resolution (e.g. fine detail)

Although the items on the list can be debated, the need to examine more than just color is generally agreed. The lack of convenient instrumentation has resulted in many of these PQ attributes being ignored.

The Personal IAS Image Analysis System, recently introduced by QEA, has made it possible to easily quantify a variety of PQ attributes. The Personal IAS is a portable handheld instrument that can make measurements of dots, lines, large areas, and more. The instrument incorporates the methods defined in the ISO-13660 international print quality standard[2] to ensure wide acceptability of the measurements.

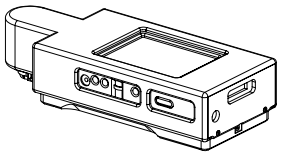
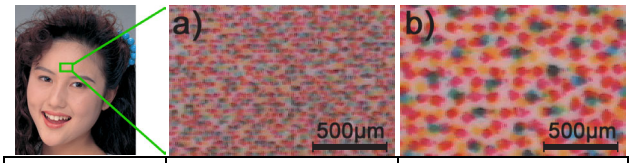


Fig 1: Personal IAS

In this paper, typical PQ defects are identified and the measurement method with the Personal IAS is illustrated. As a case study, test images from the SCID library (ISO 12640:1995) were printed by color office printers. The samples were visually examined for obvious defects. These defects were then quantified using the Personal IAS.

PQ Measurements

Graininess:
In many printed samples, graininess was found to be most objectionable in image areas representing human skin. The SCID image of an Asian woman, labeled as "Portrait," was often selected as being too grainy. Using the *Area* measurement tool on the Personal IAS, measurements were made of the center of the woman's forehead on several samples. Data comparing samples printed by two different inkjet printers on coated media are shown in Fig. 2.



Reflectance	26.8%	26.4%
$Graininess_{42\mu m}$	**5.60**	**11.65**

Fig. 2: Graininess of Two Printed Samples

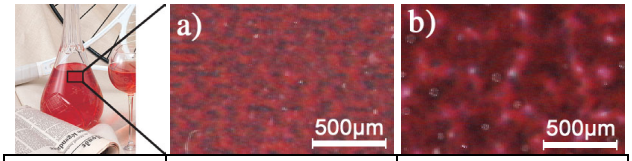
Comparing these samples, the reflectance values or tones are very similar, but the graininess values are dramatically different. Subjectively, sample "b" is clearly grainier than sample "a;" but the Personal IAS provides quantitative information about how much worse "b" is than "a." Whether a certain graininess value is acceptable or not depends on a number of factors including overall reflectance value of the patch, intended application, and competition.

The Personal IAS uses the ISO-13660 defined graininess measurement methodology. Reflectance values for 42×42µm square tiles are measured and the standard deviation calculated. The details can be found in the standard[2].

Mottle and Coalescence:

Another PQ problem noted among the samples was mottle or ink coalescence. Similar to graininess, but on a larger spatial scale (>250µm), mottle is a problem of non-uniformity and can also be measured with the Personal IAS.

Among the sample SCID images, a particular mottle problem was found occasionally in the image labeled "Bicycle." In this image, there is a decanter with red wine. Some print samples had poor uniformity of the wine due to ink coalescence, as seen in Fig. 3.



Reflectance	3.8%	1.6%
$Mottle_{250\mu m}$	**0.19**	**0.31**

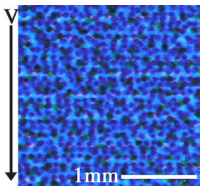
Fig. 3: Coalescence samples (Contrast enhanced)

The images labeled "a" and "b" in Fig. 3 come from samples printed by the same inkjet printer, but with two different media.

Some benchmarking data is needed to determine the acceptance level of mottle and coalescense.[3] To get a sense of the severity of the problem on the samples above, mottle data should be collected on a range of comparable or competitive samples. With these benchmarks and the appropriate measurement tool, an objective and quantitative assessment of the uniformity can be made.

Banding and Streaking:

Banding and streaking were common among the samples, examined in this study. One area frequently selected as poor was the sky section of the SCID image labeled "Cafeteria." To quantify the problem, the image area was measured using the Personal IAS's *Reflectance Profile* tool, as shown in Fig. 4.



	Reflectance (%)		
	Range	Max.	Min.
Horizontal	**7.2**	22.0	14.7
Vertical	**13.3**	27.6	14.2

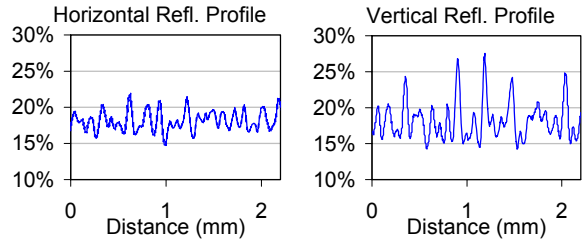


Fig. 4: Banding and Streaking

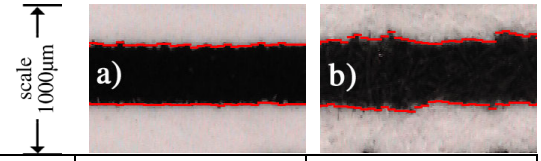
The effect of banding can clearly be seen by contrasting a horizontal reflectance profile with a vertical one. The horizontal profile is comparatively uniform with reflectance range of only 7.2. In contrast, the vertical profile shows a number of light streaks and a reflectance range of 13.3. Once again, the appropriate acceptance level depends on the intended application, market, etc., but quantification is a key first step.

Text and Line Quality:

In many office documents, the quality of the text and lines is of primary interest. When examining some of the SCID images, it was found that the text labeling the images occasionally had significant print quality problems. Such problems can be quantified with the Personal IAS using the *Line* measurement tool.

It is well recognized that media has a significant effect on the quality of text. The most important text PQ attributes are stroke density, stroke width, raggedness, and blurriness. All of these attributes can be measured with the Personal IAS and are defined in ISO-13660.

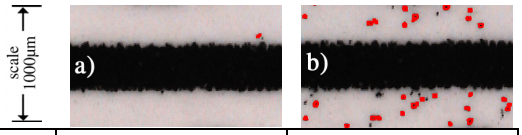
Ink wicking and poor ink holdout significantly reduce text quality, as can be seen in Fig. 5. Compared to media "a", media "b" has lower density, higher stroke width, raggedness, and blurriness. The ability to quantify such PQ attributes greatly enhances print media development as well as production quality control.



Density(OD)	1.38	1.06
Width (µm)	387	434
Rag.(µm)	6	18
Blur.(µm)	64	87

Fig. 5: Text Print Quality Attributes

In addition to media, printers can create text PQ problems as well, as seen in Fig. 6. In this case, the problem is satellites falling near the text that can give the text a fuzzy appearance. This problem can be quantified using the Personal IAS *Dot* tool. The total area, size, and/or number of satellites can be used as an indicator of severity.



Total Area	589µm²	28342µm²
Ave. Diam.	27µm	37µm
Count	1	26

Fig. 6: Satellites Adjacent to Text

Conclusions

There are many PQ attributes of importance in digitally printed documents beyond accurate color reproduction. These properties include area uniformity, and line and text quality. The examples in this paper show that with the new handheld PQ measurement device employing international standards, quantitative measurements are now easy to make.

References

1. E. Dalal, et al, Evaluating the Overall Image Quality of Hardcopy Output, *IS&T PIC's 1998*, p. 169-173 (1998).
2. ISO/IEC 13660:2001(E)
3. Nathan Jones, et al., IS&T NIP14: p161-166, 1998