Maintaining Fidelity of Electronically Generated Image Quality Test Targets

Dave Wolin
ImageXpert Inc.
Nashua, New Hampshire

Abstract

The use of analytical test targets is necessary for quantitative image quality analysis of printed output. As objective analytical methods are more widely imple-mented, development of predictable and accessible methods to transmit and print test targets has become an increasingly familiar stumbling block. Electronic test targets undergo a variety of different steps during the rendering process. During test target development, care is taken to create features with specific attributes. Color content is deliberately defined to contain to pure primary, secondary, and tertiary colors as well as other known combinations. Line and dot dimensions are created to match specific engine addressabilities. However, once files are created, the intentional or unavoidable use of various file formats, color matching engines, printer drivers and on-board ASICs all impact the translation of an electronic target into print. Often, what is intended is lost or modified significantly by the rendering process.

This paper will include a discussion on the problems impeding the successful preservation of analytical test target features from electronic file to printed output.

Introduction

Automated image quality testing depends on specific test structures positioned at predictable locations. Whether the intent of this testing is to provide diagnostics during development, production or failure analysis, or for the purpose of competitive benchmarking, these features must be mathematically definable independent of the specific attributes of any specific printer technology or addressability. The repeatability and reproducibility of these targets is essential to the validity and usefulness of the results.

Issues

There are several different types of target features that need to be defined, each having its own set of constraints and restrictions due to the series of interpretive steps a file goes through in rendering. In general, these features fall into the categories of morphology (size and shape), position, and spectral characteristics. Each of the features can be affected by any step in the process of creating the hardcopy output to be analyzed.

Morphological Characteristics

In digital printing, all images are composed of dots of some kind. The morphology of those dots and the features created by them are indications of quality at fundamental levels of the technology. In the monochrome world, the characteristics of those dots are basically a function of the dynamics and interactions of the various parts of the print process, the engine, receiving and marking media. Once color is involved, the process gets more complicated, as results are measured independent of whether the dot being measured was intended to be composed of a single color or not. However, this can make a difference in the morphology of the dot, both measured and perceived. An example of this is shown in Figure 1a and 1b.

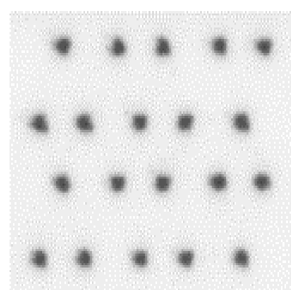

Figure 1a. Single pixel dots rendered in black only

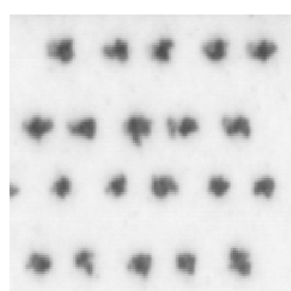

Figure 1b. Single pixel dots rendered as color.

If an application is chosen that cannot accurately interpret the intended pattern according to the particular pixel creation technology of the printer, the attributes of the printed dots will not conform to the intention of the designed performance of the printer or its driver. An example of this is shown in Figure 2.

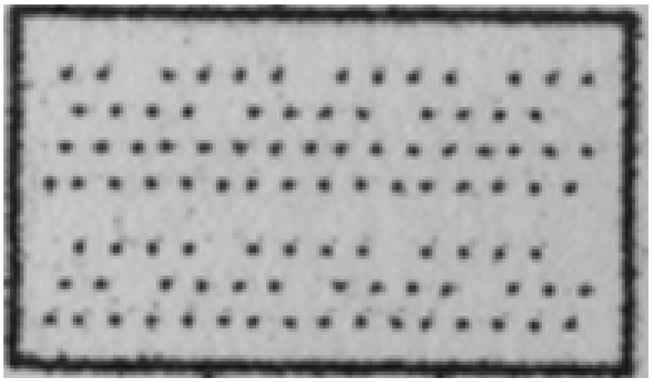

Figure 2. A pattern of single pixel dots. Missing dots are due to rendering issues.

Alternatively, the driver itself may reinterpret the pattern specified by the user in the application, or the processing resident in the printer may change the file in ways that corrupt the original intention of the target design. This is especially true when the systems have different ways to handle different data types such as text and graphics. The more sophisticated the microstructure of the addressability pixels, or "dots" becomes, the more likely the chance that what will be measured is the rendering and not the printing process. While this is valid for subjective testing, it does not provide the data required to determine whether the dot formation is occurring as intended. An example of "1-pixel dots" rendered using sub-pixels is shown in Figure 3.

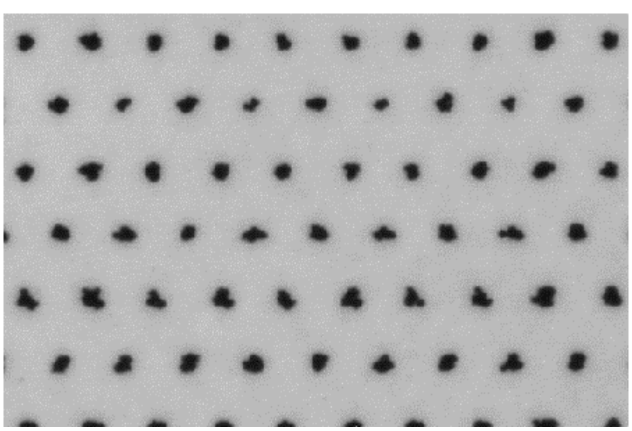

Figure 3. The affect of sub-pixels on single pixel dots

Positional Characteristics

The actual image quality is at least as dependent on the positional accuracy of these primary building blocks, usually specified in terms of dots or lines per inch. The problems with this lie in the fact that not only do printers have different native resolution or addressability, but that the tone reproduction that depends on this can be non-linear, and these non-linearities are usually unique to each combination of printer and driver. Again, especially with color, the definitions for halftones or line screens are not universally applicable and will cause interference or "moiré" patterns that are actually artifacts of the mismatch of the digital input to the addressability of the printer under test. Another common pattern used to test printers is the resolution target consisting of blocks of lines at different spacing, which is also prone to phase interference and aliasing. Features that test the accuracy of positioning the dots, including both dot and line patterns, must be defined in a way that allows rendering in the native addressability of the printer without knowing it in advance. Color registration, another position-dependent characteristic, can be difficult to measure if the application, driver, or firmware have applied some compensation, or if some implementation of color management has contaminated the primaries.

Often, features that are intended to be monochromatic are rendered polychromatically. In this case, both spectral characteristics and positional variations of the individual, contributing primaries will impact the output feature quality.

Spectral Characteristics

Color characterization of printers has inherent pitfalls as well. In the first place, the color space used should be standardized, preferably as one independent of input devices and color management software, and as one that will not become obsolete as the technology evolves. The actual definitions of the primary colors in terms of spectral data should be specified in order to provide reference standards for the accuracy of color reproduction. Interpolation of primary colorants to compensate for variance from standard values, while important for subjective comparison of output, makes it difficult if not impossible to perform true morphological and positional testing of the fundamental printer performance.

Considerations

It is important to specify the analytical target content itself and not the target layout. Rigorous mathematical definitions of analytical test target features should be provided in a manner that is independent of specific printer addressability. The proposed feature set should be inclusive to all technologies to provide the widest possible applicability. Individuals can choose to incorporate the features that are of interest to them in their test target or set of test targets.

Conclusion

The focus should be on specifying test target elements rather than their arrangement or method of creation. Choices regarding which software to use for test target design and all issues relating to delivery method should be left up to the discretion of the individual based on their requirements and the tools available to them.

Biography

Dave Wolin is Vice President of Business Development at ImageXpert Inc. After receiving his Bachelor's degree in Physics from Cornell University, Dave has spent the last twenty years working in the field of imaging. He has been involved in the development and production of imaging sensors and systems for a variety of applications. His work at ImageXpert has included metric development for image quality analysis of printers and media.