W1.1 Subgroup on MicroUniformity Update

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The W1.1 Process

INCITS W1 is the U.S. representative of ISO/IEC JTC1/SC28, the standardization committee for office equipment. In September 2000, INCITS W1 was chartered to develop an appearance-based image quality standard.[1,2] The resulting W1.1 project is based on a proposal[3] that perceived image quality could be described by a small set of broad-based attributes. There are currently five *ad hoc* W1.1 teams, each working on one or more of these image quality attributes. This paper summarizes the work of the W1.1 Microuniformity *ad hoc* team.

The agreed-upon process for developing the W1.1 Image Quality of Printers standards is described in a statement located on the INCITS W1.1 web site (ncits.org/tc_home/w11htm/incits_w11.htm), and the process schematic is reproduced here as Figure 1, (in which a final, independent confirmation step has been excluded for brevity).

Summary of Progress

Initial Decisions

By PICS 2001, the Microuniformity sub-group had (the Figure 1 referents follow each item):

1. Identified 5 sub-attributes of microuniformity. (A)
2. Constructed visual definitions of these sub-attributes. (A)
3. Posted JPEG files of the attributes on the web site. (A)
4. Agreed upon a standardized viewing distance. (E)
5. Coordinated with the Macrouniformity sub-group to ensure continuous coverage across frequency space. (P)

MicroUniformity Sub-Attributes

Assuming, for ease of visualization, neutral variations within neutral flat fields, the five microuniformity sub-attributes are:

1. <u>Streaks</u>: 1-D random line-like structures.
2. <u>Bands</u>: 1-D uniformly periodic line-like structures.
3. <u>Voids</u>: Pinhole-type defects.
4. <u>Textures</u>: Moiré, micro-mottle, half-toning and patterns with correlated phase.
5. <u>Noise</u>: 2-D random-lightness fluctuations.

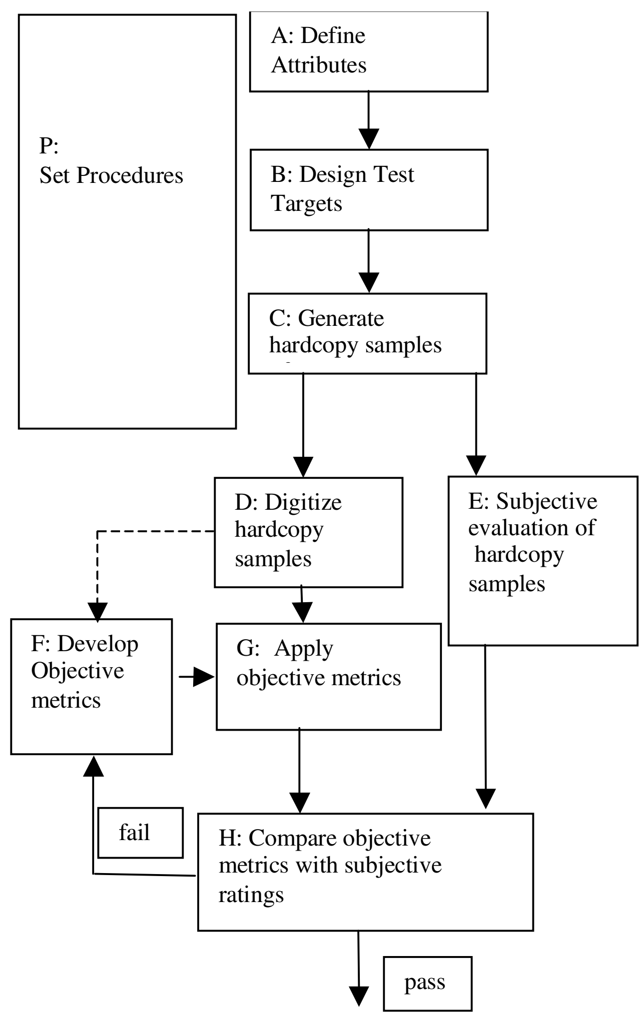

Figure 1.

In addition to these neutral, structural sub-attributes, color microuniformity variations in hue, saturation, and/or lightness will be included when they manifest any of the above behaviors.

Decisions and Tasks

By PICS 2002, the following decisions had been made:

1. The flat-field test targets designed by the Macrouniformity sub-group will be used. (B)
2. Mean sample reflection levels of L* = 40, 60, 80 will be measured, initially neutral in color. For voids, L* = 0 (or process minimum) will be used. (B, P)
3. While measurements may be made on larger areas (for adequate statistics), viewing of artifacts will be on samples cut to 25 mm square and mounted on a TBD substrate approximately 100 mm square. (E, P)
4. A procedure for the dissemination and measurement of originals of somewhat variable reproducibility (e.g., electrophotography) has been agreed upon and is detailed in sub-group notes W1.1 2002-12,13. (P)
5. Technologies to be included and investigated in this standard are inkjet, electrophotography, silver halide, and thermal dye/wax transfer. (P)
6. Some colors of general interest will be specified for measurements. Initially, "blue sky" at three lightness levels has been agreed upon. (P)
7. Psychophysical testing must measure suprathreshold functionalities, not just thresholds. (E, P)
8. The team decided initially to investigate the use of spectrogram-like analysis techniques to preserve phase information. (C)
9. Two team members submitted non-proprietary analysis code written specifically for this task. The code has not yet been evaluated. (C, P)
10. One member generated samples banded at several frequencies to test the submitted analyses. (P)

As of this conference date, recent accomplishments include:

1. Generation of hardcopy test target samples from all of the technologies agreed upon. Five sets of samples have been printed on inkjet systems, one set on a thermal system, four sets on electrophotographic systems, and one set on a digital silver system. (C)
2. Choosing "nominal/best" path to consolidate paper qualities and printer modes, i.e., a printer will typically be evaluated at two set points: a most-often used set point (nominal paper and settings) and a best-case set point (with recommended receiver and highest printer quality setting). (C, P)
3. Dialogue and input on scanner problems and observations were provided. (P)

It became apparent during the meetings that, for this standard to be useful, a convenient, affordable, reliable, and quick measurement procedure would be needed. Flatbed scanners seemed to be the logical choice for digitizing the samples, except for their lack of repeatability, accuracy, and uniformity. Other measurement approaches, e.g., microdensitometers, drum scanners, etc., are costly and not very convenient. The committee recognized that progress would be stymied until the problems with flatbeds could be diagnosed and solved. In fact, all of the sub-groups faced the same problem. Consequently, during the last several meetings, discussions generally centered on experiences with, and requirements of, flatbed scanners, which provided some impetus and support for the resolution of this general problem. (The reader is referred to the paper by W. A. Kress, "Digitization and Metric Conversion for Image Quality Test Targets," on this topic in these proceedings.)

Next Efforts

With the apparent resolution of the scanner calibration problem, measurement of the samples and the development of objective metrics should occupy the near-term efforts of this sub-group.

Summary and Invitation

Since the inception of this standards work, the micro-uniformity sub-group has made progress and has addressed most of the preliminary issues. The crux of the problem, which is the design of objective metrics which correlate well with psychophysical perceptions, lies immediately ahead. Interested parties are invited to join this effort and lend their energy and creativity to this task.

Acknowledgement

The contributions of Marguerite Doyle, Lexmark International, Inc., Lexington, KY, who has been with this sub-group since its inception until recently, are gratefully acknowledged.

References

1. E. K. Zeise and N. W. Burningham, Standardization of Perceptually Based Image Quality for Printing Systems (ISO/IEC JTC1 SC28 and INCITS W1.1), *Proc. NIP18*, pp. 699-702. (2002).
2. N. W. Burningham and E. N. Dalal, Status of the Development of International Standards of Image Quality, *Proc. PICS,* pp. 121-123. (2000).
3. E. N. Dalal, D. R. Rasmussen, F. Nakaya, P. A. Crean and M. Sato, Evaluating the Overall Image Quality of Hardcopy Output, *Proc. PICS,* pp. 169-173. (1998).

Biography

Robert E. Zeman is a research associate in the Imaging Science Division of Electronic Imaging Products, Research & Development Laboratories, at Eastman Kodak Company. Joining Kodak in 1972, he worked for 27 years on electrophotographic systems optimization, development subsystems, and image quality of EP images. He is currently working in the area of image quality metrics and psychophysics. He holds 19 patents and received his MS degree in physics from Purdue University.