Digital Imaging Performance Report
for
Indus International, Inc.

October 27, 2008

by
Don Williams
Image Science Associates

Summary

This test was conducted on the Indus International, Inc./Indus MIS, Inc.,'s Series 7000 Scanner. The same scanner is also marketed by ImageWare Components GmbH of Germany, as the PlanScan Scanner and is manufactured and marketed by Proserv GmbH, Germany as the ScannTech Series Scanner.

Four scans comprising A0 and A4 document formats at nominal sampling rates of 400 and 600 dpi were provided. Target features for evaluation were placed on-axis and in the four corners of the field of view. Though the emphasis for this evaluation is the measurement of the effective optical resolution, supporting performance evaluations are provided for noise, OECF, white balance, and geometric distortion. The Spatial Frequency Response (SFR) measurement protocols outlined in ISO 16067-1 were used to determine spatial resolution. A 10% SFR response threshold, consistent with the Rayleigh criterion, was used as the optical resolution threshold. Results were averaged across the five field positions. A summary follows:

- All of the delivered scans performed well with respect to their sampling rates. Both the 400 and 600 dpi scans achieved or exceeded the 10% SFR criteria used to judge effective optical resolution. This was the case for:
  - A0 and A4 formats
  - All color channels
  - Across the field of view.

- All horizontal resolutions exceeded those in the vertical direction.

- There was no significant difference in resolution between color channels. For any particular scan or field position the resolution did not vary significantly between color channels.

- While the Opto-Electronic Conversion Function (OECF) for all scans was very well behaved, it was somewhat low for most standard viewing conditions (γ =1.8 or 2.2). The typical gamma for the delivered scans was γ =1.6

- Follow-on supporting images showed very low optical distortion. The A0 mode had 1.4% distortion. The A4 mode had 0.4% distortion.

- There were no systematic color misregistration problems. Though some slight, but real, color misregistration was measured for individual portions of the field, in different directions and sampling rates, there was no clear trend that would suggest a logical source for such random behaviors.
- Noise levels were generally moderate to high. The 600 dpi noise levels were higher than those of the 400 dpi scans.
- The horizontal fixed pattern noise could be a potential problem if aggressive post processing of the images occurs.

Resolution

Fig. 1 illustrates the Luminance SFRs from which resolution was determined for both the A0 and A4 scan formats. A 10% or higher response value at the Nyquist frequency was the aim criteria use for judging resolution. An 85% lower limit tolerance was used to make a pass/fail judgment. Since five separate field positions were tested, a minimum/maximum envelope (dotted line) about the average SFR is also provided.

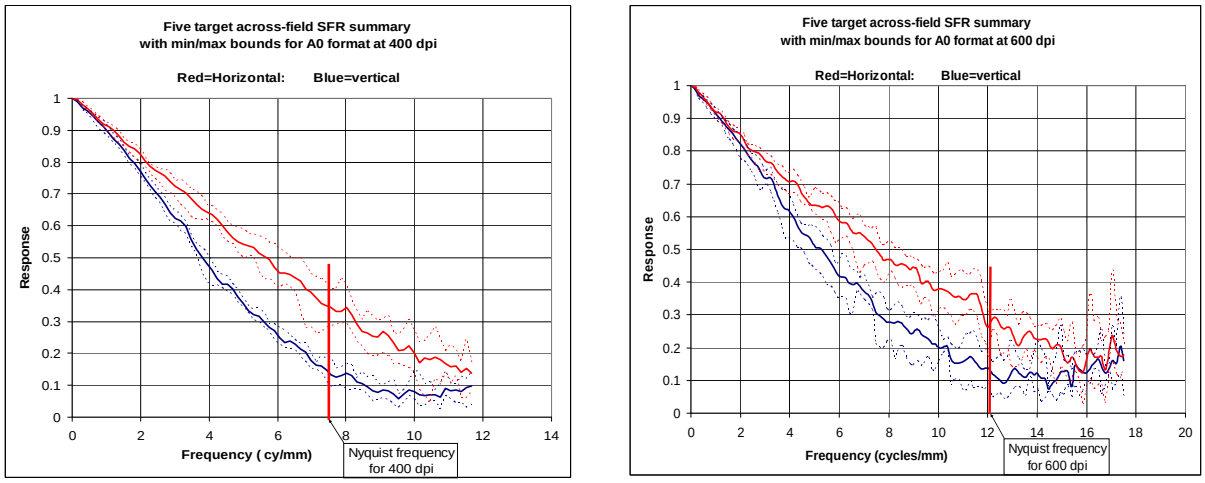

Fig. 1 – Across Field SFR responses for Indus Scanner at 400 dpi and 600 dpi scanning

The luminance SFRs in Fig.1 are very nicely behaved. They descend monotonically from the zero frequency without any ill-behaved morphology. Though not illustrated, the red, green, and blue SFRs for any edge feature effectively overlay. This indicates that there are no longitudinal chromatic errors in the scans. The differences between the horizontal and vertical SFRs indicates some form of motion blurring, most likely due to the sensor movement as it scans the document.

Above all, the limiting resolutions easily matches or exceed the Nyquist frequency and indicates that the maximum resolution potential, as determined by the sampling rate, is

achieved for both the 400 dpi and 600 dpi scans across the corners and center field positions evaluated.

The min/max bound about the average SFR are broader in the 600 dpi scans than for the 400 dpi scans. This is due to the higher noise in the 600 dpi scans which can often give unstable SFR estimates. Nevertheless, these bounds are reasonable.

Color Channel Misregistration

There was slight but measurable color channel misregistration in randomly selected features of the targets. There appeared to nothing deterministic about their behaviors though. With that in mind, it would be wise to monitor this characteristic from time to time. I would rate it a secondary priority. It doesn't seem to be a strong enough effect to attempt diagnosing.

OECF/Tone Curve & White/Neutral Balance

The OECF/Tone curves were well behaved and similar for all of the scans. Fig. 2 shows these curves. Overlaid is an accompanying curve for a standard 1.8 gamma. The tone scale from the actual scans was similar to a gamma = 1.6. While the individual RGB OECF curves of Fig. QQ appear to overlay, indicating good white balance, there are notable differences between them when viewed in detail. This is discussed next.

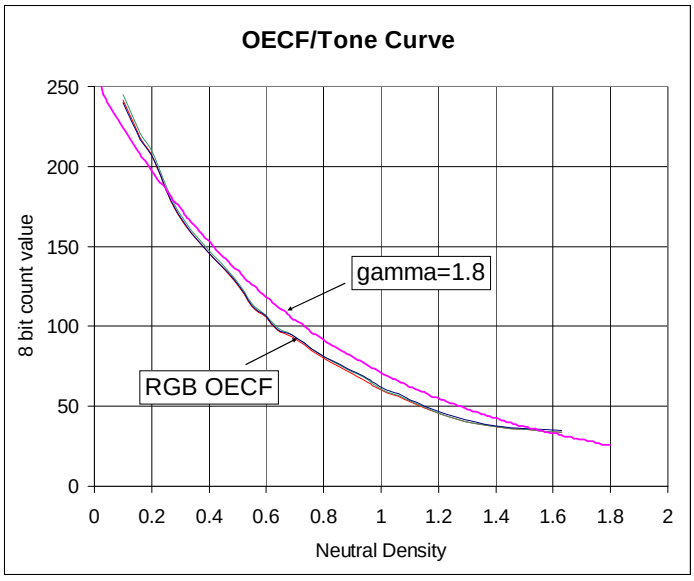

Fig. 2 – OECF curves with Gamma 1.8 reference

The gray patches around the center target feature were used to determine white or neutral balance. The assumption is that the target patches themselves are spectrally neutral. The aim of this metric is to have the large area average count values equal for the three color

channels for any of the twenty neutral patches. This is calculated by simply using the green channel patch average values as a reference and calculating the difference relative to the red and blue channel average patch values. Typically, a plus or minus tolerance of four counts values for the R-G difference or B-G difference is acceptable (indicated by the dashed red line in Fig. 3. This tolerance was met for all densities except one B-G difference in the low densities. Fig. 3 shows this result. It would a good idea to check the spectral neutrality of the target's gray patches before any corrective action is taken. It is noted that these differences may change once a different display gamma (e.g., $\gamma = 2.2$) is applied.

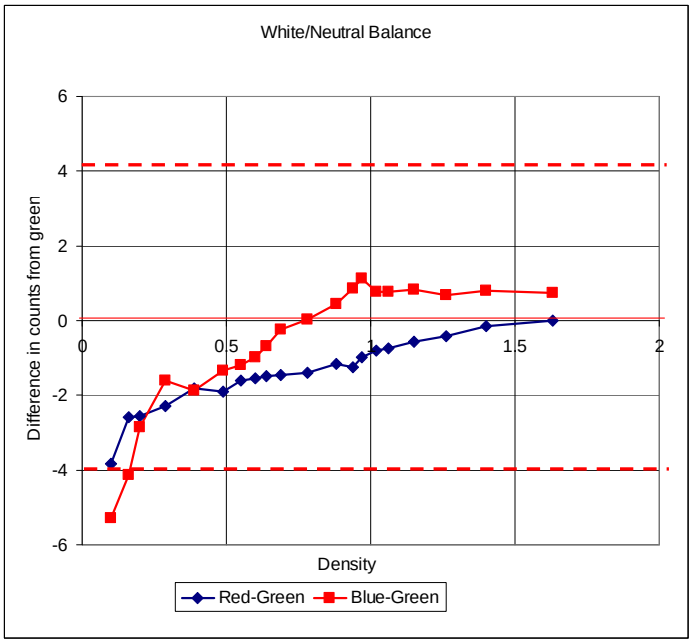

Fig. 3– White/Neutral Balance performance

Geometric Distortion

After providing remedial images in A0 and A4 formats, the geometric distortion was measured as 1.4% for the A0 format, and 0.4 % for the A4 format. These are generally considered very low and acceptable.

Noise

The noise levels for the 400 dpi and 600 dpi scans are shown in Fig. 4. There was no difference between the A0 and A4 formats. Because the target samples from which the noise statistics were calculated have some texture to them, a small portion of the noise may be due to the target itself rather then the scanner. As measured, the noise levels for the 400 dpi scans are probably at the upper limit of acceptability for general applications, while the 600 dpi scans can be considered un-acceptable. About a 3-4 rms count levels of noise at $\gamma = 2.2$ are generally cited. I believe NARA's guidelines ask for 1 count level or less for critical collection content.

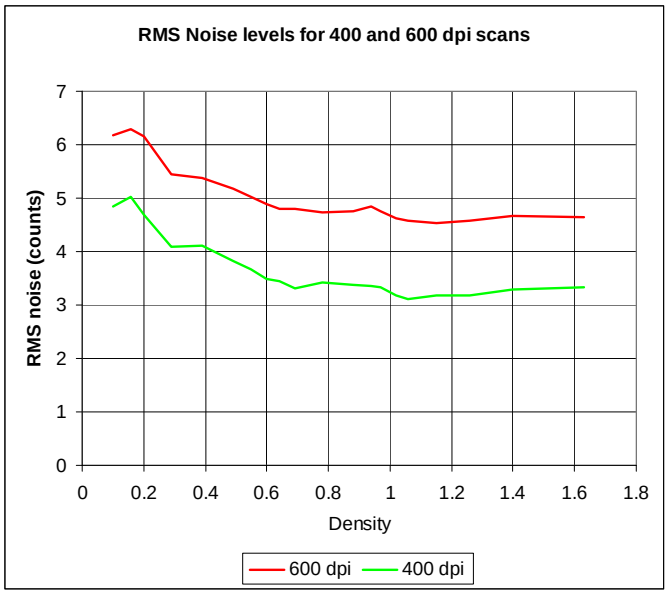

Fig. 4 – Noise for 400 dpi and 600 dpi scans
* These noise levels will increase in the low density regions as higher tonal gammas are applied.

Horizontal Fixed Pattern Noise

Finally, some horizontal fixed pattern noise was present in the scans, albeit at a very low level. An enhanced image of this patterning extracted from the full horizontal width of an A0 scan is shown in Fig. 5. While most of the pixel-to-pixel variations are normal, near the left hand side is a band of hot pixels that run the vertical dimension of the A0 format. Given that this is an enhanced image it is unlikely to be a problem unless aggressive post image processing is applied.

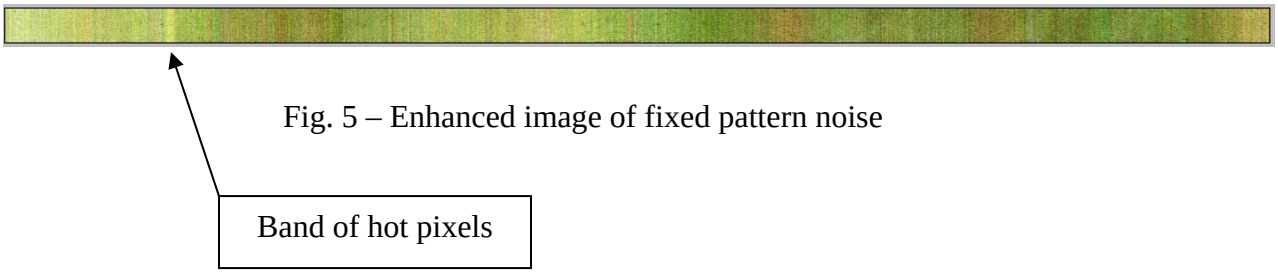

Fig. 5 – Enhanced image of fixed pattern noise