Experimental Data on ISO/IEC 24790 amd 1

1 Introduction

This amendment accommodates the following two updates,

- modify the graininess and mottle measurement methods to correlate well with subjective impressions,

- revise the conversion functions from scanner RGB to CIE Y_{d50}.

Each measurement method for graininess or mottle specified in ISO/IEC 24790:2017 had shown a good correlation between measured and subjective values when the standard had been developed. In each demonstration, the SC28/WG4 conformance test chart comprising only mid-tone patches of a variety of graininess or mottle levels had been evaluated.

However, one of WG4 members presented his preliminary study indicating inconsistencies between measured and subjective values in shadow and highlight area both for graininess and mottles. Measured values were lower than subjective in shadow and higher in highlight when CIE Y based input images as defied in the standard. While an opposite tendency was detected in case of L* based input images. The correlation was noticably improved by taking input images of the optimized power-of-Y of 1/2.

As for conversion functions from Scanner RGB to CIE Y_{d50}, a 4th-order even function to convert Scanner RGB to linear sRGB, followed by a further conversion to CIE Y_{d50} based on the CIE matrix, gave a good correlation with colourimetric measurement.

In addition, CIE Y_{d50} values in each patch with the above conversion were replaced by the mean CIE Y_{d50} value of the patch when the converted values were smaller than the mean. This reduced the discrepancy of measured mottle values with subjective scores in a series of noise added patches.

Experimental data for this amendment are recorded in the following Clauses for the convenience of users of the amendment and developers in a future revision of ISO/IEC 24790.

2 Sample preparations

2.1 Graininess

The flowchart to prepare a graininess test chart to be printed both for graininess measurements and subjective evaluation is shown in Figure 1.

Base noise images were obtained by passing a series of 2-demensional white noise images of 12 noise levels (σ = 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20 and 22 /255) through a spatial band pass filter of cut off frequency from 0.2 to 4.0 cycles/mm. The graininess test chart, comprising a matrix with the 12 noise levels and 6 gray levels (0, 32, 64, 128, 192, 224), is created by adding the base noise images to uniform patches of the 6 gray levels.

The graininess test chart was printed by Approval XP4 (Kodak Polychrome Graphics) using a halftone scree of 200 lpi and 45 degree.

2.2 Mottle

The flowchart to prepare a mottle test chart to be printed both for mottle measurements and subjective evaluation is shown in Figure 1.

Base noise images were obtained by passing a series of 2-demensional white noise images of 10 noise levels (σ = 0, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 /255) through a spatial band pass filter of cut off frequency from 0 to 0.4 cycles/mm as specified in the mottle measurement method in ISO/IEC 24790. The mottle test chart, comprising a matrix with the 10 noise levels and 6 gray levels (0, 32, 64, 128, 192, 224), is created by adding the base noise images to uniform patches of the 6 gray levels.

The mottle test chart was printed by Approval XP4 (Kodak Polychrome Graphics) using a halftone scree of 200 lpi and 45 degree.

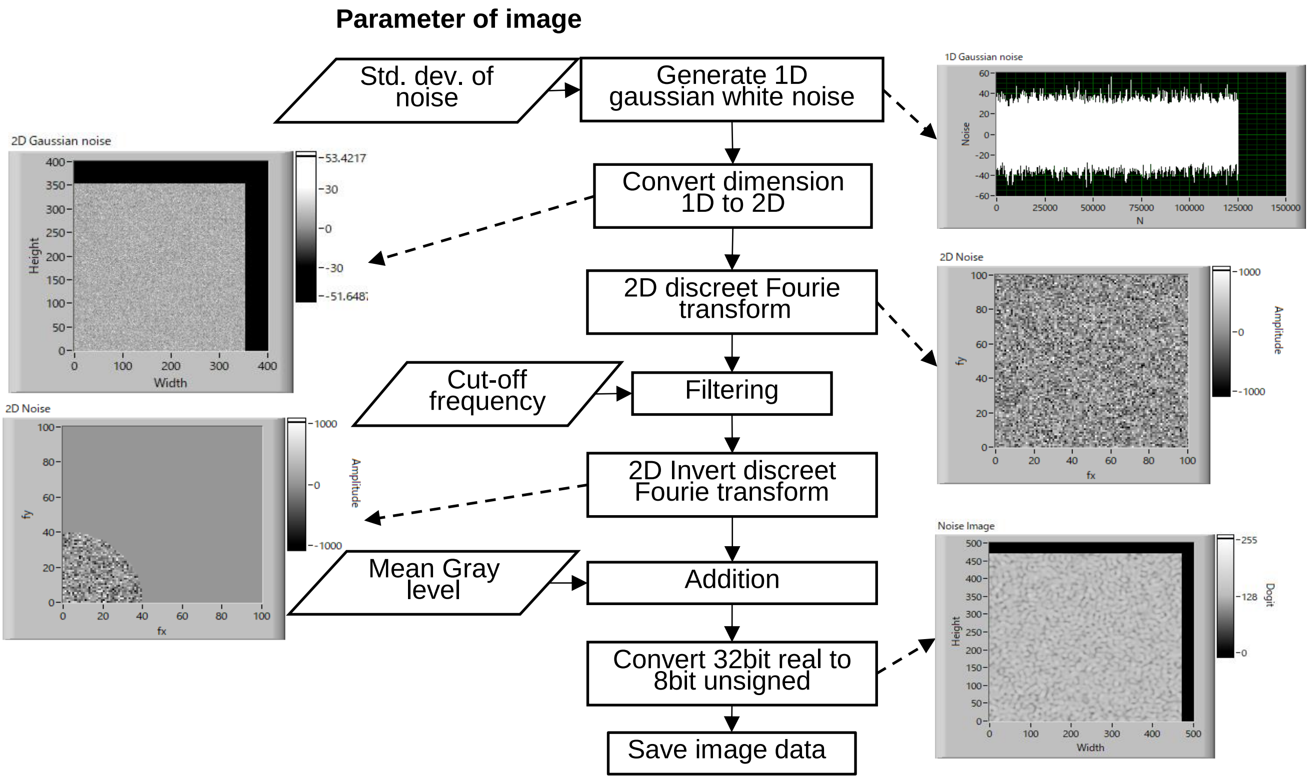

Figure 1. Flowchart to obtain graininess and mottle test chart.

3 Subjective evaluations

3.1 Graininess

The reference graininess scale was prepared by placing a series of 50% gray patches of various noise levels in the graininess print sample on a graininess scale from 0 to 5 based on their graininess scores measured in accordance with ISO/IEC 24790 as shown in Figure 2.

Ten Japanese evaluators in addition to 3 evaluators in SC 28/WG 4 experts, both comprising engineers of image quality evaluation experience, participated in the subjective graininess evaluation. Each evaluator placed each patch in the grainiess print sample in 2.1 on the reference graininess scale based on his subjective graininess impression by comparing with the reference patches arranged in the scale. A score for each patch was defined as the normarized distance between 0 to 5 in the scale.

A subjective graininess score for each patch was calculated by averaging corresponding scores over evaluators.

3.2 Mottle

There were 10 evaluators comprising Japanese engineers experiencing image quality evaluation to prepare a reference mottle scale. The reference mottle scale was obtained by placing a series of 128 gray level patches of 6 noise levels in the mottle print sample in 2.2 on a mottle scale from 0 to 25, in which firstly the noiseless patch was placed at 0, then the patch of the highest noise level was placed at 25, followed by placing the other patches between 0 to 25 based on their subjective impressions in terms of mottle as shown in Figure 3.

Nine Japanese engineers of image quality evaluation experience participated in the subjective mottle evaluation. Total of 25 patches comprising a matrix with 5 gray levels (0, 32, 64, 192 and 224) and 5 noise levels were depicted from the mottle print sample in **2.2.** Each evaluator placed each patch on the reference mottle scale based on his subjective mottle impression by comparing with the reference patches arranged in the scale. A score for each patch was defined as the normarized distance between 0 to 25 in the scale.

A subjective mottle score for each patch was calculated by averaging corresponding scores over evaluators.

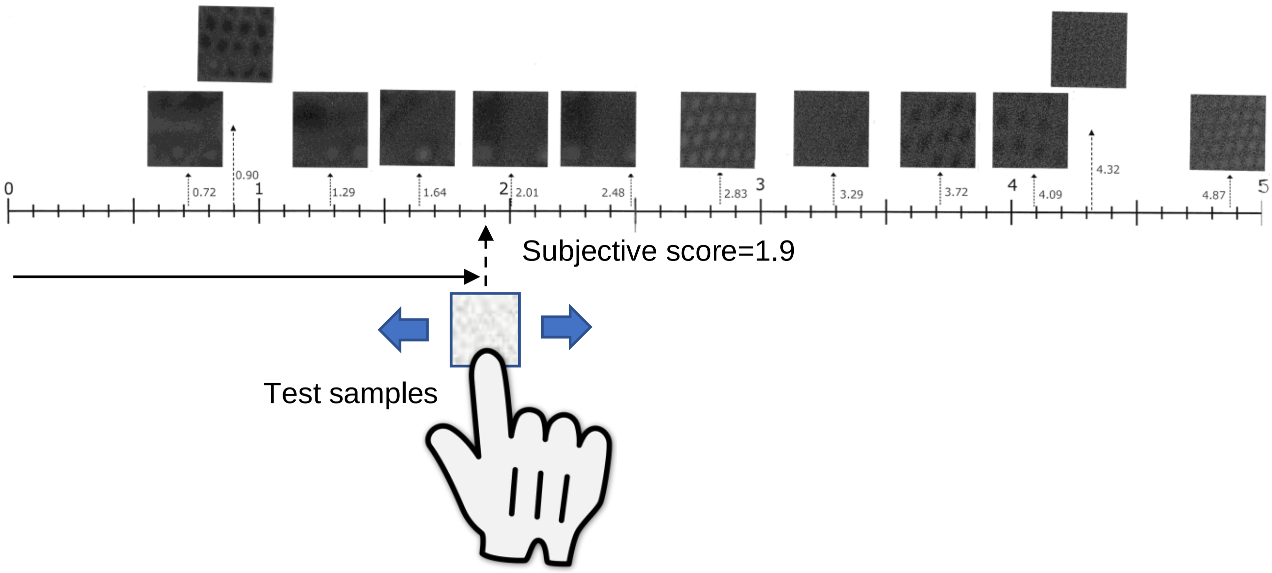

Figure 2. Subjective evaluation procedure for Graininess.

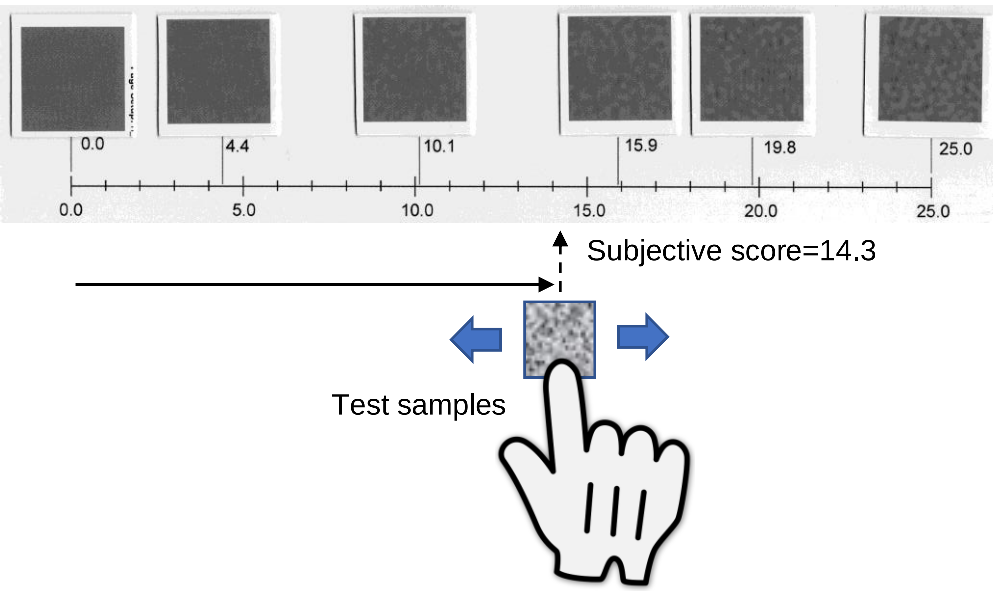

Figure 3. Subjective evaluation procedure for mottle.

4 Dependence of subjective correlations on power-of-Yd_{50}

As is pointed out in Clause 1, the correlations between measured values and subjective scores both for graininess and mottle strongly depend on power-of-CIE Y_{d50}. Changes in correlations caused only by power-of-CIE Y_{d50}, excluding the effect of colur conversions, are shown in this Clause.

4.1 Graininess

Figure 4 shows the relationship between subjective scores and measured graininess values based on ISO/IEC 24790:2017. The slops were strongly depended on gray levels.

Figure 5 shows the change in the correlations of subjective scores with measured scores under three conditions of 1/N, power-of-Y_{d50}. The correlation in N = 2 is much better than those in N =1 and N = 3.

Figure 6 shows the correlation factors, r^2 changes with N. The forcors showed a peak at around N = 2.

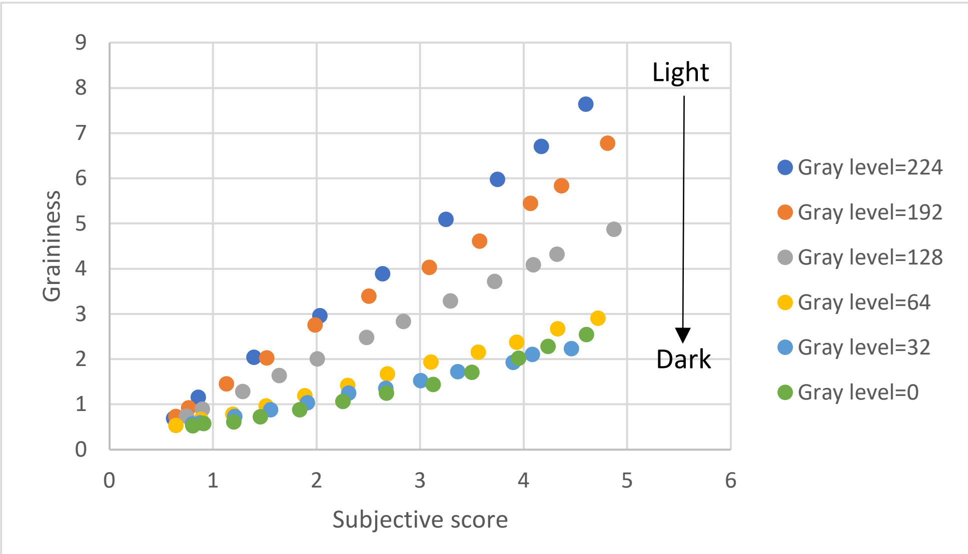

Figure 4 Relationship between subjective and measured graininess scores with ISO/IEC 24790.

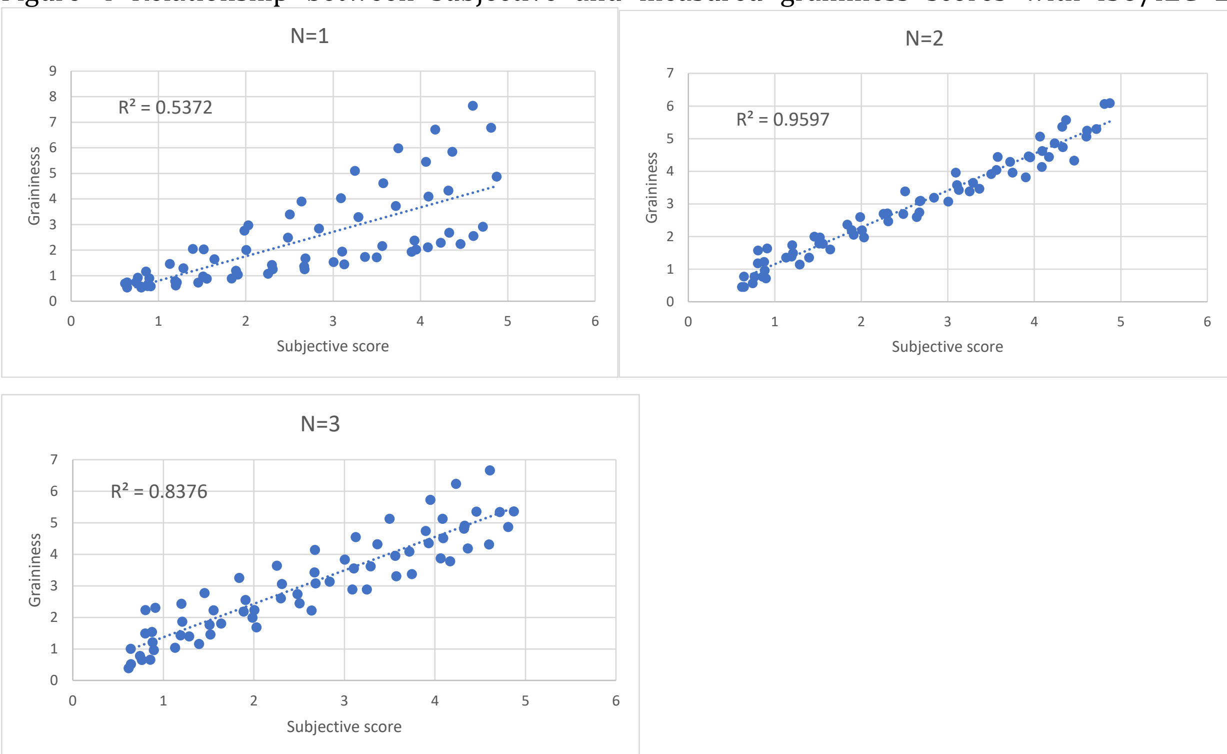

Figure 5 Changes in correlation with power-of-Y_{d50} (N) in grainíniess.

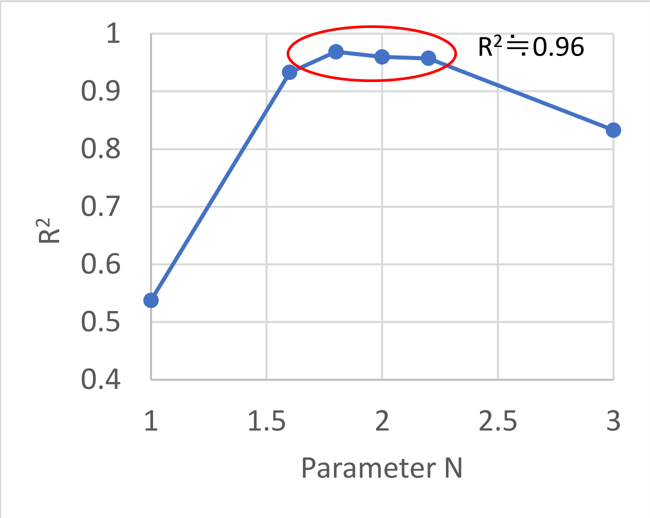

Figure 6 Changes in correlation factors with power-of-Y_{d50} (N) in graininess.

4.2 Mottle

Figure 7 shows the relationship between subjective scores and measured mottle values based on ISO/IEC 24790:2017.

Figure 8 shows the change in the correlations of subjective scores with measured scores under three conditions of 1/N, power-of-Y_{d50}. The correlation in N = 2 is much better than those in N =1 and N = 3. However, the factors in N = 2 is only 0.694. A further study was required.

Figure 9 shows the reason why correlation factors is insufitient in case of N = 2. It is indicated that mottle scores measured were significanly higher than subjective scores for shadow patches.

We solved this issue by changing the conversion functions as described in Clause 1.

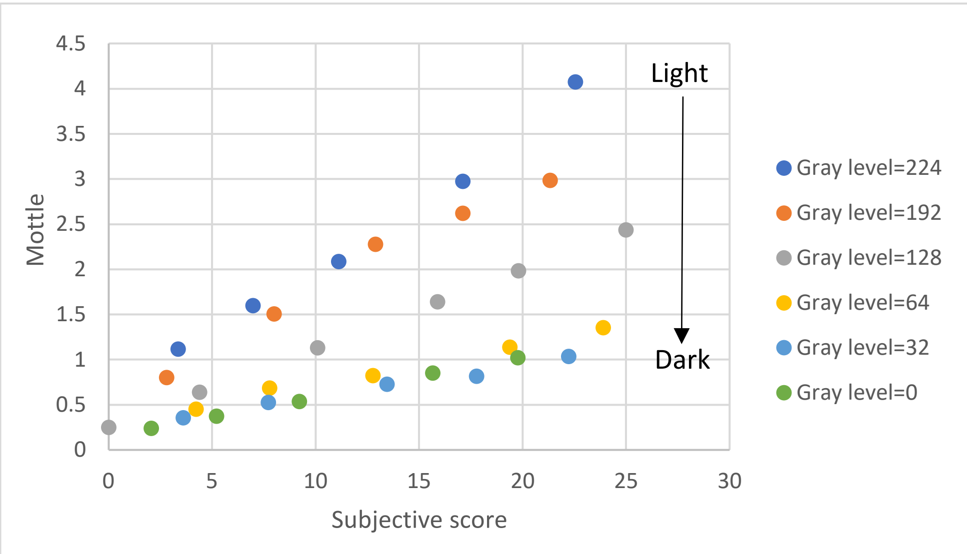

Figure 7 Relationship between subjective and measured mottle scores with ISO/IEC 24790.

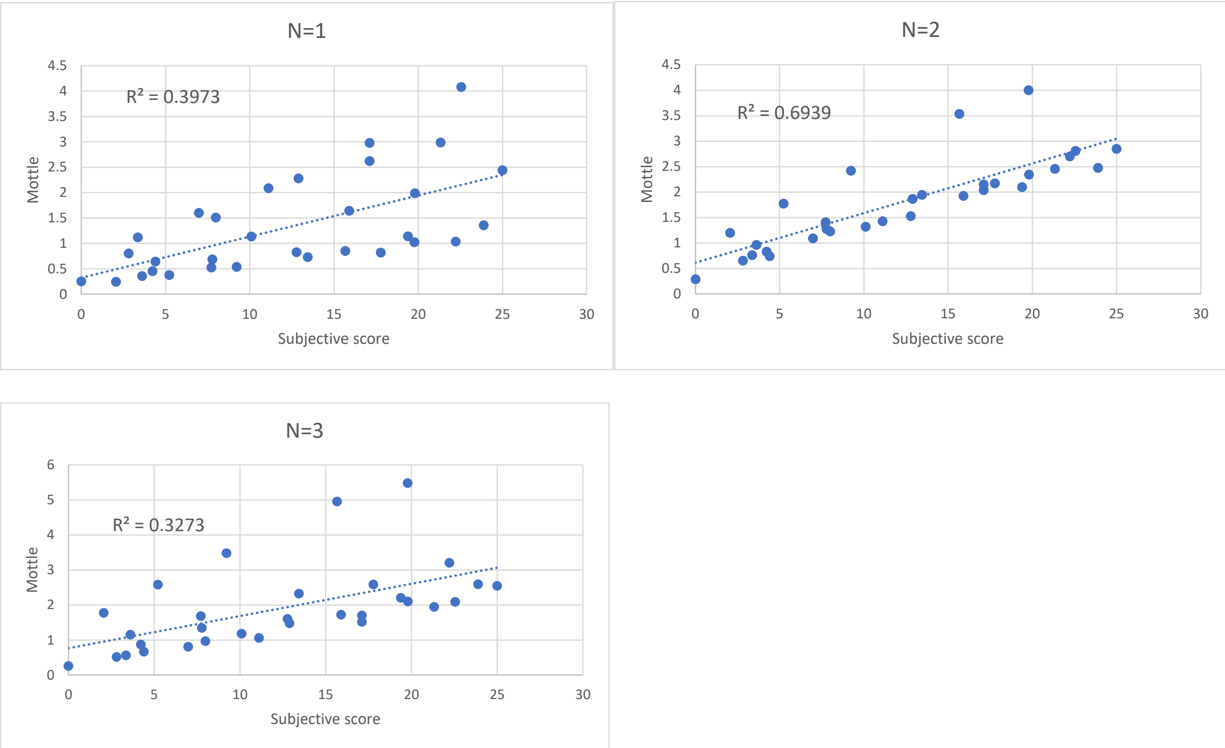

Figure 8 Changes in relationship with power-of-Y_{d50} (N) in mottle.

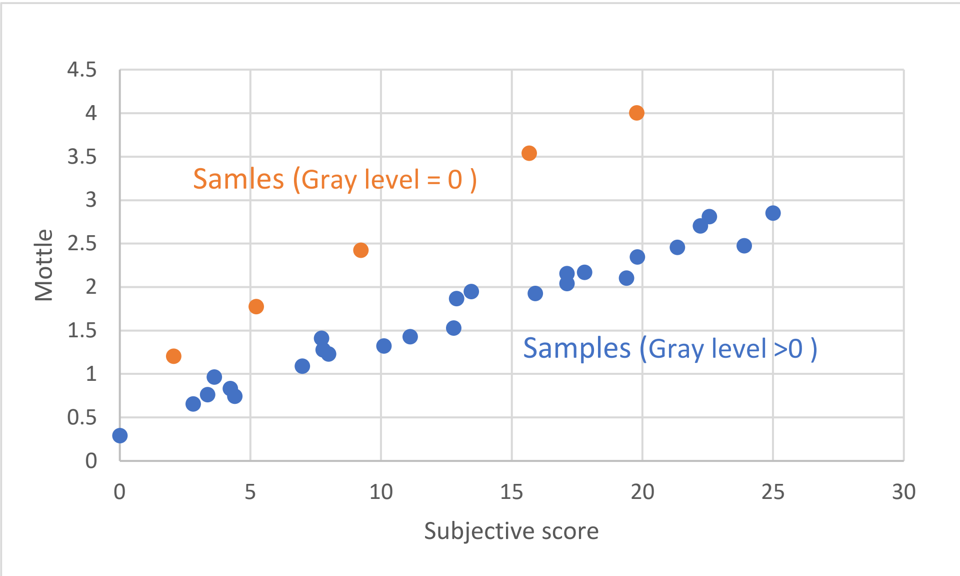

Figure 9 Changes in slopes with gray levels at N = 2.

5 Improved correlations by colour conversion

5.1 Graininess

Figure 10 shows the relationship between subjective scores and measured graininess values based on the modified colour conversion procedures summarized in Clase 1 for the three conditions of 1/N, power-of-Y_{d50}. The correlation in N = 2 is much better than those in N =1 and N = 3. The correlation in N = 2 improved up to 0.977, which is 0.02 better than the correlation based on the conventional colour conversion specified in ISO/IEC 24790.

Significance of new colour conversion procedures in addition to taking optimum power-of-Y_{d50} is proven.

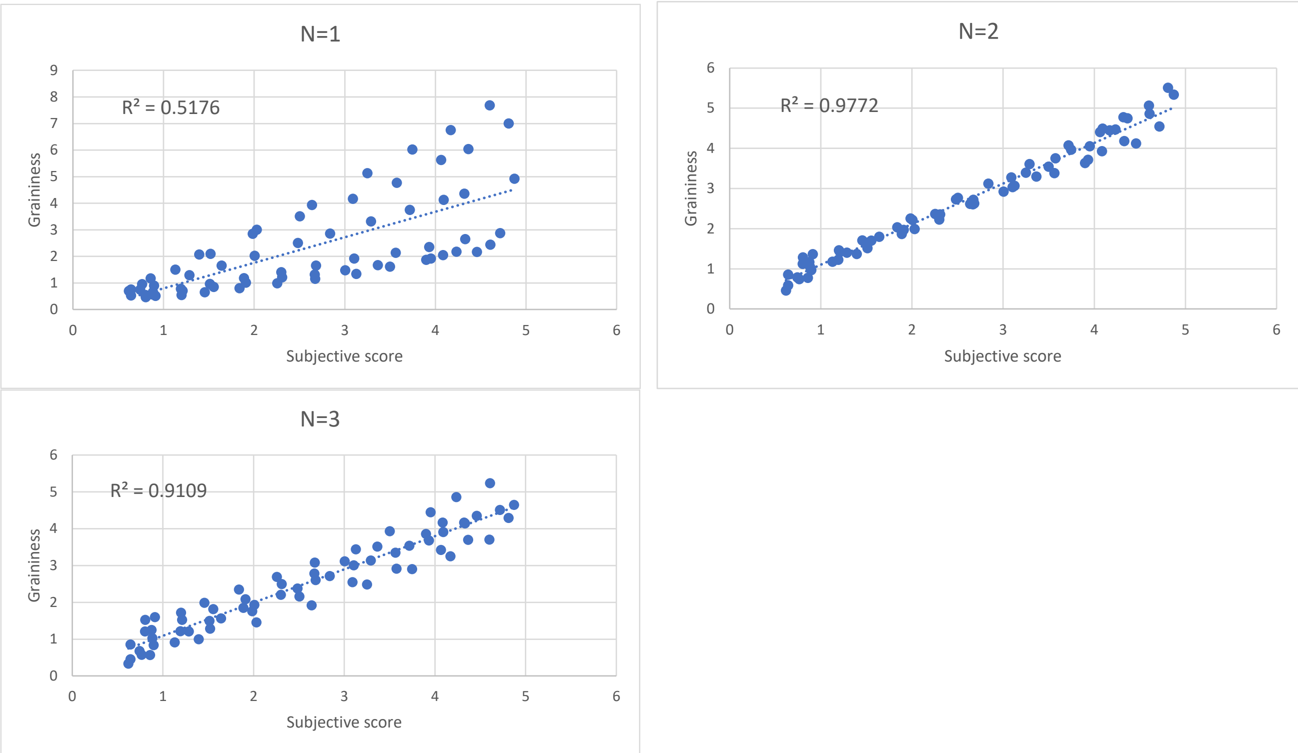

Figure 10 Correlations between measured and subjective graininess under modified colour conversion.

5.2 Mottle

Figure 11 shows the relationship between subjective scores and measured mottle values in N = 2 based on the modified colour conversion procedures summarized in Clase 1. The correlation between measured and subjective mottle scores is finaly improved up to $r^2 = 0.937$ by taking both the optimum N and modified colour conversion.

The importance of this amendment is showen.

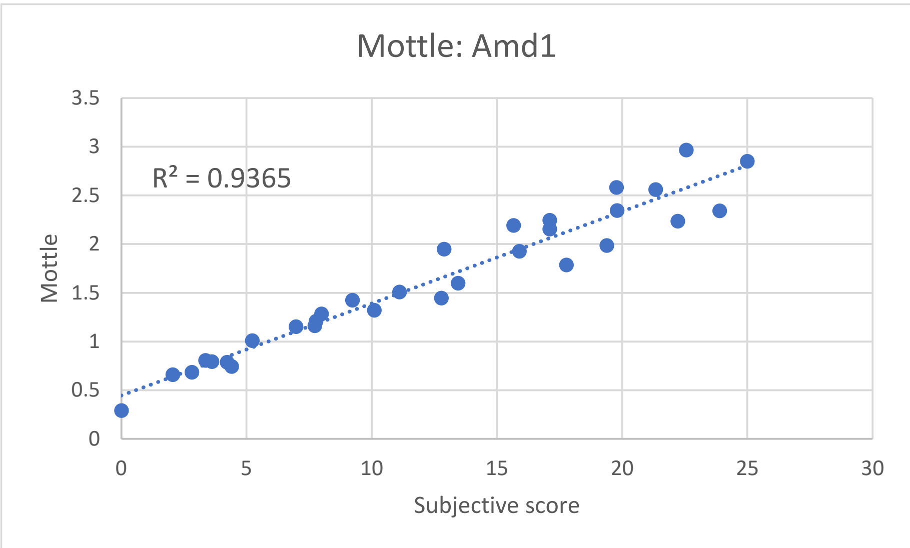

Figure 11 Correlations between measured and subjective mottle under modified colour conversion.

6 Conclusion

In order to improve correlations between subjective and measured scores both in graininess and mottle for highlight and shadow patches, ISO/IEC 24790: amd1 takes two measures, one is to change the power-of-Y_{d50} for input image data from 1.0 to the optimum value of 1/2, and the other is to change colour conversion procedures from Scanner RGB to CIE Y_{d50}.

As shown in Clause 5, the coerrelation factors in terms of r^2 are greatly improved from 0.537 to 0.977 for the graininess and from 0.397 to 0.937 for mottle. Significance of this amendment was confirmed.